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THE AGRICULTURAL DEVELOPMENT SYSTEMS PROJECT IN EGYPT

The Accomplishments of a California–Egypt Research Collaboration 1979–1983

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AGRICULTURAL DEVELOPMENT SYSTEMS PROJECT

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EXECUTIVE SUMMARY

INTRODUCTION

The Agricultural Development Systems-Egypt Project (ADS) has been an undertaking directed towards improving the performance of the agricultural sector in Egypt. To accomplish this it has focussed on (1) research and training as a means of introducing and developing new technologies relevant to Egypt's needs, and (2) on improving the research capacity of the Ministry of Agriculture and universities.

Two areas in the agricultural sector that were identified as needing improvement were agricultural economics and horticulture. The ADS project has addressed these as its prime concern.

In agricultural economics, the project has provided assistance in upgrading the Egyptian capacity for conducting policy-relevant research and has generated research results which, if adopted as policy, could increase the efficiency of the sector. In the horticulture subsector, ADS has contributed to improved research capability, has introduced and developed new technology to enhance yield and quality of important crops, and has introduced improved germplasm for important crops.

The Project was funded by USAID ($14.6 million) and the Government of Egypt (LE 3.3 million), and implemented through a 5-year Host Country Contract between Egypt's Ministry of Agriculture and the University of California, with the Davis campus (UCD) as the lead institution.

The entire project was a collaborative venture between Egyptian and American scientists and administrators. Policy throughout was determined by a Joint Policy and Planning Board comprising Egyptian and US members; component projects were approved by joint technical committees; and each research project was under the joint direction of American and Egyptian team leaders heading teams of Egyptian and American scientists. Project administration was similarly organized.

Collaborative arrangements led to the involvement of over 650 Egyptian researchers and investigators and the participation of more than 130 US scientists and economists. Almost 200 Egyptians came to the US for advanced training and professional development, and more than 50 seminars and workshops were conducted in Egypt to discuss and disseminate new findings.

THE HORTICULTURE SUB-PROJECT

Given the importance of horticultural crops in Egypt in both acreage and value, the Ministry of Agriculture and the University of California placed major emphasis on the ADS Horticulture Sub-Project.

The short-term goal of the Horticultural Sub-Project has been to enable the Egyptian farmer to produce in quantities and at prices that meet the increasing domestic demand, and of a quality that is competitive in export markets of Middle Eastern and European countries. Achieving this objective without diversion of arable land from staple food production required:

- Improvements in the yield and the quality as well as extending the harvest season to capture the benefit of Egypt's comparative climatic advantage;
- Improvements in postharvest handling and storage of fruit and vegetables in both the domestic and export markets to reduce heavy damage and deterioration.

The longer-term goal of the Sub-Project has been to strengthen the capability of the Egyptian agricultural research community so that it can meet the nation's ongoing needs more effectively. This objective has been pursued through the development of collaborative research activities between American universities and Egyptian research institutions. Working closely with US counterparts, Egyptian scientists have improved their capacity to plan,

undertake, and extend research and technology in horticulture. In this way, a sustained improvement in horticultural research can be expected beyond the life of the project.

Another important goal of the Sub-Project has been to promote a strong and effective extension program. The potential contribution can be fully realized only if the expertise of Egyptian and UCD and other US university scientists and extension workers is effectively utilized at the farm level and at the government and private industry policy and decision-making levels.

All horticulture projects have recorded major accomplishments. Projects that have been in existence longest achieved the most dramatic results. In general, progress on annual crops has been more rapid than the work on tree crops which, because of the slow maturation and long life cycle, is inherently slower, and experimental results take longer to emerge and to evaluate.

The main thrust of research has been to identify and overcome critical constraints that limit crop yield and quality. Introduction, selection, and breeding of superior varieties which are adapted to Egyptian conditions have been major factors in achieving this, along with research to improve cultural techniques such as propagation, water management, fertilizing, and pest control. In addition to informal training through collaborative research, the Sub-Project has provided training in the United States for selected Egyptian postdoctoral scientists. These 6-16 month visits provided longer-term experience in a rapidly advancing field of research not well represented in Egypt. Short courses, symposia, and workshops have been regular features of Sub-Project activities and provided an opportunity to update or train Egyptian scientists who are not participating in the overseas postdoctoral program.

When field trials were completed and the value of new techniques established, training in the new methods was given to government extension agents, the key channel for transmission of new technology to growers. The Sub-Project has also been active in exploring the most effective ways of conveying new information to target groups; in addition to extension through meetings and workshops, instruction manuals for growers have been prepared and media broadcasts have been organized to reach the widest audience.

There can be little doubt that the achievements of the Horticulture Sub-Project will be seen as a crucial step in modernizing Egyptian horticulture. The introduction of new germplasm and new techniques, along with more highly trained scientists, provide the technological basis for a quantum jump in horticultural production.

Synopses of component projects follow.

A **Central Horticulture Research Laboratory** was established at the California Research Center on the campus of Cairo University. A building was modified and fully equipped with modern instruments and staff trained to operate the facility. It is now operational for postharvest research and chemical analysis of plant-related material.

A **Horticultural Research Library** was also established at the California Research Center. It contains a comprehensive set of up-to-date journals and books totaling some 25,000 volumes, as well as audiovisual equipment. It is the only such library in Egypt.

The **Tomato Improvement Project** has succeeded in increasing tomato yields three-fold through introduction of new cultivars and cultural practices. Five of the 22 new superior quality high yielding disease resistant cultivars have been grown commercially on 40,000 feddans in 1983. It is believed that the new technology will increase the annual value of the tomato crop by 161 million LE.

Breeding work has been initiated to incorporate resistance to tomato yellow leaf curl virus, salt tolerance and nematode resistance. Fertilizer and pest control studies have resulted in new recommendations for growers. Extension work, including demonstration plots and insecticide spraying by helicopter, has resulted in adoption of new technology in several governorates.

The **Garlic Improvement Project** was initiated to select and develop improved strains of garlic, prevent and control several production and postharvest diseases, and increase yields through improved cultural practices, seed handling and use of virus-free seed. Some of the objectives have already been achieved and yields have been increased through improved cultural practices. Yields in Egypt have been 4.7 tons per feddan. The project has produced average yields of 10 tons/feddan utilizing new information obtained in higher plant densities, planting dates, fertilization and pest management. Tissue culture work on producing virus-

free propagules is still in progress. Extension activities have been initiated that include demonstration plots totaling 1500 feddans.

The objectives of the **Cucurbit Project** were to improve cultivated cucurbit species (watermelons, cucumbers, sweet melons and squash) by breeding higher yielding and disease resistant cultivars, to develop the sources of genetic variation to provide material for further cucurbit cultivar improvement, and to develop cultural practices that would improve the yields and quality of cultivated cucurbit species.

The major achievement of the project has been to introduce and to breed cultivars with resistance to fungal and viral diseases, the principal constraint to increased productivity. New improved cultivars with disease resistance have been evaluated and are being introduced into Egyptian agriculture. Also two local melon varieties 'Edfina' and 'Ananas' have been improved and released.

Increased yields have also been obtained by using higher plant densities, improved fertilizer and irrigation practices, and chemical control of disease and insects.

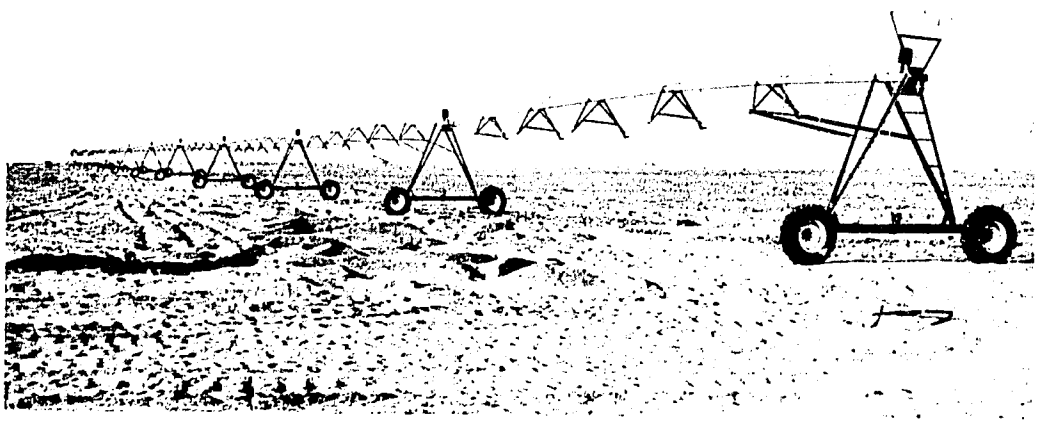
The **Citrus Project** was designed to improve the production of citrus by introducing new high yielding cultivars, by improving citrus rootstock and by the identification and correction of limiting factors causing low yields. Citrus research is inherently long-term since it takes several years before the trees start production. Activities commenced in this project will need to be continued for several years if the research investment is to pay off.

The identification of high-yielding, true-to-type citrus trees in commercial and government orchards is essentially complete, and hundreds of trees have been propagated with buds of these selections. Seeds of identified rootstock and budwood of several citrus culivars have been brought from Florida and California. The buds were grafted on orange seedlings and placed in a foundation budwood orchard.

Factors responsible for low citrus productivity in Egypt have been identified and suggestions for improved cultural practices disseminated in an extension bulletin.

The **Deciduous Fruits Project** concentrated on the introduction of improved cultivars of primarily stone and pome fruits and screening of rootstocks for increased tolerance to waterlogging and salinity. Biological and chemical control of the *Zeuzera* borer, attacking pear and apple, was pursued jointly with the Olive Project.

The project has introduced one hundred and thirteen deciduous fruit cultivars from California, Florida, Texas, South Africa, and Israel with low and moderate chilling requirements. These include apples, apricots, figs, peaches, plums, pears, prunes, nectarines and nuts. At least six of these in peaches, three in nectarines, and three in apples have already proven to be successful under local conditions. Sixteen superior apricot and six peach trees



As part of a commitment to increasing agricultural production, major efforts are being made to reclaim areas of desert for agriculture. Sprinkler irrigation is shown above at one such project near Ismailia. Several horticultural crops have been evaluated for their adaptation to growing under these conditions. *Photo: John Rowntree*

of different maturity dates have been selected from local seedling trees for use in propagating a superior line.

New methods of vegetative propagation have been introduced and adopted. Chemical means of breaking the dormancy of certain apple cultivars have been successful. A program has been initiated for screening and selecting seedlings of apricot, peach and almond for tolerance to salinity and waterlogged soils.

The **Mango Project** has mounted multidisciplinary research on eradicating the problem of mango inflorescence malformation, a disease which severely limits production. While the project has not been able to identify the causal factor of inflorescence malformation, success has been achieved in developing orchard management techniques which minimize the effects of the malady and reduce yield losses. New techniques have been established for mango propagation having the advantage of a shorter time for grafting mango trees, vigorous root systems, and a high percentage of successful grafts.

The aims of the **Aromatic and Medicinal Plants Project** were to improve production and product quality of important aromatic and medicinal plants in Egypt and to study methods to diversify production, thus expanding export markets and/or replacing imported materials. Four plants new to Egyptian agriculture (oregano, tarragon, savory, and hyssop) have been introduced. The cultural methods of geranium and marjoram have been improved giving higher yields and better quality. Two new strains of marjoram have been selected for high seed and leaf yields from a breeding population of irradiated seeds. Strains have been selected from a breeding population of chamomile and calendula for high yield and quality of active principle and pigment.

The **Nursery Industry Project** was designed to exploit the increasing potential for export of potted plants by introducing modern techniques of propagation, cultivation and postharvest handling of potted and nursery plants. New techniques of propagation of nursery plants have been introduced including installation of three mist propagation systems. Several growing media have been formulated and successfully tested using locally available materials. Improved practices for fertilizer use and increasing seed germination have been developed based on the project team's experimental work.

A large expansion of the cut-flower industry in Egypt could develop into a major export earner. To achieve this, substantial modifications would be required of the present local practices in the production and handling of the major cut-flower crops (roses, gladiolus, tuberose and strelitzia).

The **Cut Flowers Project** has introduced the most suitable technology to improve the local cultural practices, the quality, the timing and productivity of these crops, and to identify and eliminate the losses in handling of the local cut-flowers for export. Virus-free rose rootstocks were introduced from UC Davis and techniques for year-round rose production under plastic were established. Improved selection and production of strelitzia for export was achieved and the flowering of tuberose manipulated to coincide with export demands. The causes of loss in rose and gladiolus cut flowers were identified and recommendations made to minimize these.

The **New Ornamental Crops Project** was designed to identify minor cut-flower crops which might be developed as export items and to introduce crops identified by California researchers as likely to do well under Egyptian conditions. Special attention was paid to the range of microclimates available in Egypt, particularly the tropical environment of Upper Egypt.

The project initially concentrated on chrysanthemum culture, introducing new varieties, improved propagation techniques and methods for extending the flowering season. Cultivars of freesia, stocks, chamaedorea, among others, have been introduced and evaluated.

The **Olive Project** aimed to establish and evaluate fruiting and rootstock olive cultivars with potential for production of pickling and oil in Egypt and to survey sites designated for established plantings which will increase annual production. Fourteen new cultivars have been brought in from California for evaluation. Mist benches have been imported for improving the rooting ability of cuttings and a grafting technique introduced for propagation of cultivars which root with difficulty. Fruit thinning, weed control and fertilization experiments have been initiated. Olive seedlings grown at Nubaria were individually studied to select new germplasm. Seed collected from the high yielding trees has been planted for further selection.

The improved cultural practices that have emerged from the project's experimental work have been embodied in two extension bulletins available to growers.

The **Grape Improvement Project** focussed on initiating the research upon which an expanded grape industry with an improved quality product can be based. Cuttings of 39 new virus-free cultivars were introduced from California (23 table grapes, 6 wine grapes and 10 rootstocks) and planted in six governorates. During the evaluation of the local varieties, 8 cultivars of superior quality were identified. Thirty-two new clones from 'Roumi Ahmar' and one from 'Fayourni' have been selected for propagation.

The quality and productivity of existing vineyards has been investigated and new techniques tested and recommended to growers. These include thinning, girdling, treatment with growth regulators, pricing and fertilization. The new information is contained in three extension bulletins.

The **Date Palm Project** objectives have been to improve the existing traditional production and apply modern techniques to the new date palm growing areas as well as to improve the fruit quantity and quality through pest management and postharvest handling, processing, packaging, and storage. Egypt is the leading country in total date production. Much of the crop is lost either through inadequate cultural practices, ineffective insect or disease control, or poor handling techniques.

Because of the late commencement of the project (1982), the work that has been done to date is considered as preliminary to establishing the basis for further work. Eight date palm cultivars were introduced from California and others from Saudi Arabia in 1982 and 1983. Evaluation of date varieties that were introduced 25 years ago from Saudi Arabia, Iraq and Tunisia has been completed and selections of several female date palms, superior to existing cultivars, have been made. Preliminary data have been obtained from field experiments on propagation fertilization, pollination, leaf/bunch ratio, fruit thinning and insect control. This data can now be used as a basis for further work.

The main work of the **Banana Project** has centered on introducing new cultivars and comparing the performance of these with that of local cultivars. Fertilizer and spacing studies have also been initiated using the new cultivars. The present supply of domestically produced bananas is not sufficient to supply the local market and imports are increasing. There are however good prospects that with the introduction of better cultivars and improved cultural practices Egypt can supply its domestic markets and once again export bananas.

The aim of the **Vegetable Seed Production Project** was to produce vegetable seeds of high quality from superior cultivars, free from seed-borne diseases and with reliable germination characteristics. In its brief duration, the project has succeeded in multiplying seed from superior selections of six tomato, one watermelon and two sweet melon cultivars. Seed from other crops is being multiplied under rigorous conditions and recommendations have been made for establishing a seed certification program. A seed testing laboratory has been established and five postdoctorals trained in seed technology and production.

The **Tissue Culture Project** has introduced to Egypt state-of-the-art cell and tissue culture methods for use in propagating certain crops to give virus-free plants. To achieve this goal, the project has established excellent tissue culture facilities in the Central Laboratory and has trained Egyptian scientists and technical assistants to operate the facility. Five trainees have completed training in various tissue culture research laboratories in California and Texas and are involved in the research which has been initiated on tissue culture for garlic, potatoes and strawberries.

The **Postharvest Losses Project** looked at the present fruit and vegetable distribution system in order to: identify future studies to improve product handling; to examine selected fruits and vegetables at key points in the distribution process from farm to market to determine the extent of damage and disease, and to measure the weight loss and maturity at each point; to study protective packaging and refrigerated or humidified storage practices; to examine the impact of simple modifications in the current handling systems of some commodities on reduction of losses (changes in container, picking stage, quality storing, ripening methods, etc.); and to extend information about proper harvesting and postharvest handling methods using various extension practices.

The project has demonstrated that the average postharvest loss is 20% in fruits and 30% in vegetables. This means an annual loss of about 2.5 million tons which costs more

than LE 500 million. A reduction in these losses by 1%, which is estimated to be the minimum achieved as a result of this project, will result in savings to Egypt of 5 million LE per annum.

A survey of methods used in picking, handling, packing and marketing of perishables of some 13 different fruit and vegetables in Egypt has been completed and the main problems causing the high losses identified. Modifications and improvements for methods of picking, handling, packing, shipping, storing and marketing of fruits and vegetables have been suggested. New models of containers have been designed and their advantages to producers and wholesalers demonstrated. An up-to-date postharvest laboratory at the Central Laboratory, Cairo University, Giza has been established. It is equipped with 10 modern cold storage rooms, a demonstration packing line, and all the equipment needed for applied postharvest research.

The project has organized and carried out a very large extension program in various producing and marketing districts throughout Egypt. In 1983, the extension activities increased to more than 75% of the entire program.

THE ECONOMICS SUB-PROJECT

The ADS Economics Sub-Project was designed to engage in a wide range of educational and research activities to improve the ability of the Egyptian Ministry of Agriculture (MOA) to plan, implement, and evaluate programs to promote the development of the agricultural sector in Egypt. The immediate short-term contribution of the Sub-Project has been to engage about 270 members of the Egyptian agricultural economics community in policy-relevant research to offer technical and policy guidance to the MOA policy makers. Collaborative research activities combining the efforts of Egyptian, University of California, and other US agricultural economists were created as the principal vehicle through which ADS has contributed to (1) the professional development of Egyptian agricultural economists, and (2) the research and decision-making capabilities of the MOA. This on-the-job research training has been supplemented by seminars, guest lectures, workshops, symposia, exchange visits by both US university and Egyptian researchers on projects, short- and long-term training programs at the University of California, short courses of instruction in Egypt, and other educationally related activities.

During its life (1980-83), the Economics Sub-Project spent approximately $3.5 million (US $ equivalent). It sponsored 23 research activities, engaging 128 Egyptian PhD agricultural economists and 145 junior Egyptian personnel in collaborative research with 46 university agricultural economists (UC and other US institutions). Their research activities produced more than 180 working papers. There were 70 short-term training visits by Egyptian researchers to UCD. The Sub-Project sponsored more than 40 seminars and guest lectures, 10 major Economic Policy Workshops, six mini-workshops and training sessions, three special 10-week "English for Economists" courses, and a weekly class in computer training in Egypt.

The Economics Sub-Project was given a mandate to study six major policy areas designated for priority research:

1. Price Policy
2. Agricultural Marketing and Distribution
3. Human Capital and Social Institutions
4. Food Security Policy
5. Allocation of Development Resources
6. Land and Water Resource Use

Several projects on each of these themes were established and their achievements are outlined below.

The research program expenditures over the contract period amounted to $2,460,244 (US $ equivalent) or about 70% of the total Sub-Project expenditures. Each of the 23 research activities had an average life of two years, four months and an average annual budget of less than $46,000 (US $ equivalent).

The Food Subsidies Project has analyzed the efficiency and equity effects of existing price and distribution policies for some major subsidized and rationed food commodities. Its conclusions were that welfare goals were in some measure achieved by subsidies on

Transport of vegetables from grower to urban markets is a stage of the postharvest handling chain at which significant loss of quality occurs. Traditional transport, as above, exacerbates losses by poor product packaging and exposure. *Photo Eric Gustafson*

certain foods, but at a high efficiency cost. Distribution of these foods was more egalitarian than non-subsidized foods in urban and rural areas, though uneven administration means that rural consumers do not get the benefits that urban consumers do. Since rural families average lower incomes, the weakness of the subsidy policy in rural areas is perverse in accomplishing the welfare goal of the policy. Furthermore, the existing policy creates undesirable consumption patterns for subsidized foodstuffs such as encouraging their use in livestock and poultry feeding. Enforcement of agricultural laws, delivery quotas and compulsory land allotments are tied heavily to existing price and distribution policies, and they are costly to administer. Increasing producer prices could alleviate the need for this and would be conducive to more efficient resource allocation.

The Food Security Project has explored the costs and the macroeconomic, microeconomic and distribution effects of alternative agricultural price policies on the achievement of food security in Egypt. Findings suggest that removal of government interventions would stimulate mainly rice and cotton production and would benefit more small than large farmers. Forced deliveries on rice were found to be irrelevant for mobilizing a marketed surplus from producers and the macro effect of reduced food subsidies would be to enhance investment and growth.

In situations in which greater risk can be tolerated, Egyptian policymakers should stimulate the production of cotton, tomatoes, onions, oranges, and berseem. Only if they are very risk adverse should they favor increasing, instead, the production of maize, rice, sugarcane, wheat, and livestock.

The **Food Consumption in Rural Areas Project** sought to identify the most cost-effective agricultural and consumption-intervention programs for the improvement of the nutritional status of the rural poor. Following the development of a model of the rural household as an economic decision-making unit, alternative government policies such as credit programs, nutrition intervention programs, and price policies were appraised according to their cost-effectiveness.

Major findings were that the rural credit program results in lower prices, higher incomes, and better nutrition but also in more household members being underemployed when combined with mechanization. The price support program results in higher prices, higher incomes, better nutrition, and less underemployment. The input subsidy program results in lower

prices and higher incomes but more underemployment of household members when combined with mechanization. The wheat flour subsidy results in lower prices, better nutrition, and less underemployment.

An increase in income will increase consumption of nonfood more rapidly than food commodities. It will, however, also increase the consumption of food and especially animal protein.

The **Demand for Mechanization Project** has studied the demand for mechanical technology under alternative assumptions about the structure of prices and markets and has examined the interaction between the farming system, cropping patterns and employment patterns, and task-specific mechanization.

The results indicate that the contribution mechanization would make in increasing the yield of draft animals released from labor has been considerably overstated. In addition, tractor ploughing has not had a major impact on crop yields other than cotton, and cannot be used therefore as a reason to justify mechanization of this task. The linear programming farm model developed by the research team demonstrates the direct and indirect effects of commodity price policies, input subsidies and institutional constraints on the demand for mechanical equipment.

The objective of the **Livestock Project** has been to provide information that would assist in the formulation of a comprehensive strategy for livestock development. Project findings stress the key role of the traditional farm in livestock production and Egypt's comparative advantage in producing poultry and milk, but not red meat. Current feed subsidy policies hinder the development of potential improvements in livestock feeding and tend to support farms with lower productivity.

The **Cotton Markets Project** has assessed the economic efficiency and price responsiveness of domestic cotton production, the economic efficiency of domestic spinning, and price behavior of the international cotton lint market. The results of these studies were utilized to examine the efficacy of Egyptian government interventions in the cotton market and to formulate alternative policies which take advantage of the current situation in world cotton markets and improve resource allocations and incomes in the agricultural sector.

The **Farm Efficiency Project** has focussed on the individual farmer's production process, the technical substitution possibilities among inputs, constraints such as scarcity of land, capital and seed varieties, as well as on limitations in the institutions supporting and creating human capital such as farmer education. This study has been a first step in an effort to generate policy recommendations regarding prices, subsidies, education, and infrastructure development. One of the policy-related conclusions of the project is that a government policy of subsidizing tractors would not be effective in alleviating the "labor shortage" problem in rice production, for example, where the labor intensive operations are transplanting, weeding and harvesting. The need is for new technology for these tasks. The project also related labor use to fertilizer inputs and concluded that farmers would benefit from a legal private market in fertilizers. Increased product prices to farmers is regarded as the key to solving the labor problem in the face of increased costs of production inputs.

The **Agricultural Cooperatives Improvement Project** conducted a survey designed to reassess the role of cooperatives in agricultural development so as to make policy recommendations for improving their structure, conduct and performance. Preliminary findings indicate that the functioning of the cooperatives would improve if objectives and methods of operation were reorganized to represent better the members' interests, and if specialized marketing cooperatives were allowed more control over marketing decisions.

The **Lakes Development Project** investigated alternatives for the optimal development of the northern Nile Delta lakes. Research and survey results show that the lakes' fisheries are considerably more productive than the historical data suggest and that improved fishery management practices could further elevate yields. The high value of the fisheries that will be lost if the lakes are drained and the relatively poor or mixed cropping resulting from the reclaimed agricultural areas argue against significant further reductions in the lake area.

Because the most productive fishing areas and the lake bed, which is the most productive of agricultural crops when converted to land, are one and the same, the social costs of sacrificing the fisheries for agricultural production are significantly greater than the private

costs and call into question the economic value of permitting continued private reclamation efforts. Improved fisheries management is required however to stabilize lake margins and to improve fish yield.

The **Poultry Economics Project** aimed at the identification of constraints to the expansion of poultry production, providing a sound economic basis on which a well-formulated poultry development policy may arise and initiating the establishment of a poultry data collection and market reporting system. A specific focus of the project, which complements information provided by earlier studies, has been in the areas of rural flock production, the commercial private sector market, and native hatchery production. Three major surveys on these topics have been successfully completed. Due to the extensive nature of the surveys, analysis of the data and interpretation of findings is still incomplete.

The **Postharvest Efficiency Project** addressed the growing concern of improving the performance of the marketing system and introducing more efficient marketing facilities to reduce postharvest losses.

Losses at each of the stages in the postharvest handling chain of potatoes, tomatoes and grapes have been investigated in depth. The economics of loss reduction have been assessed and, where economically feasible, recommendations for technical improvements have been made. In many cases however the low prices paid to producers are disincentives to loss reduction.

The aim of the **Citrus Marketing Project** has been to contribute to the achievement of the Egyptian policy goal of increased citrus production by providing improved information on the structure and performance of the industry and the economic effects of governmental interventions.

Surveys of growers, wholesalers and orchard merchants were completed and a simulation model constructed and used to generate important new considerations for policy formulation. These include the findings that: output response to a change in production cost is somewhat inelastic with the effect lagging at least six years; under rigorous price ceiling enforcement, a long-run partial equilibrium may be established in which demand exceeds supply at the ceiling price; and variations in export quantities will have little long-run effect on grower prices (assuming no constraints on the availability of land for citrus production and that conflicts with other goals such as lower domestic consumer prices can be resolved).

The **Economic Efficiency of Farms Project** examined relative efficiencies of Egyptian farms under different environmental and economic conditions. The identification of factors that affect farm efficiency is beneficial to both farmers and policy makers and knowledge of the workings of the rural labor markets is essential for planning socially optimal price, employment, and mechanization policies.

An extensive survey of a sample of farms of varying sizes in the rice and vegetable zones has been completed. Analysis of the data has been initiated using computer algorithms modified for this purpose. Further work is required to reap the benefits from the surveys and research already completed.

The **Rural Labor Supply Project** has analyzed the incidence and character of "labor shortages" in Egyptian agriculture, the structure and functioning of rural labor markets, the relationship between agricultural policies and changes in rural labor markets, and the impacts of current trends on Egyptian agriculture in the 1980's.

The principle findings conclude that there is no "general labor shortage" in Egyptian agriculture. Instead, there are seasonal shortages of hired adult male workers resulting from migration overseas or to urban areas and spreading education. An increased demand for crop labor cannot explain the increase in real farm wages. Supply-side forces furnish the explanation; small farm holders are quite unlikely to hire themselves out to other farmers. Instead, they rent additional land, crop very intensively, and devote their labor time to livestock production. Current pricing policies have contributed to the labor shortage complaint of farmers in two ways: low and inflexible crop prices have caught farmers in a squeeze between rising wages and relatively stagnant prices, and the protected livestock market induces small farmers to devote most of their time to animals rather than to the hired labor market.

The **Land and Water Allocation Project** revealed some of the effects on the agricultural sector of shifting from a government administered price system toward a free market price

Domesticated animals are used for a variety of jobs in Egypt. Here a camel is being used for brick transportation. *Photo: Michael Reid*

system. A main thrust of the study was to reveal the input-derived demands for agricultural resources, land and water in particular. A recursive linear programming model was developed for use as a vehicle to investigate land and water allocation as well as to identify how cropping patterns would be affected by a price change for the four major crops (cotton, wheat, rice and sugarcane). Suggestions have been made on how such regional intertemporal models of the Egyptian agricultural sector can contribute to the planning process and analysis of policy questions.

The **Vegetable Export Marketing Project** sought to assess Egypt's potential for supplying fresh and processed tomatoes and other vegetables to the EEC and Near East markets during the winter months. The project has shown the economic feasibility of entering EEC markets and specifies a number of the key prerequisites for reaching and maintaining adequate product quality.

The introduction of biogas technology could save a large portion of crop residues currently being used for fuel and divert them for animal feed. The MOA has already introduced 34 biogas units to examine the feasibility of this technology and the **Biogas Evaluation Project** sought to evaluate the feasibility of introducing biogas technology into rural Egypt on a large scale by a study of these units and by analyzing crop residues and energy use patterns. The project has generated a wealth of data but the full analysis and interpretations were incomplete at the time of project termination.

The goal of the **Agricultural and Food Policy Project** has been to provide an integrating conceptual framework for looking at short- and long-term aggregate policy issues affecting development in the agricultural sector. The study focussed on eight main issues: land and water resources, agricultural production inputs, agricultural production, agricultural production services, food prices and subsidies, food consumption and distribution, foreign trade, and national investments. In each policy area the context of decision-making was explored. The roles and procedures of each ministry or organization in making decisions were investigated. This project dealt with virtually the whole area of policy formation in Egyptian agriculture and the entire range of policy research carried out under ADS. It acted therefore as a kind of policy analysis clearinghouse for all ADS policy research.

Several general policy recommendations stand out among the conclusions of the project. First, there is a great need for increased coordination among decision-making bodies in

order to reduce conflicting policy thrusts within the government. Second, policy implementation could be improved by increased decentralization of implementation responsibilities. Third, agricultural sector development policies need to take greater cognizance of the role of markets and private sector incentives in achieving national policy goals.

These general policy recommendations are supplemented by scores of particular policy recommendations on specific issues regarding subsidies, fertilizer policy, export policies, land and water resource development, investment policy, and so forth. The findings of this activity represent in large part a synthesis of all the ADS economics policy research.

The **Commodity Systems Analyis Project,** focussing on wheat and potatoes, has developed a perspective for evaluating the dynamics of the production-marketing systems of selected commodities. It is intended to provide greater understanding of the forces within each system that stimulate coordination, adaptation, efficiency, and other changes in performance of those who produce, process, and market the commodity.

The **Rural Development and Consumption Project** compared increased rural incomes with increased availability of mass market goods as indicators of economic development. This study focusses on the extent to which an array of nonfood items, including domestically produced consumer goods, is available in rural areas at reasonable prices. Estimates of expenditure elasticities between high and low income groups for a broad array of expenditure categories and items has been completed for two villages previously chosen on the basis of their representativeness for national policy purposes.

The **Price Policy and Trade Project** has studied the effect of price policies on Egypt's exports, imports, and trade balance. Using a few major crops as examples (rice, wheat, cotton), the influence of price distortions on the volume and value of exports and imports has been examined and using plausible elasticity coefficients, the influence on trade is shown to be very substantial. The conclusion is drawn that Egypt would benefit substantially from a removal of price distortions because the value of output would rise and the trade balance would improve.

The **Integrated Village Studies Project** produced an extensive review of recent village studies work done in Egypt, prepared an annotated bibliography of research in this area, and initiated the modeling of rural behavior and village decision-making using a simulation model. The goal of the project was to examine the interaction of current Egyptian rural institutions with sectoral development in order to design a model for policy analysis based on the structure of rural institutions.

INDEPENDENT PROJECTS

Several research projects which did not fit into the major categories of Horticulture or Economics were implemented. Of particular promise were those concerned with food technology.

The **White Soft Cheese Project** sought to introduce new technology to improve quality and quantity of Domiati cheese. The team has suceeded in devising methods for expanding the production and lowering the cost of Domiati cheese using skim milk powder and locally produced vegetable oils as extenders. New mechanized procedures were developed to improve sanitary conditions, reduce manufacturing costs and speed up production. A method for recovery of edible protein from whey was developed which offers a route for production of low cost, nutritious cheese-like products. The basic process for preparing a new cultured dairy product (similar to buttermilk) has been developed and now awaits pilot-scale and consumer testing.

The **Tomato Processing Project** has provided the equipment and has trained MOA staff in concepts and methods for producing good quality tomato juice and paste. The new high yielding varieties of tomato have been evaluated and the groundwork laid for making choices of raw material on the basis of variety, growing location and season, and for providing a domestic product that can match the quality of imported tomato products.

The **Improved Honeybee Project** has laid the foundation for the sustained development of a modern beekeeping system. A bee genetics and breeding program has been established complete with laboratory equipment and the instruments needed for artificial insemination. Personnel have been trained in modern beekeeping methods and in breeding theory and

techniques. Most of the new breeding hives with improved stock are in place and plans for future activities have been established involving not only research, but also extension and the participation of beekeepers.

The **Sheep Reproduction Project** explored the feasibility of using easily measured temperature changes to detect estrus and pregnancy in sheep. The value of this lies in the economic advantages to farmers who can then supplement the rations of pregnant ewes to insure high lamb survival or to offer the ewe for mating again if earlier matings were unsuccessful. Experiments are continuing under field conditions prior to demonstration and extension of results.

The **Small Power Unit Projects** attempted to develop a solar power unit suitable for low-lift irrigation for small holders. Since the intention was to produce such units locally, the design specified construction and maintenance using local facilities. A prototype Stirling cycle engine was constructed to run on solar energy collected by large locally fabricated metal parabolic reflectors. The efficiency of the engines, constructed in a simple manner, was however found to be too low to warrant continued work so the project investigated alternatives which also relied on a solar energy source.

ADS sponsored several feasibility studies intended as the basis for further development as separate projects. One of these on **Agricultural Statistics** has since been jointly implemented by the Egyptian University of Agriculture and USDA, and funded by USAID. A second feasibility study and planning proposal for a **National Agricultural Research Library** was also completed.

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FOREWORD

This document represents the final report to the United States Agency for International Development and the Ministry of Agriculture of the Arab Republic of Egypt from the University of California at Davis which operated under contract AID/E-263-0041 ADS.

The purpose of the contract was ". . .to establish a collaborative relationship between the Arab Republic of Egypt and the University through which they may discuss, identify, agree upon, and implement activities which are intended to enhance and strengthen the ability of Egyptian institutions to analyze, plan, organize, implement, and evaluate the development of the Egyptian agricultural sector and which generally are intended to improve the ability of the agricultural sector to meet Egypt's agricultural needs."

In addition, it was intended that ". . .the collaborative relationship formed for, and the activities undertaken in, this Project will benefit the University by providing to its faculty, staff, and students research opportunities to increase their knowledge and improve their skills in agriculture and related disciplines by providing an experience in assisting foreign nations to develop their agricultural sectors."

The University approached its task with three objectives in mind:

- to concentrate on what the University of California does best, namely teaching, research and institution building;
- to perform with the excellence that characterizes UCD by commiting the best of its core faculty at both the administrative and technical level; and
- to plan a long-term commitment that is essential if research and institution building programs are to succeed.

Given that the purposes for which this contract was established were ambitious and in the beginning took considerable time to put in place and also that, at the end, notice to terminate by the fifth year required cessation of the burgeoning technical program ahead of schedule, many activities did not achieve their full potential. The reader may judge whether the accomplishments justified the expense, for it is clear that some of the individual projects themselves are already in a position to return annually to the economy of Egypt the entire project costs several times over. It is certain that the rapport resulting from this project between Egyptian and US scientists will last for years to come, and it is likely that the achievements will remain in both US and Egyptian institutions because this contract was fulfilled. However, the full potential benefit will never be realized because the University's long-term perspective was abruptly curtailed.

The accomplishments recorded here are those of Egyptian and US scientists working together. All should be given equal credit for the hard work, patience, and understanding that was required to conduct research and institution building under extremely stressing administrative arrangements. The juxtaposition of three large bureaucracies like the University, USAID, and the Ministry, proved to be a most unfertile milieu for scholarly research. Too often the technical work became a sideshow to administrative process and protocols which became an end in themselves rather than servants to the primary goals. Nevertheless, the University feels it has benefited by provision of the research opportunities to increase its knowledge and skills. It also feels that it has indeed assisted Egypt to develop its agricultural sectors to meet the food security of its people.

This volume, which records the results of so much effort and dedication by Egyptian and US scientists, is presented with a sense of pride in the accomplishments and the hope of lasting benefits.

DAVID W. ROBINSON
Associate Dean, International Programs

EDITOR'S FOREWORD

The report that follows is a summary of the research and training accomplishments of the ADS-Egypt Project. No attempt is made to evaluate the project nor to report comprehensively on other key aspects of the project, such as its history, its design or its administration and management.

The summary reports which are presented in this volume on the 46 individual projects which comprise ADS, have been based largely on the terminal reports submitted to the project directors. These reports were themselves a team effort, embodying the contributions of both Egyptian and American investigators. In view of their team authorship, and the numerous subsequent inputs and editorial modifications, individual authors are not cited. Instead, a listing of professional participants by project is provided in the Appendix.

In reporting ADS achievements, no individual mention is made of the numerous proposals that were investigated for their potential as ADS projects but not selected for funding, nor of those projects for which funding was approved but which, for institutional reasons, never progressed to the research phase.

This report was made possible through the efforts of many people, whose contributions are gratefully acknowledged. In addition to their efforts in preparing final reports of their projects, team leaders have also contributed to making improvements to the edited version of accomplishment reports.

Appreciation is also expressed to those who generously loaned personal photographs from which we selected those for inclusion in this publication.

Dr. Harold Carter, Dr. Lawrence Rappaport, Dr. John Rowntree and Dr. David Robinson, each provided advice and comment that proved invaluable in compiling the report. Their continuous support is deeply appreciated.

Special thanks are due to staff of the ADS Project office in Davis: to Ruth Shea and Lindy Watts for clarifying a thousand details on project administrative matters and for preparing the appendices; to Judy Erwin and Marci Pieratt for undertaking the typing; to Nancy Cole for her assistance in proofing the manuscript; and to Abdi Zehedani for helping collect project reports.

Susan Chaffee, International Programs Office (UCD), brought her critical eye to bear on the production editing problems of the reports and managed the final document through its many production hurdles. Her tireless efforts are sincerely appreciated.

Falloucas on the River Nile at Asswan. *Photo: Michael Reid*

CO-DIRECTORS' FOREWORD

BACKGROUND

In 1977, the Egyptian government entered into an agreement with the government of the United States accepting a grant for improving Egyptian agricultural systems. This was followed in 1978 by a contract between the Ministry of Agriculture (MOA), Egypt, and the United States Agency for International Development (USAID) for the purpose of establishing a collaborative relationship between the MOA and the University of California, Davis (UCD), through which the two parties could discuss, identify, agree upon and implement activities intended to strengthen the ability of Egyptian institutions and to promote development of the agricultural sector to meet the food security needs of Egypt.

The work of the project was to be carried out through research, training, feasibility studies, institutional development, policy advice and implementation of selected development activities in agriculture.

To accomplish the purpose and goals of the project, a Joint Planning and Policy Board (JPPB) was established in 1978 consisting of high level scientists from Egypt and UCD to provide policy guidance, establish priorities and approve major categories of activity. Administration of the project was to be carried out by two Co-Directors, one representing the MOA and the other UCD. Technical advisory committees were established for each of the major fields of activity: Horticulture, Economics, and Food Science. Each of these areas of emphasis included a number of individual activities that focussed on priority problems as agreed upon by the technical committees and implemented in accordance with the directions of the JPPB.

ACHIEVEMENTS

In spite of the relatively long gestation period and administrative and financial constraints, 41 research projects in the Horticulture and Economics Sub-Projects, as well as two projects in Food Science and four independent projects in other areas have been implemented. Four feasibility studies have been completed, one of which, directed at improving agricultural statistics, has been separately funded by USAID and jointly implemented by the MOA and United States Department of Agriculture (USDA). Another feasibility study dealt with the establishment of a National Agricultural Research Library which also may lead to a separately funded project.

The concrete research results already obtained will continue to contribute to increased agricultural productivity in Egypt for many years to come. The details of these successes are described in the subsections of this report. Some of these successes are astounding, such as the huge increases in tomato yields, and the successful introduction of a wide variety of horticultural cultivars. Other successes are less obvious, and will take many years for their benefits to be felt. Many of these research findings still have to be tested for economic feasibility and then, if cost-effective, disseminated among farmers through an effective extension program.

Many of the findings of the Economics Sub-Project will also require considerable gestation time as they get translated into government policy changes and decision-making patterns on the part of farmers. That Egypt can do far better, domestically, in agricultural production is clear, and significant impact is already evident in the steps taken by government to close the huge gaps between internal and external prices of many commodities. Controls of prices of horticultural commodities should be eliminated and grain prices should move in the direction of a similar rationalization. In addition, the food subsidy program should be reassessed.

Egypt's agricultural trading system still remains badly hampered by price controls that bear little relationship to economic reality, and it will take years for the lessons derived

from ADS economic research to work their way through to an effective pricing policy pattern and to the resultant improvements in cropping patterns with improved technology. Fortunately, the effort undertaken during the ADS years will not come to a complete stop at the conclusion of the project in 1983. Egypt has a large corps of well-trained agricultural economists, most of whom have now had the experience of collaborating with UCD economists or advancing their studies as doctoral and postdoctoral scholars.

The ADS project has stressed the importance of education and training as elements in improving the capabilities of the MOA and other research institutions to evaluate and implement agricultural development programs. The project has made great efforts to create an atmosphere of scholarly pursuit and lively debate of the issues as well as to raise technical and economic awareness through group discussions, workshops, short- and long-term training at UCD and attendance at international meetings.

The role of ADS as a pioneer of the collaborative research and development project mode should not go without mention. Experience with ADS, in both its strengths and weaknesses, lead to 12 other collaborative USAID projects in the field of agriculture. In addition, ADS was the first project in which a large number of Egyptian PhDs, junior economists and technicians from the MOA, universities, and research institutes worked together as research teams on selected priority problems. Egyptian team leaders also had their counterparts from UCD and other US scientists working together. Collaborative research activities combined the efforts of Egyptian and UC scientists and were the principal vehicle through which ADS has contributed to the professional development in the field of Egyptian agriculture. This on-the-job research training has been supplemented by workshops, guest lectures, exchange visits by both Egyptians and UC researchers, short- and long-term training programs, formal training for PhD degrees and other educationally related activities. A total of 652 PhD Egyptian researchers, junior technicians, and economists of Egypt's younger second generation in collaborative research with 130 US scientists (including 52 UC professors) have been utilized by ADS. The project also sponsored more than 50 seminars, guest lectures, and workshops and produced more than 350 working papers.

CONSTRAINTS

ADS has been very successful in spite of a number of constraints including a long start-up period, administrative and financial obstacles and lingering uncertainty about the future of the project.

The first two years of the contract was a period of getting the project infrastructure established, heuristic research, and the development of a *modus operandi*. No research activities were formally approved until June 1980 when the bee genetics project was approved, followed in July of that year by approval of activities in tomatoes, citrus fruits, deciduous fruits, mangoes, and post harvest handling of horticultural crops. Approval of the first economics activities (agricultural labor, land and water pricing) followed shortly thereafter. Despite this late formalization of research activities, much was accomplished during those first 22 months. That was a time during which the administrative organization was being established, the JPPB and the technical committees formed, sub-projects being approved, with sub-project Co-Directors and associate directors appointed. Moreover, preliminary research work had to precede formal approval of individual activities by seven or eight months in many cases. Visits to Egypt were arranged and undertaken in those first years by a large number of UCD scientists and economists to meet Egyptian counterparts and to establish a meeting of minds preparatory to the development of the design of activities and the formation of research teams.

The division of project administrative responsibility between two Co-Directors using different regulations governing funds and employment was a drawback and was not conducive to smooth running operations. According to contract rules, the spending of USAID funds is the sole responsibility of UCD's Co-Director, while the Egyptian Co-Director has the responsibility of spending from the Egyptian special fund. The result was that the project has had two accounts, each subject to different spending regulations. The system of appointing administrative employees and the determination of their incentives also differed depending on whether UCD or the MOA was the employer. The resulting inevitable discrimination

among equal project administrative officers and employees was often detrimental to harmonious working relationships.

Uncertainty about the project's future proved to be a major constraint especially during its last 12 months. The momentum of research programs was severely reduced early in 1983 when it became clear that UCD would not be involved in the project beyond fiscal year 1982–83, and the slowdown was exacerbated by the long delays and uncertainties associated with USAID's unfulfilled commitment to augment the project budget for 1982–83. This delay led to the premature cancellation of training programs and workshops, and the interruption or discontinuation of research activities with much left to be done.

SUMMING UP

To sum up, we regard ADS as having contributed in a most significant way to agricultural progress in Egypt. Much more could have been achieved if a more effective job of removing the project's constraints had been done both early and late in the contract period, and if a well-planned extension of the UCD-MOA affiliation could have been worked out as had been envisaged in early 1982 by the JPPB. It is our sincere hope that the bulk of the work initiated under ADS can be effectively continued with the anticipated USAID financing provided directly to the Arab Republic of Egypt (ARE) through the so-called "sectoral approach."

The Co-Directors wish to extend their personal thanks to all who have contributed to the ADS success. Their numbers run into the hundreds and include the three Ministers of Agriculture and Food Security, H.E. Dr. Ibrahim Shoukry, H.E. Dr. Mohamed Mahmoud Dawood, and H.E. Dr. Youssef Wally; the Chairman and Vice Chairman of the Joint Policy and Planning Board, Dr. Abd El-Samie and Dr. Elmer Learn; all of the members of the JPPB; the several Chairmen of the Technical Committees, Dr. Kamal Stino, Dr. Ahmed Goueli and Dr. Mahmoud Abd El-Akher; the Co-Directors of the Sub-Projects, Dr. Mohamed Mahdy El-Azzouni, Dr. Ahmed Goueli, Dr. Lawrence Rappaport, and Dr. H.O. Carter; the Associate Directors, Dr. William Sims, Dr. John Rowntree, and Dr. Talaat Shetata; and, by no means least, our predecessors Dr. Hassan El-Tobgy as the First Chairman of the Board and Dr. Mohamed Kamel Hindy, Dr. Claron Hesse, Dr. Pierre Loiseaux, and Dr. Frank Child as Co-Directors. Dr. Child also served the project as Coordinator in Davis until January 1983 when he was succeeded by Associate Dean David Robinson.

Beyond these leaders explicitly named, there remains a long list of participants most of whose names appear in the body of this report. Also of vital importance were the many administrative and clerical assistants whose efforts are fully appreciated.

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BACKGROUND

Dramatic improvements in public health in developing countries over the last half century have led to rapidly expanding populations, usually without corresponding growth in food production. Traditional agriculture with its low productivity has not been able to meet the demands of an enlarged population. Food is often imported to cover shortfalls in domestic production and in many countries the balance between famine and getting-by is precarious. The slow growth of industrial production in most developing countries is insufficient to provide foreign exchange earnings to purchase food adequacy, let alone food security.

For several decades the U.S. has responded to acute food shortages around the globe by supplying surplus food. The capability to meet emergency needs however is no solution to a continuing problem. A long-term solution must be sought in assisting these countries to develop the capability for supplying their own food needs, thus relieving the fear of food shortages and famine, and breaking the unending cycle of poverty and deprivation.

The U.S. government, along with international agencies and the governments of other industrialized countries, has supported efforts to establish the foundations for sustained economic growth. These development assistance programs have included: assistance for building roads and railways, factories and electricity generation and distribution facilities; primary and secondary education, and technical skills training; health care systems and family planning; rural development and small scale industry. In recent years the emphasis has shifted towards development of the rural sector, which in most developing regions is the largest single resource and employer of the majority of the population and the sector in which there has been least investment.

Familiarity with the poverty and dismal conditions experienced by such a large portion of the world's people leaves little room for doubt that helping people feed themselves is a humanitarian imperative in which the U.S. is properly involved. But the value of insuring food adequacy goes beyond the well-being of the individual, for it is a vital ingredient of economic and political stability and is an important component of U.S. foreign p y.

The United States Agency for International Development (USAID), respons to the Secretary of State, is the agency charged with administering international deve pment assistance funds of the United States government. To do this, the Agency has relied heavily on the cooperation of U.S. universities and faculty in providing expert knowledge on a wide variety of subjects, usually on a short-term consulting basis. A larger role for U.S. land-grant universities in international development was provided for in the International Development and Food Assistance Act (1975) which recognized the value of the universities in technical assistance projects helping in particular with food production.

During the last decade the United States has played an increasingly important role in trying to stabilize the politically volatile Middle East and to secure a lasting peace in the region. Egypt, the most populous country of the Arab world, has been a focus of this endeavor since the re-establishment of U.S.-Egypt relations in 1973. An important outgrowth of this was the offer through USAID of economic assistance to Egypt with the issues of food security and agricultural development given a high priority on the agenda.

The USAID Mission in Cairo, lacking readily available internal resources capable of providing the assistance needed for major improvements in Egyptian agriculture, looked to a U.S. Land Grant university to provide the lead role in organizing these. Clear advantages were seen in selecting a university located in a state whose agriculture covers the crops and situations which are important to Egypt, and one, therefore, with experience in the technology of semi-arid irrigated agriculture.

The University of California, with the Davis campus as the lead institution, was invited to collaborate with the Egyptian Ministry of Agriculture in a project designed to improve productivity of Egyptian agriculture and at the same time to enhance the research and

development capability of the Ministry. The project was intended to provide fairly immediate productivity increases through technology transfer and short-term applied research in addition to conferring the ability to sustain the momentum for further improvements.

In January 1979, a five year contract was signed between the Egyptian government and the University of California to implement the Agricultural Development Systems, Egypt Project (the ADS Project). Funds for the Project were provided by a grant of 14.6 million dollars from USAID.

In recognition of the wide variety of problems that would need to be addressed in upgrading Egyptian agriculture, the project had a number of unconventional features. In particular, the ADS Project was not directed toward a particular problem set, but toward providing resources and a structure for a partnership between a U.S. university and the Government of Egypt to create problem-solving research capacity.

EGYPTIAN AGRICULTURE AND THE ADS PROJECT

An outstanding feature of agricultural production in Egypt is that it takes place on only 3% of the nation's land. The remaining 97% is arid desert. The six million acres of the nation's farmland, the Nile Valley, is a strip 600 miles long and up to 10 miles wide, broadening out into the fertile Delta region lying between Cairo and the coast.

Farming in Egypt has always relied on the annual flooding of the Nile and from water diverted from the river. The completion of the Aswan High Dam in 1965, however, created a year-round plentiful supply of water and farming shifted from dependence on flood waters to perennial irrigation. The combination of favorable climate with an abundant water supply now permits year-round cropping, effectively doubling Egypt's arable land area. Even so, the nation is not self-sufficient in basic foodstuffs. In part, the reason for this lies in increasing demands from the rapidly expanding population (approximately 2.5% per annum). Added to this is the diversion of arable land from production of food for domestic consumption to growing export crops needed to earn foreign exchange plus land use for urbanization. Failure to meet its basic food requirements has led to increasing food imports, paid for partly by high value export crops; however, large increases in the value of agricultural output are needed if the country is to meet its requirements in this way. Accordingly, the Egyptian government and international agencies have focussed on devising new or alternative cropping patterns using improved technology that would boost net output from the fixed land area while at the same time meeting critical national goals. These goals are to increase foreign exchange earnings, to produce more labor intensive crops thereby providing employment, to reduce food imports and to provide a more adequate supply of feed for the nation's livestock herds.

Surveys of the Egyptian agricultural sector, carried out prior to the ADS Project, identified a number of broad subject areas which would need attention if constraints on agricultural development and productivity were to be lifted. Two such priority areas were economics and horticulture.

Yields of horticultural crops in Egypt fall dramatically short of those now obtained in more technically advanced countries. Egypt has failed to capitalize on its high production potential of these crops largely because of outdated technology and high rates of spoilage after harvest. An infusion of new technology and a professional community able to apply and develop it further will do much to realize this potential with benefits not only for domestic consumption, but also in capturing a share of the European and Middle Eastern markets with these high value commodities.

Economic aspects of the Egyptian agricultural system merit priority research because of the enormous influence of government policies, such as prices, subsidies, planting quotas, and resource allocations, on agricultural production and cropping patterns. A more complete understanding by policy makers on the ramifications of policies and how effectively they achieve their intended purpose can be crucial to achieving such goals as improved patterns of resource allocation, production, distribution, equity, and foreign earnings.

In view of the potential for rapid pay-off in these two areas, horticulture and economics, the ADS Project has devoted most of its initial efforts to these topics, each of which has been designated for administrative purposes as a semi-autonomous "sub-project."

The California Research Center, situated on the campus of Cairo University, houses the Central Research Laboratory, a research library, and the Project's administrative offices. *Photo: Talaat Shehata*

Each sub-project comprised a number of related but independent research projects which were identified by the Sub-Project Technical Advisory Committees as technically feasible and with a high pay-off value. The Economics Sub-Project supported 22 research projects and the Horticulture Sub-Project supported 17.

Other research projects were supported which did not fit into the sub-project mold. These included several research efforts in disciplinary areas other than economics and horticulture, as well as conducting feasibility studies for use in initiating additional projects which could later be implemented independently of the ADS Project.

All research pursued in the Project was strictly "applied" research and closely geared to yielding tangible benefits. Research in each project was conducted jointly by a team composed of Egyptian and American scientists. The Egyptian participants, numbering over 600, were drawn from MOA, universities, and research institutions. In addition, over 130 American professionals were engaged in the Project. The bulk of these were UCD faculty members, but a number were drawn from other UC campuses (including Berkeley and Riverside), the Universities of Florida, Arizona, and North Carolina; Stanford and Cornell Universities, and the USDA. The vast bulk of research and development trials took place in Egypt with US participants regularly travelling to Egypt for visits ranging from several weeks to months.

The outcome of these efforts was two-fold: research results to accelerate agricultural development in Egypt, and the improvement of the capability of professional personnel in Egypt to conduct applied research which can meet needs of the agricultural sector. It should be emphasized, however, that the objectives of many projects were inherently long-term and that while the ADS Project may have succeeded in initiating a research process along promising lines, the fruits of this effort will, in most cases, depend on the continuing efforts made by our Egyptian colleagues.

The vehicle used by the Project for strengthening the capabilities of the Egyptian agricultural research community was research collaboration. A large portion of the Egyptian professional body was involved in the ADS Project, working alongside American counterpart scientists, using up-to-date techniques and equipment, and participating in a wide variety of seminars, workshops, and training exercises, as well as overseas visits and extended training programs.

Berseem clover is Egypt's most important and nutritious forage crop, usually grown in the winter season and fed to livestock on a cut-and-carry basis. The picture shows a common scene: a load of freshly cut berseem being carried by donkey to feed the cattle or buffalo on the family farm. *Photo: Eric Gustafson*

An important new achievement stemming from the collaborative mode of the ADS Project was bringing together scientists and technicians from the Egyptian Ministry of Agriculture, the Egyptian universities and research institutions to work jointly on solving a specific problem. The success of the Project in providing a model for helping overcome the highly fragmented and inefficient character of Egyptian agricultural research can be seen in the new initiatives taken recently by the Ministry of Agriculture which seeks to institutionalize collaborative research between Egyptian institutions and the Ministry.

The Project has also served as a valuable catalyst in encouraging Egyptian research scientists to be involved with extension work. This link between research and extension is vital if the development of new technology and procedures is to be directed towards solving the problems that matter to the farmer.

THE HORTICULTURE SUB-PROJECT

Lawrence Rappaport, *Co-Director, (UC)*
M. M. El-Azzouni, *Co-Director, (Egypt)*

INITIAL OBJECTIVES AND EXPECTATIONS

The Horticulture Sub-Project was conceived "to enable Egyptian horticultural enterprises to supply an ample quantity of nutritious fruits and vegetables for increasing domestic demand, and of a quality to further penetrate the export markets of Europe, Arab countries, and Southeast Asia." The objectives identified by the Egyptian/American team which formulated the Horticulture Sub-Project included the following:

- To instill a greater capacity within the Egyptian research community to improve research and extension performance through the development of cooperative research activities between the University of California and Egyptian research institutions;
- To increase productivity of vegetable and fruit crops on a per-area basis;
- To identify optimum crops and locations to maximize production of horticultural crops;
- To improve the postharvest handling, storage, and transportation of fruit and vegetables in both domestic and export markets;
- To encourage disciplinary research in areas basic to horticulture in Egypt.

Institutional constraints included the limitations of research facilities, need for maintenance of equipment and more current library research, the lack of any linkage between research and extension functions, the need for enhanced cooperation between institutions working on related problems, and the need to extend research results by way of extension activities, especially demonstration classes.

Several constraints on individual performances were also identified. These included the need to update selected Egyptian scientists, the lack of financial incentives to encourage scientists to work full time on research, the need to improve the selection of graduate students and to foster their activity and the lack of adequate facilities, particularly the lack of transport, to extend results of research to the appropriate farm sector by both extension and research personnel.

Several proposals were made to overcome these constraints. To provide adequate facilities, a strong central laboratory would be developed to house postharvest research and facilities including controlled temperature rooms and associated equipment. It would also house special analytical instruments for use by all researchers and would have accompanying field plots and greenhouses to provide research capabilities of the widest applications. The purpose of this laboratory would be to "minimize duplication and allow for multiple use of equipment, as well as to provide for maintenance and instruction on equipment usage." The central laboratory would bring researchers of like interests together to work on projects of mutual interest and to aid coordination of the activities of the Horticulture Sub-Project. A library would be developed to overcome the shortage of up-to-date information in horticulture and related sciences. In Alexandria and other areas, the establishment of limited satellite laboratories was envisaged. Research activities supported by the Horticulture Sub-Project would address major biological constraints affecting horticultural crops.

Institutional constraints would be addressed. Equipment and facility maintenance capabilities would be developed. A funded extension activity as a component of the research program would be important in overcoming the lack of linkages in research and extension. Participation of the Egyptian Horticulture Technical Committee in the evaluation of project proposals would help provide coordination of research among and between institutions.

Incentive payments would be made to compensate participants for time spent on Horticulture Sub-Project research and related activities. Training or updating at the postdoctoral

level would be specifically for personnel associated with approved activities. It was anticipated that both UC and Egyptian Principal Investigators and counterparts would involve graduate students as technicians in research activities, including thesis research. Opportunities would be developed for researchers to report the results at meetings with extension personnel, growers, and other interested groups.

Based on the report of a review team, specific research objectives were also established for the Horticulture Sub-Project with crop priorities as follows: tomatoes, onions and garlic, cucurbits, oranges and other citrus, mangoes, stone fruits, pome fruits and grapes. Particular emphasis would be placed on introducing modern cultivars and production methods for the production of high market value crops. Germplasm would be introduced over the life of the project to provide the raw materials for breeding and selection of cultivars adapted to Egyptian production areas. Specific priorities would be developed following site visitations and wide consultation with Egyptian horticulturists. Priority research areas for vegetable crops were identified: variety improvement and testing, including breeding for selected cultivars; establishment and maintenance of breeders and foundation seed sources (all vegetables except garlic); investigation of physiological disorders and limitations to yield, with special emphasis on cultural practices and disease and pest control.

Priorities for fruit production included improvement of production management; introduction and testing of superior cultivars; studies of inflorescence malformation in mangoes; rootstock studies to help overcome such problems as salinity, flooding problems, and encroachment by disease and insect pests; physiological studies, including identification of causes of low yields and necessary corrective measures, including disease and pest control; cultivar and species identification for all fruit crops, including rootstocks, as well as evaluation of cultivar and rootstock adaptability, particularly in calcareous soils; rest and dormancy studies.

Postharvest priorities were also identified, including the primary causes of deterioration of commodities and their relative importance in crop losses; improved harvesting, handling, and transportation techniques. Special emphasis would be placed on harvest maturity, temperature management, moisture loss, ethylene effects, modified atmospheres and control of postharvest diseases.

The initial proposal envisioned as many as 50 research projects in the Horticulture Sub-Project within the five-year contract life. Projects would be determined by consensus agreement between the Egyptian and American Horticulture Technical Committees (HTC) and the Joint Policy and Planning Board would approve the funding criteria.

At the termination of ADS the impact of the Horticulture Sub-Project would be evaluated. The necessity for extended research, especially for perennial crops, was foreseen. One well-equipped central facility for laboratory and field research in priority areas and with priority crops would be in place as well as one or more satellite research facilities.

It was envisaged there would be 40 or more Egyptian scientists actively engaged in research related to production of priority horticultural crops in cooperation with U.S. counterparts. Their research findings would be disseminated among Egyptian institutional staffs through seminars, field days, and other types of meetings, including extension of new information to appropriate farm sectors.

The results of the research would be reported, both in Arabic and English in suitable publications, including extension magazines. Egyptian postdoctorals will have been updated and their competencies broadened in techniques and disciplines pertinent to horticultural research. They will also have been exposed to research philosophy requiring justification, concise planning, orderly pursuit of objectives, peer review, and timely reporting.

A central theme of the initial proposal was that the research projects would be implemented through the provision of grants for one year to "be given preferentially to younger Egyptian scientists, whose productive life is yet before them." Funding for research projects and other types of projects would be in subcontracts or grants with the institution of the Principal Investigator (Egyptian or American). Research proposals would be invited from all Egyptian institutions and be presented in a structured format typical of grant proposals commonly made in the United States.

Functioning of the Egyptian and UC Horticulture Technical Committees would require a high level of interaction and an exchange of information would keep scientists on both

sides current on research developments in both countries. Critical annual review would result in decisions about whether to continue a project.

The original expectations of the ADS were optimistic, both biologically and institutionally. While acknowledging that it would be difficult to increase yields by more than 50% (a common estimate at the time the proposal was written), it was anticipated that a 20% gain in the economic value of marketable fruits and vegetables could be realized through the introduction and selection of better adapted and higher yielding cultivars bearing more uniform and more attractive fruit, optimization of planting density, increasing fruit set and retarding fruit drop, and by the development of improved cultural practices. The reduction in postharvest losses would have a marked impact on availability and improved quality of fresh fruits and vegetables.

ACCOMPLISHMENTS

An evaluation of a project must take into consideration the goals and priorities that were set (summarized above), an analysis of the perceptions upon which they were based, and the success in attaining them. Detailed summaries of research achievements of each project under the Horticulture Sub-Project appear in subsequent chapters. It may be readily concluded that the objective of providing increased quantities of nutritious fruits and vegetables for the Egyptian public and increased potential for export has been realized with the progress made in a number of projects. Those which showed significant progress in technology transfer and which could be termed "mature" at the end of five years include the Tomato, Garlic, Central Laboratory and Library projects. Those on which significant progress was made and which could be terminated in the next two to five years include Mango, Deciduous Fruits, Grape, Postharvest Physiology, Olive, Cut Flowers for Export, Ornamental Crops, Aromatic and Medicinal Plants, Vegetable Seeds, Tissue Culture, and Cucurbits. Progress was slowest in the Citrus, Banana, Date Palm, and Egyptian Nursery projects. Even those which proceeded most slowly were marked by certain achievements and it is notable, in retrospect, that so much was done considering the two-year time lag before the first project was initiated. It is worth examining briefly the factors that contributed to success and those which contributed to delayed progress.

RESEARCH ACTIVITIES

A primary objective of the Sub-Project was to introduce new germplasm which would be tested for adaptability to Egyptian growing conditions. The importance of this priority

Blindfolded domestic animals are used in shifts to turn *sakias* for water delivery.
Photo: Michael Reid

was recognized and samples of seeds, rootstocks, budwood, plants and other propagules were sent to Egypt for evaluation by research and extension. Without question, the success of the Tomato project owes a great deal to the introduction of some 200 tomato cultivars and advanced breeding lines from all over the world, and the selection and speedy adoption of a number of them in Egyptian agriculture. A large number of other vegetable, fruit and flower propagules (seed, rootstock, budwood) were tested following introduction from the U.S. and other countries. In this respect, the cooperation achieved was excellent and, assuming that the introduced materials are maintained in the future, they hold great promise for markedly increasing Egyptian horticultural yields.

The importance of these introductions was underlined by improvements in productivity which in the past had been limited by an array of pest disease problems. Introduction of new cucumber cultivars resistant to gummy stem blight, powdery and downy mildew, and other diseases should have a profound effect on cucumber production in Egypt. Similarly, the introduction of disease-free olive, deciduous and citrus rootstock and scion materials will provide an expanded germplasm store for Egyptian horticulturists to assess and utilize in the production of those crops.

A major factor which slowed the transfer of rootstock and budwood was the necessity of obtaining a phytosanitary certificate to permit the materials to enter Egypt. The difficulties encountered in meeting the requirements, and the loss of materials as a consequence, point to the need in future projects to accelerate the process of plant introduction.

Advanced methods of propagation were also introduced and should have a long-term impact on Egyptian agriculture. The Olive, Grape, Mango, and Deciduous Fruit projects, for example, each tested and adopted new grafting methods which will undoubtedly facilitate the production of materials for the orchards and groves of the future. The Vegetable Seed project has developed a modern seed testing laboratory and has trained personnel in the evaluation of seed for quality and uniformity of germination; a seed certification program has been proposed and steps initiated toward its development. The severe problems of viruses in many crops in Egypt, as well as the need for finding methods to propagate desirable date palm cultivars, led to the development of the Tissue Culture project. The need for improving propagation techniques of date cultivars which produce insufficient numbers of axillary "off shoots", as well as to develop expertise in alternate methods of plant propagation and crop improvement were important in the decision to initiate this project. In addition to designing and assembling an excellent tissue culture laboratory, a major technology transfer has been made by way of postdoctoral training in the U.S. Collectively, these approaches have great potential for improving productivity of Egyptian horticultural crops in the coming years.

Egyptian agriculture is beset with a number of very serious farm management problems, some resulting strictly from economic considerations, some historical, and many from the construction of the High Dam and the desire to expand agriculture into undeveloped areas. The issue centers on the availability, regulation and utilization of water which affects virtually every crop of interest in the Horticulture Sub-Project. The primary problem is the high water table in many parts of Egypt and the common practice of irrigating excessively with the Nile River water which, while rationed, is nevertheless provided free of charge. The use of excess water and high water tables may be the most important limiting factors in horticultural production in Egypt.

The dual role of the Postharvest Project in identifying the reasons for economic losses of horticultural crops following harvest as well as training scientists in a previously undervalued discipline rank as major achievements. Egyptian farmers produce good yields of many crops, and the introduction of high yielding, pest resistant cultivars brings promise of ever higher productivity. However, once the crops are harvested there is an apparent loss of interest and the normal process of deterioration is accelerated manyfold by a combination of poor harvest and packaging procedures, disregard for temperature control, excessive physical damage during handling, and poor conditions of transport and marketing facilities, in both the wholesale and retail markets. The study of factors contributing to postharvest losses allowed sensitization and training of postharvest physiologists in the field and laboratory in Egypt, as well as in short courses held in Cairo and Davis. The conservative estimate of

10% savings in fruit crops and 15% in vegetable crops by proper handling is ample indication of the need for continued investigation, particularly of methods to control postharvest losses.

INSTITUTIONAL CONSTRAINTS

A major objective of the ADS Project was "Institution Building." In the Horticulture Sub-Project, this was interpreted as training of postdoctorals and visitors in the U.S. and other countries, training of Egyptian scientists by collaboration with American counterparts visiting Egypt, development of the Central Laboratory and the Central Library, and analyses and critiques of proposals and reports at Joint HTC meetings and with project leaders and colleagues in the U.S. and Egypt.

It is often said that perceptions are more important than reality. This was certainly true of certain aspects of the Horticulture Sub-Project. A major feature of the original proposal was the submission of grant proposals by Egyptian scientists for review and approval by the UC HTC as a means of channeling funds to junior scientists. However, the structure of Egyptian agricultural research funding is unlike the competitive U.S. system. Egyptian agricultural scientists are unaccustomed to writing grant proposals and for American scientists to review their counterparts' efforts in the manner proposed was wasteful of time and credibility on both sides. Training in grant writing became an objective of the Sub-Project but was irrelevant in light of the Egyptian funding structure which is organized to supply research funds to "seniors." "Juniors" have little say in the decision-making process and are, by custom, not generally assertive in promoting their ideas. Thus, the original plan of submitting individual grants for funding was stillborn—unrealistic both in conception and execution.

Nevertheless, in a position paper, the UC HTC as part of its concept of institution building, advocated allocation of a portion of the funds from an anticipated second five-year grant toward this purpose. The intent was to create an important change in the Egyptian funding mechanisms to support individual research and also to maintain the ongoing funding for team research and extension activities. A mechanism to write and review grants was proposed. In the opinion of the American HTC, this was institution building at its best. This proposal was not viewed as practicable by JPPB members and in any case the failure to fund a new five-year program rendered the issue moot.

The ability of Egypt to mount a high level modern horticultural research program was seen to depend upon its providing adequate salaries to recent graduates and continuously active scientists. The purpose of paying incentives to locate and employ qualified active scientists was to supplement their salaries so they would be able to work full time for ADS. In fact, in so far as the Horticulture Sub-Project was concerned, the incentives were utilized to augment salaries of numerous scientists. Instead of the anticipated "40 or more" Egyptian scientists actively engaged in research in approximately 50 projects, 374 Egyptian scientists were employed in 17 projects. Concern was expressed by American colleagues regarding the large number of participants in each project, the unwieldy administrative structure which would militate against effective group interaction, the limitations to the efficiency of the American counterparts in dealing with so many people and, most of all, the initiation and continuation of unnecessary research fields within each project against the advice of the American collaborators.

The problems of differences in perceptions of how research should be done led to disagreement about principles. Clear cut decisions about size and scope of the activities and mutual education about Egyptian and UC priorities might have moderated these differences. In the final analysis, those members of projects who had the opportunity to observe or participate in the give-and-take so important in research undoubtedly gained from the experience.

The decision to develop integrated research projects was a good one because it encouraged interdisciplinary interaction among participants. Limiting much of the actual work to technology transfer was advantageous because it encouraged focusing on obvious needs such as importation of germplasm and methodology, and it provided basic training in experimental design and statistics. Emphasis on the need for proper controls, designing analyzable experiments, and appropriate interpretation of the results led to a marked improvement in the experimental approach by many of the teams. As a result, the nature of the questions raised during

planning phases and the process of analysis of the experimental results will no doubt have a long-term benefit for Egyptian horticulturalists. The two day work sessions of the Decidious Fruit and Postharvest projects involving all members of the team were exemplary in identifying priorities and in executing the research objectives.

TRAINING

A major objective of the Project was raising the level of knowledge and expertise of Egyptian horticultural scientists regarding current ideas and use of equipment. A significant achievement was training of Egyptian scientists in American laboratories by way of short courses, visits, and long-term training in specialized programs. There were 91 Egyptian visitors to the U.S. for long- and short-term periods, and 24 workshops were held in Egypt. Egyptians were encouraged to attend international scientific meetings, and a total of 41 participated in such meetings.

The nature of the laboratory and field work led the UC HTC to the conclusion that effective training could be achieved only by long-term exposure, preferably of one year or more. A position paper outlined the advantages of this approach for training scientists. At the same time, short-term (2–3 week) visits by senior scientists were encouraged because they permitted these scientists to understand first hand the research being done in various American horticultural departments and to give them a better appreciation of what the postdoctoral trainee would be doing. Except for instances in which a limited technology was being taught, intermediate visits of 2–3 months were not encouraged by UC. An example was the excellent training afforded members of the Seed Project by the Cal Crops Improvement Association and the Vegetable Crops Department at Davis and by the Department of Agronomy at Oregon State University. The trainees' goals were to gain information about the American seed industry and, particularly, to learn how to operate a seed testing laboratory. Such a laboratory was established in Egypt by the Vegetable Seed Project. The results of long-term training were truly exceptional in terms of the knowledge gained and actual performance of many of the visitors.

THE CENTRAL LABORATORY

The development of a Central Laboratory facility was an objective of the original project proposal as well as one satellite laboratory at Sabahia near Alexandria. The intention was that the Central Laboratory would serve both to train scientists in new technologies and to provide horticultural research facilities, including a postharvest laboratory, analytical laboratories, and a tissue culture laboratory, assorted greenhouses and other structures, including propagation benches. Following training in the Central Laboratory, it was expected scientists would develop satellite laboratories at other locations.

The problems of developing a new laboratory in Egypt, including ordering supplies and equipment long distance, the design, construction of fume hoods and walls and other modifications, as well as installation of basic services such as gas, electricity, and water resulted in rather slow development of the laboratory. Nevertheless, considering the constraints, the fact that the laboratory was completed and fully operational and that training was initiated was an important achievement. Whether it will serve the purpose originally planned for it remains to be seen. The laboratory was originally designed to fill a gap in Egyptian horticultural research, namely postharvest physiology investigations. The development of a Tissue Culture project with an appropriate laboratory at the Central Laboratory followed. Subsequently, there was a broadening of its mission to include other kinds of investigations, especially those relating to processed food quality and safety.

In a position paper stating its views on the future disposition of the Laboratory, the UC HTC emphasized the view that there are several laboratories in Cairo which have broad purposes with respect to agricultural research, but there is no other laboratory devoted to postharvest biology and technology of horticultural crops and tissues and cell culture research and training. In the opinion of the UC HTC, the Central Laboratory now has these facilities and to dilute its purpose by broadening its missions extensively would be unnecessarily redundant and inefficient.

There is a real need for continued staff training in the Central Laboratory and the development of a cadre of excellent scientists who would be assigned to the Laboratory in

appropriate disciplines Training should extend to laboratories at the MOA which also should be supplied with basic modern equipment. Thus, the Laboratory could be the premier institution for postharvest physiology and tissue culture and would provide the intellectual resources and training to extend information to other laboratories in Cairo and, eventually, elsewhere in the country. It would also be responsible for development of improved satellite laboratories at MOA stations distant from Cairo.

EXTENSION

The importance of an extension component implemented by the Horticulture Sub-Project was apparent from the onset. The existing Horticulture Extension Service was not perceived as effective in dealing with transfer of information to growers and shippers and extension in the UC model of agricultural development is an important arm of the research function. In this model, extension workers conduct applied research and work jointly with faculty to extend the information gained through their investigations.

Significant progress in this direction was registered by project researchers taking responsibility for transferring information to their clientele. Workshops, lectures, large-scale demonstration plots, pamphlets, newsletters, bus trips throughout the country with provincial horticultural extension agents accompanying American and Egyptian team leaders, and individual advice to growers and shippers were among the variety of extension approaches taken by most of the teams. The rapid dissemination of new tomato cultivars was in part due to the extension activity of the researchers involved.

RELATION TO OTHER COMPONENTS

In the drive to initiate new projects and to pursue the research, there was a perhaps unavoidable failure to integrate horticultural research with that of the Economics Sub-Project. In addition, there was a premise that until the Horticulture projects had provided a data base for economic projections little could be gained from joint research planning. This may have indeed been the case. Assuredly, in certain of the projects, postharvest physiology for example, economic analysis can likely be done better now that much data have been collected. In addition, there is a prejudice, especially on the part of applied scientists, and associated administration at all levels in the U.S. and Egypt, that little good can come from economic analysis. Despite this, it would be a valuable exercise to engage in joint research planning with members of the Economics Sub-Project prior to initiating new research. Perhaps the scientific questions asked and approaches taken would be different.

DISCIPLINES BASIC TO HORTICULTURE

Horticultural research requires the input of a range of scientific disciplines, integrated so as to address and solve practical problems. No single discipline has the breadth to cover the full range of crop needs. It is for this reason that all the Horticulture projects were conceived and executed as multidisciplinary endeavors, involving specialists in such areas as soils, water, nutrition, physiology, pathology, entomology, nematology and so forth. To achieve this approach meant that scientists from several institutions worked together on a common problem. This was an important departure from the research mode commonly followed in Egypt, and could be important in providing a model for future applied research.

The UC HTC was of the opinion that training of Egyptian scientists in disciplines basic to horticulture needs to be accentuated as a way of improving horticultural research. In a position paper the UC HTC outlined the need to provide additional training to scientists in disciplines associated with horticulture. Any future project should place increased emphasis on this objective. These disciplinary scientists could be used more effectively by providing advice to more than one project. They could act as cross-commodity consultants and, moveover, could provide additional training for Egyptian scientists associated with the project.

PLANNING FOR THE FUTURE

The UC HTC devoted considerable time to planning for a future five-year program. Because of the unstable climate during the last year of the project, little was done to begin

to implement plans that could lead to continuation or termination of particular projects. AID's prolonged vacillation in providing a proposed $1.6 million augmentation to the ADS Egypt Project resulted in a disruption in planning and organization, not to mention morale on the part of both Americans and Egyptians. Thus, there was no orderly transition from UC as the executing agency to the MOA. The result will inevitably be a hardship on the Egyptian scientists as they work without the benefit of the infrastructure assembled by the ADS Egypt Project.

Most of the American scientists engaged in the Sub-Project expressed the opinion that they had personally gained much from the experience, although the nature of the work—mainly technology transfer—was not conducive to publication in refereed journals. Thus the rewards came from the satisfaction gained from personal association and the feeling of participating in developing new and significant projects. Future projects with similar objectives to ADS could do well to analyze the nature of this participation as a means of enhancing quality and performance.

A traditional rural market in the Delta region—one of the many local institutions of importance to improving the performance of the agricultural sector. *Photo: Eric Gustafson*

THE CENTRAL LABORATORY

Early in the development of the ADS Horticulture Sub-Project in Egypt a major deficiency identified by several team leaders was the absence of a fully equipped and up-to-date laboratory needed to support critical components of modern horticultural research. Several university or Ministry laboratories possessed some of the needed equipment, but none had fully equipped facilities that were functional in all of the most important techniques. It was agreed that a major step toward improving institutional capacity for this type of research in the future could be effected through the development, at one location, of a well equipped, functioning research laboratory.

Establishing an Egyptian technical staff able to run the laboratory was seen as an integral part of the project, as was provision of advanced training for scientists in the design of experiments involving the new equipment.

ACCOMPLISHMENTS

The major accomplishment of this project has indeed been the development of a well-equipped research laboratory. A large building on the University of Cairo, Giza campus was completely renovated and sub-units of the laboratory were developed as follows:

- Plant propagation laboratory
- Postharvest physiology laboratory
- Tissue culture laboratory
- Laboratory support facilities:
  - —Analytical chemistry laboratory
  - —Histology laboratory
  - —Photographic laboratory

Development of these facilities and training has been a joint venture between Egyptian scientists and the Facility for Advanced Instrumentation at the University of California, Davis. The staff of the Central Research Laboratory was headed by a Director residing in Cairo and Co-Director in Davis. The technical staff consisted of two research assistants, four laboratory technicians, and six laboratory helpers. The critical equipment to be installed was decided upon early in the program's development so that purchase, installation, and operation of the equipment could be accomplished in time for its use in ADS research projects, the major vehicle for training Egyptian counterpart staff in its use. It is presently capable of supplying the horticultural research and training needs for Egyptian horticultural scientists and is expected to become a major center for advanced technology in this field in the Middle East.

SCOPE AND USE OF CENTRAL LABORATORY UNITS

Plant Propagation Laboratory

The facilities consist of three large temperature controlled greenhouses provided with equipment for studies on plant responses to salinity, and temperature regulated water bath equipment for studies on deciduous fruit.

Postharvest Physiology Laboratories

This facility consists of seven temperature controlled environmental chambers for research on postharvest physiology of horticultural crops, with an eighth chamber serving as a growth chamber. Principal uses are the study of quality control in fruits and vegetables. A demonstration packaging line was installed for research and training on the optimum methods of food packaging for transport and storage of soft fruits and vegetables.

Tissue Culture Laboratory

The Tissue Culture Project undertook the task of developing these facilities. This has involved remodelling of rooms, purchase and installation of equipment, and pursuing an intensive training program for scientists and technical assistants. The Tissue Culture Laboratory is now in operation and five trainees have spent one year each in tissue culture research laboratories in California and Texas and are now back in Egypt.

Analytical Chemistry Laboratory

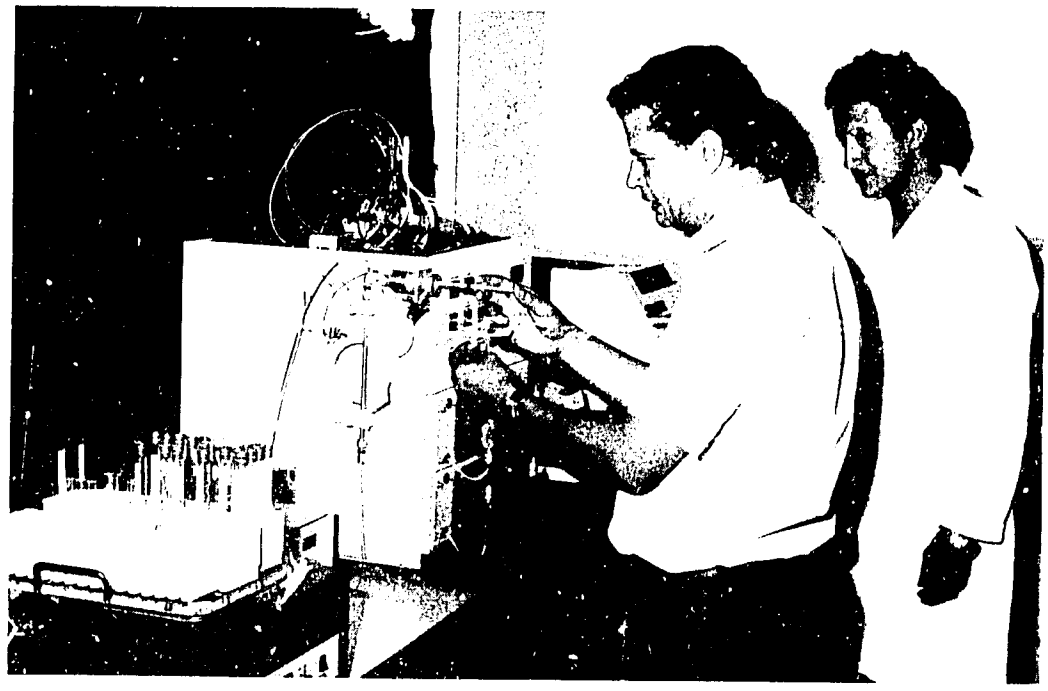
This unit provides facilities for organic and inorganic analysis of plant material. It is equipped with UV and visible spectrophotometers, a selective electrode instrument for inorganic analysis, an atomic absorption spectrometer for elemental analysis, and other standard equipment for extraction and fractionation of plant tissues such as centrifuges, rotary evaporators, ovens, pH meters, and balances.

Facilities for biochemical, enzymological and plant growth regulator studies consist of an infra-red spectrophotometer, a very sophisticated UV and visible double-beam scanning spectrophotometer provided with kinetic temperature controller and a terminal computer, a high speed refrigerated centrifuge, a fraction collector, and a freeze drier.

Equipment for chemical separation includes two gas chromatography (GC) units for the analysis of gases, one programmed for the analysis of CO_2, N_2, and O_2, and the other for the analysis of hydrocarbon gases, ethylene, methane, and acetylene. Two other more sophisticated GC units are also available. One of these units is used with regular packed columns for the analysis of a wide variety of compounds, and the other is used for fused silica capillary columns, a technique introduced in Egypt for the first time, and enabling picograms (1×10^{-12}g) of compounds to be analyzed. A high performance liquid chromatography unit with a UV detector is also available and is intended principally for analytical studies on plant growth regulators and pesticides.

Project greenhouses and the mist propagation house (left foreground) as seen from the California Research Center on the Cairo University campus. *Photo: Talaat Shehata*

Investigating the storage characteristics of fruit in one of the constant temperature rooms of the Project's Postharvest Laboratory located in the Central Research Laboratory. *Photo: Talaat Shehata*



A gas-liquid chromatography unit, part of the Central Laboratory's analytical lab, is seen here being used to provide analytical information to one of the ADS horticulture projects. *Photo: Nadir Hashem*

Histology Laboratory

Instrumentation for microscopy, microtomy, and specimen preparation are provided for in this laboratory.

Photo Laboratory

This laboratory provides for the developing and printing of film and paper as well as for drafting and photocopy procedures. Two 35mm automatic cameras and two Polaroid instant cameras are available.

Provision of Research Facilities for ADS Projects

The Central Laboratory has provided continuous assistance to scientists conducting their research in the greenhouses and the postharvest facility as well as to researchers working in the other laboratory units. The assistance given was not only in operating the instruments and conducting the analysis, but also in establishing the methodology required for their research programs. The following are some specific examples.

- Estimation of gases (CO_2 and ethylene) produced by fruit stored in jars or directly from the fruits (Postharvest Physiology Project).
- Analysis of plant growth regulators in malformed and normal mango (Mango Project).
- Plant pigments, sugars, amino acids, and vitamin analyses (Tomato, Cucurbits, and Postharvest Physiology Projects).
- Analysis of pesticide residues on fruits (Postharvest Physiology Project).
- Estimation of atropine and other alkaloids in plant extracts (Aromatic and Medicinal Plants Project).
- Analysis of sugars by GLC (Food Science Projects).

Training and Workshops

In addition to ongoing, on-the-job training, six formal training courses and workshops on chemical separation and analysis of plant tissue and other biological systems were held in the Central Laboratory during the period from January, 1982-April, 1983. The courses and workshops, given by the Laboratory Director and specialists from UCD, included the following topics: fractionation of fresh tissues for the analysis of pigments and fats, phenols, organic acids, sugars, and plant hormones; column chromatography; advanced techniques in paper chromatography; thin layer chromatography; gas chromatography; and high pressure liquid chromatography.

Plans for the future of the Central Laboratory after termination of the ADS Project have been discussed by the Joint Policy and Planning Boards, the Joint Horticulture Technical Committee, the Central Laboratory Committee, and the Committee for the Long-Term Development of the ADS Central Laboratory.

The advice and recommendation of these committees, submitted in June 1982, were unanimous in recommending that the Central Laboratory facilities should remain intact and continue to serve the research and training needs of Egyptian horticulture and related sciences.

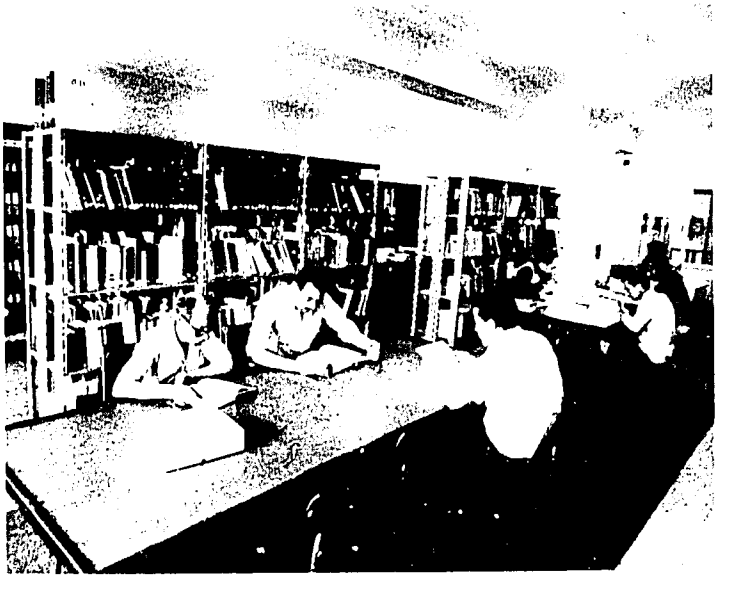
It was further recommended that the Laboratory not become another general Agricultural Research Institute, but rather that it should remain primarily devoted to postharvest physiology and tissue culture and allied horticultural sciences since facilities for research in these subjects are not well represented at any other institution in Egypt.

THE HORTICULTURE LIBRARY

A horticulture library has been established at the ADS Central Research Laboratory in Cairo. While its immediate use was to serve the needs of the seventeen ADS horticultural research projects, its long-term purpose was to provide Egyptian horticulturalists with an up-to-date collection of material at a single location. It is a library that can serve the needs of MOA and research institute researchers, university faculty, and graduate and undergraduate students.

Subscriptions to 99 journals covering horticulture and related sciences were made and current issues were air-mailed to insure timely availability to researchers. Also back issues (to 1968) of selected journals were purchased. About 25,000 books and publications dealing with horticulture, plant physiology, genetics, plant pathology, entomology, nematology, food science and technology, agricultural economics, agricultural engineering, and other sciences were sent to the library from the U.S. In addition, about 1500 books and publications were obtained locally in Egypt.

Audio-visual materials, which are now available in the Horticulture Library, include 16mm color movies, film strips, and slide sets covering many aspects of horticulture and related sciences. Necessary audio-visual equipment was also provided. This component and the up-to-date nature of the serials and book collections make this library the most useful in Egypt for researchers and students involved in horticultural and associated sciences. It is hoped that this library can be maintained and expanded in the future to assure its continued benefit.



The Project's Horticulture Library, located in the California Research Center, has been stocked with up-to-date journals and books, and provides at a single location the most comprehensive collection of its type in Egypt. *Photo: Nadir Hashem*

The Horticulture Library also contains an extensive stock of audio-visual materials for use in training students and scientists in new techniques.
Photo: Nadir Hashem

IMPROVED TOMATO PRODUCTION

Introduced over a century ago, the tomato is now the most important vegetable crop grown in Egypt. The area currently under tomato cultivation is 340,000 feddans with a production of approximately 2.3 million tons annually and a value of 161 million Egyptian pounds (LE). The average yield of tomatoes in Egypt is 7 tons per feddan which is rather low compared with that of the USA and Europe. Yields in California, for example, average 27 tons per acre. The low yields of tomatoes in Egypt are primarily a result of lack of improved, high yielding varieties, ineffective disease control and poor water management. Alternate flooding and drying results in stressing plants by depriving roots of oxygen and then of water.

The Tomato Project has initiated an integrated program for increasing yields and improving the quality of tomatoes in Egypt through research on the introduction and evaluation of tomato cultivars, breeding, physiology, cultural practices, plastic culture, and pest control (disease, insect, and weed) in addition to training and extension of the research findings to tomato growers, industry and government employees. Research and extension have been conducted by a team of 30 investigators from several universities, Ministry of Agriculture research institutes and field experiment stations located throughout Egypt.

ACCOMPLISHMENTS

CULTIVAR EVALUATION

A breeding program has been initiated, aimed at improving tomato yield and quality in Egypt through cultivar introduction and breeding. Emphasis has been on improving fruit quality, resistance to serious diseases (caused by viruses, fungi, nematodes and parasitic flowering plants), and tolerance to adverse soil (salinity) and weather (high and low temperature) conditions.

Two hundred and seventy-two tomato breeding lines and cultivars of both processing and fresh market types were evaluated in up to 54 observational or replicated trials per cultivar. These trials were conducted over three years (1980, 1981, and 1982), with up to three plantings per year (summer, fall and winter). Cultivars were planted in 11 locations (Assiut, Dokki, Nubaria, Fayoum, Giza, Ismailia, Kaha, Kanater, Khattara, Menia, and Sabahia), using 3 planting systems (single plants 30 cms apart, single plants 10 cms apart and clumps of 3 plants 3 cms apart.)

The following 22 cultivars were found to be outstanding in performance and widely adapted and thus have been recommended for use in Egyptian agriculture: processing true-breeding cultivars of the blocky, firm fruited type 'E 6203', 'E 9209', 'NCX 3032', 'Peelmech', 'Peto 86', 'Peto 95', 'Peto 96', 'Peto 98', 'UC 82', 'UCX 97–3', 'UCX 99M-3', 'UC 204' and 'UCX 211–58'; processing true-breeding cultivars of the elongated type 'Castlong'; processing hybrid cultivars of the blocky, firm fruited type 'Castlex 1017' and 'GS 30'; dual purpose true-breeding cultivars of the 'VF 145' type 'Castlemor Improved' and 'VF 145B–7879'; fresh market, nematode resistant true-breeding cultivars 'VFN 8' and 'VFN Bush'; and fresh market nematode resistant hybrids 'Royal Flush' and 'Valley Pride.' Additionally, the fresh market cultivar 'Pakmor B' was recommended for use in Menia and Nubaria and preliminary recommendation was given to the processing true-breeding cultivar 'Castlerock' and to Alexandria University fresh market nematode resistant hybrids 'Alex 61' and 'Alex 62.'

BREEDING PROGRAM

Breeding work was conducted at both the ADS greenhouse facilities at the College of Agriculture, Cairo University and Vegetable Research Division, Agriculture Research Center, Giza and experimental fields of the Agricultural Research Center at Kaha Vegetable Research Station and Barrage Horticultural Research Station, Kalubiah.

Breeding for Tomato Yellow Leaf Curl Virus (TYLCV) Resistance

One hundred and nineteen tomato cultivars and breeding lines and 26 accessions of 4 wild *Lycopersicon* species were evaluated for TYLCV resistance during 1980. Plants

The Tomato Improvement Project has successfully introduced and evaluated new cultivars for growing in Egypt. Breeding tomatoes adapted to Egyptian conditions, especially for tolerance to heat and salinity, is an ongoing program. A new heat tolerant cultivar is illustrated. *Photo: Nadir Hashem*

were subjected to artificial inoculation with the virus 1–2 weeks prior to transplanting and were left for further natural infections in the field. Scions from symptomless plants of the wild species were grafted onto healthy *L. esculentum* plants 6, 9 or 12 weeks after transplanting.

All tested commercial tomato cultivars and breeding lines were highly susceptible. All tested accessions of *L. cheesmanii*, *L. hirsutum*, f. *glabratum*, *L. peruvianum* and *L. peruvianum*, f. *humifusum* were highly resistant. None of the tested plants exhibited TYLCV symptoms or carried the virus. Accessions of *L. pimpinellifolium* varied in their reaction: LA 373 exhibited the least TYLCV symptoms; LA 121, LA 1579, and LA1690 were segregating; and all tested plants of LA 411, LA 1256, LA 1370, LA 1583 and LA 1634 exhibited severe symptoms. Grafting experiments indicated the presence of TYLCV in all symptomless plants of *L. pimpinellifolium*. (Hassan *et al.*, 1982a).

L. cheesmanii ssp. *minor* LA 1401, *L. hirsutum* LA 386 and *L. peruvianum* cv sel. I.N.R.A. remained free of TYLCV even after exposure to natural vector inoculation for nearly an entire year. These accessions were used as sources of resistance in the breeding program.

Resistance to vector transmission in *L. peruvianum* cv sel. I.N.R.A. was broken when inoculations were made at high temperature (mostly over 42° C during daytime). Plants of this accession were susceptible to graft inoculations but they were symptomless. (Mazyad *et al.*, 1982a).

Genetics and heritability of tolerance to TYLCV were studied in the interspecific crosses *L. esculentum* cvs 'E 6203', 'Peto 86', 'UC 82' and 'VF 145–B–7879' x *L. pimpinellifolium* LA 121 and LA 373. Parental, F_1, F_2, F_3 and backcross plants were artificially inoculated with TYLCV prior to transplanting and later evaluated for tolerance under field conditions. Tolerance appeared quantitative. The F_2 populations were skewed towards sensitivity and only 3–4% of the F_2 plants were tolerant. Narrow sense heritability (NSH) was estimated at 9.52 and 0.27 for tolerance derived, respectively, from *L. pimpinellifolium* LA 121 and LA 373. The percentage of the genetic variance that is additive was calculated as 61% and 44% respectively, in both accessions. The environmental variance was greatest in slightly tolerant genotypes, least in sensitive genotypes and intermediate in tolerant genotypes (Hassan *et al.*, 1983a).

Genetics of resistance to TYLCV was studied in the interspecific crosses *L. esculentum* cv 'UC 82' x *L. cheesmanii* ssp. *minor* LA 1401 and *L. esculentum* cv 'VF 145–B–7879' x *L. hirsutum* x LA 386. Reaction of parents, F_2 and F_3 plants and backcrosses of resistant F_2 plants to 'UC 82' indicated that resistance derived from *L. cheesmanii* is controlled by at least 3 recessive genes. NSH was 0.44. Reaction of parental, F_1, F_2 and backcross plants indicated that resistance derived from *L. hirsutum* is dominant and controlled by more than one gene (Hassan *et al.*, 1983b).

TYLCV tolerance and resistance found in the wild *Lycopersicon* accessions are currently being simultaneously transferred to some of the recommended tomato cultivars. Up to June 1983, two backcrosses were made in the transfer to tolerance derived from *L. pimpinellifolium* LA 121 and LA 373 and resistance derived from *L. cheesmanii* ssp. *minor* LA 1401, and one backcross was made in the transfer of resistance derived from *L. hirsutum* LA 386. In all cases, F_3 progeny testing was employed to assure the right selection of tolerant or resistant F_2 plants which were used in backcrossing.

Dr. H. Laterrot (Station D'Amelioration des Plantes Maraicheres, Montjavet, France) undertook an investigation of resistance derived from *L. peruvianum* by crossing accession cv sel. I.N.R.A. with tomato cultivar 'Mortelglan.' F_2 plants and selected F_3 progenies were evaluated for TYLCV resistance in Egypt. Resistant F_4 progenies are currently being backcrossed to *L. esculentum*. These experiments have established that resistance is to the insect vector and not to virus multiplication.

A study on TYLCV tolerance was conducted during the 1980 summer planting. It involved comparing yield of 46 tomato cultivars and breeding lines artificially inoculated with TYLCV with uninoculated controls. Infection was 100% in the artificially inoculated field, while natural infestation was 1.9% in the control field. Artificial inoculation significantly reduced yield but cultivars differed significantly in yield reduction even under conditions of 100% TYLCV infection. Also, the cultivar x disease condition (healthy or artificially inoculated) interaction was significant and indicated wide variations among cultivars in TYLCV tolerance.

The highest yielding cultivars under conditions of TYLCV infection were 'Castlex 1017', 'VF 145–B–7879', 'Castlex 499' and 'Castlemor Improved.' Their yield ranged from 10.3 to 14.7 T/acre even though all their plants were infected with the virus (Hassan *et al.*, 1983c).

Screening for Resistance to Tobacco Mosaic Virus (TMV), Root Knot Nematodes (RKN) and Fusarium Wilt

Two experiments were conducted during 1980 to screen 37 tomato cultivars and breeding lines for resistance to a previously-identified local strain of TMV. Plants were artificially inoculated. TMV symptoms and local lesion assays were used in assessing the level of resistance. Genotypes which carried gene(s) for TMV resistance reacted as follows: a) 'VFNT' (a University of California, Davis fresh market breeding line) was the best true-breeding source of resistance; b) hybrids 'Lucy TM', 'Poliset', 'X–233' and 'F.A.O. Acc. No. 50.467' were also highly resistant; c) cultivars 'Ohio-WR' and 'Trial No. 51' were symptomless hosts; and d) cultivar 'Tropic' was highly susceptible. Cultivars 'Floramerica' and 'Florida MH–1' (which carried gene(s) for tolerance) were highly susceptible. Among susceptible cultivars which did not carry any major TMV-resistance gene(s) were: a) cultivar 'Chico III' which showed very slight mosaic symptoms, but its virus titer was very high; b) cultivar 'Pusa Ruby' which showed severe mosaic symptoms, but its virus titer was low; and c) the remaining cultivars which were susceptible. No association appeared between TMV symptoms and virus titer (Hassan *et al.*, 1980a).

In a study to screen varieties for resistance to root knot nematode (RKN) conducted in 1980, 45 tomato cultivars and breeding lines were evaluated for resistance to *Meliodogyne incognita* and *M. javanica*. Forty genotypes were known to carry the *Mi* gene for RKN resistance; the others were susceptible controls. Most entries were screened under field and greenhouse conditions in 6 experiments. Practically every genotype carrying the *Mi* gene was found resistant to local biotypes of RKN. Resistance to *M. incognita* implied resistance to *M. javanica* and vice versa (Desouki, *et al.*, 1982; Hassan *et al.*, 1980b).

No extensive tests were conducted to screen for resistance to *Fusarium* wilt. Instead, an attempt was made to determine the prevalence in Giza of *F. osysporum* f. *lycopersici* race 1. Ten tomato cultivars were evaluated for resistance to a *Fusarium* isolate obtained from a commercial field in Giza Governorate. The test was repeated using 2 different inoculation methods. Results indicated that the isolate used belonged to race 1. Only cultivars without the *I* gene ('Earliana 498', 'La Plata', 'Moneymaker' and 'Rutgers') were found susceptible, while cultivars which carried the gene for resistance to race 1 ('Cal Ace VF', 'E 6203' and 'UC 82') or genes for resistance to races 1 and 2 ('Floradade', 'Peto 81' and 'Walter') were found resistant (Hassan *et al.*, 1982b).

Breeding for RKN Resistance

A breeding program began in 1982 to introduce RKN resistance into some of the promising processing and fresh market cultivars, 'Peto 86', 'UC 82', 'VF 145–B–7879', 'Castlerock' and 'Pakmor B.' Cultivar 'Pearson VFN' was used as a source of RKN resistance. BC_3 seeds are currently being produced.

Breeding for Salt Tolerance

Two experiments were conducted in plots in 1980. In the first of these, plants from 21 tomato cultivars and breeding lines were irrigated for 2 months with either tap water or with 4000 ppm of NaCl in tap water. The relative response of plant dry weight to the two irrigation treatments was considered the criterion for salt tolerance. All cultivars evaluated were found to be sensitive to NaCl. However a significant cultivar x irrigation treatment interaction indicated wide variation in NaCl sensitivity. The least sensitive were cultivars 'E 6203', 'Moneymaker' and 'VF 145–B–7879.'

In the second experiment 5 tomato cultivars and *L. cheesmanii* ssp. *minor* LA 1401 were exposed to varying salt concentrations. The number of surviving plants per experimental unit was considered the criterion for salt tolerance. Plants were irrigated for 2 months with 0, 4000, 8000, or 12,000 ppm of NaCl in nutrient solution. All genotypes tested were found to be sensitive to NaCl. The most sensitive was *L. cheesmanii*, and the least was cultivar 'Edkawy' (a local selection of cultivar 'Marmande'). Increasing NaCl concentration significantly decreased the number of surviving plants per experimental unit and reduced vegetative growth of all genotypes evaluated (Hassan and Desouki, 1982).

In subsequent tests, evaluation for salt tolerance was conducted as follows: transplants of the evaluated populations were set in sand in 20 cm clay pots at the rate of 3 transplants/pot. For 3 weeks plants were watered daily with nutrient solution only. Subsequently, plants were irrigated daily with nutrient solution in 75% sea water except during Mondays and Fridays when they were irrigated with tap water only. This practice was found necessary to wash down the surface-accumulated salt which, in preliminary tests, caused girdling and eventually killed the selected plants. The salt treatment continued for 1.5–2 months until all control plants were dead.

This evaluation procedure enabled the selection of the most tolerant genotypes. Various evaluated genetic populations were distinctively different in the cumulative percentage of dead plants with time. The genetic populations evaluated using this procedure were tomato cultivar 'Peto 86', F_1 of the interspecific cross 'Peto 86' x *L. cheesmanii* ssp. *minor* LA 1401, backcross of the F_1 (used as male parent) to 'Peto 86', F_2, F_3 and F_2 BC plants. Currently, seeds of the second backcross to 'Peto 86' are being produced.

Screening for Broomrape Tolerance

A test was conducted during the 1982–83 winter planting to screen for broomrape (*Orobanche ramosa*) tolerance. The test included 27 commercial tomato cultivars covering a broad genetic background, 10 accessions of *L. pimpinellifolium*, 4 of *L. peruvianum*, 5 of *L. hirsutum*, 3 of *L. hirsutum* f. *glabratum*, and 1 of *L. esculentum* var. *cerasiforme*. Transplanting was in a site heavily infested with broomrape.

Infestation was 100% in all tomato cultivars and wild accessions except in cultivars 'Marmande VF', 'Peto 98', 'Pritchard' and 'Tropic' in which 1 plant of each escaped infection. Seed was saved from 4 plants for progeny testing. In addition, *L hirsutum* LA 386 and *L. hirsutum* f. *glabratum* LA 1252 were highly tolerant to broomrape infection and distinctively different from the other genotypes evaluated.

Breeding for Fruit Set Ability in High and Low Temperatures

Several breeding lines, hybrids and true-breeding cultivars were evaluated for fruit set ability under high and low temperature conditions during 1980–82. Seed sowing was scheduled so that plants flowered during January and February for the cold tolerance test and during July for the heat tolerance test.

The best performing cold-tolerant genotypes with regard to percent fruit set and yield were University of California, Davis processing breeding lines 78–W–29, S78–365–3 and S78–296–2 and cultivars 'Floradade', 'FM 52009' and 'VFN 8.' On the other hand, the most heat-tolerant genotypes were 'Chico III', 'Peto 81', 'Peto 86', 'Punjab Chhuhara', 'UC 82' and 'VF 145–B–7879.'

Another approach in breeding for cold tolerance was through breeding for parthenocarpy using the parthenocarpic line 'Severianin'. (Seeds were kindly provided by

Miss J. Philouze, Station D'Amelioration Des Plantes Maraicheres, Montjavet, France.) This line sets parthenocarpic, non-puffy fruits in cold weather, but its fruits are very soft and poor in color.

Genetic studies on heat and cold tolerance and parthenocarpy are being conducted. Genotypes varying in heat and cold tolerance and parthenocarpy are also being examined for differences in endogenous auxins in flower ovaries.

PHYSIOLOGICAL STUDIES

Adverse Weather Conditions

Fruit-set under cold weath. conditions. The purpose of this work was to protect tomato plants against frost damage and to produce tomato fruits economically during April and early May when serious shortages occur in the markets. The experiments were conducted during the winter seasons of 1980–1983 at the Kanater experiment station, and involved varying the dates of transplanting, use of physical protection devices (plastic windbreaks, plastic tunnels and bamboo windbreaks), and use of chemicals for fruit-setting (4-CPA, citrimide, Cycocel and gibberellic acid). During the same years a series of experiments was performed using chemical and physical means to overcome low temperature damage in tomatoes grown at Fayoum. Chemicals used were Vapor Gard, citrimide and Cycocel. Different polythene structures were compared with the Egyptian farmer's normal practice of using bamboo windbreaks.

Data on both early and total yields and fruit puffiness were recorded. The transplanting date had a significant effect on early yield with the October 23 planting preferred over that of November 23. The clear plastic windbreak was superior to the other physical methods of cold protection for the plants. The 4-CPA + Cycocel and Vapor Gard treatment had a significant effect on early yield, giving 7.0 and 14.0 tons/feddan respectively, compared with 1.6 tons/feddan for the control. The percentage of puffy fruit was 12% for the control and 16% for the chemical treatments. Productivity at this level could easily fill the gap in seasonal fluctuations and minimize the shortage in tomatoes occurring in April and early May.

Fruit-set under high temperature conditions. The aim of this experiment was to study the effect of plant growth regulators on fruit-set under hot weather conditions. The experiment was carried out in pots with the 'VF 145' cultivar at the Giza station. The chemicals used were kinetin, gibberellic acid and naphthaleneacetic acid. Various rates and combinations were used. The most promising chemical for increasing yields under these conditions was kinetin.

Seedling Production

Transplant growing media. Under the Egyptian farming conditions the method commonly employed for production of transplants produces unhealthy and non-uniform seedlings. In a series of experiments performed between 1980–82 designed to relieve this problem the effects of different soil mixes enriched with macro and micro nutrients were tested. An experiment consisting of 11 treatments with different soil mixes was conducted, using growing media compounded from local materials such as rice hulls, sugar cane pith and soil and animal manure. Modifications and additional mixes were tested to derive the most suitable medium in relation to economic and productivity considerations. Best results were obtained from mixes based on peat moss followed by sand and rice hull bases.

Use of anti-transpirants to overcome transplant shock. Transplant shock, a common problem during summer planting, can be alleviated by reducing transpiration. The effects of different concentrations and methods of application of VaporGard were compared with the common Egyptian practice, *El Tarweef*. Records were taken for seedling performance and subsequent growth and yield at two locations, the main station at Giza, and at Fayoum. The cultivar was 'Peto 86'. Survival rate of transplants with treatment was increased over the control.

Fertilization

In 1980, fertilizer studies were conducted at three different locations representing different types of soil (Ismailia, Nubaria, and Giza). The effect of different macro and micro elements on the yield and quality of fruits and nutritional status of the 'Ace' and 'VA 145' varieties was evaluated. In 1981, additional treatments were made during the summer and winter seasons at the Kaha and Khattara sites to determine the most suitable fertilizer regime for tomato plants. For the cultivar 'Peto 86', growing in clay-loam soil, the highest economic yield was obtained using 45 kg N + 20 kg P_2O_5 + 25 kg K_2O per feddan. In the sandy soil the best results were obtained using 90 kg N + 40 kg P_2O_5 + 25 kg K_2O per feddan. The newly introduced cultivars thus require lower levels of fertilizer than those presently used.

Plant Density Studies

Two experiments were conducted in the summers of 1980 and 1981 to study the effect of plant density and nutritional levels on yield. Plant densities used were 1, 2, or 3 plants per hill 30 cms apart compared with single plants 10 cms apart. In addition, three nutritional levels were tested at each plant density. In the summer of 1983 three cultivars were included to test the effect of four different plant densities at five locations on the yield and quality of fruit. Spacings of single plants 10 cms apart in the row and those of 3 plants per hill 30 cms apart consistently gave the highest yields. These population densities are greater than those in current use.

Control of Tomato Yellow Leaf Curl (TYLCV)

Two experiments were conducted at the Giza station in 1981 and 1982 on chemical means to overcome the detrimental effect of TYLCV. The chemicals were gibberellic acid, cytokinin, Fully Fertile, and super-phosphate. The results were unsuccessful and further work was discontinued.

Irrigation

Several experiments were conducted at El Azhar University to evaluate different drip irrigation systems in

Tomato transplants of the newly introduced California varieties are grown in plastic greenhouses under controlled conditions before being released to growers. Nine million transplants were raised in Spring 1982 for this purpose.
Photo: William Sims

comparison with the normal practice of basin irrigation for tomato production. Yields were generally increased with drip irrigation and efforts have been made to design and manufacture drip irrigation systems locally.

CULTURE UNDER PLASTIC

In 1982, two experiments were carried out to evaluate 28 tomato cultivars and newly released materials for greenhouse production. The seeds were sown in January in plastic trays filled with modified peat moss. Seedlings were transplanted a month later in plastic greenhouses (16 × 60 × 3.2 m), and fruits harvested between May and mid-July. The top performing cultivars, based on quality and yield, were 'Dobio', 'F1 97TMV', 'Fireball', 'Tmc493177' and 'Carmello'.

In the 1982–83 season, 36 tomato cultivars were planted, among them the most promising cultivars selected in 1982. The seeds were sown in September in plastic trays and transplanted in the plastic house in mid-October. Harvest started in late December 1982 and continued until mid-April 1983. The most promising cultivars with regard to yield and quality were 'Vernon', 'Dombo', 'Marcanto', 'Special' and '1417179'.

PATHOLOGICAL STUDIES

Tomato Wilt Disease

Efforts were made to characterize the causal fungus of the tomato wilt disease in Egypt. Isolates were obtained from the most important growing areas (Giza, Kaha, Kalubia, Sharkia, Menia, Quena, Ismailia and Elk Tahrir) and purified using the single spore technique. Pathogenicity tests of all isolates were carried out against four tomato cultivars: 'UC 82' (resistant to *Fusarium oxysporum* f. Sp. *lycopersici* race 1), 'Peto 81' (resistant to race 2), 'Walter' (resistant to both races 1 and 2) and 'Moneymaker' or 'Super Sioux' (cultivars susceptible to both races). Results indicated that the virulent form of the fungus was *F. oxysporum* f. Sp. *lycopersici* race 1.

Pathogenic Soil Fungi

Soil-borne fungi, *Pythium debaryanum*, *Fusarium solani*, *Rhizoctonia solani*, *Alternaria solani*, *Sclerotium rolfesii* and *Helminthosporium* sp. which are responsible for tomato damping off and collar rot disease, were isolated and purified using the single spore or hyphal tip technique.

Chemical Protection against Diseases

Trials were carried out in the greenhouse, the nurseries of the main research stations and in the fields of local stations during 1982 to determine the most appropriate chemical means of controlling major tomato diseases.

A trial was carried out to control wire stem disease caused by *Rhizoctonia solani*. Four days after inoculation, treated 'VF 145' tomato seeds were planted in the infected soil and kept under greenhouse conditions at 30°C. The most effective seed disinfectants in controlling damping-off caused by *R. solani* were Tecto + Mancozeb, Vitavax/Captan and Vitavax/Thirum.

Techniques to control pre-and-post emergence damping-off of seedlings caused by soil borne fungi were examined at the nursery of the Kaha local station. The results were

clear that the chemicals Campogram, Terrachlor Super-X, Vitavax/Thirum, Campogram/Captan, Benlate and Vitavax/Captan were the most promising disinfectants in the control of *Rhizoctonia solani*, *Fusarium solani* and *Alternaria solani*, the causal fungi of wire stem root rot and collar rot diseases, respectively.

At Ismailia Governorate, systemic and non-systemic fungicides were evaluated for the control of tomato foliage and fruit diseases, such as early blight and nail head spot. The data showed that Bravo 500, Bayer 3016 and Trimiltox Forte were excellent protectants against early blight (*Alternaria solani*) and nail head spot (*Alternaria tomato*), but failed to control powdery mildew.

ENTOMOLOGICAL STUDIES

Potato Tubermoth

Insecticides were evaluated for the control of the potato tubermoth, *Phthorimaea opercullela* (Zeller) which infests tomatoes in summer planting. The first experiment was conducted in Menia in April 1982 on the cultivar 'Peto 86' and the second experiment was carried out in Kaliubia on the cultivar 'Marmand VF'. The insecticides most effective in controlling the moth were found to be Tombel (thiomethon + dithiomethon), Hostathion (triaxophos) and Ravyon (carbaryl).

Sevin (85% at a rate of 2 kg/feddan) was the most effective insecticide followed by Lannate (90%) and Nudrin (90%) causing a reduction in the percentage of larvae infesting the summer planting.

Cotton Leafworm

The cotton leafworm, *Spodeptera littoralis* attacks many field crops and vegetables, including tomatoes. The extent of damage caused by larvae of this insect expressed as percentage reduction in yield of the crop was estimated in relation to the average number of larvae per plant.

White Fly

Several experiments over the past three years examined the toxic effect of pesticides on whitefly, *Bemisia Tabaci* (Genn.) infesting tomato in the fall plantation. Spraying at consecutive seven-day intervals with certain insecticides has been shown to be effective in controlling the whitefly on tomatoes. Reviewing the data, it can be concluded that Tamaron 60% at 800 cc/feddan, Gusathion 20% at 1.5 liter/feddan, Acetellic 50% + Diamethoate 40% at 1 liter + 300 cc/feddan and Nudrin Birlane (240/270) at 1.5 liter/feddan were the most effective insecticides against the adult whitefly, larvae, and pupae. Pyrethroids also hold promise for the control of the whitefly, with best results achieved by combination of CCN 52 and Dimethoate at the rate of 400 cc and 300 cc/feddan, respectively.

The varying susceptibility of 21 tomato varieties to infestation by the whitefly, *Bemisia tabaci* was examined using abundance of the egg population on leaves as a measure of susceptibility. 'UCX 211–58' had the fewest eggs but was favored most by pupae of this fly. 'Rossol VFN' was the least attractive for pupae.

The seasonal abundance of tomato whitefly *Bemisia tabaci* (Genn.) and aphids (*Aphis gossypii*) was studied during 1981 to determine the effect of weather conditions on the populations. Eggs, larval instars and pupae of whitefly were not present on plants during March, but production began to increase during April. The initial infestation with *Aphis gossypii* in the summer planting was relatively high in April. The aphid population increased rather rapidly until it disappeared during the first week of May.

Bollworm

Effect of host plants on some biological aspects of the bollworm, *Heliothis armigera* Hb. was examined by feeding groups of larvae of bollworms, *Heliothis armigera*, on three host plants throughout their lives. The shortest larval and pupal periods were obtained on tomato fruits and leaves, while the longest larval and pupal periods were recorded on beans. On the same diet, the resulting females showed the longest preoviposition period and laid the lowest number of eggs. Females produced from larvae fed on tomato fruits gave the highest number of eggs.

Various insecticide treatments were evaluated for control of the American bollworm, *Heliothis armigera* Hb. infesting tomato in the fall planting. Sumicidin (20%) and Cybolt (10%) were found to be the most effective and the recommended chemicals, Lannate and Tamaron gave only a moderate reduction in larvae. These results proved the superiority of synthetic pyrethroids in controlling the American bollworm in tomato fields.

WEED CONTROL TRIALS

Since 1980 several experiments were carried out to evaluate different herbicides and weed control methods in tomato fields. The results showed that integrating a herbicide application with a single hand hoeing operation was significantly superior to any single herbicide treatment for annual weed control. The herbicides found to be effective were Enide (6 kg/feddan), Devrinol (2 kg/feddan), Treflan (1 liter/feddan) and Sencore (500 g/feddan).

EXTENSION

The extension component was added officially to the Tomato Project in January 1982, although several extension meetings had already been held in 1981 with growers in Fayoum Governorate. The extension program was to supervise the transfer of the recommended new cultivars and cultural practices to the growers. Growers were supplied with seeds of the new cultivars on the condition that half of their plantings contain the newly selected varieties and the other half the traditional ones in order to compare results under similar conditions. Some growers were also supplied with transplants of the new cultivars. This work was done in cooperation with local or governorate specialists. Extension meetings and lectures were held for growers and extension agents in the different governorates. During 1982 the new cultivars 'Peto 86', 'E 6203', 'UC 82', 'UC 97–3', and 'VF 145–B–7879' were grown in about 4,500 feddans in 16 governorates. Yields recorded

by growers ranged from 20–45 tons/feddan as compared with 8–10 tons/feddan of the traditional cultivar.

About 2.5 million tomato seedlings of the selected cultivars were produced under plastic tunnels and distributed to farmers during 1982 and 1983 early summer plantings. Twelve greenhouses, each 168 m^2, were built in Fayoum, Menofia, Kalubia, Dakahlia and Giza Governorates, and sown with the cultivar 'UC 97–3'.

Aerial spraying of insecticides was used for the first time in Egypt in 1981 to control the tomato whitefly. Aerial spraying by helicopter with the insecticide Tamaron (60%) raised tomato yields from 7–8 tons to 20–30 tons/feddan over an area of 5,000 feddans in Fayoum.

Based on the recommendations of the Tomato Project, the Egyptian Agricultural Organization imported 10,000 kgs of seeds of the new cultivars in 1983 and additional amounts have been imported by the private sector. It is anticipated that during 1983 40,000 feddans will have been planted to the new cultivars. A scarcity of hard currency for purchase of seed is the factor limiting even larger expansion of plantings.

The new cultivars have been acceptable to both fresh market consumers and processors. Compared with the price of the traditional ones, growers obtained 30 to 50 LE higher in price/ton for the new cultivars.

An extension leaflet was prepared in Arabic giving all the cultural practices recommendations for growing the five new cultivars, 'Peto 86', 'UC 97–3', 'E 6203', 'UC 82' and 'VF 145–B–7879' from seed bed to harvesting.

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IMPROVING OLIVE CULTIVATION IN EGYPT

The Egyptian government has recently embarked on an ambitious scheme to increase the current 20,000 acres of olive trees by the addition of 250,000 trees annually for the next five years, mainly in the areas of Sinai and the coast northwest of Alexandria. The most serious obstacle to this has been the lack of modern high-speed propagation methods. Overcoming this problem has been a high priority of the Olive Project, but if Egypt's plans to develop a large scale olive industry are to be realized, olive quality and yields must also be improved. Therefore, in addition to work on propagation methods, research has also been directed at identifying improved olive cultivars and the planting locations and cultural practices that are needed to best exploit their genetic potential.

ACCOMPLISHMENTS

PROPAGATION

Research on propagation techniques for rapid production of new stock was given early priority so that problems of rooting cuttings and slow grafting could be overcome.

All commercial olive producing countries in the world produce olive nursery trees by rapidly rooting cuttings in mist propagation beds. This technique was unknown in Egypt, where the ancient, slow, and cumbersome approach-grafting method was used. This has now been replaced by the introduction of mist propagation technology by the ADS Project enabling Egypt to produce massive numbers of olive nursery trees.

All component parts for three mist units, two experimental and one large commercial unit, were shipped to Cairo. One experimental unit has been assembled at the Central Lab at Cairo University and has been in operation since May, 1981. Subsequently, parts for adding hot water bottom heat have been shipped, along with flats in which to root the cuttings, perlite and vermiculite rooting media, and plastic containers in which to pot and transport rooted cuttings. Nine consecutive experiments have been run with this equipment and, as a result, the optimum time for taking cuttings, the best type of cuttings to take, the variability among cultivars in rooting ability, and the best rooting medium to use has been determined so that high rooting percentages can now be routinely obtained. With this knowledge and the mist equipment provided, Egypt can now produce olive trees for their new plantings.

To replace the slow, cumbersome approach-grafting method used in Egypt, trials were conducted with side-tongue, side-veneer, and cleft-grafting to work fruiting cultivars onto seedlings. The side veneer method has given consistently high "takes," often 100%. This fast and easy method can now replace approach-grafting and can be used as a supplement to mist propagated trees. This grafting study has now been completed and a grower's leaflet can be published.

Establishing and Evaluating Cultivars

Olive cultivars grown in Egypt have limitations and are not the best possible choice for future plantings. Therefore, an extensive program has been set up at the King Mariut Research Station to evaluate the productivity and quality of new and existing olive cultivars over a two year period. Particular attributes sought were: heavy, regular bearing; strong, vigorous tree growth; resistance to insects and diseases; and good fruit quality—large size, good processing characteristics, high oil content, and good flavor. This has involved:

a. Extensive mapping of the collection by recording blooming dates, amount of bloom, percent perfect flowers, fruit setting, yield, fruit size and quality characteristic of cultivars in the collection for two growing seasons.

b. Standardization of cultural practices at the King Mariut olive cultivar collection including irrigation, fertilization, and pruning.

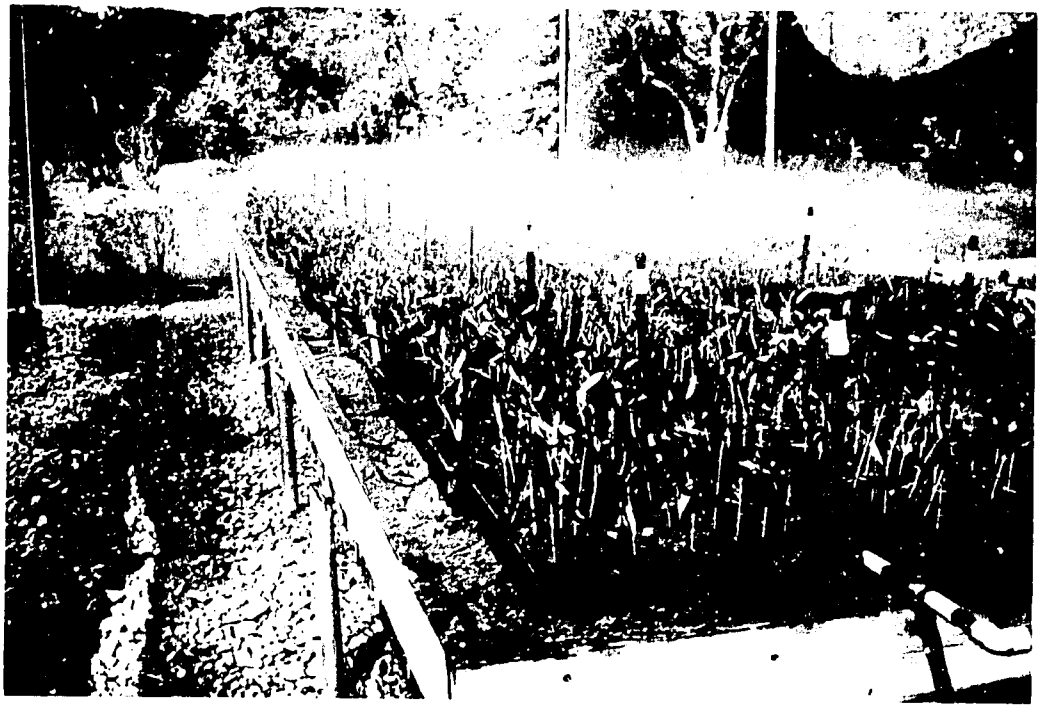
Enlargement of Cultivar Collections

A major effort has been made to enlarge the olive cultivar collections at King Mariut and at Giza research stations by importing nursery trees from the University of California, Davis. Typically these have included:

- *Verticillium-resistant rootstocks*: 'Oblonga', 'Swan Hill' (fruitless ornamental olive).
- *Table olive cultivars*—originally from Peru ('Pocomo', 'Mostazal', 'Criolla', 'Thrombolia'); Greece ('Chalkdiki', 'Calamata', 'Conservolia'); and Spain ('Manzanillo').
- *Small fruited oil cultivars*: ('Gaidonila', 'Strogglia', 'Arbequina').

The possibility of developing new cultivars from indigenous stock already adapted to the Egyptian environment has also been explored. In October, 1981, fruit samples were collected from trees of those cultivars, principally at King Mariut, that were bearing heavily, showing that they are capable of good production in the Egyptian low-chilling climate. The seeds from these plants were germinated and the resultant seedings will provide material for long-term cultivar selection experiments.

Seedling olive trees planted in 1976 at Nobaria have been evaluated for vegetative growth, flowering behavior, fruit set, yield, and fruit quality to determine if any of these are suitable for further propagation and testing as a potential commercial cultivar.



Rapid high-percentage rooting of cuttings from selected olive trees is made possible by misting techniques. Cuttings in the mist bed at the Project's Central Research Laboratory in Cairo are kept under constant mist for several months until rooted and ready to transfer to regular nurseries.
Photo: Hudson Hartmann

Study of Olive Production Sites

Studies have been conducted at new sites, and at present sites where olive expansion is proposed, to develop improvement strategies for maximum production. For olives, soil drainage characteristics must be good. At proposed new sites, factors such as drainage, salinity, hardpan, and mineral availability were examined. At existing plantations, such as at the Gianaclis farm, soil profile determinations were made using a backhoe to excavate trenches 6 feet deep in 5 or 6 spots. Layers of restriction (hardpan, etc.) were determined and opened with a sub-soiler. Frequently, a high water table or a hardpan was encountered, both of which have a serious effect on tree growth and can account for the moribund condition of some plantings. Leaf analyses of olive trees at Gianaclis and eight other olive growing locations were conducted to determine levels of N, P, K, Ca, B and Na, and to determine the fertilizer needs of Egyptian olive groves.

IMPROVEMENT OF OLIVE CULTURAL METHODS

Drip Irrigation

The popularity of drip irrigation worldwide attests to the value of this method, particularly in conserving water and avoiding waterlogging problems. To attempt to develop drip irrigation as a viable method for olives in Egypt and to give their horticulturists experience in its use, a drip irrigation plot for olives was established in 1983 in the Sinai where a comparison could be made with traditional methods. Knowledge of the most efficient irrigation methods is needed in view of plans for extensive new olive plantings in the Sinai area by the Ministry of Agriculture. At the conclusion of the ADS project, no data had yet been collected with the drip irrigation plot.

Olive Mineral Nutrition

To determine the fertilizer needs for olives on Egyptian soils, a survey of the mineral status of olive trees was made by leaf analysis in the olive districts of Burg El Arab, King Mariut, El Fayoum, Sinai, Nobaria, and Giza. No deficiencies were found except for nitrogen and, more rarely, possibly boron. This now provides the basis for formulation of new fertilizer practices based on increased nitrogen applications, adding borax if necessary, and deleting potassium and phosphorus, which are not needed but are consistently included in the traditional fertilizer recommendations.

A new fertilizer plot was established in January, 1983, to compare the effects of previous Egyptian fertilizer recommendations (NPK) with nitrogen-only applications at different levels. This plot was established to confirm results of leaf analysis experiments that P and K applications are not needed.

Pruning and Training Demonstration Plots

To bring young olive trees into bearing rapidly and then to maintain consistent maximum yields, proper pruning is necessary. Much information is known about the correct methods of pruning olives from trials conducted in other parts of the world, chiefly California. To transfer this

information to Egypt several demonstration pruning plots were established.

Young, non-bearing trees. Starting with young 3 year-old trees at Gianaclis Farm, different training systems were established in May, 1982, and will continue for 10 years. Using 30 trees per treatment, the principal training procedures were:

- Trees allowed to grow as a bush with no pruning, the conventional method used in many parts of Egypt;
- Trunks with 3 to 5 primary scaffold branches established by removing suckers and excess watersprouts. Further top pruning will consist only of very minor thinning-out of interior crowding branches.

Throughout the duration of these pruning and training experiments, records will be kept of age at onset of bearing, size of tree annually by measuring height and width of top growth, yield per tree, and fruit size.

Bearing trees. Plots were established with bearing trees to compare the effects of different degrees of pruning severity and of training trees in a manner suitable for mechanical harvesting. Records to be obtained include tree yield per year, average fruit size, and amount of vegetative growth per year.

Chemical Fruit Thinning Plots

Olives are notorious for their alternate bearing behavior. This consists of a heavy crop of fruits one year which so exhausts the nutrients in the trees that often they do not even produce flowers the following year. The fruits in the heavy "on" year compete with each other so that often they do not reach a useable size at harvest or do not develop an oil content in useful amounts. The best treatment for alternate bearing is the removal of excess numbers of fruits in the "on" year, using chemical thinning techniques. To help determine the best procedures under Egyptian conditions, two plots were established at Fayoum using 'Chemlali' trees in the "on" year. In each plot, 10 trees were sprayed with naphthaleneacetic acid at 150 ppm when the fruits were 3 to 5 mm in cross diameter.

Records subsequently taken included number of fruit per meter of fruiting shoots, percent of total fruit drop, yield per tree, number of fruits per kg, fruit weight, and fruit and seed size.

Promising first year results will be followed up so that Egyptian agriculturists can become familiar with the critical timing and concentration levels of spray needed for success.

Zeuzera Borer Control

The *Zeuzera* stem borer, unknown in California, has been a devastating problem on olive trees in Egypt, particularly in the Fayoum district. Traditional control has been to find their burrows in the branches and then kill them by inserting a wire into the burrow. This, of course, is an impractical method for control in large commercial orchards. Previous studies by nematologists had shown that certain parasitic nematodes would kill this borer. Control plots for *Zeuzera* stem borer on olives were set up by Dr. R. Rice (UCD), Dr. M. Sherif and Dr. S. Sherif (Cairo University) to establish procedures and evaluate the effectiveness of chemicals and the use of parasitic nematode species. This work is in cooperation with the Deciduous Fruit Project since this borer is also found in deciduous fruit trees.

The *Zeuzera* Borer is a serious insect pest that causes severe damage to deciduous fruit trees and olives in Egypt. The massive holes bored through branches as seen in this example soon result in loss of limbs and ultimately of the entire tree. The Olive and Deciduous Fruit Projects have jointly researched this problem and have achieved promising results using parasitic nematodes. *Photo: Peter Catlin*

Herbicide Weed Control

Plots have been established to familiarize the Egyptian agriculturists with the several pre- and post-emergence herbicides available and to instruct them on the proper timing for their use in olive orchards.

To help disseminate some of the new techniques and cultural practices which have been developed by this project, and to give growers and extension agents a background in the botany and physiology of the olive tree, a bulletin in Arabic entitled "Olive Production" has been prepared for distribution. It is based on UC leaflet 2474, "Olive Production in California" (Hartmann, Opitz and Beutel), but revised for Egyptian conditions by incorporation of the project's research findings in Egypt.

FUTURE PLANS

Studies with tree fruit crops must necessarily be continued for several years in order to obtain significant results. All the plots established in the Olive Project should be carried on as now set up for at least five years. This is self-evident in the case of cultivar selection, but is also critical in other work if long-term confidence in findings and recommendations is to be established. For each ex-

perimental activity, detailed recommendations were developed to provide for the precise needs of each experimental activity over the next 5–10 years.

In addition to work already started, an experimental pruning plot should be established with bearing olive trees, to determine the amount, timing, and types of pruning needed to give best yields. A detailed experimental work plan for this has been prepared with recommendations to record yields over a 10 year period.

As improved cultural practices become more clearly identified, a series of short publications for growers should be printed and distributed on such topics as mist propagation of olives, side veneer grafting, herbicidal weed control, spray thinning of olives, nitrogen fertilization, pruning young and mature olive trees, *Zeuzera* borer control, and cultivar studies. These publications, periodically updated, will be important not only for growers, but in training of extension agents.

INTRODUCTION AND IMPROVEMENT OF DECIDUOUS FRUITS

The Egyptian climate offers potential for the early harvest of tree fruits of good quality, appropriate for export to European and neighboring markets. The varieties of most stone and pome fruits now cultivated in Egypt have winter chilling requirements that are not met by the Egyptian climate, resulting in poor productivity and quality. In many areas this is aggravated by adverse soil conditions, principally waterlogging and salinity. A prime objective of this project has been to initiate development of cultivars of almonds, apricots, apples, peaches, nectarines, and pears which have low chilling requirements and extended harvest season, are tolerant to suboptimal soil conditions, and yield high quality fruit. Incidental benefit to California agriculture was expected to accrue from the screening and selection of Egyptian varieties for tolerance towards waterlogging and salinity, since California fruit tree stocks are regarded as sensitive to these conditions. Following an initial survey of the status of existing deciduous fruit varieties in Egyptian orchards, the project proceeded with the introduction and testing of new germplasm of several species, selection of potential clones of Egyptian apricot and peach, selection of lines of deciduous fruit rootstocks that showed unusual salt tolerance, assessment of rootstock response to waterlogging, and extensive training of Ministry and university scientists both in the US and Egypt in modern cultural practices.

CULTIVAR INTRODUCTION AND EVALUATION

At the outset the project surveyed deciduous fruit cultivars which had previously been introduced into Egypt and assessed their status. Such introductions have been made at various times since the early 1900's by the Ministry of Agriculture (MOA), various universities, and FAO projects. These cultivars were described, recorded and evaluated with regard to extent of planting, success, and potential value to Egyptian horticulture. Additional cultivars introduced by individual growers were not assessed because of constraints on exchange of information within the private sector.

The survey included cultivars of almonds, apples, apricots, figs, peaches, pears, pecans, persimmons, plums and quince. Many cultivars had been imported without regard to chilling requirements and adaptability to warm winter temperatures. In other cases, such as the Mariut region and north Tahrir, test plantings had been made in soils and with cultural practices which were inappropriate. Cultivars recommended for potential success had not been widely disseminated. Results of the survey are recorded in the 1980 Annual Report.

The major and continuing effort of the Deciduous Fruit Project was to introduce into Egypt deciduous fruit cultivars with potential for success in an environment typified by warm winter temperatures (300 hrs. or less at temperatures under 7.2°C, cumulative). The vast majority of commercial deciduous fruit cultivars worldwide would have shown abnormal flowering and vegetative growth under such conditions. Therefore, a list of desirable cultivars with low to moderate reported chilling requirements (500 hrs. or less) was developed. Initial emphasis was on almonds, apricots, apples, pears, peaches, nectarines, and plums from California. Later, additional items of these species were requested from Texas, Florida, France, and South Africa; a few rootstocks were also included.

A major obstacle to successful importation of deciduous cultivars became immediately evident in the discrepancy between Egyptian quarantine requirements and the ability of U.S. certification agencies to satisfy these criteria. Virus-free certification is very rarely available in the U.S. and not at all from commercial nurseries marketing deciduous fruit trees. No trees would have been imported without a waiver which served in lieu of an import permit and allowed issue of phytosanitary permits.

Other obstacles to import were the general disinterest of U.S. commercial nurseries in selling small numbers of trees, refusal by nurseries to export plants themselves, the need to negotiate phytosanitary certificates individually, bureaucratic requirements by U.S. and Egyptian agencies and unfamiliarity of shipping companies with the critical need to rapidly transfer highly perishable materials. Nevertheless, a procedure was worked out whereby trees could be shipped within an elapsed transit time out of cold storage of 3–4 days from Davis to Cairo.

The numbers of individual cultivars and rootstocks of the different deciduous fruit species introduced into Egypt in 1980–1982 are given in Table 1. The identities of all introductions are listed in the Project Annual Reports for 1980, 1981 and 1982.

Importations in 1980 were as dormant nursery trees from California. Exceptions were oriental pear cultivar budwood for nursery propagation and seed for peach rootstocks. Nursery trees consisted of ten plants of each cultivar.

In 1981, nursery trees and budwood of additional cultivars were imported. Especially valuable was budwood from Texas and Florida, some of which was from advanced breeding lines. In addition, two hundred trees of 'Anna' apple, together with appropriate pollenizers were obtained from Israel. 'Anna' has a low chilling requirement although supplemental chemical treatment is necessary in some years for success.

In 1982, except for figs, all cultivar introductions were as budwood and originated in Southern France or South

Africa. Especially noteworthy was inclusion among materials from South Africa of the low chilling mutant of Bartlett pear. Large numbers of a peach and an apple rootstock were obtained from Spain.

Only a few introductions from the U.S. were attempted in 1982. Unavailability of patented cultivars, commercial unavailability of others requested, and California and Egyptian certification requirements contributed to this. Delays in clearing customs and quarantine in Cairo of walnut and pecan rootstocks and fig trees in 1982 resulted in low survival of these plants. The requirement for virus-free certification was being enforced and one year in quarantine was required in the absence of certification. Moreover, there did not appear to be a mechanism for rapid transfer of plants from Cairo airport to quarantine facilities, which were often inadequate and overtaxed. No attempts therefore were made to introduce further materials in 1983.

Imported trees were planted in the introduction and evaluation plot at El-Kanater experiment station. With very few exceptions survival was high. Where loss occurred it was related to stress during premature sprouting in transit from California to Egypt. Although international shipment of trees is considerably more difficult than of budwood, this process allowed adaptability evaluations one or two years earlier than could be achieved with budwood.

Imported rootstocks as well as those of local origin were planted in a nursery near the introduction plant and cultivars received as budwood were propagated on these stocks. In general, success of propagation was less than expected and vegetative development slow. Early problems with bud failure of selected native apricots were overcome by use of whip, bark, and side bone grafting. As a result, propagation was 90% successful in 1982.

Because imported trees received chilling in California, assessment of the primary features of adaptability was delayed until after one winter in Egypt. Parameters measured were shoot and trunk increment, vegetative and floral bud phenology, fruit development and maturity characteristics, and abscission of leaves in autumn.

Table 1. **Number of Individual Cultivars or Rootstocks Introduced into Egypt 1980–1982**

	1980	*1981*	*1982*
Cultivars			
almond	2	3	3
apple	8	4	–
apricot	–	3	8
fig	–	–	3
nectarine	2	7	–
peach	4	28	3
pear	7	2	1
plum	5	–	10
prune	–	–	2
Totals	28	47	30
Rootstocks			
apple	2	–	1
peach	3	2	1
pear	1	2	–
pecan	–	–	1
pistachio	1	–	–
plum	1	1	–
walnut	–	–	1
Totals	8	5	4

Table 2. **Introduced Cultivars which Appear Adaptable and Successful in the Egyptian Climate**

Apple	*Peach*	*Nectarine*
Anna	Earli Grande[1]	Armking
Ein Shamer	Early Amber	Panamint
Dorsett Golden	Nectar	Sunred
	Rio Grande	
	Springcrest	
	Tejon	

[1]1983 results only.

It has not yet been possible to determine quantitatively the degree of adaptability of imported material to warm winter temperatures except with cultivars which are highly sensitive. At present, a flowering period of two weeks or less and growth in the spring of 50% or more of the vegetative buds on one-year-old shoots appear to be the best indicators of acceptable response to Egyptian winters. Vegetative vigor is not necessarily a reliable parameter for this response. Conclusions about adaptability to date have been largely based upon generally satisfactory vegetative growth and upon fruiting performance. Maturation of additional cultivars of the various species is needed to fully assess adaptability. The adaptable 'Anna' apple is compared with the non-adaptable 'Granny Smith' in Plate 1.

Fruiting of a number of cultivars of apple, peach and nectarine began in the year following planting. Thus, two and part of a third year's evaluations have been made on trees introduced in 1980. Cultivars of these species which appear to be adaptable and of potential value to Egyptian horticulture are listed in Table 2. Fruit size is generally small but quality was judged to be good. Nectarines are

Plate 1. Traditional apple varieties require a cool dormant season for normal foliage and fruit growth. The Egyptian climate fails to meet this need, resulting in the poor condition of the 'Granny Smith' apple tree (left) grown in the ADS experimental plots. The other apple tree, of the same age and in the same location, is a newly introduced 'Anna' variety with low-chilling requirements and hence exhibits normal growth (May 19,1982).

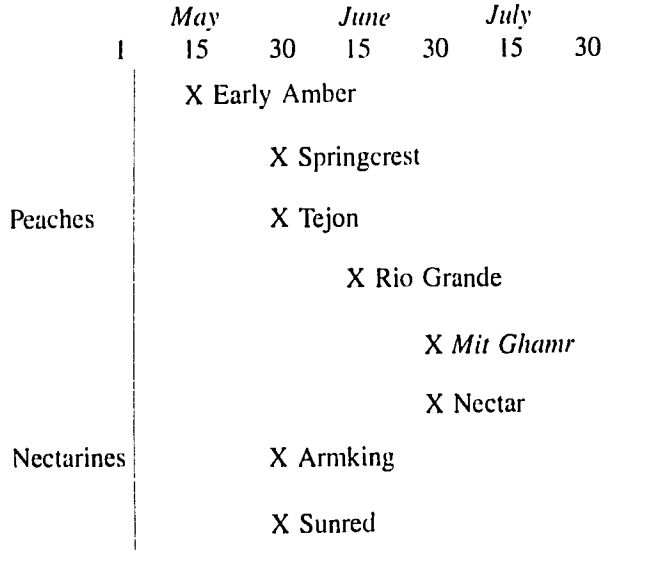
Photo: Peter Catlin

a new fruit in Egypt which has been accepted with enthusiasm. 'Early Amber' peach which appears successful in Egypt has been distributed to some 60 selected growers and researchers for further evaluation. 'Earli Grande' peach was included because it produced very large fruit by comparison with other cultivars in its first year of production, 1983. For all cultivars, it is necessary to thin young fruits to realize improved fruit size. However, peaches with a low chilling requirement are unusually early maturing, and small fruit size is associated with this characteristic.

The introduced cultivars will greatly broaden the deciduous fruit harvest season and market availability. Maturity times for peach and nectarine cultivars are compared to that of the Egyptian peach, 'Mit Ghamr' in Figure 1. Indications are that 'Earli Grande' peach matures about 15 days before 'Early Amber'. Early peach production in May and early June overlaps the harvest period of Egyptian apricots.

The introduced apple cultivars mature in early to mid-July. These extend the harvest season of apples in Egypt

Figure 1.
Time of Maturation of Introduced, Adaptable Peaches and Nectarines Compared to 'Mit Ghamr'.



beyond late May for 'Baladi' and mid to late June for 'Bircher'.

A large number of 1981 and 1982 introductions of various species have yet to flower. It is reasonable to expect that some of these will further extend the harvest season as well as improve the quality of deciduous fruits in Egypt. In a few cases suitable pollinizing cultivars may not be present.

Maintenance of successful introductions is necessary to provide a continuing source of disease-free, true-to-type germplasm (budwood) for propagation of trees. Dissemination of cultivars beyond provision of a small number of trees to selected private and public sector growers for further evaluation was not considered appropriate for this ADS project, since it is more properly the responsibility of the MOA. For regular operations however, in which there is no research component, only budwood should be provided from the source planting for dissemination.

Cultivars adversely affected by insufficient winter chilling provide an opportunity for research on the nature of this phenomenon and its manipulation. Encouraging results were obtained in 1983 with chemical modification with apple.

IMPROVED CULTURAL PRACTICES

Advising on changes in concepts and improvement in cultural management was a continuing process throughout the project. Major recommendations centered on fruit thinning, soil applications of nitrogen fertilizer, proper pruning practice, weed control and irrigation according to tree water use.

An adaptation of a "nodal cutting" technique for rapid propagation was developed using 'Mit Ghamr' peach. This method employs one-year-old stem segments with a single node, obtained in spring when leaves start to expand but before shoot extension occurs. With IBA treatment and horizontal planting under intermittent mist, 80% of the segments formed extensive root systems after 8 weeks. This technique allows rapid multiplication of large numbers of plants using 50–75% less plant material than with conventional rooting methods. Use of nodal cuttings with other species is now being investigated. It would be especially valuable if rootstocks which are currently propagated by cuttings, could be multiplied using this technique.

Other physiological studies involved attempts to chemically thin peaches and to determine the effects of an antitranspirant on fruit size of nectarines. Thinning was achieved but not at acceptable levels, an observation paralleling results in California. Nevertheless, similarities in climate between the Nile Delta and the southeastern U.S., where some success with a new material, CGA 15281, has been reported, warranted experimentation in Egypt. Even though early research results in Egypt were not positive, an important benefit has been a developing awareness of the need for fruit thinning.

The antitranspirant VaporGard was tested as a means of reducing water loss from leaves and making more moisture available to fruit. The effects of concentration and timing were investigated with 'Panamint' and 'Armking' nectarines. Three applications of VaporGard at 2.5% at 10 day intervals were given during the final stage of fruit enlargement, before maturity. Fruit size and weight of 'Armking' were increased (16% and 29% respectively) but soluble solids were reduced from 9.8 to 9.0%. Differences were significant at the 5% level. It will be necessary to establish whether the same results are obtainable under optimal soil moisture conditions.

SELECTION OF EGYPTIAN APRICOTS AND PEACHES

Most apricots and many peaches in Egypt show wide variability. A program was begun in 1980 to select individual trees from within these populations which possess superior vegetative and fruiting characteristics, as well as diverse dates of maturity. From over 21,000 seedling

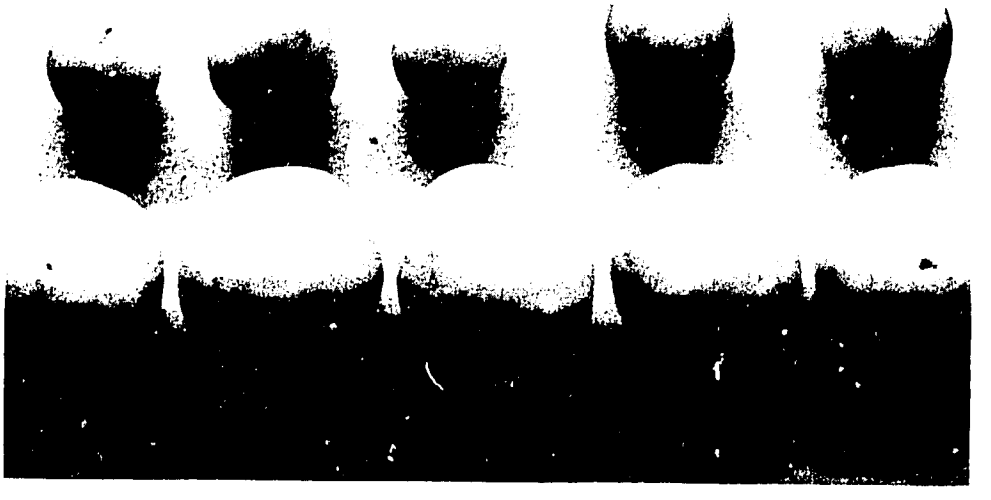


Plate 2. Fruit of one Egyptian apricot selection (bottom) and those available from a local market (top). *Photo: Peter Catlin*

apricot trees, 15 were selected, using a weighted index rating system developed by the team. Six selections of peaches were made from over 10,000 trees examined. Two or three years' evaluation of the same orchards gave consistent results with selected trees consistently out-performing others. Plate 2 shows fruit of one apricot selection compared to those available from a local market. The selected trees, propagated at El-Kanater for comparison under common conditions, have not reached the fruiting stage. Seed of several of the Egyptian apricot selections have been imported into the U.S. for plant breeders in California and Florida. This has importance as germplasm with very low chilling requirements and as a new flavor resource.

A similar selection program was undertaken with apple trees in Egypt but the program was stopped after the second year when it was apparent that the higher performance of selected trees proved to be due to environmental factors and not germplasm.

Establishment of experimental subplots at various locations in Egypt was frequently discussed. These could only be justified where important environmental differences existed at a proposed location and/or when results other than those attainable at El-Kanater would be likely. Two small plantings were started; one at Fayoum for apricots, and another at the Ministry's station at Nubaria. Fayoum is the major region of apricot production. Nubaria reportedly possesses a subtle climatic difference (which needs to be quantified and confirmed) which allows better apple and pear production than some nearby areas. A planting of introduced apple cultivars on two rootstocks was established in 1982. Potential disadvantages are a calcareous soil, a high water table, and distance from Cairo which makes maintenance and research logistically difficult. There is potential, however, for study of responses of pear rootstocks to chlorosis on calcareous soils. Seed of pear species thought to be tolerant to such soils are being introduced for testing in Nubaria.

SALINITY

Among the several soil environmental conditions which can limit successful production or even survival of deciduous fruit bearing species are waterlogging and/or salinity. This is especially the case in Egypt where tree roots are frequently exposed to high water tables, questionable irrigation practices, and/or saline water. Because plant response is dependent on duration of exposure to unfavorable conditions, and with salt, its concentration, any increased root tolerance would lessen adverse effects.

Evaluation of Egyptian rootstock materials is particularly important since these have likely been exposed to waterlogging and/or salinity at frequent intervals for a number of years. As a result, individual rootstocks or seed sources may have been selected naturally for superior characteristics. Responses of cultivars to salinity are largely due to rootstock influences.

A program to screen Egyptian rootstock materials for increased tolerance to salinity was initiated. A regime for treatment of large numbers of plants was developed for routine greenhouse screening with emphasis placed on apricot because of its prominence in saline soils in the Fayoum region. With apricot, a wide range of seedling variability in response to salt treatments was found, and survival curves similar in shape to those for response to waterlogging (Fig. 2) were obtained. Plants appeared to be affected by both osmotic and specific ion effects. Individual plants with superior tolerance were selected for potential use as clonal rootstocks and for genetic improvement.

Orchard trees from saline soils produced seedlings differing in tolerance, and several trees were identified which produced seed with considerably greater tolerance than others. The response to saline treatment of seedlings from four parent trees is shown in Table 3. Seedlings from individual trees differed in the time taken to develop symptoms and to reach 80 and 50% survival levels. All FZ-1-1 and FZ-1-2 seedlings had succumbed by 51 days whereas A-4-1 and FS-4-1 plants were at about the 20% level when the experiment was terminated after 75 days. The same relationship among the four phenotypes was obtained in another trial. Responses of seedlings from 27 other seed parents were within the limits of those shown in Table 3. Seeds of the more tolerant types were provided to US plant breeders.

Seedlings with superior tolerance to salinity are of considerable value as rootstocks for use with superior fruiting cultivars. Use of rootstocks for apricot is a developing concept in Egypt where production is predominantly from seedling trees.

Work on screening Egyptian peach and bitter almond was initiated but there is a need for additional replication and statistical verification of results.

Table 3. **Effect of 3 Applications of 2.5% VaporGard at 10 Day Intervals in May on Fruit Characteristics and Leaf Water Content of Armking Nectarine at Harvest on June 6, 1982**

	Fruit			*Leaves*
Treatment	Fresh wt. (g)	Diameter (cm)	Soluble Solids (%)	Water (%)
2.5% VaporGard	87.3	5.0	9.0	13.6
Control	68.0	4.3	9.8	6.9

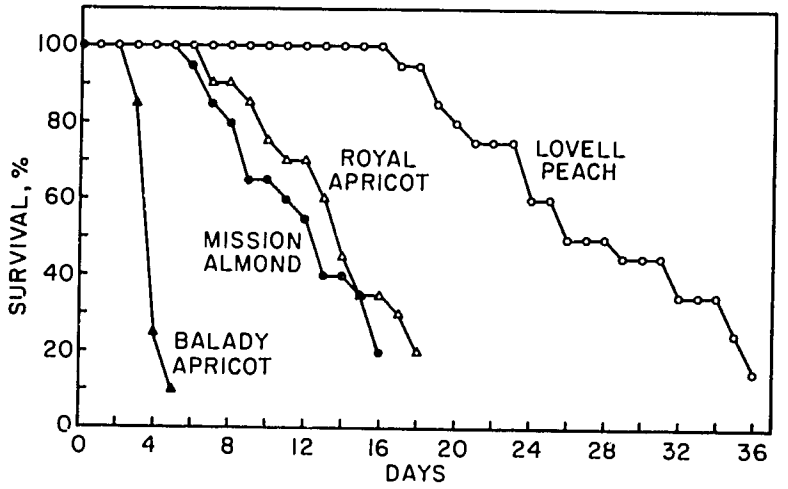


Figure 2. Survival curves for seedlings of *Prunus* species waterlogged at root temperatures of 23°C.

WATERLOGGING

Excessive soil moisture is a serious problem which arises from flooding, high water tables, or excessive irrigation. In recent years this problem has been exacerbated by the ready availability of inexpensive irrigation water from the Aswan Dam. Decline or loss of trees can often be attributed to waterlogged soils.

Little objective information was available about relative responses to waterlogging of either Egyptian or California deciduous fruit tree rootstocks. Thus, comparative evaluations among numerous types was conducted at both Giza and Davis. Experimental flooding of 2–9 month old plants, using 20 or more in each trial, was performed using controlled root temperatures under greenhouse conditions. Examples of survival curves obtained for seedlings of *Prunus* species are shown in Figure 2. A range of seedling variation within each population is typical. Seedlings without symptoms when about 80% of the plants showed damage were selected as having increased tolerance to waterlogging. After verification of responses, such plants will be clonally propagated as rootstocks and will be a germplasm resource for plant improvement.

Replication of waterlogging treatments with each type allowed assessment of relative tolerance among rootstock materials. Work at both Giza and Davis confirmed the extreme sensitivity of 'Baladi' apricot, the somewhat greater tolerance of 'Mission' almond and 'Royal' apricot, and still greater tolerance of 'Lovell' peach. Nevertheless, all are considered very sensitive to waterlogging in comparison to other species. The slight difference between 'Mission' almond and 'Royal' apricot was also found in other trials. Treatments at root temperatures below 23°C, used in routine screening, would likely establish this difference.

Work at Giza also compared 'Nemaguard', 'Lovell' and 'Mit Ghamr' peach seedlings; significant differences between the varieties were not established. One experiment compared seedlings of 'Hamawy' and 'Baladi' apricots with 'Mit Ghamr' peach. Seed of both apricots was from trees subjected to high water tables. Surprisingly, both apricot cultivars were considerably more tolerant than peach.

Though neither guava nor pomegrante was priority species within the project, their sensitivity to waterlogging was tested. If their reported tolerance could be established under Egyptian conditions they might become the tree crop of choice in badly waterlogged areas. The response of guava seedlings to waterlogging was tested in several experiments and found to be highly tolerant, surviving by production of adventitious adaptive roots.

Studies on rootstock tolerance that were pursued in California were limited to *Prunus* cultivars and establishing differences among types rather than selecting superior individuals. No difference was found among seedlings of the following peaches: 'Lovell', 'Nemaguard', '115-95' (now 'Nemared') and 'Halford.' A limited number of 'Mit Ghamr' peach seedlings from Egypt responded similarly, although insufficient numbers were available to draw firm conclusions. Comparisons of peach, almond, and apricot are described above with work conducted at Giza. Rooted cuttings of 'Marianna 2624' and 'Myrobalan 29C' plums were compared with the former being slightly more sensitive. Plums were considerably more tolerant than peaches and more sensitive than pears. With seedling populations, a 2 to 3-fold difference in time of survival from the least to the most tolerant of each type was common, depending on the root temperature employed. (Figure 2). Expectations were that clonal materials would have a much narrower range. However in all cases, survival curves for clonal materials (cuttings) were similar to those for seedlings.

Examination of treated plum root systems revealed considerable differences among plants in size and proportions of lateral and fibrous roots. Such horticultural and morphological differences among root systems may account for differences in whole plant responses of clonal material. These results also stimulated investigations of root responses in advance of the appearance of symptoms in shoots. With sensitive species, root tips turn brown within 72 hours of waterlogging and shoot growth is inhibited within 24 hours. Except for cessation of shoot

growth, symptom development on leaves occurs considerably later, depending on species. Contribution to damage by a greater proportion of root systems than root tips and/or differences in rate of transmission of effects to the shoot may be important. A weak capacity to form adaptive adventitious roots is likely involved.

In both California and Egypt, variable and often less than satisfactory levels of seed germination slowed progress. To avoid this problem in the future greater care is needed in collection of fruit from which seed are extracted. Needed also is more precise information about germination requirements of various sorts of seed. In Egypt, the need for coordinated effort in generating experimental plants by researchers concerned with both waterlogging and salinity has been recommended.

Some recommendations regarding choice of rootstocks can be made where excess soil moisture may be a problem in Egypt. Any of the California peach rootstocks would be superior to apricot or almond for cultivars of peach, apricot, almond, or nectarine. The status of 'Mit Ghamr' seedlings needs further clarification. Plum stocks of California origin, though quite tolerant, are not recommended for peach or nectarine because of graft union incompatibility, but could be useful for apricot and some almond cultivars.

ZEUZERA BORER

Early visits to Egypt revealed catastrophic damage to tree stems and trunks of apple, pear, and olive trees by the leopard moth borer, *Zeuzera pyrina*. Because a similar borer in California was being controlled by a parasitic nematode, Dr. Richard Rice, an entomologist, was invited to visit Egypt to assess the potential for this means of control. A multi-disciplinary effort was launched in early 1982 involving entomologists, nematologists, and horticulturists of the Deciduous Fruit and Olive Projects. Initial investigations of insect ecology and chemical and biological control indicate considerable potential for improved and less costly control of *Zeuzera* borers. Further work will be required before these techniques can be made reliable for use by growers.

Within the relatively brief span of the project, significant transfers of germplasm and technology to Egypt have been achieved. Similarly, liaison between Ministry and university personnel and development of the concept of the researcher's responsibility in extension have been established. Developing the experience and capability of professional pomology resources in Egypt is of great importance for the future of the deciduous fruit industry, but the process is necessarily a slow one and it is unfortunate that the ADS program must end with only the first steps taken toward this type of institution building.

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IMPROVEMENT OF CITRUS CROPS

Citrus is Egypt's most important horticultural export crop. With improved production and postharvest practices it could become even more competitive because of the excellent intrinsic quality of the fruit and the highly favorable environmental conditions for citrus production.

However, in recent years the production of citrus has declined despite the favorable climatic conditions of the country. Management practices have not kept pace with the problems, principally the high water table that has resulted from the construction of the Aswan High Dam. The Citrus Project, begun in 1980, was introduced to assess the reasons for low yield in established orchards, to make recommendations to rectify the problems, and to enlarge the germplasm resource base for both scion and stock material.

ACCOMPLISHMENTS

SCION CULTIVAR IMPROVEMENT

Two approaches were taken to improve scion cultivars: (1) improvement of genetic material, and (2) development of budwood sources free of virus diseases and stubborn disease, the latter caused by the mycoplasma *Sprioplasma citri*.

Improvement of genetic material was undertaken in two phases: first, the introduction of improved genetic material from Florida and California where budwood improvement programs have existed for 2 to 3 decades, and second, the selection and testing of apparently superior strains from Egyptian orchards.

Improved Genetic Material

The procedure for introduction involved identifying desirable materials for import, propagating and placing them under observation in Egyptian quarantine facilities, testing them in the field and ultimately releasing them to citrus nurserymen and growers. Budwood from Florida and California was also obtained through the Ramses Corporation, a joint Egyptian-U.S. venture that had recently imported large quantities of the best cultivars and established a budwood source planting for its own use. It should be noted that the finest scion cultivar budwood and rootstock seed in the world were given to Egyptian scientists by U.S. budwood registration and seed validation programs. This plant material took decades to test and to free from viruses at the cost of millions of dollars and untold scientific hours of work. This budwood has now been propagated on sour orange and placed in quarantine.

The testing plan called for propagating the introduced material on sour orange rootstock, placing four trees of each selection at several experiment stations representing distinct climate and/or soil situations, and evaluating yield and quality data for several years. Actually, the introduced material is to be increased and released as soon as possible because its potential was already proven in the U.S. and evaluation was therefore limited to yield and quality responses under Egyptian conditions.

Selection of Superior Egyptian Materials

The procedures for selecting superior material from Egyptian sources were more involved. First, teams of scientists searched for superior selections of the various cultivars throughout Egypt. Hundreds of candidate trees were identified, labeled, and maps of their locations constructed. Data on yields and fruit quality were obtained on individual trees, in addition to such factors as total soluble solids (an estimate of sugar), total titratable acid, juice content, peel thickness, color and shape. On the basis of such data, 82 selections of 'Navel', 'Mandarin', limes, grapefruit, and lemon were selected for propagation, placed in test plantings and virus-free material was produced from them.

Production of Virus-Free Material

The procedure for preparation of virus-free superior genetic material from the U.S. for introduction is complex and requires sophisticated techniques, equipment and materials, some of which were not available in Egypt. These include plants highly susceptible to virus which are used to identify viruses that might be causing symptoms, as well as special equipment and serum for the ELISA test for tristeza virus. Shoot-tip grafting and heat therapy facilities were also needed to produce virus-free material. Training progress in these areas is recorded in the report of the Tissue Culture project.

A search for trees on tristeza-tolerant rootstocks was highly successful and located a significant number of mature, fruiting trees of 'Valencia' orange on 'Troyer' citrange rootstock. Based on results in California, the latter is currently the strongest candidate as a replacement for sour orange. These trees are performing superbly. One planting of about 100 trees on 'Troyer' was located. In addition, there were a number of heavily fruiting, large 'Troyer' citrange trees that can serve as an immediate seed source. These observations, plus those of rootstock trials in Nile River soils in the Sudan and in soils of the Awash River Valley in Ethiopia, (all similar soils particularly with respect to pH) indicate 'Troyer' citrange rootstock can be used in an emergency, should tristeza suddenly become a serious problem as it has in numerous other countries.

Establishment of a Foundation Planting

Plans have been made for planting and propagation of U.S. introductions and Egyptian selections, all virus and

stubborn disease free, to be used as a source of budwood. This planting can be used to furnish superior genetic material to nurserymen and growers and thereby gradually improve the yield, quality and tree longevity of Egyptian citrus.

ROOTSTOCK IMPROVEMENT

Virtually all citrus in Egypt, except for Egyptian (Mexican) limes and a few baladi (local) oranges and mandarins grown from seed, are budded on sour orange rootstock. This rootstock has performed exceptionally well in Egypt for many years. It is particularly noted for the high quality of fruit it induces in the scion cultivar budded on it and resultant reasonably high yields. It is highly resistant to phytophthora foot and root rot and is adaptable to heavy Delta soils. Its primary weakness is its susceptibility to tristeza virus. Tristeza exists in Egypt in isolated trees but there is no evidence it is being spread by insects. However, it is important to enlarge the germplasm base so that other rootstocks are available should there be an outbreak of a new race of tristeza.

A further weakness of the sour orange rootstock is that it is not well adapted to either coarse sandy soils, such as are found in the desert areas now being developed, or in saline soils, which are also present in Egypt. An important objective of this research has been therefore to identify rootstocks at least equal to sour orange in adaptability, yield and quality, but tolerant of or unaffected by the tristeza virus, and to adverse soil conditions.

Along with these primary objectives were secondary ones of studying the root systems and general characteristics of the various rootstock species, evaluating the effects of mycorrhiza and establishing seed plantings of rootstock species.

Seed of a wide range of rootstock species were brought to Egypt by R. Soost in 1981 and by A. Krezdorn in 1982 and 1983. These were planted in nursery seedbeds by the Egyptian rootstock team under Dr. El-Barkouky's leadership.

Rootstock trials began in which all trees were planted in randomized block statistical design with 2-tree plots and from 4 to 10 replications, depending on space available. While the trials have been established, the rootstocks have not yet been budded with virus-free material.

Rootstocks have been planted and will be evaluated on their ability to grow on different soil types: the sandy desert soils and the heavier, more fertile, Delta and river valley soils. All except sour orange are tristeza-tolerant. Two as yet unnamed grapefruit x trifoliate hybrid selections from Florida, that have performed exceptionally well there, were to be included in all trials. They appear to have a wide range of soil adaptability and are tolerant of all rootstock-related viruses; they are equal to sour orange in quality and superior in yields.

Citrus macrophylla, a rootstock that has proven exceptionally good for Egyptian (Mexican) limes in Mexico was also included in rootstock trials for limes, even though it is damaged by tristeza, because these limes are damaged by tristeza regardless of rootstock.

Developing new rootstocks on which superior fruiting varieties can be grafted has been an important part of the Citrus Project. A field nursery planting of citrus rootstock seedlings at Gaifara is shown here with sorghum plantings used as windbreaks. *Photo: Robert Soost*

DETERMINING CAUSES OF LOW YIELDS OF NAVEL ORANGES

This comprehensive research effort became active sooner than cultivar and rootstock research because it utilized existing commercial trees. Many Navel orange orchards in Egypt produce very low yields; some are virtually fruitless. Why this was so was the subject of an extensive survey conducted by Dr. El-Gazzar and his staff at Alexandria. The plan of this research involved paired orchards at six locations, 12 high and 12 low-yielding under comparable soil and climatic conditions. Notations were made on the quality and condition of each orchard and of a large number of variables such as leaf mineral element content, depth to water table, prevalence of diseases, and insects that are known to affect flowering and fruit yield. The design of the experiments allowed statistical correlations showing relationships (but not necessarily cause and effect) between yield and the variables measured.

The first phase of this work was successful; certain factors were statistically related to low yield, however, some relationships appeared spurious. On the former, low fruit set, low potassium, excessive phosphorous and excessive water appeared to be sufficiently related to low yield to draw conclusions with confidence. Results of analyses of other elements—iron, zinc, manganese, boron,

sodium and nitrogen—were too inconsistent to warrant further research.

Soil and water studies were pursued according to the format provided by USDA Handbook No. 18. Detailed information was taken on 40 soil profiles and included physical and chemical characteristics of the soil, soil horizon, water table and several characteristics of each of 161 augur holes in sites with different types of drainage.

There was a fair correlation between drainage, irrigation practice and orchard performance. However, much more work needs to be done and in particular there is a need for completion of the statistical work in which yield and quality parameters will be related to soil and water conditions.

Major insects were surveyed in the orchards under study. California red scale, Florida wax scale, Australian fluted scale and the citrus mealy bug were all prevalent in Egyptian orchards. Particularly the first two are "over represented" in Egyptian groves. The counts made at 45 day intervals revealed a rapid increase in both after mid-May.

Fungi on trees in all orchards were also surveyed. The most prevalent disease-causing fungi were: Alternaria black rot (*Alternaria citrus* Ellis & Pierce), brown rot gummosis and foot rot disease caused by *Phytophthora spp.* and gummosis caused by *Diplodia natalensis*. However, despite their notorious reputation for causing disease in citrus, the observations of these fungi in orchards during the course of the surveys did not reveal a close correlation with yield.

Surprisingly high citrus nematode infestations were not statistically correlated with low yield, even though damage done by this pest is recognized in other regions. Such results are to be expected in a project involving multifactor correlation data and where the number of paired orchards is limited. Moreover, quantifying the incidence of nematodes cannot be done with precision.

A similar conclusion may be drawn for surveys of other pathogens since precise measurements are difficult to make and correlation therefore difficult to establish.

The weed studies, useful in providing a comprehensive catalog of weeds, do not necessarily provide insight into the relationships between individual weeds and orchard performance.

The research developed a wealth of baseline data that will be valuable in determining future research directions. Despite the occasional difficulties of interpretation, this research accomplished its purpose of searching out the most promising areas for investigation and these are currently under study.

Also of considerable importance was the close relationship that developed between the research team and the growers, an indispensable feature of any successful long-term applied agricultural research.

FUTURE STUDIES

The research endeavors begun in this project are inherently long-term. It takes, for example, three years to produce a nursery tree from seed and four to five more years to obtain first yields. The success, therefore, of scion cultivar and rootstock improvement research which has been underway for less than three years, must be measured in terms of progress rather than on the basis of final results. Critical to this is the provision that the project has made, in the form of training, to enable long-term high quality research to continue beyond the conclusion of the ADS contract. In addition to continuing the lines of citrus research that have already been initiated, there are several other high priority areas for research identified by the team.

The crowding of trees, and the consequent reduction in yield and difficulty of management and harvesting, is developing into the most limiting production problem in Egypt. It is a problem facing all citrus growing areas. The small citrus holdings in Egypt preclude widespread use of the large mechanical pruning equipment used in the U.S. to prevent crowding of trees. Egypt needs to investigate the use of hand-held power pruning tools and proper pruning techniques, i.e., season and frequency of pruning, distance between trees and height of trees that will maintain maximum production at the spacings that exist. This is now the highest priority research for existing orchards.

Psorosis virus is reported in all existing budded sweet orange trees. Use of psorosis-free budwood can eliminate this disease from new plantings but not from old ones. Psorosis causes reduced yields due to bark scaling lesions on large branches and trunks but generally not until trees are 12 to 15 years old. A degree of success has been obtained in the U.S. in reducing damage by scraping lesions and painting them with various chemical compounds. These methods should be investigated along with the use of growth regulator applications to the wounds.

Tristeza is still only a threat but it has the potential of killing every tree grown on sour orange in Egypt if a virulent strain develops and aphid vectors become adequate. It has killed millions of trees in other areas and the threat cannot be disregarded. Trees killed by tristeza can be replaced by those on tolerant rootstocks, but this would be extremely costly.

A massive survey would be useful, utilizing the ELISA test, to determine the number of trees infected. There is reason to believe that tristeza might be present in only a limited number of trees and not spreading. Once determined by a survey, those containing tristeza, which was apparently introduced with infected budwood, could be removed and sour orange could continue to be used, if desired. Most importantly, the threat of loss of millions of existing trees would be largely eliminated. The simplicity of the ELISA test makes such a survey possible.

Excessive irrigation is also a major problem which could be largely corrected with research information currently in hand. Thus, an intensive research-demonstration program conducted jointly by research and extension staff is needed.

The technology of citrus production in desert areas is largely unknown and an experiment station located in the desert to investigate problems related to desert citrus production and to develop an appropriate technology is needed.

MANGO PRODUCTION AND DISEASE CONTROL

The mango has long been cultivated in Egypt and mango orchards occupy 25,400 feddans, ranking third in area after oranges and grapes. Productivity is reduced significantly by inflorescence malformation, a disease which is characterized by thickened, twisted and misshapen panicles, preventing fruiting and affecting fruit growth. Most diseased flowers lack functioning sexual organs and do not set fruit. Instead of being shed, the non-productive inflorescence tissue dies but remains on the tree for many months. The malady may also affect the vegetative shoot which forms a crown of small leaves with greatly shortened internodes. The vegetative symptoms are called "bunchy top." The cause of the malady is unknown despite research over a number of years in Egypt, Pakistan and India. The purpose of the ADS Mango project, initiated in 1980, was to seek ways to alleviate the effects of the disease, and if possible eradicate it. The problem was approached in two ways. One sought to identify the causal agent of the disease as a first step in developing control measures. The other approach, pursued simultaneously, was to explore the prospects for minimizing the effects of the disease by quarantine and eradication practices combined with improved cultural methods such as pruning, fertilizing, and pesticide treatments.

ACCOMPLISHMENTS

HORTICULTURAL STUDIES

Survey of the Extent of the Mango Malformation Disorder

For the purpose of this survey, Egypt was divided into three districts and, in each, mango orchards were classified according to their management practices: excellent, intermediate or poorly managed. A survey, begun on May 1, 1980, was continued through 1982 to determine the percentage of malformation found in representative orchards in each of these categories. Ten adult trees of the 'Pirie' cultivar were selected and the number of malformed inflorescences was recorded in relation to the total number of panicles (inflorescences). At the same time local 'Baladi' seedling trees which were apparently symptomless were marked and placed under observation for three years, during which time orchards which were rated as having had excellent management ranged from 0.5 to 6% malformation, orchards rated as intermediate ranged from 24 to 33% malformation and in orchards considered poorly managed the malformation incidence ranged from 59 to 63%. In upper Egypt little malformation was found in any orchard. Those which received excellent care had virtually no malformation while those which had intermediate or poor care exhibited up to 8% malformation. In the Nile delta, where the disease is most serious, the effect of good management in reducing expression of disease symptoms was also clear. The incidence of malformation in excellent, intermediate care and low maintenance orchards ranged from 1–33%, 16–56% and 36–80%, respectively. Thus, management practices, including fertilization, irrigation, pruning, pest control and sanitation combined to influence the expression of disease.

Some of the trees which were selected as being visibly free of disease proved to have excellent fruit quality characteristics, including high soluble solids and total acidity. Such trees will be used as mother plants for a source of budwood.

Results of this survey clearly showed that providing mango trees optimal conditions for growth, as well as freedom from pests and diseases, resulted in a major increase in yield, even though some of the inflorescences showed malformation. The significance of this work was that recommendations could be made to growers on methods to maximize production, even in the presence of the disease. This information became a component of an important extension program directed toward mango growers.

Top Working Susceptible Tree Wood From Resistant Trees

In order to renew infected orchards and to assess the potential role of grafting healthy shoots (bud sticks) onto susceptible trees, a study of top working and side veneer grafting was undertaken. The practice involves grafting onto branches of the susceptible adult 'Taymour' trees bud sticks obtained from the same variety grown in El-Fayoum where trees do not show symptoms of the disease. The grafting experiments were done at El-Haram, Abou Rawash and El-Kanater. Some of the trees were covered with a mesh screen to limit insects.

In addition to top working and side veneer grafting a cleft graft method was adapted to overcome the drawbacks of the traditional grafting method used for mango propagation. Seeds were planted in a bed and, after germination, were transferred to a nursery in rows spaced 60 × 60 cms apart. When seedlings had attained a suitable size, they were selected for grafting. The base of the cuttings taken from apical shoots of disease free trees was cut to a V shape and inserted into a corresponding V made in the stock of the selected seedling tree. A polyethylene strip was tied around the graft which was then covered by a polyethylene bag. After about 10–15 days the graft union was effected. Six months later the grafted tree was dug up with a ball of soil left around the root system, and transplanted to an orchard. The success rate of this method was high: about 85% of the trees survived and no abnormality or malformation was observed.

Disease-free Propagation

With the aim of establishing new orchards which were true to type and free of disease, "nucellar" trees were grown from symptomless mother plants and propagated. Advantage was taken of the characteristic of certain mango varieties to produce naturally asexual polyembryonic seedlings (nucellar seedlings) from cultivars which were judged to be free of disease symptoms. Normal seedlings arising as a result of normal sexual fertilization were eliminated because they are typically variable. One hundred nucellar seedlings obtained from eight cultivars were planted in Giza. At present these trees are approximately three years old and appear healthy. By propagating trees in this manner it might be possible to develop orchards free of disease, although eventually they could become infected.

NUTRITIONAL STUDIES

Extensive nutritional studies were undertaken to examine the effects of levels of nitrogen and potassium on disease expression of several cultivars of mango over a period of three years. Results of these studies indicate that fertilization with different levels of nitrogen and potassium did not affect expression of the disease. Treatments altered neither the extent of the abnormality nor yield. In short, nitrogen and potassium treatments were not correlated with disease expression.

Microelement treatments were made on 25-year-old 'Taymour' trees to determine the effect on the incidence of the malformation disease. Iron, copper, zinc and manganese were applied in foliar sprays as chelates or as sulphates, separately, or in pairs, in all combinations. Iron and copper were applied at 100 ppm and zinc and manganese were applied at 50 ppm. Panicle length and branching increased significantly in response to the micronutrients, whether sprayed separately or together, probably indicating a low nutritional status in the trees at the outset. There was also a marked reduction in the percentage of diseased inflorescences. The untreated controls had 58% infected inflorescences, whereas all those treated with a nutrient applied singly or in combination, had less than 15%, except in the case of zinc and manganese treatments, when 31% were infected. Thus, the addition of virtually any micronutrients proved to be beneficial with regard to vegetative and reproductive development; even the micronutrients applied individually markedly reduced expression of the disease.

Soil-Water Relationship

Relationships between irrigation and fertilization with N, P, and K on malformation and yield were investigated. A study was carried out with 'Hindy' and 'Besinnara' trees at Anshas Orchard and the El-Kanater Experiment Station on, respectively, sandy and loamy soils, the two dominant types on which mangos are grown. Three levels of water were applied per feddan, 325, 550 and 750m^3. Nitrogen was applied as calcium nitrate equivalent to 1, 2, 3, and 4 kg/tree and in all possible combinations with potassium sulfate (0.25, 0.5 and 1 kg/tree). All trees received 1.25 kg superphosphate. The orchard was split with three irrigation regimes, and fertilizer treatments were completely randomized within each plot. Ten single tree replications were used for each treatment. Moisture levels at 15, 50 and 90 cm were determined with tensiometers and gravimetrically.

The results of this research were clear-cut. The two highest levels of irrigation tended to reduce yield; levels of moisture lower than 325m^3/feddan should now be tested to complete this experiment. Not surprisingly, all the combinations of N and K were superior to the untreated control, but there was little benefit from any combination with respect to yield of marketable fruit. Assuming these were typical orchards, a possible conclusion is that mango orchards are over-irrigated and over-fertilized or that mango trees do not require even the lowest levels of N and K tested in this experiment.

Growth Regulators

Some of the symptoms of the malformation disease—stunting of the vegetative growth, for example—are reminiscent of applied growth regulator effects. Therefore, CCC, an inhibitor of biosynthesis of the hormone gibberellin, and gibberellin A_3 (GA_3, 100 ppm), kinetin (25 ppm) and naphthaleneacetic acid (NAA, 50 ppm) were sprayed, separately and together on 'Taymour' and 'Pirie' trees in an effort to alleviate symptoms of the disease. The experiments were conducted at the Abou Rawash farm in Giza using four single tree replications. There were thirty-five panicles per treatment and panicle length averaged 5 cm; each treatment was represented on each tree. The applications were made 3 times at intervals of 10 to 15 days. The control (water sprayed) 'Taymour' trees averaged 68% deformed inflorescences and 'Pirie' 60%. Sprays of GA_3 alone markedly reduced disease expression. 'Taymour' and 'Pirie' trees showed, respectively, 15 and 12% malformed panicles. Mixtures of GA_3 and NAA also reduced malformation, and a mixture of GA_3 and kinetin were somewhat less effective (28% for 'Taymour'; 29% for 'Pirie').

Interestingly, the GA_3 treated inflorescences did not increase fruit yield over the control in 'Taymour', although combinations of GA_3 and NAA, and GA_3, NAA and kinetin, significantly increased fruit yield. Fruit yield of 'Pirie', on the other hand, was markedly increased by GA_3 alone or in combination with one or both of the other growth regulators. Perhaps these increases resulted in part from an increase in the ratio of female to male flowers on the growth regulator treated plants. For example, the control 'Taymour' trees had a female:male ratio of 16, whereas female:male ratios for GA_3 and GA_3 + NAA treatments were, respectively, 45 and 64. Results with 'Pirie' were comparable. The implication of this work is that whether or not they play a direct role in disease expression, growth regulators markedly alter the balance of female to male flowers, and thereby, the ability of infected trees to produce fruit.

PATHOLOGICAL STUDIES

Fungi and Malformation

Fungi are possible causal agents of the malformation disease. To ascertain the occurrence and infectivity of fungi in this disease, soil and root samples were collected from budded trees of different cultivars growing in several localities. Since *Fusarium* spp. are thought to be associated with the mango malformation disease, special attention was paid to this genus. Samples of unopened buds, malformed inflorescences and abnormal vegetative growth were similarly collected.

Tissue samples taken from mango buds and inflorescences contained several known fungi with *Fusarium* species the most prevalent. Trees grown in El-Fayoum, where the disease is absent, were free from foliar *Fusarium* spp. Both vegetative and reproductive structures bore the same fungi.

To determine the role of *Fusarium* spp. in disease expression, 10–15-year old 'Hindy' trees growing at the Horticultural Institute at Giza were inoculated with spore suspensions of 10 *Fusarium* species and isolates through wounds, or it was applied to apical buds. A total of 522 inoculated buds were treated and covered with polyethylene bags for 48 hours.

Subsequently many inoculated buds were dehydrated and died or developed abnormal inflorescences reminiscent of the malformation disease. Other buds developed normal inflorescences, but gave rise to vegetative shoots at the apex of the inflorescence. In such buds normal vegetative growth resumed after death of the inflorescence. Some inoculated buds developed mixed reproductive and vegetative inflorescences. *F. oxysporum* was more effective than other species in inducing these symptoms. The implication of this research was that *Fusarium* spp. particularly *F. moniliforme*, were effective in inducing some of the symptoms of mango malformation. These results parallel reports from other institutions, but are in conflict with results from the project's work at Alexandria.

As in Cairo, the Alexandria team made large numbers of isolates of *Fusarium* spp., mainly *F. oxysporum* and *F. solani*. Injection of spores of these species into one branch of two-branched, apparently healthy, trees failed to produce symptoms of the disease on either branch. Extensive malformation on both control and injected branches indicated there was latent infection. This is always a serious problem in studies of the malformation disease. Healthy trees grown in soil infested with the fungus likewise failed to exhibit symptoms. Antibiotics as well as fungicidal injections made the previous year also failed to prevent expression of symptoms on new vegetative and reproductive growth.

It is evident that conclusions favoring *Fusarium* spp. as a causal agent are equivocal. Nevertheless, the extent of the work in Egypt and positive reports from elsewhere in the world, as well as from Cairo, require that studies of the role of *Fusarium* spp. be continued.

Mycoplasma and Malformation

The possibility that mycoplasma, a viroid-like particle, is responsible for initiation of the mango malformation syndrome was investigated in Egypt as well as by Dr. George Nyland, Department of Plant Pathology at UCD, and by his associate, Dr. A. Kishta. Mycoplasma are sensitive to high temperature, to tetracyclines, and are graft-transmissible. These factors were investigated by exposing affected plants or plant parts to hot water treatment, injection with terramycin and grafting of diseased plants onto unaffected trees. Transmission of the disease could be indicated with the electron microscope by the presence of mycoplasma in the cells of thin-sectioned phloem from the stock plants.

Malformation of the mango inflorescence as seen here is a serious problem that prevents fruit and shoot development. Project researchers developed measures to control the disease and protect this valuable crop. *Photo: Lawrence Rappaport*

In none of these studies was mycoplasma ever detected. Using a pressure injection system, the antibiotic tetracycline was injected into the vascular system of infected trees with the objective of overcoming the effects of a presumptive mycoplasma infection. Experiments were carried on with injections made at different times of the year, different dosages, and different numbers of injections in individual trees.

The group at Alexandria University under Dr. Abou Dahab had previously injected trees using the Schwartz method which had been used successfully in South Africa with trees affected by citrus greening, a disease caused by a mycoplasma. The technique was effective in inducing yellowing of the mango foliage, indicating that phytotoxic amounts of terramycin had been transported in the tree. In none of the studies was mycoplasma seen nor was chemical therapy successful in alleviating disease symptoms. While it cannot be concluded absolutely from these studies that mycoplasma is not involved, there is general agreement that such involvement is unlikely. This was a very important study because reports of the occurrence

of mycoplasma in the vascular system have been made

ENTOMOLOGICAL STUDIES

There is conflicting evidence concerning the role of mites as vectors transmitting the presumptive causal organism. That *Fusarium* spp. might be involved and that mites could act as vectors for the fungus was the subject of several studies. Initially a survey of insects which inhabit diseased trees was made in three localities, El-Fayoum, a malformation-free region, and El-Sharkia and Qalubia Governorates, where mango malformation is known to occur. The possibility that mites are vectors of the organism responsible for the malformation disease was investigated by studying the kinds and population density of mites present in buds of five mango varieties with special attention to the mite *Eriophes mangiferae*.

Experiments were also conducted using chemicals to control mites and other insects and fungi thought to be associated with inflorescence malformation, and to determine the influence of treatment on disease incidence. Sixty 'Kubania' mango trees at Anshar were sprayed biweekly for nine weeks with an acaricide (Novan, at 150 ml/L of water), an insecticide (Cybolt, at a concentration of 0.05%) and fungicides (Vitavax-100, Daconil 2787 or Benlate). Half the trees were pruned. Buds were examined for presence of *Eriophyid* mites and *Fusarium*. *Fusarium* spp. were found in mango bud tissue as well as internally in the surface-sterilized mites. An association was established between the number of mites present and the prevalence of *Fusarium*. The effects of pesticides on populations of mites and *Fusarium* spp. were variable, although most treatments reduced both. The pesticide treatments only slightly reduced the percentage of malformed inflorescences. On the other hand, all pesticide treatments resulted in an increase in the number of fruits per tree, as compared with the controls (Table 1). The effects of pruning were erratic. Thus, it appears that the favorable results of the pesticide treatments were a consequence of effects other than on the population of mites and, possibly, the presence of *Fusarium* spp. Conceivably, other organisms deleterious to mango, were eradicated or reduced by the chemical treatments.

This work lends support to the growing understanding that treatments which contribute to the general well being of the trees will result in significant increases in yield of mango fruits, irrespective of some infection.

EXTENSION

Although a cause for mango malformation has not been identified, various cultural practices have been shown to contribute markedly to fruit yield in spite of persisting infection. Such practices are now being disseminated to growers. Television programs were broadcast in July 1982 and April 1983 to explain to growers the necessity for developing excellent cultural practices, and the need for selecting symptomless plants as stock for developing new orchards. Meetings with growers and Extension Service personnel were held in southern governorates in November 1981 and 1982, to describe the mango cultural program and to distribute published extension materials. There was also a demonstration held at El-Kanater in May 1982 for growers and Extension Service personnel. A workshop was held April 24–28, 1983, attended by Egyptian and international visitors. Twenty-six papers were presented. The attendees made field trips to several governorates to observe experiments, demonstration plots and nucellar mother plantations.

Table 1. **Effect of Pruning and Treatment***

	Number of Fruits/tree	
Treatment	*Pruned*	*Not Pruned*
Acaricide	108	231
Insecticide	217	97
Fungicide	170	175
A + I + F	120	301
Control	86	43

*With Novan, an acaricide (150ml/100L), Cybolt, an insecticide (50 ml/100L), and Vitavax, Daconil and Benlate, fungicides (200g/100L), separately and in combination on number of healthy mango fruits harvested per tree.

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FRUIT AND VEGETABLE POSTHARVEST LOSSES

Improvement in crop yields loses much of its economic significance if heavy losses are sustained between harvest and consumer. In Egypt, postharvest losses of fruit and vegetables due to disease, damage, and senescence may be as high as one-third of the harvest. In the absence of specific research it has remained unclear where the greatest losses occur in the postharvest handling chain, and hence possible corrective measures have been speculative. The goal of this project has been to identify key points of postharvest loss of major fruits and vegetables, and to recommend modifications in harvesting and postharvest handling systems which would minimize losses.

ACCOMPLISHMENTS

Research was initiated in 1980 with a survey of the magnitude and causes of harvest and postharvest losses occurring in selected fruits and vegetables in Egypt. The following commodities were included in this survey: citrus fruits ('Navel', 'Valencia', and 'Baladi' oranges, grapefruit, lime, and mandarin), grapes, banana, pear, mango, tomato, onion, garlic, potato and cucumber. In 1981, dates and stone fruits were also included in the survey.

For each crop, 20 samples (25 kg) were taken at intervals during the production season from 4 to 6 fields in 2 or 3 governorates. All samples were sorted initially, then held for a simulated transit and marketing period, and evaluated for qualitative and quantitative losses. An average overall quantitative loss of about 19% in fruits and 29% in vegetables was estimated. This translates to an annual loss of about 2.5 million tons, valued at more than 500 million LE.

In most commodities surveyed, the largest percentage loss was due to mechanical defects (bruises, abrasions, cuts, punctures, etc.), which predisposed the product to accelerated water loss and attack by various pathogens. The main factors responsible as causes of loss or as obstacles to minimizing loss are listed below.

Preharvest: The relatively high percentage of physiological, pathological and insect injuries in some commodities resulting from poor cultural practices.

Mechanical: Picking soft-ripe or immature fruits which are more susceptible to impact bruising and surface injuries, respectively;

Using methods of harvesting which result in excessive mechanical damage to the commodity;

Using shipping containers, mainly palm-rib crates, which cause additional injuries to the commodity;

Using transportation, especially animals and animal-drawn carts, moving on unpaved and unleveled country roads.

Environmental: Long exposure of fruits and vegetables to direct sunlight which accelerates shrivelling and wilting, and reduces their keeping quality;

Absence of any cooling practices and inadequate storage and marketing facilities.

Institutional: A very limited and inactive cooperative marketing system making it possible for a few wholesalers to control the market;

Government price controls of most major commodities do not provide incentives for producers and handlers to grade their crops by quality and improve their practices to maintain quality after harvest;

Unavailability of tools and supplies needed for proper harvesting and postharvest handling procedures.

On the basis of the initial survey and identification of the main causes of losses, various modifications in the harvesting and postharvest handling system for each commodity were devised and tested during 1981 and 1982. A small group of team members carried out the required research on each crop. The results of these tests are summarized below.

Citrus Fruits: To avoid damage during harvest, the best picking method for citrus fruits involves using clippers, bags and aluminum ladders, and packaging fruit in small lined palm-rib crates or plastic boxes. The current practice of pulling fruits and shaking trees, then packing the fruits into large palm-rib crates damages the fruit.

A survey of postharvest losses due to diseases occurring in export orange samples was carried out during the 1980, 1981, and 1982 seasons. This included a survey of the incidence of strains of *Penicillium italicum* and *P. digitatum* which are resistant to Topsin and thiabendazol (TBZ). In addition to their resistance to Benlate most *P. italicum* isolates were more resistant to TBZ than those of *P. digitatum;* both however were sensitive to Imazalil or prochloraz. Thus, successful control of postharvest diseases of oranges should involve use of fungicides other than TBZ alone. Preliminary results indicate that the use of Imazalil when applied in combination with wax gave consistently better control than TBZ alone.

A survey of the occurrence of strains of *P. italicum* and *P. digitatum* which are resistant to biphenyl or sodium-o-phenylphenate (SOPP) was carried out in 1983. In combination, SOPP and TBZ did not show an effect greater than that of TBZ alone on the *in vitro* growth of TBZ-resistant and sensitive isolates of *P. digitatum* and *P. italicum*.

Preharvest fungicide applications with Imazalil or TBZ checked the dominant rots on 'Valencia' oranges during storage. Imazalil was the most effective fungicide either as protective or curative when applied as a postharvest fungicide for controlling *Penicillium* and *Alternaria* rots. *In vitro* studies indicated the effectiveness of Imazalil as well as CGA 64251 against the most serious pathogens attacking citrus fruits. The fungicidal treatment prior to

Price control does not provide an incentive to producers to grade their products by quality. Shown here is an example of a box of tomatoes with large variation in maturity, size and quality. *Photo: Adel Kader*

The method of harvesting oranges was identified as a major cause of excessive mechanical injuries. Separation of fruits by tree shaking or by pulling and throwing them to the ground as shown here must be replaced by carefully clipping or snapping fruits and placing them in picking bags. *Photo: Adel Kader*

waxing was more effective than wax treatments containing fungicides. Preharvest Benlate application exhibited marked decay control on 'Navel' oranges during storage. Benlate or Imazalil as postharvest dip treatments were more effective in controlling decay on 'Valencia' oranges than CGA 64250 and CGA 64251. However, dip treatment in CGA 64251 controlled decay on limes for up to 2 months in storage.

Avoiding delays between harvest, delivery to the packinghouse and treatment at the packing house is important to reduction of losses. For example, leaving loaded trucks for 1–2 days exposed to direct sun while waiting outside packinghouses was found to increase the severity of orange fruit defects including decay. The long delay in shipping which sometimes extends to 10–15 days at the ports, also increases decay percentage and reduces quality. The export monopoly of citrus fruits by El-Waddy Company eliminates competition and reduces chances for improvements in the currently used postharvest practices.

Grapes: Use of quick-release sulfur dioxide generating pads was effective in reducing decay in stored 'Banati' grapes at 0°C. *In vitro* tests on the effectiveness of quick-release "grape-guard" in suppressing rot pathogens of grapes *(Botrytis Cinerea Pers)* revealed that this fungus grew only after 12 weeks' incubation at 0°C. The use of SO_2-generating pads and a polyethylene lining inside the container of 'Rumi Red' grapes resulted in better keeping quality when grapes were left at room temperature. Preliminary studies show that placing ½–1 pad on the bottom and another on the top gave the best results. In addition, the corrugated fiberboard boxes and lined palm-rib containers were the most suitable for packing and storing grapes, followed by plastic boxes.

Preharvest Sumiselex applications on grapes appeared promising in reducing postharvest rots incited by either *Rhizopus sp.* or *Aspergillus niger.*

Bananas: In most cases, bananas in Egypt are neither picked at optimum maturity nor ripened at optimum temperatures or relative humidity in ripening rooms. Care has to be given to picking and handling bunches if any improvements in reducing mechanical damage are to be achieved. Mechanical injuries were reduced by handling bananas after cutting into "hands" under the plant, then packing them in boxes. Bruises and pedicel damages were higher on bananas cut into hands after transport as full bunches to the accumulation center.

Ten fungal diseases were found on tested banana fruits but *G. musarum* was the most dominant, followed by *Fusarium Sp.*, then *B. theobramae*. Chlorox proved to be the best surface disinfectant, followed by Benlate, detergent, wax, then water washing; Chlorox is also safer and more economical.

The "ethygen" system (ethylene-generating solution) was used for the first time in Egypt for enhancing banana ripening and proved to be more effective and safer than the traditional method of using acetylene. Small differences were noticed in the quality of local bananas ripened with acetylene or ethylene, but when imported bananas were used, ethylene resulted in more uniform ripening. This difference in response may be due to the proper maturity of imported bananas and immaturity of local bananas.

Pears: Proper postharvest ripening of pears with appropriate color change was found to require a period of cold storage before holding at ambient temperature. Storage at 7°C for two weeks, for example, produced fruit with good color and firmness. In general the higher the storage temperature, between 0 and 12°C, the shorter the storage period required for ripening. Packaging during cool storage was found to be important. Paper lining, shredded paper and wrappings of individual fruits in the palm-rib crates restricted air circulation, and therefore the cooling efficiency. Accordingly, it took a relatively long time to reach the desired internal fruit temperature which resulted in appreciable fruit softening. Bruises were also higher in fruits packed in palm-rib crates than in plastic boxes.

Packing pears in plastic boxes, which provide better aeration, and storage in a temperature-controlled room at 0 to 2°C minimized scald development which can be a serious problem with currently used practices.

Ethylene was more effective than acetylene treatment in stimulating ripening and yellow color of 'Le Conte' pears, and again the "ethygen" system can be recommended for this purpose because it is efficient and safe.

Mangoes: Reduction of mechanical injury during picking is especially important and picking with hook and bag on a long pole is recommended, since it resulted in significant reduction of postharvest decay.

Treatment with a surface coating ("Prolong") increased the acceptable fruit storage period at 10°C by 3 weeks and resulted in superior firmness, color and appearance of mango fruits.

Preharvest Thiabendazole application reduced decay by about 50% for the main pathogen, i.e., *Botryodiplodia Sp.*; a major reduction of *Aspergillus* rot resulted from treatment with Benlate or Rovral. Excellent postharvest decay control was achieved using Imazalil as a dip treatment on freshly harvested mangoes. Hot water treatment at 50°C to 55°C for 15 minutes resulted in considerable decrease in decay due to *Botryodiplodia palmarum* and *Aspergillus niger.* Postharvest fungicidal wax treatment indicated the effectiveness of Imazalil at 1,000 ppm against both tested pathogens. The 'Misk' cultivar was found to be generally more susceptible to *Botryodiplodia* rot than 'Tymour.'

Stone Fruits: Harvesting by picking gently by trained workers using plastic buckets and ladders, reduced the mechanical injuries in apricots, plums and peaches by about 40%. Small, divided fiberboard containers proved to be the best in reducing weight loss and decay of stone fruits during marketing.

Inspected samples of apricot, plum and peach collected from orchards and markets indicated that the most dominant pathogen causing decay losses was *Rhizopus Sp.* No obvious postharvest decay reduction on peaches was obtained by preharvest applications of Botran, Rovral or Thiabendazole. Hot water treatment at 45°C for 5 minutes reduced decay on peaches by 50% during subsequent handling.

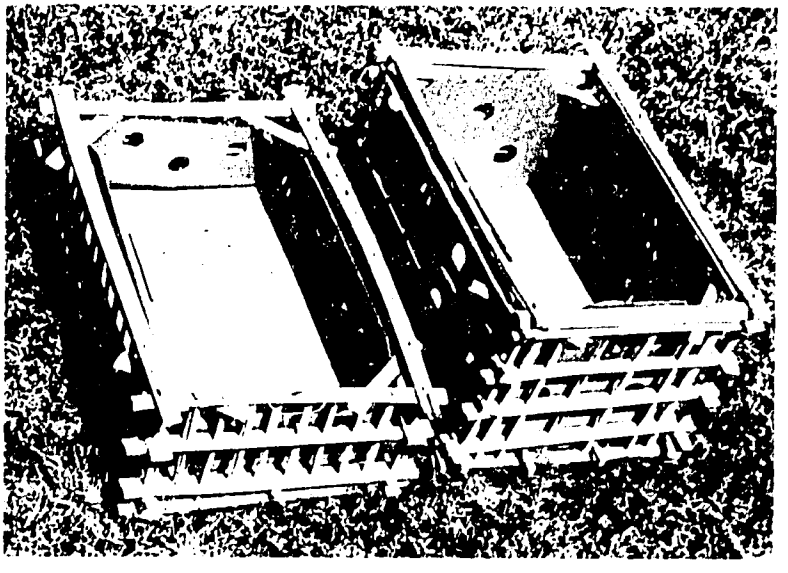
Dates: Harvesting by shaking bunches to remove individual fruits increased defects more than cutting the whole bunch into short stalks with a few fruits on each stalk. The percentage of cuts, decay and weight loss was higher in fruits packed into palm crates than in those transported in plastic boxes, but there were more shrivelled fruits in the plastic boxes.

The most dominant pathogens responsible for postharvest losses in date fruits were bacteria, followed by *Alternaria* and *Cladosporum* rots. Dates packed in 2 kg cartons (as a consumer package) showed the least decay at the end of 4 weeks storage at 0°C.

Tomatoes: Fruits picked at the mature-green and light-pink fruit stages were best for export and domestic marketing, respectively. Picking immature fruits which leads to surface mechanical injuries, shrivelling and decay, poor development of flavor and marketability, must be avoided.

Overfilling of palm crates has been responsible for a high percentage of mechanical injuries and consequent decay. Lining the palm crate with corrugated cardboard considerably minimized the percentage of injured fruits, even in over-filled crates. Use of plastic boxes for shipping reduced the severity of mechanical damage.

Many of the new cultivars grown in open air and plastic greenhouses were evaluated for their ripening behavior and keeping quality. Fruits of the 'UC 82' cultivar which have thick pericarp, few locules, and firm skin, were very firm when ripe, and maintained their firmness even after storage at ambient conditions for 2 weeks.



Palm rib crates such as this are common containers for harvest and marketing. Extensive damage to fruits through overfilling and from the sharp edges of ribs is a major cause of loss. The Postharvest Project has helped develop an inexpensive remedy using locally produced cardboard liners for the crates (lower photo). *Photos: Adel Kader*

Postharvest disease problems of tomato can be reduced by use of chlorine in the washing water and application of one of the following fungicides: Teco, Bravo or Botran at the recommended concentrations.

Potatoes: Experimental postharvest handling of potatoes in returnable plastic boxes (25 kg capacity) resulted in the lowest mechanical damage and decay, compared with the commonly used jute bags and palm crates.

Sugar cane pith was tested as a filler for well-cured and stored 'alpha' potatoes in jute bags at ambient temperature and in cold storage. While potatoes stored in pith showed lower weight and total losses compared to the control without filler, losses due to decay and percentage of sprouted tubers were higher. The use of sugar cane pith as a filler is not recommended.

A method of storing 'seed' potatoes without refrigeration was investigated. In the usual methods, white, long (4–7 cm) and weak sprouts developed during storage. When diffuse light was used, short (½–1 cm) sturdy green sprouts formed. It is recommended therefore that unrefrigerated seed potatoes be stored under diffuse lighting conditions.

The jute sack, with perforated black polyethylene liner, is recommended for export of the winter immature potato (new potato) in place of polypropylene bags. The 18 kg fiberboard box (Egypack Co.) was widely used for export of mature potatoes to Arab countries during the period between March and May, 1983; its continued use is recommended.

The survey of postharvest losses of potato tubers showed that large losses occurred in exported new potato samples of the 'King Edward' cultivar, indicating that field inspection and packing facilities were not performing their essential inspection and sorting functions. In consequence, heavy losses in exported Egyptian new potatoes occurred upon arrival in the United Kingdom during the 1980 season. Such losses were significantly reduced during the 1981 season due to the organized program of inspecting potato fields and potatoes at collecting centers and to the careful sorting at packinghouses.

Onions: Studies showed that curing onion plants in the field greatly enhanced bulb quality and decreased total losses when stored for up to six months under ambient conditions. A pre-storage curing period of 15 days with tops attached is highly recommended for decreasing subsequent weight loss and decay during marketing and storage of onion bulbs.

Packing onions in jute sacks and palm crates lined with Kraft paper resulted in lower weight loss than packing in all types of wide mesh bags. Perforated polyethylene bags resulted in increased decay compared with other packaging methods.

Daconil and Botran, dusted on the onions at harvest, effectively controlled decay of onion bulbs caused by *Botrytis allii* (neck rot) and *Aspergillus niger*. Also, Thiobendazole and Revoral, at a rate of 4 g/kg, applied as dust on freshly harvested, cured or non-cured onion bulbs greatly reduced the incidence of onion rots during a five month period of storage.

Garlic: Maturity tests confirmed that garlic in most production areas in Egypt is harvested at too immature a stage, resulting in poor keeping quality of the bulbs. Mandatory minimum maturity standards are required so that garlic can be maintained in marketable condition for a longer period.

In storage, 'Baladi' garlic showed a lower loss percentage, fewer empty cloves, but a higher incidence of loose bulbs than 'Chinese' garlic. Loose bulbs represented the major losses in retail and wholesale markets of Alexandria, while mechanical and pathological losses represented the highest damage in the fields and Cairo packinghouses. *Penicillium spp.*, *Aspergillus spp.* and *Fusarium spp.* were the most common fungi invading garlic cloves, with 'Baladi' garlic bulbs more susceptible than 'Chinese.'

Physiological age greatly affected weight loss and total defects in dry garlic with tops: the more mature the bulbs the less the total weight loss. For a given physiological age, weight loss and total defects were higher in large cloves, followed by medium and small cloves. Waxing cloves decreased total waste. Consumer packaging of garlic reduced postharvest losses. Packing garlic cloves in perforated Kraft paper bags gave the best results in reducing weight loss and deterioration followed by perforated polyethylene bags, and small plastic mesh bags.

Cucumbers: The major factor responsible for unmarketable fruits was mechanical injuries, followed by insect injury and pathological defects. The early samples in both summer and autumn seasons exhibited the least amount of postharvest defects. Postharvest losses were generally lower in the summer than in the autumn. Numerous pathogens attack cucumber fruits in the field and during marketing and storage including *Phythium Sp.*, *Choanephora Sp.*, *Fusarium Sp.*, *Sclerotinia Sp.*, *Alternaria Sp.*, *Rhizopus Sp.*, *Aspergillus Sp.*, *Penicillium Sp.*, *Cladosporium Sp.*, and *Mucor Sp.*

Fruits dipped in 0.05% copper sulphate solution or 4% Borax solution showed relatively lower decay loss than control fruits.

Gentle picking, the use of plastic buckets, careful handling and packing in perforated plastic boxes (25 kg. capacity) minimized the percentage of mechanical and pathological defects and maintained firmness and other quality attributes. While the eating quality of 2-day old fruit is better than that of 4-day old fruit, the 2-day old fruits (picked 2 days after anthesis) were more susceptible to mechanical injury. Sorting out diseased and damaged cucumber fruits before packing was found to minimize the risk of spreading infection.

Percentage of sound fruits was higher in plastic boxes than in jute sacks and palm crates. The life of postharvest cucumbers can be increased by storage at 12.5°C.

The key role played by shipping containers in protecting fruit and vegetables from losses due to mechanical injuries was common to all commodities examined by the Postharvest Project. The major contribution to injuries and losses stemming from the use of unlined palm-rib crates and the overfilling of containers was large enough to warrant an effort to modify this traditional inexpensive container.

A simple adaptation developed by the project was to line the crate with corrugated fiberboard to protect the commodity from its sharp edges. This effective modification is economical since its costs are not more than one piaster per kg. In addition, new corrugated fiberboard or plastic boxes and consumer packages were designed and produced in cooperation with local companies. These were used successfully for packing fruits and vegetables, whether for the domestic market or for export. Plastic containers and lined palm-rib crates were comparable in protecting the commodity during postharvest handling.

EXTENSION ACTIVITIES

The project conducted 13 postharvest training courses for agricultural extension workers in different districts, to help show what practical measures could be adopted to reduce postharvest losses.

A considerable extension program was carried out by the team members in the several production areas and marketing centers to make direct contacts and establish good working relationships with the producers, shippers, wholesalers and retailers. These direct and personal contacts were very effective in informing those involved in fruit and vegetable handling of the correct methods for harvesting, handling and marketing. Most of the demonstration research was done in cooperation with handlers and this approach proved to be the most effective method of extension. These demonstrations emphasized proper harvesting and packing methods, sorting into various quality grades, elimination of serious defects, and simple temperature management procedures.

In 1983 when the extension activities were expanded to cover new areas and increased to represent more than 75% of the total team effort, we demonstrated successful modifications in packaging, cold storage and ripening procedures in addition to the improved methods of picking, handling, transporting, and marketing.

Many successful industry meetings were held in different governorates and districts, sponsored by governors and attended by growers, producers, wholesalers and local extension workers to discuss the postharvest problems and suggest suitable solutions for them. These meetings, held in the governorates of Giza, Ismalia, Minia, Beni-Suef, Behaira, North Sinai, Port-Said, Kalubia, Fayoum, Kafr-El Sheikh, and Alexandria, have resulted in an increased awareness of the magnitude of postharvest losses and means for alleviating the problem.

The entire matter of postharvest handling is clearly of such economic significance in Egypt both in avoiding losses and in providing quality commodities for export, that national policy makers have been involved. We participated in developing a national plan for reducing the losses in Egyptian vegetables and fruits between 1983 and 1990. We were able, through consistent efforts in communicating with policy makers, to affect some positive changes in the price control regulations for fresh fruits and vegetables. These included relating price to two quality grades in some commodities and removing others from the list of crops which are subject to price control.

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IMPROVEMENT OF GARLIC PRODUCTION

Garlic (*Allium sativum*) has been one of the more important crops in Egypt since the early history of the country. It continues to be a main crop, with annual production of 100,000 to 200,000 metric tons, is extensively used for home consumption and has the potential of generating export revenue for Egypt.

The fertile soils, fine climate, and good growers in Egypt provide potential for excellent yield of high quality garlic. However, production, harvest, storage, handling and marketing problems are often responsible for shortages of garlic even for home consumption. This project has been directed towards relief of the most important constraints in Egypt to garlic yield, quality and storage, and accordingly emphasizes research, training and extension activities on the following topics: 1) cultivar selection; 2) cultural problems; 3) diseases; 4) insects; 5) nutrition; 6) physiological problems; and 7) weed control.

ACCOMPLISHMENTS

CULTIVAR SELECTION

The three most important locally available cultivars were included in test plantings in three garlic production areas. In order to avoid the risks of introducing new diseases or insects to Egypt garlic clones from other parts of the world were not introduced and tested, except for virus-free tissue cultured material from Davis. Unfortunately the two California cultivars tissue cultured and sent to Egypt for tests were found to require longer days than occur in Egypt for good bulbing; therefore, they produced very poor bulbs and are unsuitable for growing in the

'Chinese' (imported in 1962), 'American' (imported in 1966) and 'Baladi' or 'Egyptian' (the local cultivar) were sent to Davis for inclusion in a tissue culture program. One additional early type garlic clone was collected in the USA and sent to Davis for tissue culturing. The intent was to provide disease (primarily virus)free garlic cultivars for further tests and to establish a satisfactory procedure for introducing garlic cultivars from other countries, particularly from latitudes similar to those of Egypt.

The 1980–82 tests determined that 'Chinese' was more productive in Shalakan and Zagazig and that 'Egyptian' produced higher yields at Sids. The tests of tissue cultured (virus free) 'California Early' and 'Late' cultivars showed the importance of selecting those adapted to Egyptian latitudes for testing in Egypt. The tests also demonstrated that the 'American' and 'Egyptian' cultivars emerged faster and had higher percentage stands and that the 'Chinese' cultivar produced higher fresh and dry weights of whole plants. As soon as virus free (tissue cultured) material of these three cultivars is available, the virus free foundation stocks should be increased under virus free conditions and tested in comparison with virus infested (standard) stock to determine and demonstrate the benefits of eliminating virus. If the expected improvements in yield and quality are demonstrated, a program to eliminate virus from Egyptian garlic industry will be justifiable.

Table 1. **Differences in Yield Response of Three Common Egyptian Cultivars**

	Fresh Weight		*Dry Weight*		*% Dry Weight*
Cultivar	*Leaves*	*Bulbs*	*Leaves*	*Bulb*	
Egyptian	13.5	6.1	3.3	1.12	22.5
American	16.7	7.1	3.7	1.18	20.3
Chinese	25.8	10.4	5.7	2.13	21.8
L.S.D.05	3.3	1.9	1.4	0.57	

CULTURAL PRACTICES

Planting date and plant spacing tests determined that earlier plantings provided time for the development of large enough plants to produce good size bulbs. It was concluded that optimum planting dates for high yields were September 1 to 15 at Shalakan, September 15 to October 1 at Sids, and September 15 to October 15 at Zagazig. Planting at an appropriate date resulted in yield increases of up to 82%, compared to later planting dates (Table 2). Significant yield increases were obtained at the 5 cm compared to 15 cm spacing. Depending on location of production, closer spacing gave from 30 to 80% higher yields than the wider spacing.

Table 2. **Effect of Planting Date on Average Yield of Three Garlic Cultivars**

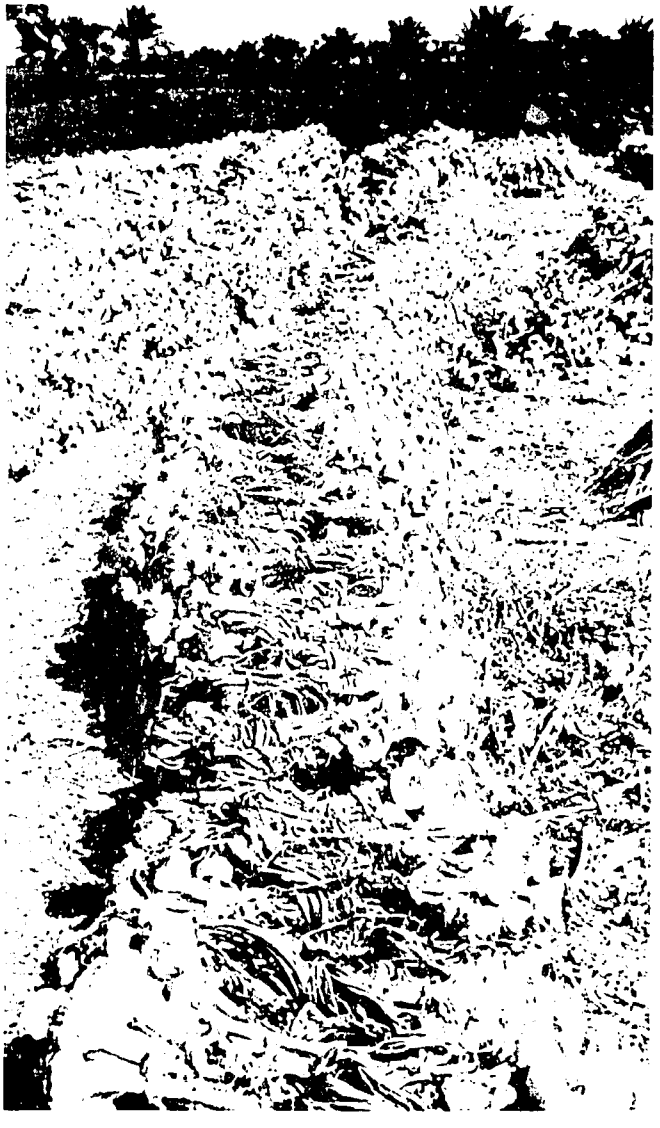
	Fresh Weight		*Dry Weight*	
	Leaves	*Bulbs*	*Leaves*	*Bulbs*
Sept. 16	27.4	11.3	5.8	2.0
Oct. 1	15.4	6.5	3.7	1.2
Oct. 15	13.3	5.8	3.2	1.3
L.S.D.	5.9	1.6	0.73	0.4

DISEASES

Although white rot and other diseases are considered to be a potential threat to Egyptian garlic production, it was decided to stress work on virus rather than to spread resources and staff too thin. Elimination of virus in garlic has been reported to result in 20 to 30% yield increases in France and in large yield increases in California tests. All garlic cultivars tested have been found to be infested with virus and no alternate hosts have been found. Thus

resources and staff too thin. Elimination of virus in garlic has been reported to result in 20 to 30% yield increases in France and in large yield increases in California tests. All garlic cultivars tested have been found to be infested with virus and no alternate hosts have been found. Thus elimination of virus via tissue culture from foundation stock offers the most promise in combatting this problem.

Research on tissue culture of garlic was initiated at Ain Shams University in 1980 to promote callus growth and plant regeneration from garlic shoot tips. The object was to obtain proliferation of shoots, roots and then plants that could be used as foundation stock for virus free garlic production in Egypt. This work was enhanced with the aid of the Tissue Culture Project. Screen cages to exclude vectors were provided and Egyptian scientists were instructed in procedures to increase virus free material so that the resulting foundation stock would be kept virus free.



In addition to problems in garlic production arising from disease or cultural practices, yield and quality in Egypt are also commonly depressed by harvesting before maturity. Curing the mature bulbs in the field significantly increases postharvest quality. *Photo: Adel Kader*

INSECTS

The most important source of insect damage in the Egyptian garlic industry is the mite which represents a serious problem in storage and in production fields. A survey of mites was initiated to discover which species are the most prevalent and harmful in Egypt. The most destructive mites were found to be *Eriophyes tulipae*, *Rhizoglyphus echinopus* and *Tetranychus arabicus*. The research program demonstrated that the mite problem can be reduced by soaking garlic cloves in solutions of Akar, Neoran or Formalin for 1, 3, 6 and 24 hours one day before planting, or by field treatment of the growing plants. Both treatments resulted in a delay of mite infestation until the third month after planting, thus reducing the malformation caused by mites. Elimination of the mite problem in production fields will also contribute to eliminating the mite problem in storage. This work was successful in initiating programs to control mites and should contribute significantly to improving the Egyptian garlic industry.

NEMATODES

A survey of nematode populations revealed the presence of *Ditylenchus dipsaci*, a common parasite of great economic importance in temperate zones. However, the nematode was not found to attack garlic in Egypt, nor did *Meloidogyne* spp. and *Rotylenchus reniformis*. These nematodes do not appear to be a threat to Egyptian garlic production at present.

PHYSIOLOGICAL STUDIES

A common practice in Egypt, especially when there is a shortage of garlic, is to harvest some of the garlic leaves from young (immature) garlic plants for home consumption. The Garlic Project tests determined that yield and quality of garlic bulbs may be influenced by removal of leaves from immature garlic plants. Removal of four leaves per plant in the first half of the growing season did not reduce bulb yield significantly in any of the three cultivars; nor did removal of up to 4 leaves per plant of 'Egyptian' and 'American' cultivars later (163 days after planting) reduce final bulb weight. However maintenance of at least half the leaves, including the top leaf, during the active growing season was found to be essential for good bulb formation.

Some garlic cultivars, if planted early, are slow to germinate and may produce poor stands. Previous reports from California indicated that low temperature treatment of seed stock before planting hastened germination and gave more uniform establishment of stands. Accordingly, tests were run to assess the effect of temperature on germination of garlic of the three common cultivars. Storage of bulbs at low temperature (5° C) before planting decreased plant growth but hastened maturity, as compared with the controls (bulbs held at room temperature until planted). Bulb size and yields were decreased by the lower tem-

perature treatments and increased bulblet formation. Induction of bulblets could be of value as a technique for rapid increase of virus free foundation seed stock. Lower yields resulting from cold treatment would, in most years, be more than offset by higher prices paid for early maturity of part of the Egyptian garlic crop. Experiments to determine the effect of population density on yield of garlic were carried out by planting garlic cloves at 5, 10 and 15 cm distances within the row and at 2 row spacing. In the preliminary experiments distance between or within rows did not affect yield. This study will need to be repeated with a more complete experimental design to give confidence in this finding.

NUTRITION

Garlic is considered to be a relatively shallow rooted crop. In California it generally responds favorably to fertilizer application, particularly nitrogen. The project's fertilizer tests demonstrated that the greatest response on some parameters measured was from application of nitrogen fertilizer; a favorable response was also demonstrated from additions of phosphorus in the Shalakan and Sids tests. In particular, dry weight of leaves was increased in the Shalakan test by high N. Further tests are needed to determine the optimum $N:P_2O_5$ ratio for the various production areas in Egypt.

WEED CONTROL

Weeds are a major problem in the cultivation of row crops like garlic. Most weeding is done by hand, but it was apparent that selective herbicidal treatments could supplement hand weeding. Thus a series of tests was initiated to assess the effects of herbicide during production of garlic. Fall, winter and spring weeds were controlled by specialized herbicidal treatments though it must be recognized that hand weeding is an essential part of any practical weed control program in Egyptian garlic production. Some chemical weed control treatments and solarization (mulching with transparent plastic 4–6 weeks before planting) plus combinations of chemical, solarization and hand weeding were found to be effective in controlling weeds.

The high cost of labor makes chemical and, possibly, solarization treatments practical, particularly for larger operations. Hand weeding will likely continue as the primary method for controlling weeds and is the most practical method for small farmers.

The highest yields in the weed control tests were obtained from four hand weedings, followed by three hand weedings, followed by solarization for 6 weeks. These treatments are not commercially feasible, but were useful in helping scientists assess the effects of excellent weed control on yield of garlic. Effective weed control with consequent increased garlic yields was obtained from EPTC plus Penoxalin and EPTC and Terbutryn mixtures (1.0 kg per feddan), followed by light hand weeding (hoeing) as needed. A number of other compounds tested were not effective.

TISSUE CULTURE

The three garlic cultivars, 'American', 'Chinese' and 'Egyptian', were used in an attempt to proliferate virus-free plants from the shoot tips of garlic. Meristematic tips from each cultivar were cultured on MS medium supplemented with 1 mg/liter 2,4-D, 1 mg/liter 2iP and 0.5 mg/liter NAA. The developed explants were recultured on MS medium after three weeks.

The developed callus was transferred to MS medium supplemented with 1 mg/liter 2iP and 1 mg/liter IAA. Numerous small roots were formed. The percentage of callus that formed roots was 46%, 0% and 16% for the 'American', 'Chinese' and 'Egyptian' cultivars, respectively. Shoot differentiation was not achieved with that concentration except in the 'American' cultivar, where it amounted to only 7%.

The results of six combined concentrations of cytokinin and auxin indicated that the best combination for differentiation of shoots and roots of the 'American' cultivar was 1 mg/liter 2iP without auxin. On the other hand, with the 'Egyptian' cultivar, 1 mg/liter IAA with or without 0.5 mg/liter 2iP promoted shoot and root development. None of these mixtures was suitable for encouraging differentiation of the 'Chinese' cultivar.

EXTENSION ACTIVITIES

Numerous meetings attended by farmers, extension workers, students and governmental representatives have been held in villages and at college farms to extend information on improved practices and varieties of garlic. A number of demonstration plots totalling over a thousand acres in several governorates have been established by the Ministry of Agriculture in collaboration with the project staff. Demonstration of new spacings between plants has, for example, already resulted in adoption by many growers.

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IMPROVEMENT OF CUCURBIT PRODUCTION

Cultivated cucurbit species, watermelon *(Citrullius lanatus)*, sweetmelon *(Cucumis melo)*, cucumber *(Cucumis sativus)*, and squash *(Cucurbita pepo)*, are major vegetables in Egypt for local consumption. They are grown on approximately 200,000 acres, representing 20% of the total vegetable acreage. The total production of cucurbits amounts to about 2 million tons and their value is estimated to be 86 million Egyptian pounds.

Besides their domestic importance, cucurbits have considerable export potential. Watermelon is clearly a leading export vegetable. In 1978, 20 thousand tons were exported with a value of 10 million dollars. There is a potential market in Europe for sweetmelon in the spring and fall; however the local Egyptian cultivars cannot compete effectively because of poor quality, lack of uniformity, and poor postharvest condition.

Low productivity, chiefly a result of disease, is also a problem of cucurbit production in Egypt. Fusarium wilt caused by a soil-borne fungus is one of the most important diseases of watermelon and sweetmelon, and neither crop rotation nor chemicals offer adequate control. The best results are obtained by growing the crops on disease-free soil or by planting wilt-resistant cultivars.

A prevalent leaf and stem disease of sweetmelons, cucumbers and squash is powdery mildew. It can be controlled by fungicides, but in Egypt and other countries where machinery for effective application is frequently unavailable, control by the use of resistant varieties is much more satisfactory. An additional disease which can be especially serious on the fall crop of cucumbers is downy mildew caused by *Pseudoperonospora cubensis* for which resistance is again the best means of control.

Several virus diseases attack all four cucurbits and frequently cause the most severe crop losses. The development or identification of resistant cultivars seems to offer the only satisfactory control.

Recently, gummy stem blight *(Mycosphaerella citrullina)* has become a serious disease in watermelon and sweetmelon. Resistant genes have been identified but they need to be transferred to adapted varieties. Physiological disorders, such as blossom end rot of watermelons, also need investigation.

In view of the several factors limiting cucurbit production, the project undertook work with the following objectives:

1. To improve cultivated cucurbit species (watermelon, melon, cucumber, and squash) by breeding cultivars with better quality, disease and insect resistance, market acceptability, and greater yield potential;
2. to develop basic genetics and sources of genetic variation to provide material for further cucurbit cultivar improvement;
3. to investigate diseases of cucurbit species and control them by disease resistant breeding and other means;
4. to develop cultural practices to improve the quality and yield of cultivated cucurbit species.

The research program was carried out at six locations: three in the Nile Delta in the vicinity of Cairo (El Dokki - Cairo Experiment Station, El Giza - College of Agriculture Farm, and Barrage Experiment Station) and three at more distant locations (on various research and commercial farms near Ismailia, at the Sids Experiment Station approximately 150 km south of Cairo, and at the Noba Seed Company Farm in Nubaria).

Experiments with cucumbers and squash were conducted three times in the fall season of 1980, 1981, and 1982 and three times in the summer season of 1981, 1982, and 1983. Experiments with melons and watermelons were conducted in the three summer seasons.

ACCOMPLISHMENTS

VARIETY EVALUATION AND IMPROVEMENT

Cucumber

Cucumbers in Egypt are almost entirely of the 'Beit Alpha' variety—light green, smooth, and intermediate in length, similar to those grown throughout the Middle East but unlike those commonly grown in the US and in Europe. Numerous observational and replicated trials showed clearly the importance of using 'Beit Alpha MR,' rather than regular 'Beit Alpha,' which is currently being grown in Egypt. The mosaic resistant strains are available from several European and American seed sources and should be adopted immediately. These trials also showed very clearly the need for resistance to powdery and downy mildews, as well as to cucumber mosaic virus. The only variety with this combination of resistance currently available commercially appears to be 'Medina Hybrid' from Peto, but others are likely to be available in the near future from other US and European seed companies.

Since the mildew and mosaic resistant 'Beit Alpha' cucumbers likely to be available commercially in the near future are proprietary hybrids, it is important that open pollinated 'Beit Alpha' with this combination of resistance be bred as quickly as possible so that seed production can be accomplished in Egypt. Accordingly, a backcross program to incorporate mildew resistance into mosaic resistant 'Beit Alpha' was initiated and is now about half complete.

'Beit Alpha' hybrids from both European and American seed companies on the average outyield the 'Beit Alpha MR' but results are somewhat inconsistent. The high proportion of female flowers on the hybrids contribute to their earliness and yield advantage, but when mildews are

serious, it appears more important to have mildew resistance than to use a hybrid without it.

Downy mildew occurs in Egypt and is difficult to control with fungicides, even on varieties with good resistance such as 'Medina' and 'Poinsett.' The variety 'Yomaki,' a source of resistance to powdery and downy mildew, is being used for breeding a 'PMR Beit Alpha' and an effort is being made by the project's research team to select the highest PMR level as well as checking the level of downy mildew resistance whenever possible. Viruses other than cucumber mosaic virus (CMV) are obviously present on cucumbers in Egypt, but their effect on 'Beit Alpha MR' and other CMV-resistant varieties appears to be significantly less severe than on CMV-susceptible varieties. Sources of high resistance have been found recently for Watermelon Viruses 1 and 2 (WMV1 and WMV 2) and for Zucchini Yellow Mosaic Virus (ZYMV). These varieties are being increased to provide seed for future plantings which will be used to determine the relative importance of the different viruses and for making appropriate crosses to transfer resistance to 'Beit Alpha.'

Squash

Numerous replicated trials of summer squash varieties have been conducted but no commercial variety performed better than the local 'Eskandarani,' a light green squash with a Zucchini-like shape. The local variety lacks uniformity, and to remedy this, inbreeding with selection has been carried on for several years. However, none of the selected lines has shown any clear advantage so far.

Most experimental plantings of squash and a majority of commercial fields observed have a high incidence of virus disease which drastically reduces yields. It is not uncommon to see entire fields producing no marketable squash. In view of the devastating effect of virus disease on 'Eskandarani' squash, breeding for resistance should have the highest priority and any other work on summer squash is unlikely to be advantageous until virus-resistant varieties are available. Of the several viruses found in squash in Egypt three are prevalent: ZYMV, WMVI, and CMV. The relative importance of these has not been established and is probably different in plantings made at different seasons of the year. At present, germplasm derived from interspecific crosses made at Cornell University offers the best hope of virus resistance. Mildew resistance is also present in this material, the importance of which is secomd only to virus resistance. It is most urgent that every effort be made to breed squash of the 'Eskandarani' type with resistance to the three most important viruses plus powdery mildew.

Watermelon

'Giza 1' watermelon bred for *Fusarium* resistance by the MOA has been grown on over 90% of the watermelon acreage in Egypt. An important accomplishment of this project has been the selection of 'Giza 21' from 'Giza 1,' which had deteriorated in fruit quality and resistance to fusarium wilt. 'Giza 21' seems likely to replace the original 'Giza 1' as soon as adequate seed has been multiplied. The main improvements needed over 'Giza 21' are resistance to virus diseases and to gummy stem blight. Since almost nothing has been done elsewhere to breed for resistance to these two diseases, no introduced variety seems likely to be much better that 'Giza 1' or 'Giza 21.' 'Congo' is the one variety which has appeared to show somewhat better growth in trials where virus disease is serious. However, 'Congo' had oblong fruit, which makes it subject to blossom end rot. As a stopgap measure, it is suggested that the single gene which changes fruit from oblong to round be incorporated into 'Congo.' This change is almost certain to overcome the blossom end rot problem and permit growers to take advantage of the superior growth of 'Congo,' which has been observed in growers' fields as well as in variety trials.

Eighty-two cultivars, mostly introduced from US seed companies, have been evaluated in observational trials at five locations for two years. Some have been advanced to replicated trials. In consideration of their yield, quality, and disease tolerance, the following varieties were recommended for commercial trial plantings: round cultivars - 'Giza 21,' 'Dixilee,' 'Crimson Sweet,' and 'Sugar Baby;' oblong cultivars - 'Congo,' 'Peacock WR60,' 'Charleston Gray 133,' and 'Sweet Princess.'

Since so little has been done to incorporate disease resistance in watermelon other than to fusarium wilt, a long-term improvement program is needed starting with the identification of virus resistance. A few leads on resistance were obtained in screening plant introductions for WMV1 and WMV2 resistance, as carried out by Dr. Saana Awni at Cornell in the fall of 1982. The variety 'Egun' from Nigeria, identified by R.E. Webb of the USDA as a source of WMV1 resistance, and some wild citron from Egypt, plus a few other introductions, seem to offer some hope. However, intensive work over a period of years will be needed to further identify and utilize good sources of resistance. Resistance of gummy stem blight has been reported and its inheritance studied but apparently it has not been incorporated into any usable variety. This, like the virus resistance, will require a breeding program over a period of years.

Melon

Essentially all melons produced in Egypt are local varieties including 'Edfina,' 'Ananas,' 'Ismaillawi,' and 'Koos Assal.' A program of selection and inbreeding has been in progress for several years to improve the quality in these varieties. Improved varieties obtained in this way were evaluated by the project in 1981–1983 along with numerous varieties introduced from the USA and Europe. 'Edfina Improved' and 'Ananas Eldokki' ranked highest on the basis of yielding ability, disease resistance, and quality. These are under propagation for distribution to growers. Next in rank were the imported varieties 'Edisto 47,' 'Imperial 45,' 'Charentais,' 'King Henry,' 'Topmark,' 'Orlinable,' and 'Hales Best Jumbo' along with the local variety 'Kahera 6.'

'Chilton' and 'Gulfcoast,' bred in the US for gummy stem blight resistance, have commercial possibilities be-

cause of good appearance and quality as well as a tendency to escape virus infection. They are also being crossed with local varieties.

Although gummy stem blight and fusarium wilt are considered to be the most serious diseases of melon in Egypt, virus diseases have caused much more damage in the plantings made by this project in the past two years. ZYMV is probably the most threatening to melons in Egypt. A source of resistance to this virus has been located by French and American virus specialists and will be sent to Egypt as soon as seed becomes available so that crosses may be made with locally adapted varieties.

CMV and WMV1 are almost certainly of great importance on melons as well as cucumbers and watermelons. Sources of resistance are known and should be incorporated into adapted varieties as quickly as possible. Two plant introductions used as parents because of resistance to gummy stem blight appear to be resistant to virus disease in Egypt, although which virus they are resistant to is not known at present. Crosses made for gummy stem blight purposes should be evaluated for virus resistance also.

Genes are known for resistance to nearly all the serious diseases of melons in Egypt. A strong effort continuing for a number of years will be needed to incorporate known resistance into adapted melons. To date only one generation per year has been grown, namely in the period when commercial melons are grown from March to July. The time required to develop disease resistant varieties could be reduced greatly by growing a fall crop to get a second generation per year and take advantage of the conditions especially favorable for disease development.

CHEMICAL CONTROL OF DISEASE

In addition to its emphasis on breeding resistance to viral and fungal diseases, the project has also extensively investigated chemical control of fungus diseases. Several fungicides can now be recommended to growers for use until resistant varieties become available. Bayleton and Rubigan have been found effective in the control of powdery mildew and Ridomil or Bravo for downy mildew. Ridomil should probably be used with either Bravo, Maneb, Mancozeb or copper to prevent development of resistant strains of fungi as has happened in other parts of the world.

CULTURAL PRACTICES

Plastic Tunnels and Greenhouses for Early Production

Growing cucurbits under low plastic tunnels or in small plastic greenhouses not only protects them from low temperatures, but also seems to reduce the incidence of disease. All four cucurbit species produced much earlier crops when grown this way. The economic feasibility of using tunnels has not been clearly established, and participation of economists in further work is highly desirable.

Plant Density and Fertilizer Levels

At nearly all locations and in each planting season from fall 1980 to summer 1982, factorial experiments with varying levels of nitrogen fertilizer (0–80 Kg N/feddan) and traditional *vs.* twice the traditional plant densities were conducted. Almost no significant fertilizer × density interactions were found and seldom was there a significant fertilizer response in the Nile Delta. Modest and significant yield increases were found for the higher densities in several of the experiments. As might be expected a greater response to fertilizer was found on the lighter textured, less fertile soils near Isma'lia and in Nubaria.

Though the primary focus of the Cucurbit Project has been on disease control through introduction of new cultivars, improved growing practices have also been developed. The use of plastic tunnels to protect young seedlings and thereby extend the growing season is shown here. *Rappaport*

It has not yet been established how these experimental results relate to conditions in farmers' fields. From the time of the first experiments, there was discussion about relocating them from experimental fields to commercial farms. This change was made in the summer of 1983 but results are not yet available. In one such experiment, however, the same problem previously encountered on several experimental fields was apparent, namely more variation in growth within a plot than between plots with different treatments. In some cases, as much as a 2- or 3-fold difference in size of plant might be seen on one side of the plot as compared to the other, even though the plot was supposedly treated uniformly. Such heterogeneity suggests that some environmental or cultural factor was of greater importance than those being varied in the experiment. Possible reasons for this uncontrolled variability include the residual effects from different crops or treatments applied to crops grown previously, or non-uniform irrigation or drainage.

Observations such as these may provide a basis for different cultural experiments in the future, but it seems that most further work along these lines should be deferred until diseases are less of a limitation on yields.

IMPROVED GRAPE PRODUCTION

Grapes rank as the second most important fruit crop in Egypt; 60,000 feddans are devoted to this commodity. Most fruit is marketed fresh in bulk by small pushcart vendors or shopkeepers in the villages and principal cities, but the selling price is regulated by government decree, which reduces the incentive to produce a high quality product. No export trade has developed and production of wine, grape juice and raisins is small. In spite of this, the grapevine offers great potential for commercial exploitation in Egypt because of its very low chilling requirement, a relatively high tolerance of saline soils, potentially high yield and quality under desert conditions, relative freedom from destructive diseases and pests, and diversity of processing outlets such as table fruit, raisins, fresh juice, wine and vinegar.

To capitalize on this opportunity, both the quality and quantity of grapes produced in Egypt need improvement. The objectives of the Grape Project were to assist with such improvement by: (1) introducing productive, virus-free table cultivars for local consumption and exports; (2) evaluating local cultivars; (3) introducing rootstock tolerant to nematodes, salinity, calcareous soils, and unfavorable environmental conditions; (4) attempting to produce two crops per year.

The Grape Project was approved in December, 1980, and work began in February of 1981. It should be kept in mind that a period of three years is involved in growing the vine cutting to the fruiting stage and a full crop can be expected only in the fifth or sixth year. Thus, almost all the experimental work is still in progress.

ACCOMPLISHMENTS

CULTIVARS AND ROOTSTOCKS

Although Egypt is recognized for its ancient heritage of viticulture, a national survey undertaken by the project in 1980 disclosed a glaring deficiency of commercial varieties. Two cultivars, 'Banati' ('Thompson Seedless') and 'Roumi Ahmar' account for 80% of the grape acreage. The marketing season for fresh table grapes is, therefore, very short. 'Banati' is available July-August and 'Red Roumi,' a late grape with seeds, from August-October.

The existence of indigenous cultivars of local importance such as 'Fayoumi', led to a search of more isolated oases, from which several previously undescribed strains were collected. Five local varieties were identified as a result of a survey of local grapes in different parts of the country. Two of these, 'White Baladi' and 'Black Baladi,' were shown to have excellent qualities. These may have direct value as new cultivars and are of great interest because of their survival for long periods without the benefit of cultural attention such as disease control or pruning. Thus, they have genes of interest to breeders worldwide.

Improved Cultivars and Rootstocks

To diversify the variety base, 23 table grapes, six wine grapes, and 10 rootstocks were introduced in February, 1981. These were all certified and ordered from the Foundation Plant Materials Service of the University of California. They were propagated and grown in pots in the greenhouse quarantine facility at Sabahia, Alexandria.

Vines in Egypt are generally planted on their own roots since phylloxera has not been a threat. However, nematodes have caused damage and the *vinifera* roots are not as well adapted to wet clay soils or saline desert soils as are certain rootstocks derived from native American species. Thus, rootstock studies must have high priority to overcome the stresses engendered by unfavorable soil conditions.

New and promising rootstocks introduced in 1982 will permit vineyard expansion on soils thought unfavorable, especially those of high salt content and with high water tables. It has been observed repeatedly in the heavy clay soils of the Delta region that the variety 'Red Roumi' is much better adapted, more durable, vigorous, and productive than 'Thompson Seedless.' We have suggested using 'Roumi' as a rootstock in such problem areas.

The discovery of severe infestation of root knot nematode *(Meloidogyne)* on young 'Thompson Seedless' vineyards in the Fayoum district called for the introduction in 1982 of new nematode resistant rootstocks for sandy soil, namely 'Harmony,' 'Freedom,' and 'Salt Creek.' These are currently being propagated.

In the spring of 1982 the plants were transplanted to trial blocks in the principal grape growing regions. Modern trellis systems were installed and the bilateral cordon training system employed. These plots will bear their first crop in the 1984 season and will be used for evaluating the best cultural methods to improve fruit yield and quality. Each plot is under the supervision of a trained horticulturist who will also serve as an extension agent to disseminate the results to farmers by vineyard demonstrations. These regional plots can now serve as a source of propagation material for farmers to promote vineyard expansion.

With the introduction of rootstocks, two 'Sprinks' model grafting machines made in Napa, California, were imported. In May, 1982, three Egyptian postdoctoral team members studied and observed the commercial production of grafted grapevines in California, and these methods can now be followed in Egypt.

In September, 1981, thirty-two individual vines were selected for good yield and fruit quality. Cuttings were taken from each vine and are being propagated and their performance compared. An outstanding vine of 'Fayoumi' has also been selected for increase. This experiment is of value in demonstrating the methods and advantages of clonal selection. The cuttings of each clone were planted

in the nursery at Gianaclis and the rootings established in vineyard trials in March, 1983.

The main variety collection, consisting of 31 of the most promising varieties, is now established in a new vineyard at El-Kanater. It includes older varieties as well as the indigenous cultivars recently discovered and collected from outlying oases.

Mineral Nutrition

Although some of the desert soils are highly calcareous, extensive soil sampling of present vineyard areas has not led to concern about iron deficiency, especially with the use of *vinifera* on its own roots. In establishing new vineyard sites, it would be desirable to test the soils for active lime before extensive plantings are contemplated. It is recommended that different rootstocks be tried to alleviate some difficult soil problems.

In many of the sandier desert soils, such as at Ismailia, Tahrir and Nubaria, zinc and magnesium deficiency symptoms have been observed, but they were not in the critical range. Applications of these elements over a two-year period have not produced increases in growth or yield. Use of excess manure as fertilizer in local areas may bring about deficiencies of minor elements.

A recent summary of the mineral status of vineyards in the principal grape regions by using petiole analysis has been published by Ms. Hoda Habeeb. The results fortify field observations that fertilizers are used excessively, especially nitrogen, sometimes in the toxic range. Toxic salt levels were also verified in some areas. For the first time, this work provides a guide to growers on prudent fertilizer application and avoidance of problem soils. Field fertilizer trials in Minya vineyards are being pursued with petiole analyses. Thus far, no response to even heavy applications of N, P or K on these heavy clay soils has been evident. Generally negative results obtained from fertilizer applications should lead to reduction in use of fertilizer and resultant savings to growers.

Use of cattle manure and pigeon dung without prior composting is a source of noxious weeds in many vineyards.

Irrigation

The irrigation season for vineyards extends from February to the end of September, with peak usages in May and June. Annual use is estimated at 2940 m^3/acre compared to 4200 for deciduous fruit and 5880 for dates. The consumptive use of water by grapevines is among the lowest of all crops.

In the Minya district, late irrigation is applied by some growers in September and October to delay the harvest of 'Red Roumi,' in order to obtain a more favorable market price. This also keeps the vine actively growing much later than normal.

The traditional small vineyards of a few acres in extent were usually a part of a more generalized farm in which diverse crops are grown on the heavy clay soil close to the Nile or tributary canals. After the construction of the Aswan High Dam, water became available the year round and free for the asking, eventually fed by gravity flow through a maze of open field ditches. Raising the water above the feeder canals alongside the farm required only

A vineyard planted on new lands near Gianaclis Farm, shows vines moribund several years after planting, a result of overwatering and inadequate drainage. This problem is increasingly common and has been a theme of research on improved cultural practices.

Photo: Eric Gustafson

a few feet of lift accomplished by animal powered water wheels or by manually operated pipes with the Archimedes screw. These are now being replaced with small portable centrifugal pumps.

In several of the larger desert reclamation projects, large volumes of water are available by gravity flow from the main canals. The basins are very large and excessive quantities of water are applied to the sandy soils. These lands are not even rough-leveled, so water application is very uneven, some areas receiving too little water and others becoming waterlogged at lower elevations where no drainage was provided. Transport of water in the vineyards was usually in unlined ditches, and seepage raised water tables above the root zone. Thus, vineyard rows alongside irrigation ditches were the first to show decline, following asphyxiation and death of the root system.

This problem is widespread, and as new land reclamation projects continue to be spawned, there is increasing concern about the quality and supply of irrigation water. Drip irrigation is considered a promising and economical method. Two experimental plantings have been made by ADS scientists, the first at Anchas, comparing drip *vs* sprinkler, and a second plot of five acres at Gianaclis, comparing the usual flood irrigation *vs* drip with subplots having winter cover crops *vs* clean cultivation. Future results will determine the effectiveness of drip irrigation for vineyard production.

A single furrow used for irrigation alongside rows of young vines was adopted in establishing trial vineyards and gave excellent results at both El-Kanater and Seds. Much less water was needed and weed growth was confined to furrows. Tractor cultivation between the rows was managed easily. This is setting a pattern for private growers. At the Castour vineyard the grower converted one acre of mature vines to drip irrigation in 1982, using summer application of four liters per day over a four-hour period. Treflan weed control and plots with mulch are also part of his experiment. The grower is now so interested he is enrolled in the University to pursue graduate work in drip irrigation.

Cover Cropping

The traditional forage crop used as fodder for farm animals is berseem clover *(Trifolium alexandrinum)* which is cut by hand (scythe) during the cool season. Its value as a soil amendment is generally recognized in crop rotation and in soil reclamation. Vineyards established in large blocks of ten acres or more on newly reclaimed desert soils have been kept clean-cultivated as far as possible to avoid the expense of hand-hoeing weeds. Winter rains are not sufficient to support a cover crop and the bare sands are eroded by the large heads of water used in summer irrigation as well as by prevailing winds. Even where water is available for winter cover crops, the practice has been considered undesirable for vineyards, the belief persisting that water used during the dormant period would cause vine growth to begin prematurely. This idea was disproved in the winter of 1982 by growing and cutting a cover crop of berseem at Gianaclis vineyards. Not only does soil erosion become a problem, but the organic matter decreases. Lack of root residues or channels restricts infiltration of water. If winter cover crops are used, some land leveling is necessary. However, sprinkler irrigation might be possible.

On very sandy soils, other leguminous cover crops were suggested for trial such as subterranean clover, peanuts, etc. These may be very beneficial in ameliorating thin soils before the conversion of raw land to vineyards as well as supplying a supplementary production of fodder.

Growth Regulators

Growth regulators play an important role in commercial grape production in thinning and crop regulation, promoting berry set, increasing the berry size of seedless varieties, altering the time of harvest, and promoting coloration of the fruit. Since appearance is the only guide available to consumers to judge quality, table grape growers use a wide variety of treatments to improve acceptance.

Field experiments by ADS scientists have demonstrated the efficacy of proper flower cluster and berry thinning, girdling, and gibberellin GA_3 application to greatly improve the fruit quality. Three replications of four vines each were treated as indicated in Table 1.

The data of Table 1 indicated that GA_3 treatments and/or girdling increased cluster weight of 'Thompson Seedless' grapes, and cluster thinning had no significant effect. Cluster weight was favored by a combination of girdling and GA_3 applied at least once. Other combinations had no additional significant effects. Berry size increased by all treatments with the exception of cluster thinning. Berry weight was increased by girdling plus GA_3 treatments; cluster thinning did not improve size when performed in association with girdling and hormone treatment.

Berries treated with GA_3 adhered more strongly to the rachis (cluster stem) than did those without this treatment. This is an important indication for storage, since berries would not "shatter" as readily.

Quality factors such as total soluble solids and acid content were unaffected by the treatments but acidity was higher compared with the control. The high total soluble solids/acidity ratio indicated that the clusters treated twice with GA_3 were delayed in maturity. Commercial application of these findings in the same vineyards in 1982 were highly successful.

A uniformly red-colored berry is interpreted by the consumer as a sign of good maturity and quality in the 'Roumi Ahmar' cultivar. Grown most intensively in the Minya district, it is also widely scattered in other areas. Failure of the fruit to color properly reduces market value. Ethephon sprays were applied at Gianaclis in 1982 at concentrations of 0, 75, 150, 300, or 500 ppm when 10–15% of the berries had begun to turn color. Treatment resulted in increased coloration, especially at the highest concentration. Berry adherence was, however, reduced by the treatment as was firmness, factors which would force earlier marketing and limit storability. Follow-up experiments in other districts are needed to determine the best timing and concentration.

Table 1: **Effect of girdling, cluster thinning and GA_3 on some mechanical and chemical characteristics of 'Thompson Seedless' grapes**

Treatment	*Cluster Wt. (kg)*	*100 berries Wt. (g)*	*Power of berry adherence (kg)*	*T.S.S.*	*T.S.S./ Acid Ratio*
1. Girdling	0.685	220.8	0.81	21.0	38.88
2. Cluster thinning	0.350	173.3	0.55	21.9	34.8
3. GA_3 10+40 ppm	0.680	253.3	0.75	19.1	34.1
4. Girdling + cluster thinning	0.537	272.5	0.61	21.8	38.2
5. Girdling + GA_3 10+40 ppm	0.734	303.3	0.94	20.5	36.0
6. Girdling + cluster thinning + GA_3 40 ppm	0.620	241.3	0.86	20.5	35.3
7. Cluster thinning + GA_3 40 ppm	0.548	268.3	0.75	20.8	37.0
8. Cluster thinning + GA_3 10+40 ppm	0.597	233.3	0.68	20.3	34.4
9. Girdling + cluster thinning + GA_3 10+40 ppm	0.709	265.0	0.89	19.9	34.3
10. Control	0.441	169.2	0.51	19.6	39.2
L.S.D. @ 5%	0.188	41.26	0.284	N.S.	

Market preference for seedless grapes has increased since the introduction of 'Thompson Seedless.' Using a series of gibberellin treatments, the Japanese succeeded in aborting both pollen and ovule development in the 'Delaware,' obtaining seedless fruit of greater market value. Several Egyptian team members applied similar treatments with the 'Muscat Hamburg' cultivar, but failed to achieve seedlessness.

Growth regulator experiments have been valuable in training technicians and researchers because many replications are possible, vine development is observed during the whole growth cycle, and results are forthcoming in a short period of time and are usually highly significant, if not spectacular. Such experiments in the field have furnished training in plot design, sampling methods, and statistical treatment of the data.

Weed Control

Because of the basin and flooding irrigation methods weed seeds are distributed over the entire soil surface. With as many as six to eight irrigations in the shallow clay soils, removal of weeds by hand-hoeing is onerous and expensive. Because of open irrigation ditches and the basin ridges mechanical cultivation is often not possible. Older vineyards are closely planted and weed control may be neglected after mid-summer when the vines interlace.

The most prevalent weeds are Bermuda grass and nut grass (*Cyperus* spp.). In 1981, we recommended a trial with Roundup (Ranger) for weed control in 24-year-old blocks of 'Roumi Ahmar' at the Gianaclis vineyards. This was very effective but retreatment appears necessary to eradicate 'halpha,' a tough-leaved rhizomatous perennial that infests older vineyards with poor drainage.

Because of the high cost of eradicating perennial weeds, it was recommended that badly infested vineyards should be cleared and after fallowing and deep plowing to eradicate weeds, they be replanted with new vines.

DISEASE AND PESTS

Nematodes

An extensive survey of nematode populations and associations with vineyards was conducted in 16 localities in eight governorates. Eleven major plant parasitic nematodes were identified; population densities and frequencies of occurrence varied greatly and are undoubtedly influenced by soil and climate. This survey has pointed the way to analysis of the nematode/plant associations that are most destructive in Egypt and to consideration of controlling nematodes or making the difficult decision to eliminate infected, unproductive vineyards. Root knot nematode was found to be prevalent in the sandy soils of Fayoum. Resistant rootstocks are recommended for such areas.

Viruses

A survey of viruses in vineyards revealed at least four main symptomologies; these were characteristic of "fan leaf," "mosaic," "leaf roll" and "vein binding." However, the survey also revealed that by comparison with other regions of the world, the grape regions of Egypt are relatively free of virus diseases. This most likely is a result of the infrequency of introduction of foreign varieties, the

long period of propagation by cuttings, and the absence of propagation by grafting. Rootstocks derived from native American species and their hybrids are often symptomless carriers of some virus diseases. However, when a diseased variety is imported, usually all plants are diseased, as happened in a nonproductive wine variety observed in the Gianaclis vineyard. Destruction of such plantings was recommended, followed by crop rotation for five years before replanting.

Other Diseases

Fusarium and *Rhizoctonia* are prevalent as fungi responsible for root rot in several areas of Egypt. Severe symptoms of *Eutypa* disease have been found in old Roumi vineyards near Mariut. This is the first report of this disease in Egypt.

The absence of some cosmopolitan grape diseases, such as phylloxera, and pests is notable, and reinforces the view that the restriction on import of rooted vines should continue and be strictly enforced. It must be remembered that resistant vines are only tolerant and do support phylloxera on their roots.

Powdery and downy mildews are both prevalent in Egypt in the major cultivars. Powdery mildew may be the worst fungus overall and the latter approaches epidemic proportions in Lower Egypt, affecting the lower leaves but not the fruit.

Birds

Depredation by birds at harvest time is extensive, either resulting in the whole berries being devoured or pecks in the later-ripening 'Red Roumi' resulting in heavy losses by mold infecting the injured fruit. In some areas in Minya, where vineyards are near grain storage areas, over half the harvest is lost. One grower has reported success in warding off birds by tying strips of colored plastic tape ¾" wide three or four feet above every fifth vine row. After securing one end, the tape is then twisted and forms a loose spiral that gyrates continuously, even with slight air movement. This unique approach is inexpensive (tape costs $2.50 per acre) and its efficacy should be verified by controlled experiments.

Insects

Only two insects are troublesome on grapes and are found in all grape areas in Egypt. These are the solitary carpenter worm, *Paropta paradoa* and the wasp beetle *Chlorophorus varius* (Coleoptera). Both are destructive by boring galleries into the woody cylinder, interrupting water transport of the trunk and arms, but never girdling the vine. Occasional outbreaks of red spider mites (*Tetranychus* and allied species) need to be identified and controlled.

Two vine disorders are newly recognized but the causal agents have not been discovered. The first is yellow miniature leaf, affecting whole vineyards of 'Thompson Seedless' on heavy clay soils that have a high water table. The leaves are much reduced in size, are cupped and have irregular margins, with marginal coloration much like potassium deficiency. The vines make very weak growth but may be productive nevertheless, though having smaller clusters and berries. Unfavorable soil aeration and suffocation of roots are suspected. On the same sites, 'Roumi Ahmer' shows the same symptoms to a minor degree and is tolerant. We have suggested that the 'Red Roumi' might be utilized as a rootstock for 'Thompson Seedless' on difficult soils.

The second disorder is yellow leaf blotch, which first appears on single arms of the vine. The leaf yellowing pattern does not resemble any form of yellow mosaic virus known to us. This disease is causing concern as the vine dies after several years and spreads from focal spots in the vineyards. This malady needs immediate investigation.

WINE PRODUCTION

Recently, efforts have been made to import and utilize modern winery machinery at Gianaclis. Six Vaslin roller presses and a portable screw press were installed in 1982; but it is foolish to put new wine in old bottles. Old and dilapidated cement fermentation tanks, transfer pumps and hoses were in a poor state of repair, and buildings and floors are beyond refurbishment. The lack of cold storage facilities for stabilizing and aging wine was evident. Constructing and equipping an entirely new winery from the ground up is long overdue. Stainless steel tanks with temperature controls are needed for fermentation and storage of white wines.

The present choice of wine varieties needs upgrading to include those expressly produced for hot climates, such as those recently patented by the University of California. Arrangements are being made to license these varieties for Egyptian use. These include 'Symphony' for white wine and 'Carmine,' 'Centurion,' and 'Carnelian' for red wine.

As might be expected, the quality of the wine is very poor, much of it below the legal limits required in most countries. The problems stem from the use of old equipment, lack of proper grape varieties, poor condition and handling of the fruit, and long delays in processing.

There are three principal table wines produced—red, white, and rose. The best red wine is sold under the label "Omar Khayam" and the white as "Queen Nefertiti." A small quantity of sweet wines and brandy are produced. A white pasteurized grape juice has been fairly successful.

Wine production is a virtual government monopoly. Therefore it is a very profitable enterprise despite delay in modernization of plant and methods, since it is protected from competition by high tariffs on imported wines. Increasing tolerance for the moderate use of wine is evident in the populace and the increasing tourist demand guarantees a much greater outlet when higher quality and more widespread distribution is achieved. Entry of the private sector by government license in production of wine and other grape products would be a great stimulus. Trained enologists and technicians must be available to plan, equip, and manage new wineries.

FUTURE RESEARCH

Correlation of the various climatic zones with vine performance is needed in particular, and the effect of temperature on time of fruit maturity, and quality and susceptibility to pests and diseases should be investigated. Weather recording instruments should be installed in present or potential zones of grape culture. For example, it should be possible to identify the best zone to produce sun-dried 'natural' raisins.

Introduction and testing of new and promising varieties should continue. Trial blocks in the various climatic and soil types should be increased in number and size. Collection and study of indigenous varieties may provide important gene resources for breeding improved types.

Once sufficient information becomes available on the merits of varieties, a breeding project should be initiated to produce new varieties tailored to the Egyptian needs for domestic and export use.

Improved and modern machinery to process the fruit into raisins, fresh juice, wine, and vinegar is needed to improve product quality. More intensive investigation of the diseases and pests present in the grape growing areas is necessary. Extensive loss of crop due to bird damage needs immediate attention and remedies.

Greenhouse and vineyard studies on the relation of soil types to root development should be made. Comparisons on old delta clay and desert soils and varying moisture and salinity regimes are needed. The reaction of different rootstocks should be studied as part of this experiment.

Tests of new and promising growth regulators to improve fruit quality and yield should be continued. The postharvest treatment of the grape crop needs to be improved to minimize losses and maintain quality, and modernization of the grape processing industry is essential if products are to meet international quality standards.

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IMPROVED TECHNIQUES FOR THE EGYPTIAN NURSERY INDUSTRY

The nursery industry in Egypt, while not large, supplies a keen demand for a range of ornamental plants, and has considerable export potential, not only for the sale of plant materials to other Arab countries, a trade that is already established, but also for the provision of plants to Europe. There are many obstacles however to attaining this goal, not least of which is the outdated nursery technology which leads to poor productivity and products of often dubious quality. For example, propagation of cuttings is usually conducted out-of-doors, in the soil, with flood irrigation in basins and results in high losses and cuttings that are non-uniform in size. Where nursery crops are container-grown, unamended Delta soils are used for the growing medium. This soil is very poorly drained when used in containers and results in erratic growth and loss of plants. Moreover such plants, with native soils, are unsuited for export because of weight and phytosanitary regulations. Since there has been little research aimed at solving problems of this nature in the nursery industry, a research program was initiated aimed at improving growing methods for plants in containers and upgrading the quality of nursery stock so as to be acceptable in the export market as well as supplying improved quality plants for domestic consumption.

One of the highest priorities was to furnish the research facilities with minimum equipment for a research program, *viz.* mist propagation systems and fabric covered shade houses. Concurrently with developing these facilities, research was begun in several areas: growing media for container production, plant propagation, and plant nutrition.

ACCOMPLISHMENTS

RESEARCH FACILITIES

Mist systems, designed and assembled at Davis, were shipped to Egypt. Inexpensive shade houses were designed to be built, in part with materials available in Egypt. Sites were selected at Cairo (Qubba Botanical Garden), Kom Ombo (north of Aswan), and Alexandria (Sabahia). Houses were constructed, mist systems installed, and completed facilities made ready for use.

GROWING MEDIA

Composting experiments were conducted at all three selected research locations in Egypt to seek possible substitutes for sphagnum peat moss which is used to a limited extent in Egypt as a soil amendment and which must be imported from Europe at considerable expense. Sawdust from milling operations was tested at all locations; the use of sugar cane waste (bagasse) was explored at Kom Ombo; compost from water hyacinth (*Eichornia crassipes* (Mart.) Solms-Laub) was tested at Cairo, Alexandria and Davis. Results from composting were variable, especially with water hyacinth. Chemical analyses at Davis of samples of water hyacinth from Egypt indicated a wide range of carbon/nitrogen (C/N) ratios which may have accounted, at least in part, for the variability of these results. C/N ratios ranged from 12.3 for samples from Bahe El Bagar to 27.0 from the River Nile near Cairo, compared with a ratio of about 30 for ideal composting. The sawdust compost appeared to be fairly good but subsequent pot tests with begonia indicated a nitrogen deficiency. Analysis of the compost material before composting and mixing with proper proportion of water hyacinth and sawdust should give better and more uniform composts. Work needs to be continued with composting but prospects of obtaining dometic supplies of organic matter to substitute for all or part of the imported peat moss are good.

Sand is an important component of artificial growing media but the particle size distribution of the sand must be such that good drainage is obtained. Common builders' sand in the Cairo area has a fairly uniform percentage of coarse, medium, and fine particles but an excessive silt and clay fraction. Three sands were located by Dr. Abou Dahab, Co-team leader, with much better particle size distribution. The best had 62% coarse, 18% medium, and 14% fine sand. Two had a majority of sand in the medium grade, one with 72% medium, 4.4% coarse and 21% fine sands, and the other with 61% medium, 8% coarse and 27% fine sand. All were satisfactory in the silt/clay fraction. Air filled porosity and water content at field capacity needs to be determined on such sands to further estimate their suitability for container mixes. This research needs to be continued to find suitable sands in other areas of Egypt.

Imported perlite as a component in growing and propagation media is costly, and in view of the small, dispersed nature of the nursery industry in Egypt, distribution to growers may be difficult and expensive. Tests were begun on two possible substitutes, crushed brick wastes which are in plentiful supply, and crushed clay pottery. Samples of each were screened to various sizes and tested for bulk density, total porosity, water-holding capacity and air-filled porosity after drainage. Both materials appear to have promise as substitutes for perlite. For example, crushed brick passing a 5-mesh screen and held on a 10-mesh screen had a total porosity of 61%, air-filled porosity of 40% and water holding capacity of 21%. Material held on an 18 mesh screen had the same air-filled porosity of 36% and a water holding capacity of 25%. Parameters for brick were similar. A preliminary test, involving rooting

chrysanthemum cuttings in these materials, indicated that they would be suitable substitutes for perlite. *Chrysanthemum morifolium* cuttings were rooted in three particle sizes of crushed brick waste and crushed clay pot waste. This was a trial with a limited number of plants but it indicated that with the selection of the proper particle size, either should be suitable for use in propagation and growing media. Materials screened through a 5-mesh screen and sizes retained on a 10-, 18-, and 35-mesh screen were compared by rooting cuttings in the mist system at the Central Laboratory. The 5–10 mesh size of both materials resulted in 12.5% unrooted cuttings, and light, medium, and heavy rooting totaling 87.5%. Plants rooted slightly better in the 10-mesh crushed brick. Plants in 18-mesh brick had 50% rooting with light roots, 12.5% with medium roots, and 37.5% with heavy root systems. All the cuttings in the 18-mesh clay pot material had heavy root systems. Rooting in the 35-mesh brick improved to 25% with medium roots and 75% with heavy roots and decreased slightly in the clay pot materials. Differences between the effects of these materials may have been due to differences in air filled porosity and water holding capacity.

Seedlings of *Begonia* x *semperflorens-cultorum* were grown in various combinations of sand, composted sawdust and peat. Plants were not fertilized. The best growth was in 100% peat followed by the peat-sawdust compost mixes. Poorest growth was in the sand-sawdust compost mixes and pure sand. Color of plants grown in sand appeared normal but those grown with sand-sawdust compost were light green to yellow suggesting nitrogen deficiency. Fertilization with 10:20:10 fertilizer at the end of the experiment resulted in improved leaf color. These results may be an indication that the composting process was not complete.

PLANT PROPAGATION

Seeds

Propagation trials were conducted on several tree species which are of potential importance in Egypt, and which do not propagate easily: *Cassia fistula*, an important ornamental tree in Egypt and possible source of medicinals; *Bombax ceiba* L. (Syn.: *Bombax malabaricum* DC.), (red cotton tree), *Khaya senegalensis* (Desr.) A. Juss. (African mahogany), and *Tectona grandis* L.F. (teak) which are potential timber crops for the Lake Nasser area.

Germination of *Cassia fistula* seeds is difficult because of the hard seed coat. Trials were conducted at Aswan (Kom Ombo) and Cairo (Qubba) using various seed treatments, germination media and comparing greenhouse *vs.* outdoor conditions. Germination of seed soaked for one-half hour in concentrated sulfuric acid and sown in three media, Jiffy 7 (peat) pots, sand, and sand-peat, in mid-May outdoors at Kom Ombo was 71%. Germination in Jiffy 7 pots was 87%. Seeds similarly treated and sown in July had only 18% germination. Treatments of a hot water soak at 70°C for one-half and 1 hour, concentrated sulfuric acid for one-half and 1 hour, scarification, and scarification and gibberellic acid (GA) treatments were compared to a control of 3 days soak in tap water. Seeds were sown out-of-doors and in the greenhouse. Media were sand, sand/sawdust compost, and sand/peat. The best germination (Cairo, September 15 sowing) was with the one-half hour treatment with sulfuric acid, germinated in the greenhouse. Mean germination for all media was 89% with germination in sand or sand/peat of 93%. Excellent germination was also obtained with scratching and scratching and soaking in GA and with sand medium. Overall germination in the greenhouse was 35% compared to 13% out-of-doors. Results on germination studies of *Bombax ceiba*, *B. malabaricum*, *Khaya sengalensis*, and *Tectona grandis* have not yet been summarized.

Cuttings

The effects of hormone treatment (indolebutyric acid (IBA) and indoleacetic acid (IAA) at 500 and 1,000 ppm), applied as a 5-second dip, type of cutting (single *vs.* split node), rooting media (sand/peat *vs.* sand), and season (February 5, April 15, and June 15, 1981) on the rooting of *Dracaena* cuttings were studied at Cairo.

There was little or no rooting in February. This was attributed to the fact that all media were watered excessively, on a time schedule rather than "as needed." There were small differences between hormone treatments and the controls in the April rooting experiments. Rootings with IBA averaged 41%, and IAA 26% control at 36%. Cuttings stuck in June rooted 26% for control, 15% for IBA, and 19% for IAA. Rooting of single nodes was 45% in April and 24% in June compared to 29% and 14% for the split node cuttings. Rooting in sand/clay in April was 46% *vs.* 29 and 30% for sand/peat and sand respectively and in June, 23% *vs.* 7 and 16% for the sand/peat and sand respectively. Overall rooting in April was 36% compared to 26% in June.

The best individual treatments for April and June were with single node cuttings. In April these were in the sand/clay medium with 72% rooting with 1,000 ppm IBA and the control, and 67% rooting with 1,000 ppm IAA. In June 44% rooting occurred with 500 ppm IAA in sand/clay and for the control in sand/peat, and 39% rooting with 1,000 ppm IBA in the sand/clay medium.

Single (whole) node cuttings were distinctly superior to split-node cuttings. This may have been due to differences in food reserves or to invasion of pathogens into the additional exposed wounds of the split-node cuttings. The reasons for the superiority of the sand/clay medium are not clear, since this medium was not as well drained as the other two media. Although rooting was good in individual hormone treatments, these never exceeded the best rooting control treatments. Rooting in April was superior to rooting in June. The overall results suggest that environmental conditions are the critical factor in the rooting of *Dracaena* under conditions at Cairo.

An identical experiment on the rooting of *Dieffenbachia maculata* gave very similar results except for differences in response to media. Rooting in February was nil. Rooting in April was 42% compared to 34% in June. Single node cuttings rooted substantially better than split-nodes: 46 and 41% *vs.* 32 and 18% for April and June respectively.

Rooting response to media was variable. In April rooting was about equal in the sand/peat and sand, 46 and 47% and lowest in sand/clay, 32%. In June rooting was best in sand/peat, 41% and poorest in both sand, 31% and sand/clay, 32%. In June rooting was best in sand/peat, 41% and poorest in both sand, 31% and sand/clay, 29%. There were little differences between hormone and control treatments in April with 44 to 45% rooting except for the 1,000 ppm IBA treatment with 31% rooting. In June 1,000 ppm IAA was best at 44% rooting followed by 1,000 ppm IBA at 38%, 500 ppm IAA at 34%, 500 ppm IBA at 28% and the control at 26%. The best treatments in April were 1,000 ppm IAA in sand/peat and 1,000 ppm IBA in sand and the control in sand/peat at 61%. In June four treatments, 500 ppm IAA in sand peat, 1,000 ppm IBA in sand/clay and 1,000 ppm in sand rooted equally well (67%). These were followed by four treatments that rooted at 61%: 1,000 ppm IAA and IBA, 500 ppm IBA, and the control, all in sand/peat medium. These results also suggest that environmental control may be the limiting factor of rooting this species in Cairo.

Rooting of *Codiaeum variegatum* was investigated at Alexandria (Sabahia) in the spring of 1982. Cuttings 20 cm long were taken in March, April, and May, dipped for 24 hours in IBA solutions of 10 to 100 ppm and planted in 1:1 peat/sand medium and kept under a polyethylene tunnel in a lathhouse. No cuttings formed roots without IBA treatments. The highest rooting percentage (all dates, 89%), mean number of roots (11.3) and mean total length of roots (5.5 cm) were obtained by treating the cuttings with 20 ppm IBA. At this concentration, rooting was 93, 75, and 100% for March, April, and May respectively. Excellent rooting was also obtained at 40 ppm in April, and 10 and 40 ppm in May.

Tip cuttings, 20 cm long with 5 leaves, were taken of *Ficus elastica* 'Decora' in April, May, June and July at Sabahia Experiment Station. The basal 2 cm of each cutting was dipped for 5 seconds in IBA solution at concentrations of 1,000 to 8,000 ppm. Cuttings were placed in a 1:1 mix of peat and sand and placed under a polyethylene tunnel in a lath house. The highest percentage of rooting was with 8,000 ppm IBA in April, though rootings of 90% or more were also obtained at concentrations of 2,000, 4,000, and 6,000 ppm. Rooting was poor on all other dates with a maximum rooting of 25% at 8,000 ppm in May. Maximum rooting of the controls occurred in April and was 47.5%.

Monstera deliciosum (Syn: *Philodendron pertusum*) cuttings were treated with a commercial chemical, Hormodin, at 1,000, 3,000, and 8,000 ppm in April and May 1982. This product is prepared as a powder and the ends of the cuttings are dipped in it. The cuttings were planted in a 1:1 mix of peat and sand and placed under a polyethylene tunnel. April cuttings had 97% rooting with the 1,000 ppm treatment, but this was not significantly better than the control. Rooting was 94% with 3,000 and 85% with 8,000 ppm Hormodin. Rooting in May was reduced somewhat, averaging 71% for all treatments. There were no significant differences in the number of roots or total length of roots among treatments.

Additional cutting propagation was begun at Kom Ombo using *Acalypha* sp., copperleaf and *Bougainvillea*. These experiments compare the effects of hormone treatments, media and season of taking cuttings and are being conducted in the new mist propagation facilities. Results were not available at the time of project termination.

CULTURAL PRACTICES, MEDIA AND NUTRITION

Research was undertaken to study the nutritional needs of a number of ornamental plants grown in containers. Some of these experiments were still in progress in the spring of 1983 and final data are unavailable.

Nutrition experiments still in progress include the effects of N, P, and K on the growth of *Monstera deliciosa* and *Ficus elastica* 'Decora' at Sabahia, of the effects of foliar fertilization on *Pelargonium hortorum* using Osmocote, a slow-release fertilizer, on *Vinca rosea* at Cairo and of various fertilizer sources on *Hydrangea macrophylla* at Sabahia.

PLANT INTRODUCTION

Twenty-three different varieties of turfgrasses are being grown at each location, Cairo (Qubba Palace), Alexandria (Montazah), and Kom Ombo. The aim is to select varieties which will remain green all year for gardens and playgrounds. Seeds were imported from Holland and the United States. Seed of *Laurus nobilis*, Grecian laurel, were imported from the United States and are being grown at Cairo. This plant is native in the Eastern Mediterranean but has not been grown or has been little used in Egypt. It has value as an indoor plant for the European export market, as an ornamental in Egypt and countries with similar climates, and as a plant for the spice industry since it provides the bay leaves of commerce.

CUT FLOWERS FOR EXPORT

Though Egypt has for some years been exporting cut flowers for sale in European markets, the volume of trade falls well short of potential. Because of its warm mediterranean climate, Egypt has a significant advantage over competitors for increasing the volume of its export sales and the range of flowers offered. With the use of greenhouses and shadehouses the season for many of these flower crops can be extended to year-round, while maintaining high quality.

Current constraints to realizing this potential with existing flower crops include both production and postharvest components. Major production improvements that would be needed include weed control, pruning practices of roses, production of propagules for gladiolus and iris, and proper pretreatment of gladiolus and iris propagules before planting. Inexpensive but durable protective enclosures need to be constructed if flowering seasons are to be extended. High quality is essential for the European export market. The specific causes of decreased quality after harvest need to be identified and optimum postharvest techniques need to be implemented.

The aim of this project, which began in February, 1981, was to introduce the most suitable modern technology to improve local cultural practices, production and quality of the harvested crops.

ACCOMPLISHMENTS

ROSES

Rose production in Egypt takes place almost entirely in the open field. The plants are widely spaced (60 × 80 cms) with a density of about 8000 plants/feddan, and the cultivars 'Baccara', 'Queen Elizabeth', 'Mercedes', 'Visa' and 'Chrysler Imperial' predominate. The estimated yearly export is about 2 million roses with a value of over half a million Egyptian pounds (LE).

Local production is characterized by either low yield in the winter season or by low quality in spring and summer. To increase the yield and improve quality in winter and spring during the main export season and to extend the period of export into early summer, experiments were designed to demonstrate year-round production of roses under plastic. The practice modifies climatic stresses and protects the plants from dust, avoiding the necessity for rinsing, with its attendant risks of spreading disease. Production under plastic is also known to increase growth, resulting in taller rose plants with increased flower yields.

Plastic Houses for Rose Production

Inexpensive locally produced materials were used for construction of these enclosures. Four experimental plastic houses were installed, three at the College of Agriculture, Ain Shams University and one at the College of Agriculture, University of Alexandria. Different materials were tested in the construction of the three houses at Ain Shams University. The costs of construction, supports, fasteners, ventilators, plastic and miscellaneous materials were carefully monitored so that they could be used as a basis for extension in the future. The total cost per feddan was between LE 3,300 and 4,000, depending on type of construction.

Comparison Between Rose Plants Grown Under Plastic and in the Open Field

One-year-old 'Mercedes' rose plants were planted in the soil on June 20, 1982. Six plots were planted in a plastic house (7.2 × 18 m) and six in the open. Each plot contained 20 plants in two rows at a distance of 20 cm between plants and 40 cm between rows.

The initial results showed that production of roses was favored by growing in plastic houses. On March 31, 1983, the plants in the plastic house were taller than those in the field (99.9 cm *vs* 70.9 cm). Between February 5 and April 16, 1983, 120 flowers were harvested from the six plots under plastic, whereas only 61 flowers were harvested from the same number of plants in comparable plots in the field.

At the Alexandria site, growth and flowering of potted 'Mercedes' roses were compared in the plastic house and outdoors with comparable results to those obtained in Cairo.

Effect of Fertilizer Levels on the Growth and Flowering of 'Mercedes' Roses Grown Under Plastic

One-year-old field budded 'Mercedes' roses were planted in the soil in a plastic house at Ain Shams University on February 16, 1982. Each plot contained 20 plants in two rows spaced 20 cm between plants and 40 cm between rows. There were three fertilizer treatments, each repeated four times: (1) 225 kg of ammonium nitrate, 150 kg of calcium superphosphate and 50 kg of potassium sulphate per feddan; (2) twice the amount of treatment 1; and (3) three times the amount of treatment 1. The fertilizers were added as three side dressings starting June 24, until September 7, 1982. The plants were pruned to 70 cm on October 7, 1982. Fertilizer applications were resumed between November and January and March and May, 1983. Fertilizer levels did not significantly affect height of plants grown under plastic and stem heights ranged between 92.3 and 95.8 cm, irrespective of treatment. At that time, plant heights and weights were affected more by the plastic cover than by nutrient levels. The data for flowers harvested by November 30, 1982, 54 days after pruning, indicated that the higher the nutrient level, the

larger the number of flowers produced (5.8, 7.4 and 8.4 for the low, medium and high levels, respectively). These experiments are continuing and results will be analyzed on completion.

Shading Potted Rose Plants to Improve Stem Quality

High light intensities are known to produce plants with shorter, thicker stems. Therefore, an experiment was run at Ain Shams to determine the optimal level of radiant energy to produce longer stems. On February 20, 1982, 1-year-old field-budded 'Mercedes' roses were transplanted, 1 plant per pot, to 30 cm clay pots containing a loamy soil as growing medium. Each plant was pruned to three shoots before transplanting.

On May 19, 1982 the potted plants were placed under four conditions for comparison. Two were placed under wooden frames (260 × 200 cm, and 175 cm high) covered with cheese cloth which provided 74% light to the plants (Treatment 1) or plastic sheets which allowed 60% light to penetrate (Treatment 2). Other plants were placed in a plastic house which allowed 75% light to penetrate (Treatment 3). The control plants (Treatment 4) were not covered. Each treatment plot consisted of 7 or 9 plants, and the treatments were replicated four times.

As expected, shading resulted in taller plants than when plants were grown in full sun. The average heights per plant on September 6, 1982 were 78.4, 70.8, 69.5 and 61.3 cm for the plants grown under cheese cloth, plastic sheets, in the plastic house and in full sun, respectively. The height of stems on plants grown in the plastic house was thus 30% greater than those grown under full sun. The stems were also significantly taller on these plants compared with those grown under cheese cloth or plastic sheets. The fresh weights of the vegetative growth removed by pruning plants to a level of 50 cm on October 10, 1982 were 158.4, 133.8, 146.6 and 124.0 gm. The mean numbers of flowers harvested from October 26, 1982 until February 19, 1983, per plant under four light conditions were 6.50, 4.28, 4.84 and 4.93, respectively.

Effect of Deshooting on the Flowering and Growth of Rose Plants Under Plastic

In another experiment begun December 1981 with three-year-old rose plants on a private farm, the deshooting of plants was tested as a means of controlling the timing of the flower development. The results showed that deshooting for 4 to 6 weeks delayed the time of flowering for the same time. However, deshooting did not clearly affect the number of bottom breaks and flower yield as expected. This experiment will be repeated under more controlled conditions at Ain Shams University.

Comparison between Plastic and Clay Containers for Roses

Clay pots are most frequently used for plant production, but there is growing interest in plastic containers because they are less subject to breakage. The purpose of the following experiment was to compare the effects on rose growth and production in locally produced clay pots and different sizes of plastic containers. The containers used were standard 30 cm clay pots or small and large plastic pots, which each held, respectively, 8.9 kg, 17.7 kg and 44.3 kg of loamy soil. An additional treatment with plants grown in a soil bed was included.

One-year old 'Mercedes' roses were planted in containers on February 20, 1982 in a plastic house. Five to nine plants were used per treatment plot and treatments were replicated four times. On October 14, 1982, the plants were pruned to a height of 50 cm. Between November 1, 1982 and February 19, 1983 the mean number of flowers cut per plant was 3.4, 5.2, 7.8 and 7.8 for the plants grown in 30 cm clay pots, small plastic containers, large plastic containers and in the soil, respectively. The initial results indicated that the larger the pot, the greater the vegetative growth and the greater the production of high quality flowers.

Introduction of Several Virus-indexed Rose Rootstocks

As part of the plant improvement program, four virus-indexed rose rootstocks were brought from the University of California, Davis: *Rosa manetti*, *Rosa multiflora*, *Rosa odorata*, and *Rosa indica*. They were planted at the Ain Shams site together with the local rootstock, *Rosa canina* and were pruned on February 20, 1982. Since there were only 2 to 8 plants of each rootstock, budding has been delayed until sufficient plants can be increased to permit experimentation. The nursery now contains 253 plants of *Rosa odorata*, 110 of *Rosa canina*, 69 of *Rosa multiflora*, 31 plants of *Rosa manetti* and 240 plants of *Rosa indica*.

Handling of Cut Flowers

The rates of development and senescence of cut flowers are known to be greatly affected by temperature and water stress. Desiccation of cut flowers, especially roses, causes the "bent neck" disorder which renders the rose unmarketable. In addition, the quality of water has dramatic effects on the vase-life of cut flowers. Since local practices in handling cut flowers do not usually take into consideration these important factors, losses due to handling were assessed. The major causes of loss in this postharvest study were identified as:

a. the effect of field heat on the freshly cut flowers;
b. the methods of transportation;
c. storage and transit temperatures;
d. the use of tap water.

The following experiments were designed to determine the benefits of holding flowers at low temperatures immediately after harvest and during transportation, packing and in storage. The effects of water quality, "pulsing" with sucrose, and addition of preservatives to the vases were also studied.

'Mercedes' roses were harvested at a farm 25 km north of Cairo, and transported to Ain Shams University. Suitable boxes made of plastic foam (5 cm in thickness) were used to transport the roses from the field to the laboratory. Plastic bags with ice cubes or ice packs were placed in

the boxes to keep the transportation temperature at 8–10°C. There were five to ten cut flowers per treatment, and treatments were replicated four times. Each cut flower was placed in an individual vase with a narrow mouth. The effect of temperature during transportation and handling were compared at 8–10°C and at room temperature.

The vase-life of the roses significantly increased the longer the flowers were kept at 8–10°C after cutting and during transportation. Exposing the cut flowers to ambient temperature during transportation for any length of time drastically shortened the vase-life of roses from 13 to 8 days.

A second experiment confirmed the results of the previous one and showed, furthermore, that when the flowers were stored for 48 hours at 4–6°C after transportation at 8–10°C their vase-life was increased even more. Adding 3% sucrose to the vase before storage at either temperature led to extended storage life.

The effect of temperature and water stress on longevity and quality were also tested. Exposing the flowers to the normal May temperature during the one-hour transit period resulted in only 10% of the flowers exhibiting bent neck if they were held in distilled water. The mean percentage of bent neck increased to 62.5 if the flowers were left dry for 6 hours before placing in water. Storage in cold tap water resulted in 50% of flowers with bent neck. Thus distilled water, free of microorganisms and salts, was shown to be very valuable for prolonged storage and transportation of roses.

In a final experiment, the effects of sucrose, fungicides and low pH were compared. The results showed that 2% sucrose and 250 ppm 8-HQC eliminated the occurrence of bent neck in cut flowers, but 25% of the flowers held in sucrose alone or in 300 ppm citric acid had bent neck.

GLADIOLUS

Production

Gladiolus is considered one of the most important cut flowers for export from Egypt. It is planted on more than 500 feddans and about 5 million spikes are exported each year. Flowering size gladiolus corms are usually imported yearly from Holland, but as a result of unfavorable storage and shipping conditions, the corms perform poorly and their percentage of flowering is often very low. Importing small corms is more appropriate as they are less sensitive to handling and are cheaper. They are planted on arrival and, after one growing season, produce flowering size corms (⅞ or 8/10). If the rest period of these flowering size corms could be broken by chemicals or cold storage they could be planted in October or November and, conceivably, would yield a high percentage of salable flowers during the export season. Indeed, it is likely that small cormels can be produced locally. With such a program, coupled with optimal cultural conditions, strict pest control measures and proper storage conditions, it is possible that Egypt could become self sufficient in corm production.

Handling of Cut Flowers

Besides the losses due to field heat and high temperature during transportation and storage it is known that gladioli curve upward at the tip when they are packed in a horizontal position. The importance of water temperature, position of packing and additives to the water in the vase were assessed in a series of simulated transit experiments.

In one experiment, performed at Ain Shams University in March 1981, 'Eurovision' gladioli were stored either dry or in water for 24 or 48 hours in the horizontal or vertical position. Plastic boxes 55 × 55 × 110 cm tall made of 5 cm thick styrofoam were used to transport the gladiolus spikes in the vertical position. Boxes were iced to remove field heat.

When the spikes were held in the horizontal position, the upper portion started to bend after four hours. The angle of bending was 23° after 24 hours and 61° after 48 hours. In contrast, spikes kept in the upright position did not bend. Storage of the spikes for 24 hours with their bases in water resulted in longer vase-life than after a 24-hour dry storage period.

Two experiments were carried out at Ain Shams University to test the effect of low temperature storage and addition of sucrose to the vase water. The first, was begun March 16, and the second on May 25, 1981. 'Eurovision' gladiolus spikes were harvested when their basal florets started to show color. The results showed that those cut on March 16 had longer vase lives than those harvested in May. Regardless of harvest date, low temperature during transportation and storage of the cut flowers resulted in longer vase-life than storage at ambient temperature. Cold storage treatment up to 8 days delayed the opening of the florets and kept them at a stage suitable for export. Pulsing the flowers by adding 20% sucrose solution to the vases for 24 hours before the cold storage period prolonged the vase-life of gladiolus flowers. Thus, addition of sucrose to the shipping container and holding at low temperature could be used as a means of extending the life of cut flowers during the transit period.

BIRD-OF-PARADISE

Bird-of-Paradise (*Strelitzia reginae*) is a cut flower known all over the world for its unusual form and extraordinary keeping quality. The plants grow very well in Egypt in the open field. The estimated export in 1981 was about 100,000 inflorescences, and the area planted with this species can easily be expanded for export purposes. Since the practice of hand pollination for seed production of bird-of-paradise started in Egypt 30 years ago there has been no further improvement program in production or shipping technologies. Many variations in plant type occur in the local population. The following survey and experiments were undertaken with the aim of improving the production of *Strelitzia* in Egypt.

Vegetative and Flowering Characteristics

A survey was initiated in April 1981 to characterize the vegetative and flowering characteristic of 30 three-year old plants at Alexandria and in September 1981, on 57 plants at Ain Shams. The purpose was to characterize groups or strains by recording the length and width of the blades of mature leaves, the length of the petioles, the

length of the flowering spike, spike diameter and the life of the inflorescence on the plant.

Three groups of plants (short, medium, and tall) were identified. The lengths of the leaf petioles among the three types were different but those of the leaf blades were about the same. The number of inflorescences per plant harvested during the 1981–1982 season averaged 7.5 per plant with a maximum of 15 per plant. Additional tests of production and, particularly, quality of the flowers will be made.

Ten plants from the medium sized group at Ain Shams were used to follow the rate of vegetative growth (number of leaves and "fans") which was recorded monthly. While there was a gradual increase in leaf production with time, two periods of rapid leaf production activity were identified; April to June and August to October. Almost the same pattern of growth occurred with the division (fan) formation.

There are plans for two experiments in 1983 to study the nutrition and water requirements of newly divided bird-of-paradise plants.

Germination of *Strelitzia reginae* seeds.

The mature seeds of bird-of-paradise are known for their slow germination. An experiment was designed to find the most effective conditions for faster and more reliable germination. Freshly harvested local seeds (collected in May, 1982 after hand pollination at Ain Shams University), and stored seeds from California were used. Four growing media were tested: sand and silt (1:1), sand, silt and peat moss (1:1:1), sand, silt and manure (1:1:1), and peat moss alone. The containers were either clay pots (25 cms) or plastic propagation flats (35 × 50 cms). Prior to planting, the seeds were immersed in hot water (60°C) for 30 minutes, 10% sulphuric acid for 10 minutes, or gibberellic acid (500 ppm) for 48 hours. The planting dates were July 10, August 1, September 5 and November 4, 1982. The treatments were replicated three times with each plot consisting of 10 seeds. The seeded pots and flats were placed in a lath house.

The results showed clearly that freshly harvested seeds were more viable than stored ones. Up to 90% of the former germinated whereas no more than 50% of stored seeds germinated.

Treating the freshly harvested seeds with sulphuric acid for 10 minutes and planting in a mixture of silt, sand and peat moss in clay pots resulted in the most rapid and highest germination percentage (90%); a treatment of 75 days in gibberellic acid treatment resulted in 80% germination in the same period. In contrast, in the second planting (August 1) these percentages were as low as 13.33 and 16.7 after 125 days from seeding. These results are consistent with the established information that aging of seeds results in loss of viability, which is hastened by storage at high temperature and high humidity.

GERBERA

Gerbera is a potentially valuable local and export crop in Egypt. A relatively new crop in the U.S., it is now ready for transfer to Egypt for development under Egyptian conditions. The purpose of this study was to germinate and grow a sample of seeds from a high-yielding UC Davis population of *Gerbera jamesonii* in order to determine suitable conditions and growing media, and to select plants of commercial value. The seeds were sown on September 15, 1981 in 1) Petri dishes, 2) sand, 3) sand and peat moss (1:1), and 4) sand and silt (1:1). The germination percentage of gerbera seeds in sand was higher than in any of the other media. Fifteen plants were selected and were transplanted to soil on August 22, 1982, and are growing under plastic. Vegetative and flowering data are being recorded for each plant and those judged to be of commercial value will be selected for propagation and large scale testing.

TUBEROSE

Tuberose (*Polianthes tuberosa*) plants grow and multiply readily in Egypt, normally producing flowers in the summer. The estimated export for 1981 was 100,000 spikes. Delaying flowering to match a more lucrative export season would be of great advantage. Preliminary experiments were undertaken at Alexandria University to alter flowering time, including tests with growth retardants (Embark and maleic hydrazide), alteration of the fertilizer regime, comparison of corm size, pinching and light treatments. The results are promising, but require confirmation.

FUTURE WORK

The aim of this project has been to introduce the most suitable modern technology for the improvement of local cultural practice, quality, timing and productivity of the major cut flower crops for export.

Trials and experiments to achieve the anticipated goals are long-term endeavors and need more time, especially with such plants as roses, bird-of-paradise and gladiolus.

Roses: The rose plants grown under plastic are now less than one and half years old, and will reach their peak of production at 3 to 5 years of age. Experiments concerning pruning and nutrition should continue for at least 2 to 3 years. Testing of the new rootstocks must continue more than 3 years and studies of plant spacing and media composition started in 1983 need to be continued.

Gladiolus: Two more years of experimentation are needed for the program to produce flowering size gladiolus corms locally; this includes seeking optimal cultural practices and achieving weed and pest control.

Handling of cut flowers for export: While the losses in handling the rose and gladiolus cut flowers were identified and the means for the elimination were recommended, another season of trials is needed to assess losses of all commodities during the export season.

Bird-of-Paradise: Identification and multiplication of high yielding superior cultivars require at least two more years. The survey which began two years ago has indicated the great potential of the bird-of-paradise flowers for export. Work over several more seasons is needed to confirm the results of the preliminary experiments on seed treatments, media, containers and seed germination.

Tuberose: In preliminary experiments, delaying the normal summer flowering season of tuberose to a time when higher export prices can be obtained in the fall was achieved by delaying the planting date, preplanting cold storage, and by growth retardants and pinching. Since these experiments were with potted plants, at least two seasons of field tests are needed with the best of these treatments to achieve improvement of flower quality for export purposes.

Gerbera: Two more seasons are needed to assess the quality of selected gerbera plants with special reference to commercial value and high yield under Egyptian conditions. Tests on multiplication of flowers by tissue culture of the selected cultivars have been planned for the next two seasons.

NEW ORNAMENTAL PLANTS

A main objective of this project was to introduce and test new species of ornamental plants that could be propagated and grown commercially in Egypt. The ultimate purpose was to improve cut flower production suited to development of a significant export trade, not only with current clients, the Arabic countries and the Eastern block, but also with the highly demanding European market. Towards this end, a number of species not previously planted extensively in Egypt were introduced and studied experimentally in several locations in order to establish the most appropriate cultural practices under Egyptian environmental conditions.

ACCOMPLISHMENTS

CHRYSANTHEMUM PRODUCTION

Chrysanthemum morifolium is a species that is easily propagated and for which the time of flowering can be easily manipulated by selecting appropriate temperature conditions, adjusting the duration of light exposure, and varying the time and location of planting. Thus, conceivably, chyrsanthemums could be grown commercially over an extended period of time for use in Egypt and for export trade.

In an initial experiment, rooted cuttings of 24 cultivars of chrysanthemum were brought from the United States in July, 1981 and planted at weekly intervals at the Sabahia station at Alexandria and at Giza, Cairo. Experiments were designed to determine when chrysanthemums would flower naturally under the environmental conditions of Alexandria and Cairo. Subsequent experiments would concern the effects of artificially extending day length. However, because of the limitations of electricity in rural areas it seemed most feasible to grow chrysanthemums under natural conditions. In the first studies, plants were grown in pots in a mixture of half sand and half peatmoss, which was known to be a good medium for chrysanthemums. While these plants received a standard commercial fertilizer treatment, an experiment was conducted to determine the optimum level of nitrogen required for production of 'Tan Verdova' chrysanthemums.

Plants flowered in October, November and December and the quality was judged to be good for most of the cultivars. 'Flamenco,' 'Forty Niner' and 'Deep Telstar' cultivars proved to be especially adapted for early flowering whereas 'Ice Cap,' 'Ice Flo' and 'Elegance' were judged to have potential for late production. The latter flowered 17 days later in Alexandria than in Cairo. Table 1 shows differences in time to flowering of 24 cultivars tested in Cairo and Alexandria.

The same cultivars were studied in the 1982 season but four others that are popular in Holland and Europe were included in the tests. They were selected for testing following a valuable visit to European markets by the project co-team leaders. The trip to Holland was fruitful in revealing the preferences of the European market and how flowers are graded and packaged to sell at auction, the only commercial outlet. The four Dutch cultivars, 'Horim,' 'Refour,' 'Spider,' and 'Westland' were found to be suitable for the Egyptian climate and initial growings were successful. The plants were again grown from imported rooted cuttings planted in July, 1982.

The second year's investigation on flowering time corroborated the results obtained in 1981. The time of flowering was about the same for all cultivars as in the 1981 season. The most uniform, highly productive, and highest quality cultivars, 'Flamenco,' 'Forty Niner,' 'Corsair' and 'Beauregard,' were selected during the 1982 growing season and experiments were conducted in soil beds at Cairo University. The plants were fertilized and water was supplied by furrow irrigation. The height of most of the cultivars was found to be adequate for commercial use. Plants at Sabahia were very tall and of good quality because temperatures are lower there than in Cairo. The quality of flowers produced in Cairo was adequate.

The value of supplemental lighting to regulate the time of flowering is well established in the literature. As part of the technology transfer it was decided to introduce artificial lighting procedures to evaluate the use of supplemental lighting for extending the growing season for export crops. In principle, by shortening or lengthening the duration of the exposure to light flowering in certain plant species is either inhibited or promoted. Chrysanthemum, a 'short day plant,' will remain vegetative if exposed to an extended photoperiod as might be provided by fluorescent light. In contrast, if the daylength is shortened by covering the plants with black cloth to eliminate external light, flowering may be accelerated.

In 1981, some plants grown in Cairo received supplemental lighting. Flowering was delayed for about six weeks so that they were harvested in February and March of 1982. However, the quality of flowers was inferior because the lighting was accidentally interrupted by roaming animals. There was an indication, however, that lighting to delay flowering would work, though further investigations would be necessary. In 1982, a large number of plants (50,000) of the four Dutch cultivars was purchased for testing in Egypt by Abdul Bari, a commercial grower. These plants were provided with additional lighting in the Delta region in order to delay flowering and thereby permit desirable elongation. Unfortunately, there was a power failure and most of the plants flowered on short stems; nevertheless some of them were saleable and many of the flowers were shipped to the USSR as a trial to study

Table 1. **Number of Days from Planting to Flowering (Full Bloom) of Chrysanthemum Cultivars Grown at Two Locations (1981)**

	- *Planting Dates* -		
Cultivar	*Cairo 1 Aug. 1981*	*Cairo 8 Aug. 1981*	*Alexandria 6 Aug. 1981*
Northern Lights	133	128	132
Yellow Divinity	121	101	115
Yellow Galaxy	131	123	119
Deep Telestar	101	93	101
Ice Cap	143	143	135
Illini Goldray	105	99	111
Flamenco	86	80	88
Caravelle	107	97	112
Forty Niner	98	93	94
Divinity	109	101	108
Beauregard Supreme	96	99	103
Iceflo	130	122	133
Goldflo	131	123	129
Christmas Star	143	135	135
Golden Elegance	150	150	167
Elegance	150	150	167
Tan Vedova	–	115	112
Gold Cap	143	143	140
Corsair	130	123	128
Galaxy	130	123	119
Peter John (Pink)	103	–	–
Peter John (Bronze)	107	–	–
Peter John (White)	103	–	112
Peter John (Yellow)	102	–	112

consumer acceptance. All flowers that arrived in good condition were sold.

To assess the effects of temperature on the flowering of the Dutch cultivars, trials were conducted at Cairo University and at Sabahia, near Alexandria. Temperatures at the latter location are considerably lower than in Cairo, and though flowering occurred from one to three weeks later than in Cairo as a consequence, the quality of the flowers was superior. Thus a spread in the dates of flowering can be obtained, not only by growing appropriate cultivars, but also by selecting warm and cool locations for production. Perhaps the early crops should be grown near Alexandria and the mid-winter crops should be grown near Cairo. Only further experimentation will provide the answer.

Up-to-date technology for growing chrysanthemums has now been transferred to Egypt. Production of high quality flowers at times to match the market demand has been demonstrated. Extension of information to commercial growers is now possible with training of advisors being planned by Dr. Abou Dahab and his staff. A pamphlet in Arabic on chrysanthemum production based on ADS experiments has been prepared and widely distributed.

PRODUCTION OF OTHER SPECIES

Several other species of ornamental plants were tested at a number of locations in Egypt to assess their potential for commercial production.

Chrysanthemum frutescens: The 'Marguerite' daisy is a plant in which flowering is promoted by long days which

The New Ornamental Crops Project has concentrated on developing high quality chrysanthemums for export markets. New cultivars are shown undergoing trials in one of the project's shade houses. *Photo: Nadir Hashem*

could be provided by supplemental lighting. Plants were grown in soil beds and flood irrigated. Incandescent lamps were placed over some plants but not over the controls. The lighted plants flowered about a month earlier and produced about 30% more flowers than the unlighted plants.

Chamaedorea elegans: Though growing wild on the Caribbean coast of Mexico, transport costs to the market in Europe are much higher than for plants grown in Egypt. This study was to determine if *Chamaedorea* could be grown for cut foliage for export to the European market. *Chamaedorea elegans*, *C. constricta*, *C. erumpens*, and *C. seifritzii* were tested at Kom Ombo. Small transplants of *Chamaedorea elegans* were planted under two light intensities provided by Bombax and Khaya trees. The former is deciduous and light diffuses through readily in the winter, whereas the Khaya tree is evergreen and allows less light to penetrate. Two levels of nitrogen were applied in each treatment, 10 grams and 20 grams of N/sq. M/quarter. This plant grows slowly and results will probably not be available for 3 or 4 more years. The fronds are harvested only after plants are about 6 years old when they are grown under ideal conditions.

Matthiola incana (Stocks) were sown in August and September of 1981 and 1982 and furrows irrigated. They were sown densely to increase the number of doubles (increased number of petals on each flower) which are more vigorous than singles and also to reduce the weight of the stems. Plants flowered in January and February with excellent quality. Those plants which were densely planted had thin stems adequate for shipping. The heavier stemmed plants could be sold locally.

Molucella laevis (Bells of Ireland) seeds were sown in the field in August, 1982 at Cairo University for winter flowering. Plants flowered January through March and the quality was excellent. Thus they may be suitable for export, but they would have to be treated with glycerine to preserve them. The stems should be disbudded and then placed in a mixture of 1 part glycerine to 2 parts water for at least 24 hours. Flowers can be sold locally without the glycerine treatment.

Antirrhinum majus (Snapdragon) seedlings were transplanted in September 1982 in rows for furrow irrigation at Cairo University. The plants flowered in the winter (January and February). Quality as indicated by height and uniformity of flowering spikes observed in February was excellent. These are of commercial quality suitable for the local market, but for export they would have to be treated with silver thiosulfate to delay abscission (flower drop). In addition, they would have to be shipped in an upright position to prevent spike curvature.

Freesia hybrida (Freesias) was grown to determine potential yield and productivity of flowers and of corms. Corms were planted several times during August and September to observe time of flowering in the spring. These experiments were conducted by Dr. M. Monsour at Al Azhar University. Those grown in partial shade had longer stems and better quality than those grown in full sun.

A screen house of 10 × 20 meters was planned in the U.S. and was erected by the Egyptian collaborators in the summer of 1982. These houses at Cairo University, Quba Palace and Ain Shams University are to grow flowers and nursery crops that cannot withstand full sun in summer. The shade houses were also fitted with intermittent mist benches to enable propagation by cuttings of species to be grown in the future.

PUBLICATIONS

Abou Dahab, A.M. (1982) Natural Season Chyrsanthemum Culture Under Egyptian Conditions.

Abou Dahab, A.M. and A.M. Kofranek. (1983) Natural Season Pompon Chyrsanthemum Cultivars in Two Locations under Egyptian Conditions.

Kofranek, Anton M. (1981) Affecting the Spray Shape of Pompon Chrysanthemums During Natural Season Flowering. *Acta Horticulturae* 125:167-172.

Monsour, B. and A. M. Abou Dahab. (1983) Effect of Different Planting Dates on Growth, Flowering and Corm Formations of Freesias.

AROMATIC AND MEDICINAL PLANT PRODUCTION

Production and export of aromatic and medicinal plants is a traditional industry in Egypt with foreign exchange earnings in the order of $30 million annually. Increased yields of these crops can make Egypt less reliant on imports of medicinal plants and offer good prospects of expanding exports of aromatic products. This project has aimed at improving the productivity and quality of existing aromatic crops as well as exploring the feasibility for introduction of new crops.

ACCOMPLISHMENTS

SURVEY OF THE EGYPTIAN AROMATIC AND MEDICINAL PLANT INDUSTRY

Throughout the period of the activity, the UC collaborator spent substantial time assessing the significance of the numerous problems facing Egyptian herb and spice producers. This was difficult because of the fragmented nature of the industry, the scattered distribution of international literature, and the unavailability of reliable data on production and prices.

Oil Crops

The major problems are those associated with rose geranium production. While the local scientists considered that the substantial reduction in acreage (Fig. 1) and production since 1979 was disease related, it was subsequently revealed that a more important factor was the world price for geranium oil, which had been depressed by major quantities reaching the international market from China. Nevertheless, it appeared likely that there were several horticultural factors reducing the productivity of this crop, and hence its profitability.

Other problems considered important in the production and marketing of oil crops included the high cost of labor for harvesting crops such as jasmine, rose and violet flowers, and the need for substantial organic chemistry expertise in developing a separatory and synthetic capability using Egyptian raw materials.

Culinary Herbs

Egypt is an important world supplier of dried culinary herbs and oleoresins. Table 1 shows the imports into the USA of certain culinary herbs, the proportion originating in Egypt, the prices for the Egyptian herb and the average price paid in that year. The table makes several important points. There is a large market for certain culinary herbs in the US, and while Egypt is a major supplier of some of them, others which could be readily grown in Egypt such as oregano, thyme (574 tonnes imported in 1977), rosemary (238 tonnes) and sage (1393 tonnes) are not imported from Egypt in significant quantity.

Prices for Egyptian products generally tend to be low, usually considerably less than the average world price. Poor quality in the finished product is the root cause of these low prices and as a result Egypt shares a small portion of the world market in herbs. Quality is a critical factor for purveyors of herbs and spices; they set strict standards for uniformity, essential oil content, and absence of adulterants and contaminating material. Several industry sources commented on the high incidence of foreign materials (other plant parts, insects, fecal matter) in Egyptian herbs and the variability in their quality (dry matter content, size, color, oil content, oil quality).

Clearly, research on the culinary herbs should emphasize means of improving the uniformity and quality of Egyptian herbs and introduction of important commercial herbs. Improving postharvest procedures, introduction of new species such as oregano and tarragon, as well as improved cultivars of the present major culinary herbs, therefore, were chosen for primary research.

Table 1. **Imports of certain culinary herbs into the U.S.A.**

Herb (year)	*Total Imports (Tonnes)*	*From Egypt (Tonnes)*	*Egypt Price ($/kg)*	*Average Price ($/kg)*
Mint (76)	34	7	1.04	4.03
Marjoram (77)	408	236	1.28	1.27
Bay lvs (77)	369	10	.58	1.28
Basil (77)	376	120	.89	1.12
Oregano (77)	2580	0	- - -	1.42

Medicinal Plants

Although there has always been a steady production in Egypt of medicinal plants such as Datura and Digitalis, there did not appear to be any justification for the widespread optimism among Egyptian scientists that this might be a growth area for horticulture. Dr. Marilyn Burbage, head of the Tropical Products Institute's (London) group studying the production and marketing of such plants, noted that a number of factors would be major obstacles in the development of a major industry based on medicinal plants: the total market for these materials is rather limited so that potential returns for a new medicinal plant would be small relative to major food and even aromatic horticultural crops; the users of existing medicinal plants already have established sources of supply (some of them Egyptian) and would be unlikely to change to a new supplier because of the likelihood of the need for changed extraction and purification procedures; and the development of new drugs (as distinct from the identification of plants with medicinal components) requires considerable resources and is an activity well outside the scope of the ADS project.

Herbal Tea

One potentially important growth area among the aromatic and medicinal plant crops is the increased use of herbal teas in Western countries. Egypt is an important supplier of chamomile (*Matricaria chamomile*), largely to West Germany, where the Egyptian product fetches a high price because it is harvested by hand and contains little contaminating stem and leaf material. A major problem with this crop (for the researcher as well as the industry) is the enormous labor cost for hand harvest. Among other potential materials for herbal teas is the Kakadi or Roselle, whose brilliant red sepals are collected and dried to make a refreshing cold or hot drink.

Pigment Plants

Egyptian workers in the area of aromatic and medicinal plants frequently expressed the opinion that the trend away from artificial materials in processed foodstuffs would generate a substantial demand for natural pigments. They felt that there was a major need for examination of a range of cultivars of plants such as *Targetes* which might be a potential commercial source of carotene for use as a food coloring.

EVALUATION OF RESEARCH CAPACITY

The well-established trade in culinary herbs, aromatic oils and medicinal plants in Egypt is supported by a research base in the universities and Ministry of Agriculture Horticulture Stations where horticulturists usually specialize in the broad group of floricultural, nursery, medical and aromatic plants. Visits to major university departments and research stations revealed them to be staffed, for the most part, by dedicated and enthusiastic researchers hampered by inadequate training and lack of essential facilities. Communication among the different research groups appeared to be poor, and particularly so between members of the Ministry of Agriculture and staff at universities. Research results seldom reach publication and are often available only in the form of theses at the universities.

There seemed to be little evidence of feedback from industry to the researchers (or extension of research findings to the industry), a particularly difficult problem because of the substantial involvement of private enterprise in the essential oil industry. It was also apparent that in many cases the more senior researchers frequently lacked direct contact with the experiments in progress. In general, the scientists in this activity were rather isolated from the small group of scientists in other countries working on these crops.

The research being carried out at the various stations and universities was devoted largely to studying the effects of various fertilizers (macro and/or micronutrients) or of different growth regulators (especially gibberellins and cytokinins) on growth, yield, oil quality, and other parameters of the crop under study. Rarely were the major problems summarized above directly addressed, and frequently the research studies were being conducted on crops of minor importance, on problems of rather local significance or of little economic importance.

Experimental designs were often flawed, most notably by the use of experimental plots so small that the variance of the replicate data was too high to allow comparison of different treatments. This variance was usually aggravated by incomplete stands of plants in the individual replicate plots. Frequently it appeared likely that treatment effects would be masked by over-riding horticultural factors (weeds, over-irrigation, variable soil quality, etc.). In many cases the experiments made use of multifactorial designs (in the interests of eliciting maximum information from the experiment) which required large numbers of experimental plots and thus forced the use of smaller plots because of restricted land availability.

Analytical facilities were usually limited and even the Dokki laboratory of the Ministry of Agriculture, dedicated to analysis of volatile oils from aromatic plants, lacked the facilities prerequisite to reproducible results.

These findings set the agenda for the project, which was:

1. To assemble a team of researchers from the different locations and organizations involved in research on aromatic and medicinal plants;
2. To attempt to summarize previous studies on aromatic and medicinal plants in Egypt;
3. To refurbish the laboratory facilities at the Dokki and El-Kanater stations of the Ministry of Agriculture;
4. To facilitate communication between Egyptian and other scientists working with aromatic and medicinal plants; and
5. To carry out some experiments designed not only to address the most pressing research needs of the industry but also to provide a pattern for the design of future horticultural experiments with these crops.

The Research Team and the Experimental Locations

The team for this project was initially structured to include participants from the Ministry, the universities

and from the major private aromatics enterprise in Egypt, Kato Aromatic. As the project progressed, the Principal Investigator from Kato withdrew and scientists were appointed from the National Research Center to replace his analytical expertise. Other important personnel changes during the short duration of the project included replacement of the Principal Investigator (when he accepted an appointment in Saudi Arabia) and of a senior investigator in Assiut (who accepted an appointment in Libya). Project experiments were carried out at the Dokki, El-Kanater, and Seds research stations of the Ministry of Agriculture and at Assiut University. This enabled a sampling of the important production areas for herb and spice crops in Egypt and brought together representatives of the major research groups in the country.

Refurbishing and Equipping the Analytical Laboratories at El-Kanater and Dokki

Because analysis of essential oil content and quality is an important part of experiments on aromatic and medicinal crops, it was necessary that the laboratories at El-Kanater and Dokki be provided with at least the minimum facilities and equipment required for routine analyses. The necessary equipment was purchased and installed after the laboratories had been cleaned, repainted and provided with electrical outlets and workbenches.

INTRODUCTION, EVALUATION AND SELECTION OF NEW PLANT MATERIALS

New Introductions

As discussed above, several important culinary herbs which could be produced in Egypt are almost unknown there. As part of the project, seeds of oreganum and summer savory were introduced (together with seeds of a range of less important herb and spice crops). These materials grew well in experimental plantings and there was much interest expressed by farmers who attended field days at which the plantings were shown. A seed-propagated line of tarragon proved also to be of considerable interest. It was unfortunate that the early termination of the project prevented introduction of the preferred French tarragon, which is propagable only by cuttings and which was to have been introduced from material grown at Davis.

Introduction of Improved Varieties of Existing Crops

The herbs and spices grown by the Egyptian farmers are usually sown from seed collected from the farmers' previous crops, although sometimes provided from crops grown by other farmers. There is no program of seed certification, testing or selection of improved cultivars, so that the herbs and spices grown are designated 'Baladi' or 'local.'

Seed lines of some of the important seed-propagated culinary herbs and spices were obtained from a variety of sources by the principal collaborator and compared with the 'Baladi' cultivars at El-Kanater and Seds stations. Typical results from these experiments are shown in Table 2 for two important umbelliferous seed crops, coriander and fennel.

Table 2. **Yield and flowering date of Coriander and Fennel grown from seed obtained from various sources**

Herb	*Source*	*Location*	*Seed Yield (g/plant)*	*Flowering date*
Coriander	Russia	Seds	277	1/3
	Roumania	Seds	98	2/14
	Sudan	Seds	320	12/20
	U.S.A.	Seds	299	12/27
	Baladi	Kanater	69	2/15
Fennel	U.S.A. (I)	Kanater	48	2/11
	U.S.A. (II)	Kanater	78	4/23
	Britain (I)	Kanater	70	4/14
	Britain (II)	Kanater	38	4/10
	Baladi	Kanater	39	2/11

The important conclusion from these experiments was that there is enormous potential for increasing yield of some of the important Egyptian herb and spice crops by introducing germplasm from other countries. Experimental introductions of some of the economically important aromatic crops now need to be initiated using larger plot sizes, more seed sources, and more test locations.

Selection of Improved Lines from Local Germplasm

In the course of an experiment examining the effect of cutting fresh herb on the ultimate seed yield from marjoram, it was noted that there was substantial variation in the habit, morphology, flowering date and vigor of the individual plants in the experimental plots. This variation indicated that the seed source (the Seds research station's own plantings) was highly heterozygous. Plants from American seed in an introduction experiment at the same station were uniform. Apart from the immediate experimental implication of the need for vegetatively propagated material or a more uniform seed source, this variation offered a good opportunity for selection of improved varieties from within the Egyptian populations. Accordingly, nine plants varying dramatically in phenotype were selected for vegetative propagation so that replicate plants could be studied to determine whether the variation observed was truly genetic. This experiment has not yet been completed.

PRODUCTION PROBLEMS WITH ROSE GERANIUM

The dramatic fall in area planted to the rose geranium in Egypt over the past few years (Fig. 1) is almost certainly the result of an equally precipitous fall in the world price. However, the widespread occurrence of a vascular wilt disease and poor establishment of new plantations may have also contributed to the decline by reducing productivity

so that lowered geranium oil prices made the crop uneconomic.

Disease

In preliminary examinations of mature plantations, it was clear that some wilt disease was present. Material from infected plants was submitted to the Commonwealth Mycological Institute, London, who reported, "We isolated *Verticillium dahliae* consistently from this material, so it seems pretty certain that the disease affecting the geraniums is verticillium wilt. We could not isolate *Fusarium* or any pathogenic bacteria." Because *V. dahliae* persists in the soil as microsclerotia, infected areas should not be replanted unless sterilized. In addition, it is probable that rapid spread of the disease would result from propagation of plants with diseased cuttings. Suggested procedures to overcome the disease include:

1. Provision of certified disease-free planting stock for development of mother blocks from which production cuttings could be taken;
2. Assay of microsclerotia in soil before planting new blocks; and,
3. Use of solar sterilization prior to planting (*V. dahliae*) has been shown to be rapidly killed by high soil temperatures: and,
4. Use of new specific fungicides to combat infection. Experiments presently in progress are designed to test some of these suggestions.

Establishment

In visits to newly planted areas of geranium, it became apparent that poor field stands were at least partly due to the use of poor cuttings and adverse rooting conditions. Preliminary experiments at the El-Kanater station showed that relatively short (15 cm) cuttings rooted more readily than longer ones. The results of an experiment designed to test the effect of the type of cutting and of the climate on establishment of geranium plants are shown in Table 3. Clearly terminal cuttings are preferable to those taken further down the stem (which are perhaps more woody). This difference is particularly noticeable in the experiment at Assiut or at El-Kanater in April, presumably reflecting the effect of warmer weather. The relatively poor success of the El-Kanater plantings may reflect the presence of *Verticillium* at this location.

In experiments designed to explore the feasibility of providing better planting stock for geranium farmers, cuttings are being rooted in mist at the Horticulture Department of Cairo University prior to planting in the field. The results of this experiment are not yet available.

EFFECTS OF WEED CONTROL IN AROMATIC PLANTS.

The mild climate and fertile soils of Egypt encourage the growth of a wide range of annual and perennial weeds in horticultural crops, and weed control is an important labor cost in the production of aromatic and medicinal plants. Chemical controls are available for many types of weeds but they are expensive compared with weed control

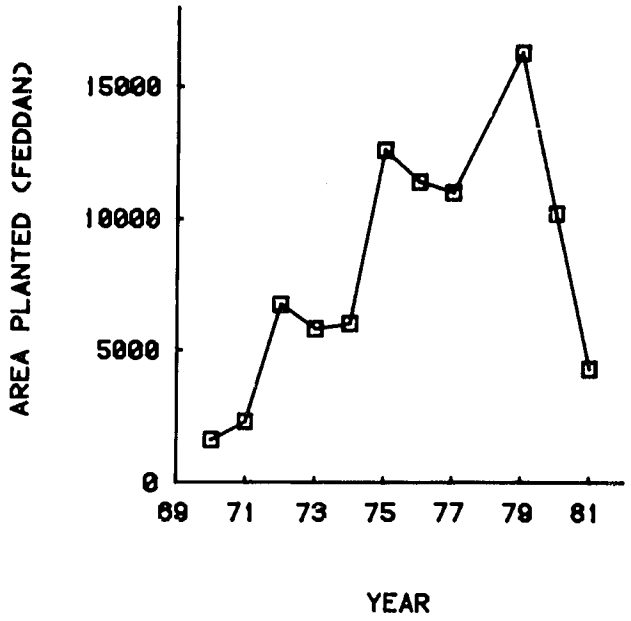

Figure 1. Changes in plantings of Rose Geranium in Egypt over the period from 1970 to 1981. The 1981 figure is a verbal estimate, other data from MOA.

Table 3. **Effect of cutting type and date on establishment (% survival) of plants of geranium *(Pelargonium graveolens)***

Cutting	*Planted at*	*Planted In*		
		February	*March*	*April*
Terminal	Kanater	60	30	38
Median	Kanater	57	30	27
Basal	Kanater	48	30	16
Terminal	Assiut	89	76	78
Median	Assiut	35	51	42

by cultivation. A series of experiments was conducted to examine the effect of weeds and of different frequencies of cultivation on the production of some of the important herb crops. The effect of different cultivation frequencies on the yield of chamomile is shown in Table 4.

Yield of flowers (fresh or dried) was significantly increased if the plants were cultivated to remove weeds. At the Seds station, cultivation increased yield of chamomile by 40%. A similar effect of cultivation was observed in a subsequent experiment with coriander (Table 5). In this experiment the effect of the herbicide glyphosate and solar sterilization (by spreading clear plastic tarpaulins over experimental plots prior to planting) were compared with hand weeding. Although the yield was higher in the glyphosate-treated plots than in the controls, this treatment was less productive than hand weeding presumably because it is effective against a rather narrow spectrum of weeds.

Table 4. **Effect of cultivation on yield of *Matricaria chamomile***

Location	*Kanater*		*Seds*	
TREATMENT	fresh wt. of flowers (kg/plot)	dry wt. of flowers (kg/plot)	fresh wt. of flowers (kg/plot)	dry wt. of flowers (kg/plot)
Unweeded control	9.2	1.8	5.1	1.0
Weeded every 4 wks	10.6	2.1	6.8	1.4
Weeded every 2 wks	10.7	2.1	6.6	1.3
Weeded daily	10.0	2.1	6.8	1.5

Solar sterilization has proved very effective in weed control in California and the yield of coriander was highest in plots that were treated in this way.

A conservative 30% reduction in yield of coriander through failure to control weeds would result in a loss to the grower in excess of LE 90 per feddan. Three cultivations would cost only LE 60 for the same area, indicating the benefit to be obtained from proper cultivation. These potential losses also give a guide to the amount which might economically be spent on new methods of weed control without reducing the farmer's profit. Experiments are presently in progress to test the use of a range of herbicides in the production of Egyptian herbs.

Table 5. **Effect of various weed control measures on seed yield of Coriander at Kanater.**

Treatment	*Seed yield*
Control	233
Manual weeding every 2 wks	333
Manual weeding every month	369
Glyphosate pretreatment	276
Solar sterilization	372

EFFECTS OF IRRIGATION FREQUENCY

The ready availability of water for agriculture in Egypt has permitted frequent irrigation of all crops. In many cases it seemed possible that irrigation was more frequent than might be desirable, decreasing root growth through frequent anaerobiosis and undesirably altering soil structure. The effect of water management on yield and quality of aromatic plants was examined initially in experiments in which plants were first established in the experimental plots and then watered at different intervals. To avoid diffusion of water between the plots, it was necessary to set large boundaries between them. In an experiment with marjoram at Assiut (Fig. 2), yield of fresh or dried herb was closely correlated with the frequency of irrigation. In contrast, seed yield in coriander plantings at El-Kanater was highest if the plants were irrigated at two-week intervals (Fig. 3). Obviously, simple timing is a rather crude method for determining optimum irrigation practices which should

Irrigation trials to improve the quality and yield of culinary herbs are part of the research program of the Aromatic and Medicinal Plants Project. The experimental plan can be seen on the board in one of the experimental plots. *Photo: Michael Reid*

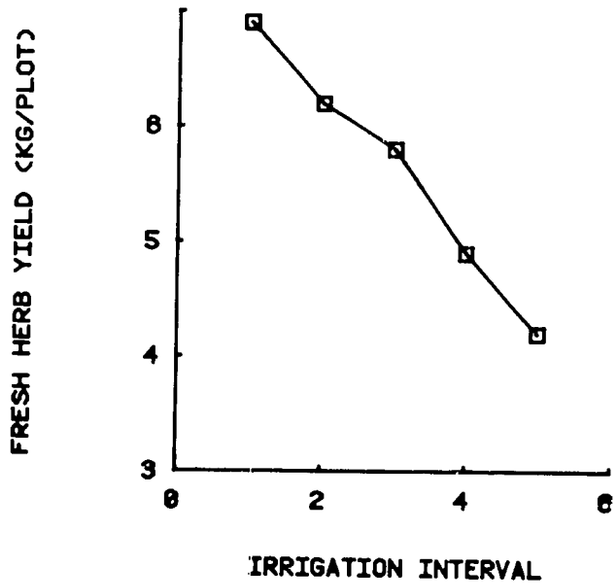

Figure 2. **Effect of irrigation interval on the yield of marjoram.**

vary according to the stage of crop development and environmental influences. These experiments need to be repeated using tensiometers to indicate soil moisture con ditions, but these preliminary results do indicate the potential for optimizing yield by proper management of water.

EFFECT OF FERTILIZER APPLICATIONS

Among the more traditional research projects for Egyptian graduate students in horticulture is the examination of the effects of fertilizer applications on crop yield and quality. This type of experiment has frequently been conducted with aromatic and medicinal plants, but little information of substance has been extended to the producers of these crops. The problem is usually the result of the experimental design. Students are taught to carry out multifactorial experiments which greatly increase the number of replicates (and hence the labor) required to carry out the trial. A frequent subject for discussion between the Egyptian scientists and the UC collaborator was the need for simplified experimental design to answer a single question.

In planning an experiment to be carried out on chamomile at Assiut, the team used the simpler approach of a split plot design (to examine the usefulness of a base dressing of superphosphate during ground preparation) on which was superimposed applications of a complete fertilzer (5-10-5) at three different rates. The base dressing (a common and recommended practice for the farmers) had no significant effect on yield, but even the lowest complete fertilizer application increased yield by 30% (Fig. 4). The simpler experimental design now leaves us in a position to determine which of the nutrients at one fertilizer level was limiting production.

In this project, as in others in the Horticulture Sub-Project, one of the most important activities has been the interaction between visiting scientists and the Egyptian team. A great deal was accomplished during discussion of industry problems, potential new crops and the like.

In many ways the experiments started with this project led to new areas which will require vigorous prosecution and adequate funding. Perhaps the most important would be development of a program for disease control and improved propagation of geranium. In addition, much work needs to be done to establish proper horticultural practices for the new crops that have been introduced. A most important project, frequently discussed with the team but not yet implemented, is to improve the quality of the dried herbs exported from Egypt by improving postharvest procedures. This would probably require a change in the way in which the herbs are dried, possibly with the use of

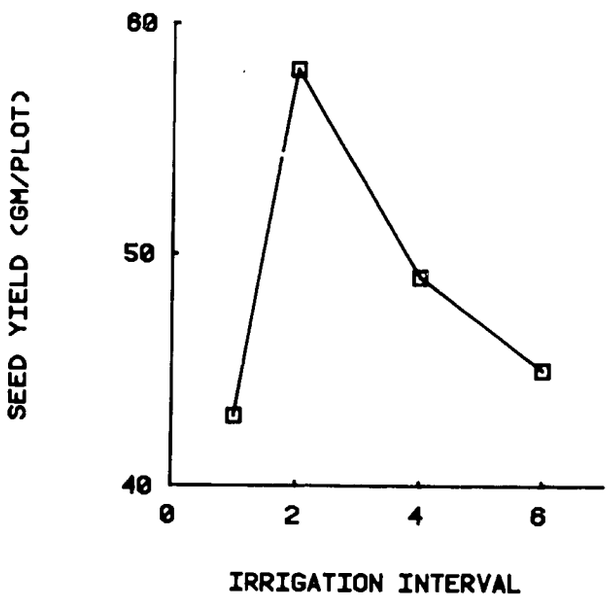

Figure 3. **Effect of irrigation interval on the yield of marjoram.**

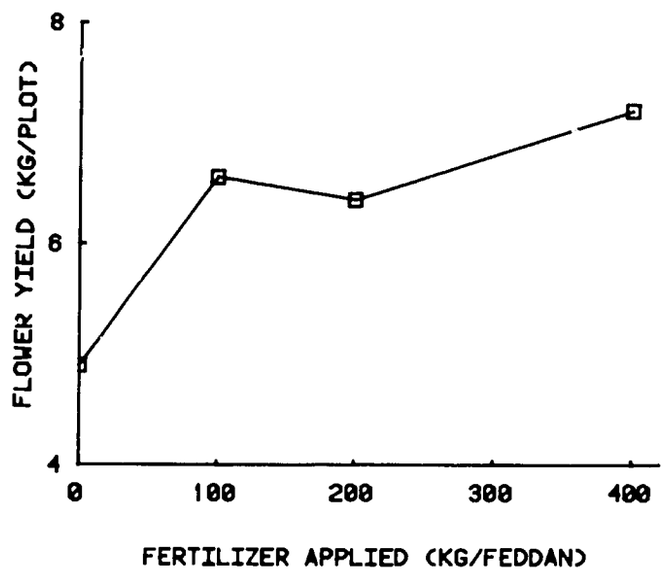

Figure 4. **Effect of different applications of a complete fertilizer on yield of chamomile at Assiut.**

portable solar-powered driers. The programs started in irrigation management, weed control and plant nutrition can profitably be continued by Egyptian scientists to provide the information necessary to the farmers. In all these areas, it will be vital to engage the services of scientists experienced in the disciplines on which horticulture draws, particularly pathologists, physiologists and engineers.

CLONAL PROPAGATION OF PLANTS BY TISSUE CULTURE

Large-scale production of high quality, disease-free seed and plants is fundamental to crop improvement and to major advances in Egyptian food production. For certain species this may best be achieved by using tissue culture techniques.

The ADS Project has focused attention, for the first time in Egypt, on the possible uses of tissue culture technology for improving production of certain vegetable crops. To do this it has been necessary to design, build, and equip a tissue culture laboratory in the Central Laboratory and to train scientists in the various tissue culture procedures. The laboratory is intended to provide the facilities and expertise required for training of scientists and technicians in Egypt and to develop a research program aimed, in the short run, at clonal propagation of disease-free plants and, in the long run, the genetic improvement of horticultural crops.

ACCOMPLISHMENTS

DEVELOPMENT OF FACILITIES

Plans for remodeling a laboratory in the Central Laboratory complex for tissue culture were developed through the collaborative efforts of A. Bondok, L. Rappaport, and W. Hackett (Co-Team Leaders), A. Menini (UCD Physical Plant), J. Pangborn (UCD Director of the Facility for Advanced Instrumentation), and S. Tewfik (Director of the Central Laboratory). The design provides for air conditioning, limiting dust contamination, controlled temperature, and space for specialized equipment.

Tissue culture requires an array of equipment and facilities which can be operated under very clean conditions so that cultures may be kept sterile and not be lost to contaminating microorganisms. The task of acquiring the necessary equipment and remodeling a laboratory began in June, 1980, and was not completed until January, 1983, when the laboratory became fully operational.

DEVELOPMENT OF RESEARCH OBJECTIVES AND PLANS

Crop orientation priorities for clonal propagation of crop plants from disease-free materials were developed in collaboration with the Egyptian Horticultural Technical Committee (HTC). A short-term research objective was to adapt techniques so as to propagate disease-free crop plants on a large scale ready for commercial planting. Where possible, scientists were encouraged to work on a crop of immediate importance in Egypt. It was deemed more important, however, to provide a laboratory situation where ideas could be fostered and modern techniques learned by trainees. In addition to these immediate practical goals, project leaders recognized the need to teach technologies of future use in Egyptian agriculture. These included the application of cell suspension cultures for promoting somaclonal variation, protoplast culture for obtaining single cell descent colonies of cells, as well as single cells for protoplast fusion, and aspects of genetic transformation of cells which, in the future, will be important in introducing useful "agricultural genes" into crop plants. Somaclonal variation is a heritable genetic or cytoplasmic change expressed in some plants regenerated from tissue cultures. Such variation may be exploited as a means of finding desirable traits, e.g., resistance to disease and tolerance to salinity.

Protoplasts are cells from which the walls are removed by exposure to cell wall degrading enzymes; they may be obtained from any part of a plant. Given appropriate cultural conditions, protoplasts of some species may begin to form cell walls, then divide and form callus. Given the right nutritional and hormonal conditions, plants may regenerate from callus. These plants, because they originate from a single cell, will likely be genetically identical. Protoplasts also have the propensity to fuse and there is optimism that new kinds of plants may be obtained by using cells of the same or closely related species which are not sexually compatible.

Based on these priorities, project leaders developed general plans for research in Egypt and the United States. The following paragraphs describe research progress along these lines.

Citrus

This program, initiated in Cairo, concerned the elimination of viruses and establishment of virus-free bud lines using tissue culture techniques. Methods of inducing initiation and development of citrus embryos from nuclear tissue were investigated as well as methods of multiplying disease-free material by tissue cultures of virus-free shoot tips.

Micrografting

It is important to eliminate such virus diseases as tristeza, psorosis, and exocortis from citrus varieties. On the one hand, while tissue culture and vegetative propagation procedures are useful, the resulting plants are in the juvenile state and it takes years before they become valuable producers. On the other, plants obtained by shoot-tip micrografting appear to bypass the juvenile state. Micrografting can be used to transfer virus-free shoot tips onto a virus-free citrus seedling stock. Working with Dr. David Burger,

Dr. Edriss tested 'Troyer' and 'Carrizo' citrange (*Poncirus trifoliata* (L.) Rat. × *Citrus sinensis* (L.) Osbeck) and 'Sacaton' citrumelo (*P. trifoliata* (L.) Rat. × *C. paradisi* Macf.) as rootstock cultivars. Sterile seedlings were grown under constant temperature conditions and after two weeks they were removed from the germination medium, decapitated leaving 2–4 cm of the epicotyl, and the root shortened to 2–4 cm; cotyledons and axillary buds were also removed. Shoot tips of 'Mexican' lime (*C. aurantifolia* Swing.), 'Valencia' orange (*C. sinensis* (L.) Osbeck), and 'Star Ruby' grapefruit (*C. paradisi* Macf.) composed of the apical meristem and three leaf primordia were isolated from actively growing branches on field or glasshouse grown plants. These were transferred to the top cut surface of the decapitated epicotyl in contact with the vascular cambium, or the shoot tip was set on the cortex surface in the inverted-T incision. The grafted rootstocks were placed on U-shaped paper bridges supported in test tubes containing a sterile liquid Murashige and Skoog (M & S) basal medium plus additions. The culture tubes were capped and sealed to insure high humidity and sterility. Growth regulator treatments were used to promote development of the graft union.

It is evident in Table 1 that greatest success was obtained by micrografting 'Mexican' lime, 'Valencia' orange, and 'Star Ruby' grapefruit on 'Carrizo' citrange, and grafting 'Mexican' lime and 'Valencia' orange to 'Sacaton' citrumelo. However, the 'Star Ruby' × 'Sacaton' citrumelo graft was less successful as were all grafts where 'Troyer' citrange was used as the rootstock.

Table 1. **Percent Successful Grafts among Three Scions on Three Rootstocks**

Rootstock	*Scion*		
	Mexican Lime	Valencia Orange	Star Ruby Grapefruit
Troyer citrange	24.4b	17.7b	23.3b
Carrizo citrange	63.8a	50.0a	28.3a
Sacaton citrumelo	64.4a	44.4a	28.2b

Mean separation within columns by Duncan's New Multiple Range Test, p = 0.05. The letters next to numerals indicates similar responses or statistically different responses.

Grafting of 'Star Ruby' was enhanced by using the inverted-T incision on the rootstock epicotyl. Grafting was accomplished more effectively when scions were treated with 2,4-D at 10 mg/l or kinetin at 1 mg/l used individually, but not together.

Dr. Edriss also developed a clonal propagation system for 'Troyer' citrange (*Poncirus trifoliata* (L.) × *Citrus sinensis* (L.) Osbeck), a potential rootstock in citrus production. To establish tissue cultures, isolated epicotyl, root meristem, and root segment tissues were established in continuous culture to study regeneration potential. An M & S medium containing NAA (10 mg/l) and BAP (0.1–10 mg/l) was used throughout. With 10 mg BAP/l and 1 mg NAA/l, regeneration occurred directly without callus formation on root segments; regeneration also occurred from stem segments. Shoot differentiation from stem callus occurred with combinations of BAP and NAA (0.25, .01 mg/l, respectively) while rooting of regenerated shoots occurred when 2.0 mg NAA/l was supplied. Thus, it was possible with 'Troyer' citrange to achieve plant regeneration in high yield by varying concentrations of two growth regulators. Plate 1 shows callus formation and shoot formation obtained from root meristems of 'Troyer' citrange. It is estimated that seven weeks after explanting epicotyl segments, plantlets from culture would be ready for transplanting to soil.

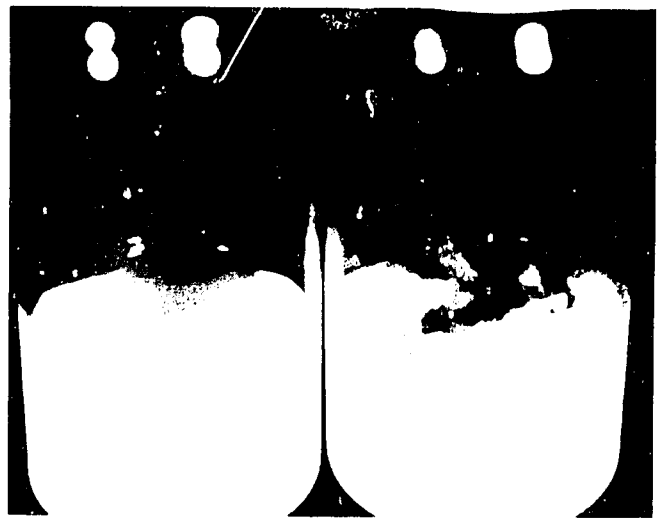

Plate 1. Callus formation (left), an M & S medium containing 10 mg NAA/l and 1 mg BAP/l, and shoot formation (right) directly on an M&S medium containing 1 mg NAA/l and 10 mg BAP/l from root meristems of 'Troyer' citrange.

Anther Culture

A desirable objective in plant breeding is to obtain haploid plants which can be used for speeding up genetic improvement of horticultural crops. Pollen grains (contained within anthers) have only half the number of chromosomes of a fertilized embryo. It has been shown that the vegetative nucleus in pollen grains can sometimes be caused to divide and, ultimately, to produce callus from which plants can be regenerated. Because only one set of chromosomes is present, it is much easier to sort out useful genes in a breeding program using haploids. It has been a particularly successful method with tobacco, rice, *Datura*, wheat, and several other species. Success has also been achieved with *Citrus aurantium*, and Edriss and Burger attempted to obtain similar results with *Citrus paradisi* Macf., 'Ruby Red.'

Immature flower buds were collected from individual grapefruit trees, sterilized in 70% ethanol and washed in de-ionized water. Four flower bud size stages (1 to 4) were established and anthers were excised at each flower bud stage and placed in petri dishes supplied with M & S and Nitsch & Nitsch medium, supplemented with various concentrations of sucrose and hormones.

Callus formation occurred on anthers from 'stage 2' buds more so than in buds of any other stage, and the M & S medium proved to be superior with these buds. Callus formation was greatest when the anthers were incubated in darkness, when concentration of sucrose was 5% and 0.5 mg kinetin and 5 mg NAA(mg/l) were included. There was insufficient time to determine whether the callus was haploid or to obtain plantlets. However, the experience of developing the anther culture system will be of great value in pursuing this technique further in Egypt.

Reviewing the progress made in a brief period both in Cairo and the U.S., it is evident that tissue culture procedures for citrus will have great importance in both countries.

Date Palm

A major problem with date palms is that many of the high yielding, high quality cultivars and seedlings are difficult to propagate. Propagation is normally achieved by excising side shoots from the tree, rooting them, and growing seedlings from them. However, they are either produced in limited numbers or, because of poor propagation technique or other reasons, are not sufficient to provide stock for new, modern orchards in Egypt. Therefore, a specific objective of the Tissue Culture Project was to develop procedures for producing large numbers of date palms *in vitro*. Previous research by Tisserat and Murashige had shown that plantlets may be obtained from lateral buds and shoot tips of date palm via callus formation and that this process induced adventitious embryos. The objective of studies by Egyptian scientists was to verify that these methods are suitable for Egyptian cultivars. Moreover, efforts are being made to multiply shoots from shoot tip cultures in the absence of callus formation. This would circumvent potential problems of mutations and other genetic aberrations that might result from use of callus. Once regeneration was achieved on a regular basis, methods of successfully transferring plantlets propagated in tissue culture to free-living greenhouse and field conditions would be investigated.

Culturing Sterile Date Palm Seedlings

An immediate problem in tissue culture of date palm is obtaining sterile plant material so as to avoid contamination problems in the tissue culture flask. The first step was to develop methods to surface sterilize the seeds from which shoots could be obtained. In a comparison of chemical treatments, Dr. Sabour found that incubation in 10 g/l iodine dissolved in 95% ethanol for 15 minutes was sufficient to eliminate surface contaminates without visible damage to the germinating embryos. Germination could be improved (40 to 60% vs. 10 to 40% success) by immersing seeds in 2.63% sodium hypochlorite or 10 g/l iodine, followed by immersion of the isolated embryos in the disinfectant prior to plating on culture medium (Table 2).

Vacuum infiltration of the solutions markedly enhanced the activity of the compounds in reducing contamination and promoting germination.

Table 2. **Influence of sodium hypochlorite and various iodine, and alcohol treatments on the sterility and germination of date palm seeds cultured on modified Murashige and Skoog media containing 0.8% agar after 32 days. Seeds were vacuum infiltrated by immersing them in the test solutions and pumping out the air from the chamber for 15 minutes. Seeds were surface sterilized for 15 minutes for all treatments.**

Treatments	*% Contamination*	*% Germination*
2.63% NaOCl	40	50
95% ETOH	60	40
0.1% I + 95% ETOH	30	60
0.5% I + 95% ETOH	0	100
1.0% I + 95% ETOH	0	100

In an effort to remove contaminating phenols from the medium, activated charcoals were tested in comparison with granular charcoals; the former were slightly more effective in adsorbing phenols. The growth of sterile seedlings derived from decontaminated seeds was not affected by the addition of 5 to 15 mg/l benzyladenine and 0.5 mg/l NAA to the medium, indicating that the seedling endosperm provides sufficient nutrition for growth on the medium.

Cloning Date Palms in Tissue Culture

Date palm shoot tips were cultured on M & S medium containing up to 1.0 mg/l naphthaleneacetic acid (NAA, 0–15.0 mg/l benzyladenine and n–(2-isopentyl) adenine, (2iP), to enhance shoot growth and proliferation. Dr. Gabr found that the optimal explant for propagation consisted of the apical meristem region and 3–6 adjacent leaf primordia. Shoot development was improved by initially establishing explants on an agar medium for two weeks, and then transferring them to liquid medium, or from tips cultured on agar medium only throughout the culture passage. After eight weeks in culture, 3mm-long tips usually produced three to five green visible leaves, elongated to about 3 cm in length (Plate 2*a*).

Since relatively few axillary buds were produced from the apical meristem region, attention was directed toward producing plants from callus. The best callus production was achieved by culturing date palm shoot tips on basal nutrient media supplemented with 100 mg/l 2,4-D, 3 mg/l 2iP, 0.3% charcoal and 0.8% Phytagar. Inclusion of higher percentages of charcoal into the medium caused proportionately more shoot development than callus production.

In an evaluation of a number of palm species and cultivars for callus formation, six produced embryogenic callus after four months of serial subculturing. Transfer of callus to nutrient medium devoid of hormones resulted in portions of the callus initiating many asexual embryos and adventitious roots.

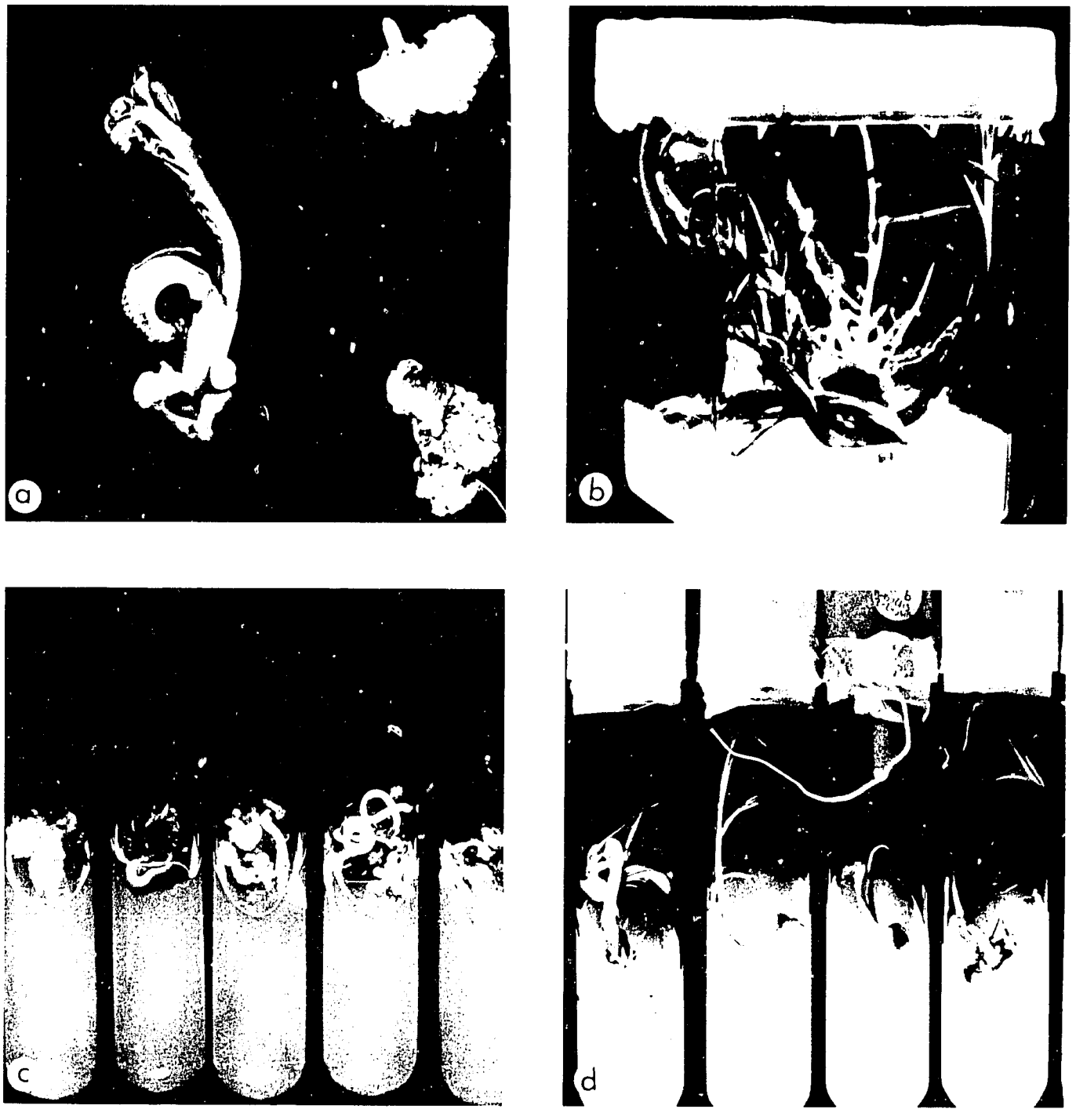

Plate 2. Various morphogenetic responses obtained from palm shoot tip cultures *in vitro*. *a*. Morphogenetic bifurcation of date palm shoot tip after 8 weeks in culture. Shoot on left cultured on basal medium supplemented with 0.1 mg l NAA; shoots on left cultured on basal medium supplemented with 100mg l 2,4-D, 3 mg l tip and 0.3% charcoal. *b*. Thirty-week old date palm shoot tip with 2 axillary shoots and well-developed adventitious root system. *c*. Date palm callus derived from tips giving rise to embryogenetic callus. Note curling embryos in cultures. *d*. Examples of thirty-week old shoot tip cultures from various palm species on nutrient medium containing 0.1 mg l NAA. From left to right: *Washingtonia filifera*, *Erythea edulis*, *Phoenix canariensis*, and *P. dactylifera* cv. 'Zahidi.'

It is clear that the methodologies developed were applicable to other species of date palms. Thus, the initial objectives of culturing date palm tissue culture and obtaining plantlets were obtained. In time, such plantlets would be grown out in containers and eventually transplanted to the field to test their viability, growth, and developmental behavior. This work, therefore, sets the stage for future investigations of the practical application of tissue culture for establishing date palm orchards in Egypt and elsewhere.

Date Palm and Carrot Protoplasts

A recent development which is having a marked impact on thinking in plant genetics is the ability to isolate protoplasts from tissues and regenerate plants from them. In a comparative study, Gabr and Tisserat made an important first step in the process. Callus cultures of *Erythea edulis* L. and *Daucus carota* L., and shoot tip and leaf explants of *Phoenix dactylifera* L. (Guadaloupe fan palm) were used.

In order to prepare protoplasts from carrot, embryogenic callus was initiated from petiole segments cultured on a modified M & S medium containing 0.1 mg/l 2,4-D. The callus from Guadaloupe fan palm was obtained in a similar manner but with a different medium and hormonal constituents. Protoplasts were prepared by treating the callus with a wall-degrading enzyme mixture and incubating for 24 hours, 25–29°C under a 16-hour photoperiod at 100 ft.-candle illumination. Cellular debris was filtered off through a stainless steel mesh, and protoplasts were isolated from the debris by centrifuging, washing, and then plating on agar. To culture protoplasts, M & S salts, 3% sucrose, 1% D-mannitol, 0.4 mg/l thiamine HC1, 100 mg/l i-inositol, 0.6 mg/l NAA, 0.01 mg/l 2,4-D, 0.1 benzyladenine, and 0.6% sea plaque agar were utilized. Various light regimes, enzyme mixtures, and agitation of the medium were tested to promote release of protoplasts and regeneration of cell walls and subsequent cell division.

The source of the protoplasts was very important; the leaf primordia adjacent to the apical meristem tip produced the most viable protoplasts. Protoplasts remained intact and viable in the original enzyme mixture up to 21 days. After 24 hours of incubation, spontaneous fusion of protoplasts was observed, resulting in the formation of numerous giant protoplasts which were not capable of cell wall regeneration and which burst shortly after or during transfer to agar medium. After plating on agar medium, 'normal' protoplasts from both carrot and fan palm initiated cell walls within 10 days and produced multicellular colonies within 2–3 weeks which could be seen without the aid of a microscope.

This research has shown that both with various palms and carrots, it was possible to train the Egyptian scientists to isolate protoplasts and to promote cell wall regeneration, cell division and ultimately callus development. There was insufficient time to achieve plant regeneration from the callus, but this is a reasonable objective of future work.

Viability of Cryogenically Treated Date Palm Pollen

Date palm pollen is often stored at low temperature (about 0°C) from one season to the next to insure that adequate pollen is available for pollinating the subsequent crop. Because date palm pistillate receptivity lasts for only about 20 days and male and female inflorescences may vary considerably in their time of opening, pollination with cold-stored pollen is a common practice. However, pollen maintains viability at conventional low temperature only temporarily. Previous work by USDA scientists Tisserat, Ulrich, and Finkle indicated that pollen could be maintained indefinitely when stored at ultra-low temperatures in liquid nitrogen (−96°C) with successful subsequent germination. The study by Tisserat, Gabr, and Sabour shows that cryogenically treated pollen could be utilized in the field in normal fertilization practice.

Date palm pollen was collected in Indio, California, and stored at −20°C until pollination tests were conducted. Ten to fifty mg of pollen were wrapped and exposed to liquid nitrogen in a thermos for about 1 hour. Thawing of the pollen was achieved by removing each of the packages with forceps and allowing them to come to room temperature. Thawed pollen was immediately transferred to cotton balls to hand pollinate previously unopened spathes (inflorescences) on 10-year old 'Deglet Noor' trees; the spathes were then bagged to prevent cross pollination. The pollination was performed on February 12, 1981. The fruit bunches were thinned and treated according to commercial procedures. They were harvested October 21, 1981, dried for four weeks, weighed, and the seeds removed. An evaluation of the germination and growth status of these seedlings was made eight months later. The results of utilizing date palm pollen which had been exposed to liquid nitrogen on yield and subsequent seed germination are presented in Table 3. It is evident that the fruit weight/bunch is not significantly altered and that seed germination and growth of the seedling shoots are not negatively affected by the treatment. Thus, long-term storage of date palm pollen is possible and could be used as a way of providing viable pollen for long periods of time.

A starch gel electrophoresis analysis was done to determine whether the genotypes of germinating seedlings could be ascribed to the two parents that were crossed. Initial results indicated that the presumed crosses actually were made.

Strawberry

The aim of tissue culture of strawberry is primarily to produce virus-free plants on a large scale for commercial production. This is a standard procedure in the U.S. and could be useful in Egypt. Initial steps have been taken in Egypt for development of an appropriate program. The first step is the process of selection of healthy parent clones. Plants of five cultivars were subjected to heat therapy; then meristems (a few millimeters of the stem tip) were excised and cultured aseptically. The shoot tips elongate at a faster rate than the virus can move upward in the plant, so it is possible to cultivate virus-free tissue from the apical meristems.

Table 3. **Influence of Low Temperature Treatment of Date Palm Pollen on Fruit Yield and Seedling Growth.**

Parents and Progeny (a)	*Fruit Weight/ Bunch (Kg)*	*Seed Germination (%)*	*Seedling Shoot Length (b) (cm)*
Deglet Noor x Deglet Noor L10 BC5 (−LN)	3.511	78.0	19.8+/−0.5
Deglet Noor x Deglet Noor L10 BC5 (+LN)	3.669	60.0	18.5+/−0.9
Deglet Noor x Halawy L14 BC3 (−LN)	6.847	77.1	16.5+/−0.7
Deglet Noor x Halawy L14 BC3 (+LN)	5.255	88.7	18.5+/−0.9
Deglet Noor x Thoory L42 BC (−LN)	8.544	86.6	16.6+/−2.1
Deglet Noor x Thoory L42 (+LN)	10.350	57.5	15.3+/−1.4

(a) Specimen pollen samples untreated represented by −LN; specimen pollen samples frozen to −96°C represented by +LN. In some cases, −LN progeny were lost due to cultural handling.

(b) Average lengths and their standard errors were calculated.

Procedures for transfer of regenerated plantlets from tissue culture to the free-living condition in the greenhouse and field will be developed. Indexing plants to assure they are virus-free will be accomplished using indicator plants and serological tests.

Preliminary studies in Egypt have shown some success in inducing callus formation and plantlet regeneration on a M & S medium containing appropriate hormonal levels.

Garlic

Methods are available in California for obtaining disease-free garlic plants using heat therapy and meristem culture. The major limitation to propagating disease-free garlic for commercial purposes is the low level of plant multiplication from shoot tips in tissue culture. Attempts are being made to induce adventitious bud formation on shoot tips, cloves and basal plate tissue of Egyptian cultivars as well as to establish shoot tip-derived suspension cultures with high embryogenic capacity. These approaches could permit rapid propagation of plants, and, possibly yield genetically variable material for plant improvement. This is important because commercial garlic does not flower and breeding, therefore, is not possible.

Potato

Because diseases are extensive and there is no potato virus-indexing program in Egypt, virus-free potato 'seed' (small tubers) is brought from Holland for planting in Egypt, an expensive procedure. The production of virus-free stock in Egypt is scientifically and probably commercially feasible and, therefore, worth achieving. Procedures are similar to those for strawberry: heat therapy, meristem culture, plantlet proliferation and transfer of plants to soil. Mass production of disease-free plants will require growing the tissue cultured plants in an area free of insect vectors or in a screen house which will prevent invasion by insect vectors. Initial steps have been taken in the Tissue Culture Laboratory to develop necessary technology for production of virus-free stock. Meristem tips of the cultivars 'Mirton Pearl,' 'Atlantic,' 'Keswick' and 'Nipogen' were excised and cultured on M & S basal medium containing 0.1 mg/l gibberellin A_3. This was a preliminary study to familiarize workers with tissue culture techniques. In addition, cultures of nine other cultivars were obtained from the International Potato Center (CIP) for investigation of possible new sources of potato germplasm.

Mango

Studies were initiated in Egypt to obtain virus-free tissue material from tissue cultures. Mango, in common with a number of other species, produces dark colored phenolic compounds in tissue culture which interfere with growth of the plant materials. Efforts to reduce development of phenolics by altering media constituents were unsuccessful. To produce disease-free mango plants by tissue culture methods initially will require overcoming this problem.

Celery

While celery is not an important crop in Egypt as it is in California, it is very adaptable for tissue culture research

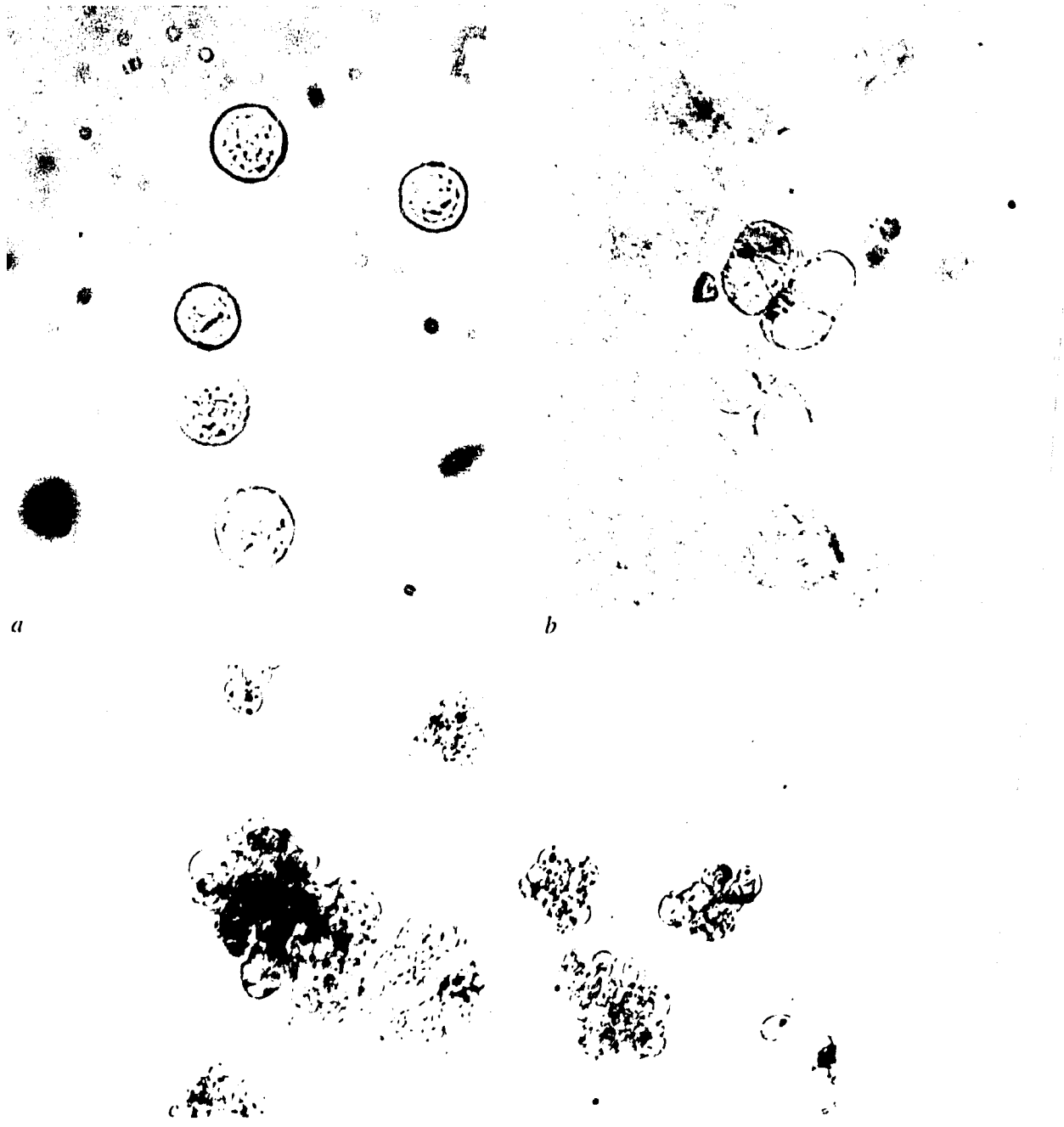

Plate 3. *a)* Appearance of celery protoplasts after enzymatic hydrolysis of cell suspension culture. *b)* Dividing protoplasts after 6 days. *c)* Protoplast division after 12 days.

as well as training. Significant progress has been made in L. Rappaport's laboratory on tissue and cell suspension culture of celery with the aim of producing clonal material, inducing genetic variation and in utilizing tissue culture procedures for selecting plants tolerant to *Fusarium oxysporum* f. sp. *apii*, which causes the fusarium wilt disease.

Research already underway had shown that protoplasts could be obtained from celery callus and the protoplasts could divide. Dr. Faiza A. Taha, working jointly with Dr. G. Pullman, developed suitable media and conditions for culturing protoplasts so that cell wall synthesis, protoplast division, callus development and plant regeneration could be obtained with regularity. Plate 3 shows appearance of dividing protoplasts.

Dr. Taha contributed to this research by modifying the standard M & S medium with respect to concentration, nutrient and hormonal additions. In a comparison of different levels of M & S inorganic salts (0.1 X, 0.5 X, and 1.0 X), media containing 0.1 X M & S salts proved to be the most favorable to promote callus development.

Nitrogen source was an important determinant of callus growth. In a test of nitrogen sources, M & S medium was prepared with the following nitrogenous constituents:

(i) M & S medium minus ammonium nitrate;
(ii) M & S medium minus ammonium nitrate and potassium nitrate; ammonium potassium succinate added (8.25 mM ammonium succinate and 25 mM KCl);

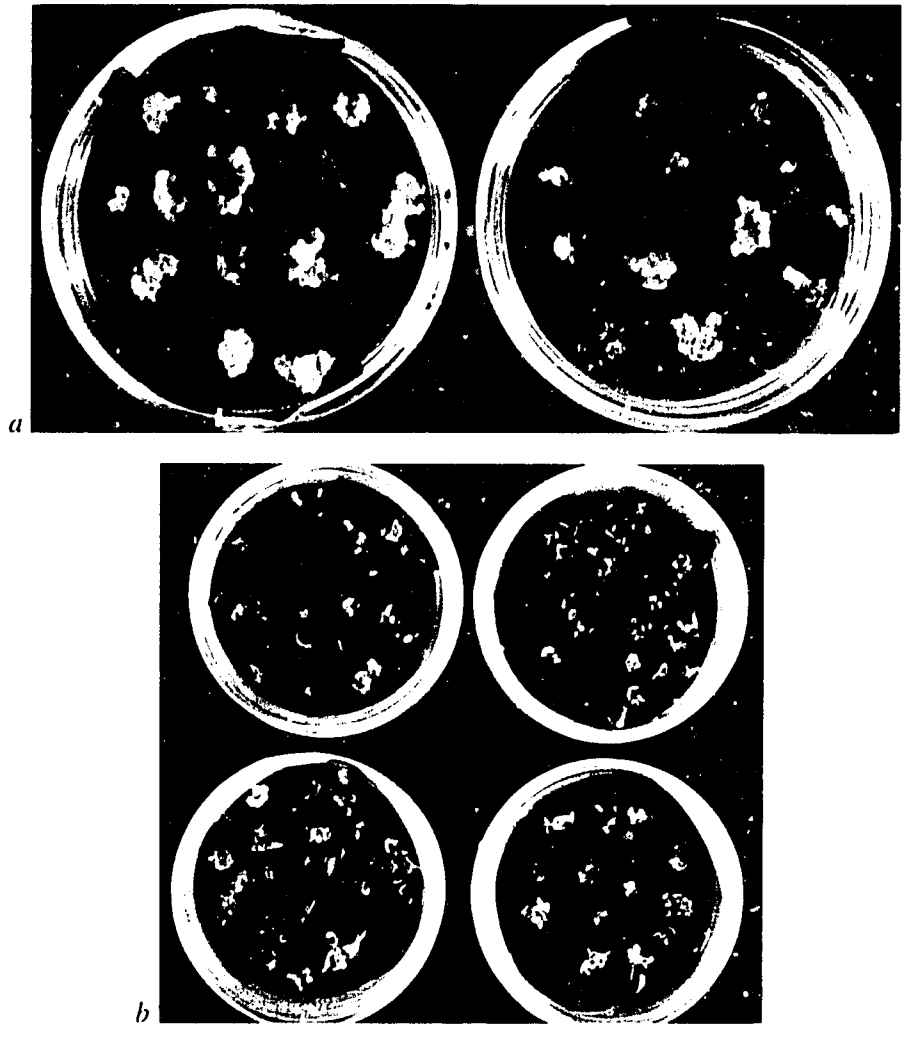

Plate 4. *a)* Callus development from celery. *b)* Plant regeneration. Protoplasts were prepared in November, 1982 and plants were regenerated in June, 1983, about 1.5 months after transfer to regeneration medium.

(iii) M & S medium minus any inorganic nitrogen source. To test the effect of hormonal additions, M & S medium was prepared with six different combinations of 2,4-D, NAA, kinetin and coconut milk. The medium containing 0.5 mg/l 2,4-D and 0.1 mg/l kinetin gave the best callus growth from protoplasts (Table 4). NAA was not effective in inducing callus development.

The microenvironment for promoting rapid protoplast division and callus growth was next investigated. The number of protoplasts required to maximize growth was tested by plating them at different densities in petri dishes (5×10^2, 1×10^3, 1×10^4, 5×10^4 and 1×10^5 protoplasts per ml). A density of 1×10^5 protoplasts/ml gave the best plating efficiency.

The plating method was also studied. Protoplasts were either transferred to the surface of nobil agar or suspended in sea plaque agarose on top of previously plated nutrient medium gelled with nobil agar. The latter method of culture proved to be most suitable.

Illumination often influences behavior of cell cultures. Plated protoplasts were exposed to 1) darkness for six weeks plus dim light for two weeks and 16 hours bright fluorescent light for the duration of the experiment, and 2) 16 hours of fluorescent light. It was observed that the plating efficiency was promoted if protoplasts were incubated under condition 1.

Callus formed from protoplasts was transferred to regeneration medium with gradual reductions in the osmotic

Table 4. **Effect of Coconut Milk, Kinetin (kn) and Auxins on Callus Production from Celery Protoplasts *(P. Calli)*. Medium Contained 0.1 M & S Salts Minus NH_4NO_3.**

Hormonal additions (mg/l)			*# P. calli/ dish**
0.5	2,4-D	+ 0.1 kn	6
0.5	2,4-D	+ 10ml/l coconut milk	3
0.5	2,4-D	+ 20ml/l coconut milk	2
0.1	NAA	+ 0.1 kn	0
0.5	NAA	+ 0.1 kn	0
1.0	NAA	+ 0.1 kn	1
2.0	NAA	+ 0.1 kn	0

*Average of two petri dish replicates.

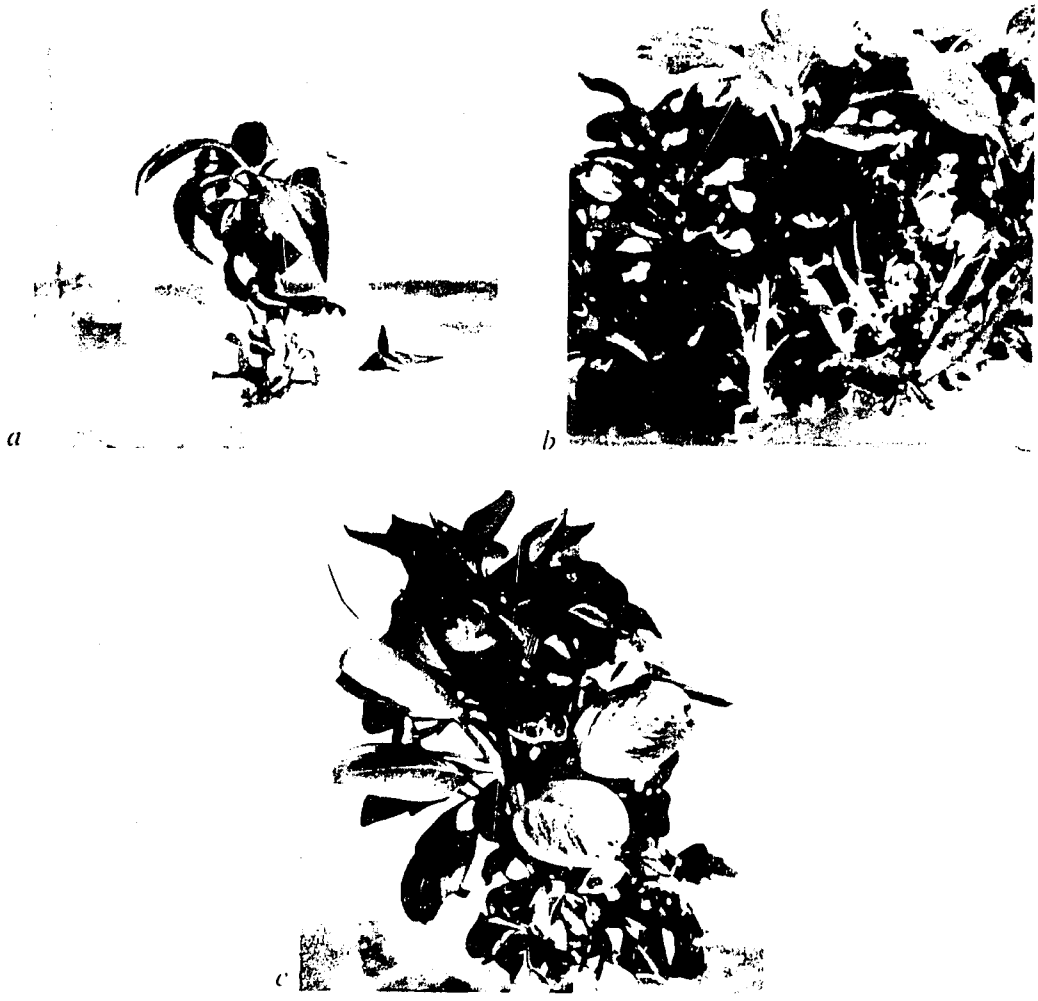

Plate 5. Tissue culture of *a) Pyrus betulaefolia*, *b) P. calleryana* and *c) P. communis* cv 'Winter Nellis.' Note the high level of proliferation of shoots of *P. cal leryana* and the limited growth of *P. betulaefolia*.

concentration from 0.3 M to 0.058 M sucrose. After transfer to regeneration medium, shoots and roots differentiated and plantlet formation was observed after 1.5 months or longer, depending upon the original cell line (Plate 4). Plant regeneration occurred after eight months from the start of these studies.

Thus, Dr. Taha engaged in a research problem which has great significance for cell culture work and, potentially, for genetic engineering of crop plants.

Pear

Micropropagation of Meristem Tips. Lateral buds, shoot tips and meristem tips originated from suckers of *Pyrus betulaefolia*, *P. calleryana*, and *P. communis* cultivar 'Winter Nellis' trees were collected in the fall from an orchard at UCD. Explants were sterilized, isolated and cultured on M & S medium supplemented with various growth regulators. *P. calleryana* shoot tips grew more rapidly than those of 'Winter Nellis' and *P. betulaefolia* in tissue culture. When pear shoots were transferred to fresh medium, a number of new shoots was produced on each mother shoot. Distinct differences were observed in axillary bud development between species. There were 1.8, 7.3, and 51.6 shoots, respectively, per original explant for *P. betulaefolia*, 'Winter Nellis' and *P. calleryana*.Thus, depending on species, it was possible to propagate significant numbers of pear shoots in tissue culture.

Once shoot proliferation had been induced, it was necessary to promote root formation on the regenerated shoots. The medium used to promote rooting consisted of M & S salts and vitamins, 3% sucrose, and either indolebutyric acid (IBA) or naphthaleneacetic acid (NAA) at 0.1, 1 or 10μ^M. Rootone-F, a commercial formulation which contains IBA and NAA, applied at 0.5 and 1.0 g/l either alone or in addition to 162 mg/l phloroglucinol, were also tested. Rooting experiments are continuing.

Regeneration of Plants from Callus Tissue. Stem segments, leaf petioles, or lateral bud-tips were excised from sterilized suckers of *P. betulaefolia* and 'Winter Nellis' pear. Explants were cultured on M & S salts and vitamins plus (per liter) 100 mg myoinositol, 1.0 mg 2,4-D, 1.0 mg BA, 40 g sucrose, 0.8 g agar; pH was adjusted to 5.8. Results indicated that all pear organs tested showed different propensities to initiate callus *in vitro*. Stem segments of

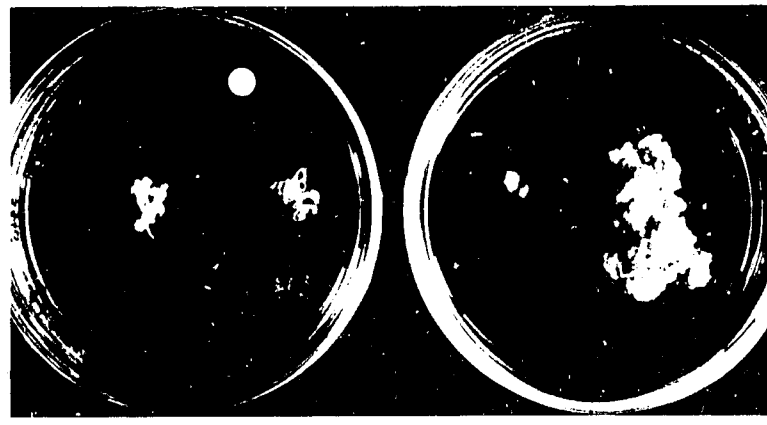

Plate 6. Organogenesis from *P. communis* cv 'Winter Nellis' leaf blade callus tissue.

P. betulaefolia and lateral buds of 'Winter Nellis' produced the most callus. After several months in culture, only 'Winter Nellis' leaf blades tended to form shoot-like structures. The differentiating tissues were transferred to fresh medium either alone or with some associated callus. Initial responses indicate that embryogenesis and organogenesis are occurring (Plate 6). This work by Dr. Taha and Dr. Carole Meredith indicates that propagation by tissue culture of pear rootstock materials is feasible and could be adapted for commercial production in Egypt.

Onion

Dr. Khairat Dawood, a plant pathologist from Mansour University, attempted to develop tissue culture methods useful for selecting plants resistant to disease. Initially, he worked with lettuce, which is being studied in Dr. Michelmore's laboratory, to learn tissue culture technology. Once he had done so, he directed his attention to studies of onion white rot, caused by *Sclerotium cepivorum*, a disease of importance both in the U.S. and Egypt. His plan in studying the white rot problem had two components: to develop an appropriate cell genetic system and to characterize a presumptive toxin produced by the fungus which could be used to select mutant cell lines resistant to the toxin. Having found that M & S medium supplemented with appropriate hormones would foster callus formation, he transferred callus to a liquid medium and was able to obtain proliferation of cells. Using the cell culture system, the occurrence of a putative fungal toxin which could induce symptoms of the disease was explored. Extracts of the fungal culture filtrate were shown to cause toxic effects on onion seedlings and onion cells. This first step indicated that the fungus produces agents which are associated with toxic symptoms on the plant and in plant cell cultures. Much work on purification of a presumptive toxin remains to be done, both chemically and biologically, to assure its role in disease expression. With the proposed toxin, Dr. Dawood plans to select onion cell lines resistant to the toxin by adding the active compound to cells in suspension culture and regenerating plants from surviving cells. Such plants might be resistant to the onion white rot disease. While this is a long-term program, Dr. Dawood developed the basic concepts and methodologies necessary to undertake a cell genetic approach to finding white rot resistant onion plants.

PUBLICATIONS

Edriss, M.H. and D.W. Burger. Clonal Propagation of 'Troyer' Citrange from Somatic Tissue Cultures. Submitted to Scientia Horticulturae.

Edriss, M.H. and D.W. Burger. Influence of Mycorrhizal Fungi on Cytokinin Production in Sour Orange. Submitted to Hort. Science.

Edriss, M.H. and D.W. Burger. Studies on Anther Culture of *Citrus paradisi* Macf. Submitted to Hort. Science HSMS 5683.

Edriss, M.H., D.W. Burger and R. Michael Davis. Mycorrhizal Dependency of Citrus Rootstock Cultivars to Infection by Several Species of Mycorrhizal Fungi. Submitted to Hort. Science.

Sabour, Asma and B. Tisserat. Culturing Sterile Date Palm Seedlings *In Vitro*. Submitted to Egyptian J. Hort.

Symposium on Tissue Culture, University of California, Davis, February, 1983:

a) Pondok, Alaa El-Din A, W. Hackett and L. Rappaport. The Tissue Culture Laboratory: Facility Development, Personnel Training and Utilization.

b) Dawood, M. K. and R. Michelmore. Studies on Tissue Culture of Lettuce and Onion.

c) Edriss, M. and D. Burger. Clonal Propagation of Citrus from Somatic Cultures.

d) Gabr, Mahdia F. and B. Tisserat. Cloning Palms Using Tissue Culture Techniques with Special Emphasis on Date Palm.

e) Sabour, Asma M.T. and B. Tisserat. Obtaining Sterile Date Palm Plantlets from Cultured Seeds.

f) Taha, Faiza A. and C. Meredith. Propagation of Pear Rootstocks Using Tissue Culture Techniques.

VEGETABLE SEED PRODUCTION AND CERTIFICATION

Since its initiation in October 1981, the goal of the project has been to assist in expanding the production of high quality vegetable seeds in Egypt, primarily to meet domestic needs but also to take advantage of possible export opportunities. The main thrust of the project has been to provide training opportunities in seed production and technology and to put in place the basic technology required to multiply superior cultivars by methods which maintain disease resistance and genetic purity through an independent certification and seed testing system.

A comprehensive plan of work was developed at the outset which could lead to the local production of certified seeds of various vegetable crops. The first steps have been taken in accomplishing the several objectives of the plan of work, including purification of stock seed, production of seed under seed certification guidelines, establishment of seed quality standards, establishment of a seed testing laboratory and activation of training programs. The project concentrated its initial technical effort on the improvement and production of tomato and cucurbit seeds.

ACCOMPLISHMENTS

TOMATO SEED IMPROVEMENT AND PRODUCTION

The objective was to produce high quality disease-free seed of six tomato cultivars ('VF 145', 'UC 82', 'Peto 86', 'E 6203', 'Ace' and 'Super Marmand') which had been judged superior in productivity and quality to other commercial cultivars. Within a planting of each cultivar the best plants were selected and their seed increased through Foundation, Registered, and Certified generations to provide sufficient seed to meet the requirements of tomato growers for these cultivars.

Details of the work undertaken in seed production being carried out at Nuba Seed Farm, Kaha Farm and Alexandria Farm follow.

Nuba Seed Farm

Nursery production of seedlings: the soil in a plastic greenhouse was plowed three times while superphosphate was added at a rate of 5 mg for each 100 square meters. The soil was treated with Temic as a nematocide, ridged at 50 cm spacings, and a peat moss layer 5 cm thick added to the surface of the soil to improve seed germination. Seeds of cultivars 'E 6203', 'Peto 86', 'VF 145', and 'UC 82' were treated with Vitavax-Captan (1½ gm/kilo) and sown on January 17, 1982. After full germination, seedlings were sprayed with Tamaron (1.25 cm/100 liter) and Dithane M 45 (0.25%), alternately, every five days for the control of white fly, aphids, and fungus diseases.

Field production of plants: the soil was plowed three times after the addition of 30 m^3 of stable manure per feddan, and ridges one meter wide were set up and both sides smoothed. Seedlings were transplanted 30 cm apart in the presence of water on the north side of the ridges. Transplanting was carried out between March 14–17, 1982, for the three cultivars 'VF 145', 'Peto 86' and 'E 6203', while the cultivar 'UC 82' was transplanted on March 23, 1982.

Seedlings were irrigated at relatively long intervals after transplanting to facilitate deeper penetration of the roots. Plants were irrigated as needed and hoed several times to control the weeds. Ammonium sulphate, urea and superphosphate were used at rates of 215, 164, and 412 kg/feddan, respectively. These amounts were divided into six equal portions and applied at 10-day intervals starting two weeks after transplanting. A leaf foliar spray (Fully Fertile 3/1000) was applied twice, on April 8 and May 5, 1982.

Pest control was achieved using three sprays with Dithane at 0.25% on April 10, May 15 and 25, 1982 and a single spray with Coprozan at 0.35% on May 20, 1982. Two sprays of Tamaron at 0.002% were applied on April 4 and 25, 1982 to control white fly and aphids.

Selection of elite plants: during the sixth and seventh weeks after transplanting, 100 plants from each cultivar were selected for their superior vegetative and flowering characteristics as well as their apparent freedom from diseases. Close observations of these plants continued during the growing and fruiting periods, and plants showing any inferior characteristics were eliminated. The remainder of the plants were divided into three quality categories according to their total yield, general vegetation, and freedom from disease. Fruits from the best category of the original 100 selected plants were harvested and their seeds separately extracted to be used as elite seed for subsequent steps in the seed improvement program. The remaining plants were harvested for Foundation seed.

Production of Foundation seed: isolation distances of 20 meters between the adjacent cultivars were provided and corn plants were grown around the area of each cultivar as an additional barrier. No tomato or other plants of the *Solanaceae* family were grown on the area in the past three years. Roguing and inspection were carried out on May 19 and 26, and June 8, 1982, when off-type plants were removed and counted.

After close inspection of the growing fields of the various cultivars and continuous exclusion of any off-types, the mature fruits were harvested and transferred to the Nuba seed line for tomato seed extraction. To avoid any con-

Table 1. **Area and Total Seed Yield from the Four Tomato Cultivars at Nuba Seed Farm in 1982**

Variety	*Area* M^2	*Total Fruit Yield (ton)*	*Seed Yield (kg)*	*Average Fruit Yield ton/fed.*	*Average Seed Yield kg/ton Fruit*
E 6230	2296	12.138	36.300	22.20	2.99
Peto 86	2114	10.070	23.100	20.07	2.29
VF 145	2800	6.886	25.450	10.33	3.69
UC 82	2800	8.156	29.900	14.27	3.66

tamination or mechanical mixing of cultivars, fruits of each cultivar were extracted on separate days. The seeds were fermented for 24 hours without adding any acid or water and then washed and dried on wire trays in the shade.

The total weight of the harvested fruits and seed yield of each of the four cultivars grown at Nuba Seed Farm are shown in Table 1.

Operations at Kaha and Alexandria farms where the cultivars 'Ace' and 'Super Marmand' were grown respectively, were similar to those employed at Nuba Farm, with modifications as appropriate for local conditions.

SWEETMELON SEED IMPROVEMENT AND PRODUCTION

One feddan of 'Kahera 6' and two feddans of 'Shahd Edfina' sweetmelons were grown at Nuba Seed Farm in 1982 under conditions suitable for selection and production of improved seed for Foundation purposes.

'Kahera' 6 Cultivar

Cultural practices: the soil was plowed twice and ridged after adding organic fertilizers at the rate of 30 m^3/feddan. Seeds were soaked for eight hours in water to which 1% Vitavax-Captan was added and then wrapped in a wet cloth and kept in a warm place for 16 hours to start germination. Seeds were planted on March 23, 1982 with 75 cm between hills. Absent hills were replanted after two weeks using transplants of similar age. The plants were thinned twice, first when the plants had two true leaves leaving two plants per hill and second, one week later, leaving only one plant per hill.

The plants were sprayed at the age of 50 days with Fully Fertile (3/1000) and fertilizers added in five applications (kg/feddan) as follows:

a–30 kg ammonium sulphate + 30 kg superphosphate + 15 kg potassium sulphate, 53 days from sowing;

b–30 kg urea + 60 kg superphosphate, 58 days from sowing;

c–30 kg urea + 60 kg superphosphate + 30 kg potassium sulphate, 70 days from sowing;

d–45 kg urea + 90 kg superphosphate + 45 kg potassium sulphate, 77 days and 83 days from sowing.

Plants were sprayed with Dithane M 45 on May 2 and 19, and with Benlate on May 2, for protection against spotting diseases and gummy stem blight. Plants were also sprayed with 2/1000 Tamaron, for protection against aphids and white fly, on April 13, 23, and 25.

Selection of superior plants: one hundred plants, selected for their strong vegetative growth, freedom from disease, and early flowering, were selfed on May 12. At the last stage of fruit maturity, wilting and complete death of about 20% of the plants due to infection by nematode and *Fusarium* was observed. Reselection for plants tolerant to diseases, especially nematodes, in addition to plant vigor and excellent fruit characteristics was carried out. The growing plants were grouped into three main categories, as follows:

The first category: strong vegetative growth plus relatively high tolerance to nematode;

The second category: strong vegetative growth, but with less tolerance to nematodes;

The third category: moderate vegetative growth and susceptible to nematode and viruses.

The plants of the last group were discarded. The first and second categories contained 108 fruits. Nineteen fruits having a total soluble solids (TSS) value of 13 or more were selected, and their seeds were separately extracted to be used in the continuing improvement program in successive growing seasons.

'Shahd Edfina' Cultivar

Cultural practices: two feddans, within an area of 12 feddans planted with seeds of the same cultivar and from the same source, were plowed twice after adding 20 m^3 of stable manure. Ridges 4 meters long and 2 meters wide were raised after the addition of superphosphate at 100 kg per feddan in the bottom of the ridges. The soil was then flooded with water. Pre-germinated seeds treated with Vitavax-Captan were sown on March 23, 1982. Replanting took place on April 7, 1982.

Chemical fertilizers were added at the following rates: 100 kg ammonium sulphate + 50 kg superphosphate per feddan on April 21; 50 kg urea per feddan on May 12;

50 kg potassium sulphate per feddan on May 25. Foliar spraying with Fully Fertile was also carried out on May 8 and with Eral on June 7.

To prevent spotting diseases, mildew, gummy stem blight, aphids and white fly, plants were sprayed with: Bayleton + Tamaron on April 19; Nemalode + Tamaron on April 28; Dithane + Tamaron on May 8; Rubigan on May 29; Bayleton + Dithane on June 19; Dithane on June 19. Plants were sprayed with Videt on June 22 to control nematodes.

The isolation distance from the other sweetmelon cultivars was not less than 3 km nor had the field been planted with any cucurbits for three years. Inspection and roguing were carried out three times and off-types destroyed.

Plants selected on the basis of good vegetation, having the characteristics of the cultivar, freedom from disease, earliness of female flowers and their ratio, were selfed. Fifty selfed fruits were produced from these selected plants.

Seed extraction: after rejection of plants infected with nematodes in their later stage of growth, fruit data was recorded and seeds of each fruit were separately extracted. On the basis of fruit shape (must be true to type), good vegetation, freedom from disease, and resistance to nematodes, 1,080 fruits were selected and divided into two categories. The first contained 380 large excellent fruits and produced 3.5 kg of seeds, while the second category contained 700 relatively good fruits and produced 8 kg of seeds. These seeds are to be used as Foundation material for subsequent work.

WATERMELON SEED IMPROVEMENT AND PRODUCTION

Original seeds of 16 selected strains of 'Giza 1' cultivar were supplied by the Vegetable Research Department, Ministry of Agriculture.

Cultural practices: the soil at an experimental field located at Nuba Seed Farm was plowed twice after the addition of manure at the rate of 30 m^3 per feddan. Ridges 4.5 m and 2.5 m wide were raised and irrigated after smoothing their sides. Pre-germinated seeds were sown at 1-meter spacings with ten ridges used for each strain. Replanting of absent hills with seedlings, grown in pots was carried out after two weeks. Plants were thinned twice: the first after the development of two true leaves, when two plants were left in each hill, and the second 10 days later, leaving only one plant per hill.

Cultivation was practiced four times to remove weeds and to add soil to the side of the ridges, until the plants came to be in the middle. Irrigation was somewhat delayed in the early stage of plant growth to let the roots grow deeply in the soil, then it was practiced whenever it was needed. Similar fertilization and pesticide treatments were used as for sweetmelon.

Selection, selfing and harvesting: one hundred forty-one plants were selected on May 15 on the basis of good vegetation, freedom from disease, and earliness of opening the first female flower. Strains 1, 6, 9, 12, 13, 14, and 16 were generally characterized by good vegetation, while strains 3, 4, 8, and 11 showed generally weak vegetation. Selfing was carried out in all selected plants.

Selection was also carried out later among plants not subjected to selfing because some of the selfed plants wilted as a result of infection with nematodes. At harvesting, the plants were divided into three groups according to their vegetation and tolerance to nematodes, *Fusarium* and virus diseases.

1. The first group included the plants having good vegetation and relatively high tolerance to both *Fusarium* and nematode, and without any virus symptoms;
2. The second group included plants with good vegetation but less tolerance to *Fusarium* and nematode, and also without any virus symptoms;
3. The third group contained plants with weak vegetative characteristics and susceptible to infection with nematodes, *Fusarium* and virus.

Two hundred and seven fruits were harvested from the plants of the first and second groups and subjected to testing. Fourteen fruits were finally selected from plants with good or moderate vegetation and tolerance to nematode and *Fusarium*, that were true to type, with TSS values higher than 9, with good taste, and with rind thickness of not more than 1.5 cm. Seed separately extracted from these fruits will be used to continue the improvement program in the successive growing seasons.

CABBAGE SEED IMPROVEMENT AND PRODUCTION

Cabbage seed was added to the program for the fall 1982–83 season. The local cultivar 'Baladi' was planted at Nuba Seed Farm. Appropriate procedures were followed for nursery preparation and seed sowing, shading, soil preparation and transplanting, replanting, fertilization, pest control, selection, field preparation for stem cultivation, and roguing and inspection. Four hundred and twenty-eight heads were selected, and their stems and roots were planted to produce registered seeds. From these plants, 20 plants with the best characteristics were considered as elite plants.

PEA SEED IMPROVEMENT AND PRODUCTION

During the winter 1982–83 season, one feddan of 'Little Marvel' was sown at Kaha Farm, and two feddans each of 'Little Marvel' and 'Perfection' were sown at Nuba Seed Farm. Appropriate production and roguing procedures were followed. Four hundred superior plants were selected from each cultivar during the growing season, and this number was further reduced by roguing of inferior plants. Dry plants were harvested in bulk and spread on canvas for drying. The harvested seeds will be the Foundation generation and used for further multiplication.

LETTUCE SEED IMPROVEMENT AND PRODUCTION

Seedlings of 'Dark Green' cultivar were transplanted at Kaha in an area of ½ feddan, and 'Baladi' was planted on one feddan at the Faculty of Agriculture Farm at Alexandria. Appropriate production procedures were followed. After roguing, a total of 20 plants of 'Dark Green' and 18 plants of 'Baladi' were finally selected. The seed

of each plant will be harvested and sown separately to continue the improvement program the following season. After inspection of the two fields grown with the two cultivars and roguing of off-type plants, the seeds of the remaining plants will be harvested as basic seed.

SEED CERTIFICATION PROGRAM

A seed certification program was initiated so that seed of superior cultivars may be grown and distributed in such a manner as to maintain their genetic identity and purity. Vegetable seed crops included are tomato, watermelon, sweetmelon, cabbage, pea and lettuce. Detailed standards were established for land requirements, field history, isolation distances, diseases, cultivar purity, seed germination and mechanical purity for each crop.

During the first year's production of tomato, watermelon and sweetmelon seed, fields were inspected and rogued of plants and fruits that were diseased or off-type. Efforts have been made to establish a certification authority that is separate from production and to give it the legal authority to reject unsatisfactory products and issue certification certificates.

A seed testing facility is an essential part of the seed certification program. For this purpose, two rooms in the former vegetable crops building on the Cairo University campus at Dokki were remodeled to house the new seed testing laboratory. Equipment was ordered for the laboratory with sampling, purity, germination and moisture testing equipment. One room is used for entering the dividing samples and purity testing and the other for germination testing.

The project's training of six Egyptian scientists in the U.S. in all aspects of vegetable seed production will play a vital role in the future in maintaining momentum established by this project.

IMPROVED DATE PALM PRODUCTION

The economic importance of date palms in Egypt and in other Middle Eastern countries cannot be overemphasized. To desert dwellers, date palm is considered a main source of food and shelter besides being the major, if not the only, cash crop.

Egypt is reported to have about 7 million date palms growing in different governorates with a total production of about 420,000 metric tons.

However in recent years a decline in production has been reported and an estimated 50,000 tons of dates are imported annually, mostly from Sudan. The Aswan High Dam reservoir eliminated approximately one million palms and large areas are reported to be going out of production because of poor drainage and increased salinity.

The key to solving current problems in production lies in developing extension and research services which modify available modern techniques in date culture to conditions in the several date growing regions of Egypt. When applied to existing plantings, these techniques should result in increased production and quality of dates.

The Date Palm Project was started in March, 1982 at seven locations in Egypt. In view of the long term nature of this crop, little conclusive data can be presented after little over one year of investigation. On the other hand, vigorous efforts were made to probe the most serious problems in order to establish priorities for future work. In this respect, excellent progress has been made, and propagation, pollination, fruit thinning and fertilization were identified as areas for priority research.

The importance of the date palm in Egypt's overall economy lies not only in the value of its fruit, but also in tree by-products which are used to manufacture baskets, mats and ropes. This illustration shows the removal of leaves from the tree to manufacture baskets. Enthusiastic use of this practice severely reduces fruit yield. The Date Project has made recommendations on the optimum ratio of leaves to fruit bunches. *Photo: Lawrence Rappaport*

ACCOMPLISHMENTS

PROPAGATION

The date palm does not grow true to type from seed. It is propagated asexually by offshoots, which are essentially branches developed from vegetative, auxillary buds usually developing from the base of the parent tree. In Egypt, the survival of offshoots after transplanting is frequently poor because of small size, poor cutting techniques and erratic irrigation. Many small offshoots are discarded during the cutting of commercial-size shoots. Experimental propagation of commercial-size date palm offshoots was undertaken to analyze the requirements for high survival rate in the nursery and field. Trials were made at El-Kanater, Kom Ombo, and Abo-El Rish, using various soil mixes and offshoots from several sources. At 6 months, survival of 'Bint Aisha' and 'Samany' offshoots 6 to 20 kg or more in weight was essentially 100%, irrespective of the soil composition of the nursery beds. New growth occurred in a higher percentage of offshoots over 13 kg in weight than in smaller ones.

At Kom Ombo and Abo-El Rish, about two-thirds of the 'Sakkatoy' offshoots 8 kg and heavier survived at the end of 6 months. Offshoots taken from irrigated and non-irrigated palms were compared at Abo-El Rish. The non-irrigated offshoots had a survival rate of about 50% compared with about 35% for irrigated offshoots. In the nursery all offshoots received uniform irrigation. Further offshoot propagation trials were begun in September, 1982.

Small offshoots of 'Bint Aisha' date palm weighing from less than 1 kg to 6 kg were propagated at El-Kanater, Abo-El Rish, and Zagazig. The treatments included application of various concentrations of indolebutyric acid (IBA), a presoak in water and fungicidal treatments. The data at 6 months were inconclusive although most treatments showed promise of good survival of small offshoots.

The main determining factor in all of these initial studies was offshoot size: The larger the offshoot, the greater the chance of survival and subsequent growth.

POLLINATION

Under natural conditions the date palm relies on wind-pollination to convey pollen from the male to the female flowers, which are borne on separate trees. The unreliability of wind pollination led long ago to widespread use of hand pollination of the date to insure a good set of fruit. This practice is still followed in Egyptian date orchards which are not yet adapted to mechanical pollination equipment.

The pollination requirements of several date varieties were examined at El-Kanater, Kom Ombo, Fayoum, and Pelbeas. The amount of pollen needed to insure good fruit set was studied using a rough measure of pollen quality. Pieces of fresh male flower strands, 15 cm long, were used at rates from 2 to 18 strands per female inflorescence; different males were used in each test. The available data indicate that at least 6 to 8 strands of good male flowers should be used for each female inflorescence to obtain optimal fruit set of dates. Table 1 shows data for the cultivar 'Amri', which is similar to the response of 'Aglani'.

The best time of pollination varied from 0 to 6 days after female flowers (spathes) opened. An interval of only 0 to 3 days was the optimal period for pollination of all varieties studied—'Zagloul', 'Sakkoty', 'Amri', 'Aglani', and 'Seewy'. However, 'Zagloul' and 'Seewy' gave good fruit set even when pollinated between 3 to 6 days after spathe opening.

Two tests with pollen of different seedling males confirmed the fact that males differ, sometimes widely, in their capacity to fertilize female flowers. Identification and use of higher potency male plants in different areas could result in increased yields. Physical and chemical evaluation of the fruit from the several pollination experiments showed almost no significant differences in fruit quality that arise from modifications in pollination.

FRUIT THINNING

A date inflorescence may carry from a few up to 8,000 flowers. To obtain uniform sized fruit and to reduce alternate bearing of palms, the inflorescences (bunches) are thinned to carry 1,000 to 1,500 fruit at harvest, depending upon cultivar, with due allowance being made for some fruit shattering during the season. Such bunch thinning is practiced in the United States and Israel, but in most date growing countries the only thinning is removal of whole bunches at the end of the pollination season. This may reduce alternate bearing behavior but it does not have much influence in ensuring uniform fruit size.

Thinning experiments were made at El-Kanater, Fayoum, Pelbeas, and Kom Ombo. Those trials involved, at various periods after pollination, complete removal of part of the strands of a female inflorescence (bunch), shortening of all strands in a bunch, or removal of whole bunches. The preliminary results on the different cultivars—'Zagloul', 'Seewy', 'Sakkoty', 'Amri' and 'Aglani'—indicate that though removal of about 25% of the strands at 6 weeks after pollination gives good fruit set and yield in a few of the cultivars, most did not respond to thinning. Statistical analysis indicated that thinning had little effect on the physical and chemical properties of the fruit. Clearly there is need for additional studies in this area.

LEAF PRUNING

The palm frond is a valuable commodity in Egypt. It is used for covering houses and the midrib is used for making palm rib crates for packaging and transport of many commodities. Because of their value in commerce, the leaves are harvested, often without regard for the fact that photosynthate produced by leaves is necessary for tree growth and fruit production. If optimal yields of fruit are to be obtained, it is necessary to determine under Egyptian environmental conditions the minimum ratio of leaves to fruit. This information would provide growers with an index of the number of leaves that may be removed for other purposes without endangering the tree or crop yield.

Experiments on leaf bunch ratios were performed at El-Kanater to determine the number of leaves required for proper growth and development of each of several cultivars—'Halawy', 'Sayer', 'Zahidi', and 'Zagloul'.

A leaf bunch ratio of 8:1 gave the best yields for 'Halawy', 'Sayer', and 'Zahidi', a ratio of 10:1 was best for 'Zagloul' (Table 2). Thus yields were related to cultivar and greater attention to cultivar responses will have to be paid in the future.

One of the additional conclusions of this study was that the leaf bunch ratio is an important index that should be

Table 1. **Effect of Number of Male Strands per Female Spathe on Percentage of Fruit Set and Yield of 'Amri' Dates in 1982**

No. of male strands/ female spathe	*Fruit set %*	*Bunch weight (kg)*	*Fruit weight (gm)*	*Fruit length (cm)*	*Fruit diameter (cm)*	*Flesh wt. %*
2 strands	10.80	2.77	17.47	4.40	1.92	92.50
4 strands	12.75	3.67	17.42	4.76	1.83	93.05
6 strands	14.80	3.28	17.71	4.70	1.85	91.47
8 strands	18.07	3.42	17.36	4.69	1.94	93.49

Table 2. **Effect of Leaf/bunch Ratio on Yield and Average Bunch Weight of Some Date Cultivars Grown in El-Kanater, 1982**

Cultivars	Leaf/bunch ratio:	*Yield (kg)*				*Bunch wt. (kg)*			
		6:1	8:1	10:1	L.S.D. at 5%	6:1	8:1	10:1	L.S.D. at 5%
Zagloul		124.40	109.00	132.80	12.12	13.51	14.26	14.47	0.53
Halawi		112.20	132.20	88.20	3.00	14.03	13.22	14.70	0.268
Sayir		74.40	90.20	71.40	N.S.	10.63	11.28	10.20	0.882
Zahidi		63.50	74.40	74.60	2.35	10.46	10.63	10.66	N.S.

used in other kinds of studies related to development and yield. For example, alteration of nutrition or water status of plants may shift the index significantly. Clearly, one future goal should be to study the relationship between the leaf bunch ratio and cultural factors that affect yield in a predictable manner.

FERTILIZATION

Elaborate fertilization studies at Fayoum on 'Seewy' palms and at Pelbeas on 'El Hayany' palms were undertaken to assess the relationship between nitrogen and potassium and various parameters of date palm growth, fruit set and yield. These were started in February of 1982 and it is premature to reach definitive conclusions on the effects of nutrition on date palm plant growth and development. The experimental design included 144 nitrogen treatments and 72 potassium treatments; phosphate was broadcast at the level of 2 kg per tree. There were two sources of nitrogen, ammonium nitrate and urea, three levels of each fertilizer, one to three fertilizer applications throughout the year and two methods of application—broadcast, or in holes bored at the base of the trees. Data were taken on the number of leaves produced, average leaf length, percent fruit set and percent retained, total yield, average fruit weight, fruit dimensions, and pulp/seed ratio at two stages of development. In addition, total soluble solids, acidity and tannin content were measured in the fruit.

In these initial studies, there was no indication that nitrogen levels at the amounts supplied favored fruit set and development, although vegetative growth was enhanced significantly in 'Seewy' date plams, especially in plots in which fertilizer was broadcast. The increase in vegetative growth at the expense of reproductive development suggests that nitrogen levels were too high in these experiments. An interesting effect appeared to be prolongation of the period of leaf growth and function which has implications for extending photosynthetic capacity of leaves and, thereby, the potential for increased yields. In contrast to nitrogen, potassium was shown to markedly affect fruit set as well as the average weight per bunch and the average yield per tree: average fruit weight and percent flesh weight were greatest in the experiments receiving potassium.

Such experiments require several repetitions over time to assess long term effects of fertilizer treatments. Only after rigorous statistical evaluation can final conclusions be reached regarding the optimal levels of nitrogen and potassium needed to produce maximum yield. Another consideration is that trees in this experiment were rather severely leaf pruned; the leaf bunch ratio of 4:1 is considerably lower than the optimal ratio of 6:1 determined in other experiments. Therefore, future experiments should assess the relationship between optimal leaf bunch ratio and potassium fertilizer and other cultural treatments.

Additional fertilizer experiments were carried out with 'El-Hayany' dates in sandy soils in El Pelbeas Province, Sharkia governorate in a somewhat simpler experiment designed to assess the effects of ammonium nitrate applied at three different levels at three times of application, March, May and July. The total applied in different treatments did not exceed 1000, 1500 or 2000 grams of nitrogen per tree. Potassium was supplied at levels of 500 or 1000 grams per tree with either two or three applications made in March, May and July. The May application was omitted from three of the treatments. In these experiments, potassium seemed to have no significant effects on yield, number of bunches per tree or average bunch weight.

Again, because of the very brief period of observation, it is difficult to draw conclusions. It is important that extensive experiments in fertilization be continued for at least three years to determine optimal levels of nutrition for highest crop yields and quality.

INTRODUCTION OF NEW CULTIVARS

While there are millions of seedling trees in Egypt, some of which produce high yields of quality fruit, a major concern is that overall they are not capable of competing in productivity or quality with certain established cultivars which are not currently available in Egypt. A major objective of the Date Palm Project was to introduce high quality cultivars which have been tested and are used in a number of date producing countries. These could serve as the germplasm base for a modern, hygienic, date handling and packaging industry.

Eight female varieties were introduced from California in August, 1982 and were established at the Sabahaya quarantine station. The cultivars are 'Barhee', 'Dayri',

Dates rank second in importance among tree crops in Egypt. In some districts they are the primary crop, a staple foodstuff, and provide seasonal employment opportunities. The problem of falling productivity in recent years has been addressed by the Date Palm Project. New cultural practices have been developed and improved cultivars imported.

Photo: Lawrence Rappaport

'Deglet Noor', 'Halawy', 'Khadrawy', 'Khalasa', 'Medjool', and 'Zahidi', all of which are high quality cultivars of commercial importance.

Attention was also paid to native germplasm resources. The project team identified and described 12 cultivars introduced about 25 years ago to the Mallawy station. Seven seedling female palms in various districts were also identified and described for future study.

ENTOMOLOGICAL INVESTIGATIONS

The entomological work consisted of intensified insect surveys in the principal date palm districts. Field surveys and studies in fruit handling facilities were included. This supplements work that had been underway at various Egyptian institutions.

In the orchards at El-Kanater and Pelbeas, good insect control was demonstrated with two applications of Malathion or Dimethoate.

RECOMMENDATIONS TO EGYPTIAN GROWERS

1. Date palm offshoots trimmed for commercial propagation should weigh a minimum of about 10 kg. Offshoots can be established well in the sandy to silty loam common in Egypt, providing that good care is provided. A fungicidal treatment of the cut base of the offshoot should be used to help prevent butt rot.

2. Pollination should be done within 0 to 3 days after female inflorescences open in the 'Armi', 'Aglani', and 'Sakkoty' cultivars. A period of up to 6 days after flower opening is maximum for 'Zagloul' and 'Seewy'.

3. Exact quantities of pollen required are not known for optimal fertilization since this varies with the male parent and the freshness of pollen. Use of 8 or more 15-cm strands of male flowers should be adequate for each female bunch.

4. A minimum leaf bunch ratio of 6:1, and preferably 8:1, is recommended. Pruning of bunches to eliminate between ¼ and ⅓ of the female flowers on each bunch should provide a satisfactory crop of good-sized fruit depending on variety.

5. Use of at least 1 kg nitrogen/tree/year improves tree growth, fruit set, and yield. Potassium and phosphorus requirements of the date palm have not yet been determined.

6. Control of injurious insects is essential to good yields, high quality, and a proper storage environment, and suitable pesticides have been recommended.

Aside from research results an additional important achievement has been the development for the first time of a coordinated research team approach to improvement of date palm culture in Egypt. The adaptation of current modern technology to culture and fruit handling could make Egypt self-sufficient in date production and could lead to a significant export industry.

Research accomplishments have been limited because less than one year has elapsed since initiation of this long-term project. Nevertheless, the Egyptian team has made remarkable progress in coordinating research efforts and utilizing the facilities at hand. Work has begun under difficult conditions including lack of suitable young orchards, use of old, tall trees for experimental work, lack of equipment, and often limited field experience of research personnel. Complete data on short-term experiments are not yet available and long-term experiments need three to five years for completion. However, enough has been accomplished for the data already available to serve as guidelines for new work and improvements in present cultural methods.

IMPROVEMENT OF BANANA PRODUCTION

Bananas are a locally produced fruit which is nutritious, affordable, but seasonal. In the past bananas have been a good cash crop for the farmer, but in recent years, the production has declined drastically and imported bananas are commonly found on the local market. The Banana Project was established in 1982 to initiate the research and extension necessary to reverse this trend by general improvements in production. This was to be achieved through transfer of information on up-to-date cultivation techniques from the commercial banana producing zones, and by introduction and testing of new banana cultivars.

The cultivation of bananas is unique in that a permanently established plantation of a perennial plant is grown with annual regeneration of the production unit. Vegetative growth is renewed yearly and fruit are developed on the new growth. In contrast to the situation in the banana growing areas of Central America, the effect of chilling in Egypt (low, but above freezing temperatures) and subsequent destruction of plants during the winter period, has resulted in cultivation of the plants on an annual basis with growth renewing in the spring and the crops being harvested the following winter. Through illustrated seminars and informal discussions, the methods of commercial banana production in the highly productive banana growing zones of the world have been compared to the production practices in Egypt. Many of the improved methods of production could be directly transferred to Egyptian conditions following only limited field testing in Egypt.

ACCOMPLISHMENTS

INTRODUCTION OF BANANA CULTIVARS

The four banana cultivars used to produce the majority of the fresh fruit for the world market, 'Williams' (Israel), 'Valery' (Honduras), 'Grand Nain' (Honduras) and 'Poyo' (Somalia) were introduced into Egypt from the indicated countries. The MOA obtained 'Williams' in May 1982 and 'Poyo' in March 1983. 'Valery' and 'Grand Nain' were obtained by the co-team leader in February 1983.

Banana plants are reproduced by vegetative propagation from corms. Due to the danger of introduction of viral, bacterial or fungal diseases or nematode and insect pests from abroad, the plants were placed in quarantine for one year. The cultivars 'Valery', 'Grand Nain' and 'Poyo' came from areas where disease, nematode and insect problems exist that are not prevalent in Egypt. Of particular concern was *Fusarium* wilt, Panama disease, *Psudomonas* bacterial wilt, moko, the nematode *Radopholus similis*, the banana root borer, and several fruit damaging thrips.

New cultivars introduced by the Banana Project are seen here undergoing field evaluation under varying conditions of fertilizer and irrigation.

Photo: Nadir Hashem

The cultivar 'Williams' was certified by the Ministry of Agriculture in Israel prior to release in the Middle East. Therefore, this cultivar was obtained in large numbers and planted directly in quarantine field nurseries in Egypt. These plants were judged to be clean and subsequent field testing was begun during the 1983 growing season.

FIELD TESTING OF CULTIVARS

During the 1983 growing season field tests were established to compare 'Williams' with the cultivars currently grown in Egypt. Upon establishment of a banana plantation, the first, or ratoon crop, only gives marginal yield and experimental data are generally not used to draw conclusions. The best data are obtained from the third generation and three years of data are used as a basis for decisions regarding cultural practices and choice of cultivar.

With the introduction of 'Williams', quarantine field nurseries were established at Kena, Aswan, Kalubia, Monfia and Gharbia to provide initial information on the adaptability of this cultivar to the banana growing zones of Egypt. Trials were established at the El-Kanater Agricultural Experiment Station where greater control of cultural practices could be assured.

Two major experiments were planned to compare the relative performance of cultivars and the effects of planting density on performance. In the cultivar test, the tall 'Williams' and 'Maghrabi' cultivars were planted on 2.5 by 2.5 meter square plantings and the short 'Basray' and 'Hindi' at 2.0 by 2.0 meter square plantings. Data will be taken on plant growth, flowering date, yield and quality of the fruit; yield data should be taken for at least five years.

Proper population and spacing are two of the primary production concerns in most of the banana growing regions of the world. Because much of the research on bananas is done by commercial companies, results are not published and guidelines are therefore not readily available. Due to the varying climatic conditions between banana zones, optimal plant populations will vary for the same cultivar. Therefore, a field planting program was designed in an hexagonal orientation to test the response of 'Williams' banana at different planting distances. The plants were spaced on equilateral triangles at distances of 2.25, 2.50, 2.75 and 3.00 meters. Data will be taken on plant growth, flowering date, total yields and quality of the fruit to determine the best spacing to maximize yields in Egypt.

Two additional observation plots were planned to compare nitrogen levels at 200, 250, 300, and 350 grams per plant per year and potassium at 0, 250, 500 and 750 grams of potassium oxide per plant per year. Potassium in particular appears to be limiting banana production and extensive research on this element is needed. A graduate student's research has already indicated a positive response to the application of potassium sulfate on local cultivars grown at the El-Kanater Experiment Station.

THE ECONOMICS SUB-PROJECT

HAROLD CARTER, *Co-Director (UC)*
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Egypt's rapidly expanding population, and the desire for a higher standard of living continue to make demands for increased domestic agricultural production. The scarcity of good farmland however has forced planners to concentrate their efforts on providing plentiful year-round water, so that crop production can take advantage of the favorable climate. The keystone of this was the Aswan High Dam completed in 1970, making irrigation water plentiful and inexpensive to farmers. Improvements in the drainage system, however, did not keep up with the development of the irrigation network. The result has been water logging, increased salinization, and decreased yields. Besides this serious land deterioration problem many economic problems persist that limit the growth of the agricultural sector.

There is general agreement that the government has adopted a number of policies and practices, such as price controls, taxes and subsidies on imports, compulsory planting rules, and so forth, that have caused divergences between "free market" prices and the actual prices farmers receive for commodities and prices consumers pay. The "price distortions" influence the amount of production, consumption, the techniques of production, the distribution of income, the volume of exports and imports, tax revenues, saving and investment, and virtually every aspect of economic activity, besides having a crucial effect on the development of the agricultural sector.

The ADS Economics Sub-Project was designed to engage in a wide range of research and training activities to improve the ability of the Egyptian Ministry of Agriculture (MOA) to plan, implement, and evaluate programs promoting the development of the agricultural sector in Egypt. The immediate short-run contribution of the Sub-Project has been to engage about 270 members of the Egyptian agricultural economics community in policy-relevant research and to offer technical and policy guidance to the MOA policymakers. Collaborative research activities combining the efforts of Egyptian, University of California, and other U.S. agricultural economists were created as the principal vehicle through which ADS has contributed to (1) the professional development of Egyptian agricultural economists, and (2) the research and decision-making capabilities of the MOA. This on-the-job research training has been supplemented by seminars, guest lectures, workshops, symposia, exchange visits by both U.S. university and Egyptian researchers on activities, short- and long-term training programs at the University of California, short-courses of instruction in Egypt, and other educationally related activities.

During its life (1980-83), the Economics Sub-Project spent approximately $3.5 million (U.S. $ equivalent) sponsoring 23 research projects, engaging 238 Egyptian PhD agricultural economists and 145 junior Egyptian personnel in collaborative research with 46 university agricultural economists (UC and other U.S. institutions). Their research activities produced more than 183 working papers. There were 70 short-term training visits by Egyptian researchers to the University of California, and more than 40 seminars and guest lectures, 10 major Economic Policy Workshops, six mini-workshops and training sessions, three special 10-week "English for Economists" courses, and a weekly class in computer training in Egypt, all sponsored by the Sub-Project.

Starting in mid 1980, the Economics Sub-Project focussed on soliciting, reviewing, developing, and implementing research proposals. Substantial efforts were devoted to developing collaborative research teams composed of University of California personnel and the MOA, as well as Egyptian university researchers. During the second and third years of the project, emphasis was directed toward developing the educational program, promoting short- and long-term training, and disseminating research findings and fostering policy

discussion through workshops and seminars. During the last six months of the project the administration devoted itself to carefully monitoring the activities, encouraging the orderly closing and completion of ongoing research work. On conclusion of the project on August 31, 1983, it was apparent that the Economics Sub-Project had made a substantial contribution to achieving its objectives of promoting policy-relevant research to aid MOA decision making, supporting the professional development of the Egyptian agricultural decision making, supporting the professional development of the Egyptian agricultural economics community, and developing the institutional capacity of the MOA for carrying out the policy-relevant research necessary for developing the agricultural sector in Egypt.

ACCOMPLISHMENTS

The ADS Economics Sub-Project was given a mandate to study six major policy areas of priority research:

1. Price Policy
2. Agricultural Marketing and Distribution
3. Human Capital and Social Institutions
4. Food Security Policy
5. Allocation of Development Resources
6. Land and Water Resource Use

Research proposals were solicited from and submitted by both Egyptian and American university economists (predominantly UC) and were reviewed by the Joint Egyptian-California Economics Technical Committee. Guided by the advice of the technical committee, the Sub-Project administration implemented 23 research projects focussed in one or more of the areas of priority research.

The research findings and policy recommendations of each project are presented later in this report. Below is a general overview of the research program according to the six major policy areas of priority research. Many recommendations are unanimous; others are conflicting. Some merely pose the problem; solutions await further research. The attempt in these few pages will be to identify common threads and highlight important findings. The key to revitalizing the agricultural sector seems to be in redesigning the system of incentives and institutions.

PRICE POLICY

For many years the Egyptian government has imposed a high degree of control on agricultural prices. Since the initiation of the Open Door Policy in 1974, the Egyptian government has been moving towards a more open, market-oriented economy. There are numerous examples of low government-set producer prices acting as disincentives to increased domestic production and low government-set consumer prices encouraging increased consumption. These price policies encourage imports, adversely affecting the balance of payments, and discourage the development of the agricultural sector. Many of these price intervention policies of the Egyptian government led to resource misallocation, reduction of national income, and maldistribution of income, conflicting with the goal of achieving social justice. Numerous ADS research activities were focussed on contributing to the rationalization of these pricing policies to promote economic efficiency, social equity, and the development of the agricultural sector.

The price policy area was given the greatest attention by the Economics Sub-Project. Three projects which focussed primarily and directly on the price policy questions were the Food Subsidies, Food Security, and Price Policy and Trade projects.

Substantial contributions to the price policy area were also made by the following projects: Land and Water Allocation, Mechanization, Cotton Markets, Livestock, Farm Efficiency, and Policy Analysis.

Various studies showed that when farm-gate prices of some commodities are controlled at low levels, farmers transfer resources to production of those commodities which are relatively more profitable. Hence, Egyptian farmers curtailed production of cotton and grains and expanded production of those commodities with free market prices: fruits, veg-

etables, and livestock products. But this resulting product mix was not what the government intended. Rather, more cereals and cotton were needed, so a system of allotments and quotas was imposed and subsidized inputs offered, which slowed the shift to alternative crops. Evasion of compulsory acreage and deliveries was common because the benefits of violation exceeded the cost of penalties, even when paid.

Because of the existing and ever-worsening food crisis, the government "expects" farmers to devote production to major staples for human consumption but price signals are not encouraging them to do so. Favorable (free) livestock project prices for example, induce farmers to grow feed and fodder, especially berseem.

While it may be possible for a centrally-planned agricultural system to impose area controls successfully to optimize national food security, the problem with Egypt's attempt is that price policies contradict the allotment-compulsory delivery system. The result is massive evasion of controls. Further research is needed to weigh the cost and benefits of having rules and regulations that are so widely violated.

For several commodities, e.g., rice and beans, farmers can sell quantities grown beyond quotas on the free (black) market and thus at least partially mitigate their losses. Apparently, the existing system benefits larger farmers relative to small ones because they have more to sell on the residual market. Also, the existence of this surplus supply beyond quotas of certain commodities makes their forced deliveries totally irrelevant to the national food security goal. Where quota prices rose to or near world price levels, farmers would be given economically efficient signals and would respond accordingly. On the other hand, if the domestic open market price for a commodity is greater than its international price, then import restrictions should be removed and imports increased.

A conclusion of one study was: To encourage the switch from berseem to grain, administered grain prices should be raised and supplies of low-cost feed from other sources provided. Another study suggested a price support system similar to that in the United States. Surely, subsidizing wheat imports has discouraged local production. Indirectly, maize production is affected whenever cheap wheat is used for feed.

Another group of analysts found that substantial improvements in agricultural productivity would be associated with regional specialization. The current price and area controls, e.g., for rice, seriously undermine Egypt's potential for regional specialization.

Existing institutional arrangements, government interventions, and controls are all responses to a situation in the past, frequently a crisis. Actions, which when taken had an urgency, were continued and became ingrained into the economic-political structure—so ingrained that it becomes risky to remove them even when they are no longer meaningful—,e.g., compulsory deliveries on commodities produced in surplus. The result is that, rather than an integrated comprehensive agricultural policy, a crisis-oriented, piecemeal, commodity-by-commodity approach is in use.

Various ministries with different objectives often operate at cross-purposes. For example, the Ministry of Supply imports yellow maize and distributes a large part of it at subsidized prices to the Ministry of Industry which makes feed mixes according to formula provided by the Ministry of Agriculture. Cottonseed used in the mix is obtained from gins operated by the Ministry of Economy. A consistent call from the many project papers is for a more integrated approach to policy and its operation in the food system.

The recurrent theme is for a coordinated drive to reorganize the entire food chain towards a more open-market economy in which government interventions in price-making and subsidization are curtailed. A sudden switch to a free market economy is unlikely however and probably not advisable. Instead a more gradual progress in this direction seems desirable and, again, on a commodity-by-commodity basis. Given the complex array of interdependencies among commodities and between micro- and macro-levels, repercussions of these changes will be felt throughout the system. The end result is difficult to predict. A better understanding of all the interconnections is called for in order to determine the actual effect of a proposed policy change.

The ratio of Egypt's agricultural exports to agricultural imports was once above three. It was greater than one until 1974; it has now fallen to unprecedented low levels. The domestic agricultural pricing system has been divorced from international prices measured either by the official exchange rate, which overvalues goods traded, or by the true international

rate. The insulation of the agricultural sector from international market influences has resulted in its repression. When Egypt "opened" to a greater participation in the international marketplace, nonagricultural sectors were stimulated, but agriculture was left behind. In fact, belief that nonagricultural sectors have more potential for continued development became a self-fulfilling prophecy as measures biased against agriculture were applied. One study on intersectoral transfers confirmed the substantial outflow from agriculture to other sectors of the economy.

The recommendation of several analysts was to loosen the constraints holding back the agricultural sector so farm exports can play a stronger role in the economy. As a start, one linear programming study suggested an optimum trade pattern among several commodities that would reduce the current agricultural trade deficit by about one-fifth. The effects of the international market on Egypt's production strategies need careful attention. For example, to expand areas in wheat may actually work contrary to food security goals by taking away land from crops that could earn foreign exchange.

Egyptian government agricultural price policies are indeed changing. Price decontrol is underway for all horticultural and most field crops. ADS research and policy workshops on these issues have contributed to these changes in governmental involvement and policy revision.

AGRICULTURAL MARKETING AND DISTRIBUTION

Handling, storing, transporting, processing, and marketing agricultural output are recognized as potentially serious constraints on the development of the agricultural sector. Prior to the establishment of the ADS Economics Sub-Project, there had been little agricultural marketing research in Egypt, there had been poor coordination among researchers, little building on past research, and a serious lack of marketing data available to researchers and policymakers. The Sub-Project research activities focussed on both domestic and export marketing constraints on Egypt's agricultural development. In the area of marketing research the Sub-Project made the strongest efforts to integrate the economics and the horticulture research studies within ADS.

Five research projects contributed directly to the priority area of agricultural marketing and distribution research: Marketing Potential (for Egyptian horticultural exports), Post Harvest Efficiency, Citrus Marketing, Commodity Systems Analysis, and Price Policy and Trade. In addition, the following projects made partial contributions to the marketing area: Livestock, Cotton Marketing, Cooperative Improvement, Poultry, and Policy Analysis.

It is widely believed that Egypt has a suitable climate to produce horticultural crops for export, especially fresh tomatoes and cut flowers to Western Europe. Several studies tested elasticities in potential receiving countries and determined that quantities added from Egypt would not have a depressing effect on prices. Export marketing, however, should be a definite strategy involving producing for the international market, not just shipping whenever production exceeds local requirements. Not only should Western European markets be considered, where Spain's entry into EEC may pose too much of a competitive threat, but also Middle Eastern and Eastern markets should be expanded to include a wider variety of products than flowers which Egypt currently ships to Russia and the Middle East.

If the export market is to be revived, many changes besides production reorientation will be needed. Consolidated decision making, rather than the current multiple-agency involvement, was recommended. The ADS Economics workshop on export promotion suggested that a high council for agricultural exports be established, special committees on each principal exportable product be formed, and an agent be located in each foreign marketing center to act as a liaison between these special committees and importers.

Bottlenecks in the many services between the farm and the international consumer need to be discovered and alleviated. For example, the complex documentation required for flower exportation needs to be simplified. Positive action must be taken to improve handling, storage, and shipping facilities and to reduce postharvest losses.

Not only is it necessary to improve facilities for exporting commodities and for handling imports—more cold storage, for example—but the infrastructure for marketing all commodities in Egypt needs further development. Agricultural marketing research has received insufficient

attention with a higher priority being placed on endeavors to increase production. Modifications in the handling-processing system, however, should be in a direction appropriate to the economy—that is, too capital-intensive a development may be wrong for what is basically a labor-surplus nation.

The Cooperative Improvement Project identified the lack of cooperative involvement in marketing of agricultural products. The marketing procedures are cumbersome and slow, and the members feel generally that the marketing arrangements through the cooperatives are unsatisfactory. The current marketing centers are not located for the convenience of the farmers.

Reorganization of the cooperatives' objectives and methods of operation so as to better represent the members' interests would undoubtedly improve the functioning of the cooperative system. In particular, the role of cooperatives in marketing could make a more valuable contribution to the development of the agricultural sector in Egypt and to assuring adequate incomes for cooperative farmers if specialized marketing cooperatives were allowed more decentralized control over marketing and were able to respond to the desires of the farmer members more directly than in the present system.

HUMAN CAPITAL AND SOCIAL INSTITUTIONS

Research efforts in this area of priority research have focussed on specific human and institutional features of the Egyptian agricultural economy. Problems studied include those of agricultural labor supply and demand, on-farm and off-farm employment opportunities, the impact of the choice of technology and mechanization on labor, productivity, and rural welfare, village decision making, the evaluation of cooperatives in the agricultural sector, studies of the efficiency of the Egyptian farm and farming system, and studies of energy use and alternative energy sources available in Egypt.

Major contributions to this area of research were made by five projects: Rural Labor Supply, Farm Efficiency, Cooperative Improvement, Economic Efficiency, and Integrated Village Studies. Additional research in the area of human capital and social institutions was done by projects on Post Harvest Efficiency, Biogas Evaluation, Policy Analysis, and Rural Development and Consumption.

Over the last few years there has been a definite rise in the real wages of hired farm workers, an occurrence which is often taken as justification for capital-for-labor substitution. One study investigating whether increased wages resulted from the demand side, such as a change in cropping patterns, concluded that it was a supply-side phenomenon. Survey data lent support to the hypothesis that wage increases stemmed from migration-induced supply changes. Egypt's prime age males have been leaving by thousands to work in other Arab countries short of labor. Partly because of the inherent selectivity of the migration process, in which the strongest, brightest, and best venture out, labor shortages have been created in the agricultural labor supply for specific key tasks. Thus, emigration seems to be the source of the current "labor shortage" complaint in Egypt.

The government's response has been to encourage and subsidize mechanization. Studies suggest it may be a mistake, however, to install irreversible capital-for-labor changes in a situation in which overseas employment of Egyptian labor may diminish. The construction boom in other countries may end. Egypt's political relations with receiving countries may deteriorate further, and increasing numbers of Asian workers have recently been arriving in the Middle East.

Further, there are many uncertainties about mechanization. Appraisal reports of mechanization-funding agencies tend to make sweeping assumptions about social benefits. There is little or no evidence that mechanized farms have higher yields than non-mechanized ones, though mechanization may help to curb deteriorating yields. Care must be exercised in reading latent signals given by resource scarcity in a country where most of the links are regulated. Subsidies on energy and equipment and "taxes" on some crops have severely distorted inducement signals. Existing agricultural labor shortages are rather specific and seasonal so that mechanization efforts might better be directed to alleviate particular problems rather than as an overall general strategy.

A study of landless farmworkers found that their main jobs were to apply fertilizer, hoe, harvest, and do various postharvest operations; major jobs of threshing and land

preparation have already been mechanized. Further mechanization might entail a high social cost if jobs are removed from these "poorest of the poor," particularly if and when emigrants return.

Other studies, however, urged readiness to expand mechanization of certain tasks if the labor shortage persists. An integrated effort among agricultural engineers, plant scientists, farmers, the MOA and the universities would be needed to mechanize production of non-traditional crops. Again, care should be taken that the mechanization effort is appropriate to the situation at hand.

Tractor numbers in Egypt are now about 38,000, but parts and service facilities are scarce. Progress toward standardization of equipment is important. Not enough attention has been paid to technical training for operating and maintaining machinery. Recently, however, an agricultural extension effort has been made in this direction. A successful mechanization strategy must proceed hand in hand with efforts to upgrade the rural infrastructure.

Research is still needed to evaluate the multifaceted aspects of mechanization, particularly its social impacts. "The truth is," one researcher wrote, "we don't know whether mechanized or nonmechanized farms have higher yields or whether there actually is a labor shortage and, if there is, how long it will last. It is disturbing that vital policy decisions with long-term consequences are made in such a knowledge vacuum."

FOOD SECURITY POLICY

Egypt is confronted by the task of providing increasing amounts of food for a rapidly growing population with a relatively densely populated and fixed land base. ADS Economics Sub-Project research efforts regarding food security, just as government policies themselves, were not limited to problems of improving production, but also dealt with pricing policies, food processing, transportation, and other post harvest and marketing problems as well as nutrition, income distribution and foreign trade relationships.

The Food Subsidies, Food Security, Food Consumption, Livestock, Poultry, and Commodity Systems Analysis research projects focussed principally on food security policy issues. The Post Harvest Efficiency, Citrus Marketing, Economic Efficiency, and Policy Analysis projects also contributed to policy-relevant research in this central area of policy formation.

Although the average per capita consumption of calories and protein in Egypt is adequate, and even excessive for some parts of the population, malnutrition is prevalent because of maldistribution of food. The problem is most severe in rural Egypt among the poor. Malnutrition, originating in this way, is perpetuated by a vicious circle. When people are poor, their level of nutrition is low; poor nutrition in turn lowers productivity, reduces income, and exacerbates the poverty at the root of the problem. Some government programs are attempting to break into this cycle.

Proposed measures to alleviate the malnutrition-due-to-maldistribution problem include: crash programs directed at nutritionally vulnerable groups, for example those who seek to increase legumes in the diet relative to cereals; nutritional education; enrichment of commonly consumed foods by addition of critically short nutrients.

Although the most popular suggestion from a survey among fellahin was to establish more retail cooperatives amply supplied with reasonably priced food, the main problem does not seem to be availability of food but being able to afford to buy what is available. An obvious suggestion, then, is to increase rural incomes. But low rural incomes themselves rely largely on outcome of current government crop pricing programs.

Income elasticity studies showed greater responsiveness in rural than in urban areas—that is, where rural incomes increase, people would buy more food. But other studies showed that, given the existing price structure in which prices of basic crops are controlled, but those of animal products are unregulated, fellahin will consume more vegetable protein with a rise in income, but continue to sell animal products to others. On the other hand, a strongly recommended way to increase the protein intake of rural households was to encourage them to raise livestock and poultry. Extending credit to farmers for livestock purchases was suggested.

Meanwhile, the government has made a serious attempt to alleviate malnutrition by extending food subsidies. Although Gini coefficient studies have shown that subsidized or rationed commodities are more equally distributed by income class than those not subsidized or rationed, distribution of the former is much less effective in rural areas. Since rural people are, on average, poorer than urban people, food subsidies may have an unintended perverse effect on income distribution.

Population growth and rising per capita nonagricultural income over the last 15 years have led to a rapid increase in the demand for food. With the stagnation of domestic agricultural production, the food gap between demand and supply has widened at an alarming rate. Ever-increasing imports fill the gap and all food prices would escalate but for government food subsidies. Devaluations of the Egyptian pound have made food imports more costly, calling for expanded subsidies.

The government's goal has been to guarantee a minimum level of food availability for all Egyptians. One analyst showed that removal of the subsidy on wheat would result in a large nutritional sacrifice by the poor. However serious problems and unintended effects have ensued from food subsidies. There has been a very high growth rate in the consumption of subsidized items, and vastly increased dependence on imports. Uncertainties of supplies have led to irregular buying habits, costly queues, and a black market in several commodities.

Another serious problem is waste, and diversion of subsidized food from human consumption. The most frequently cited example is bread, which is so cheap it is allegedly sometimes used as livestock feed in the country. One survey in three cities showed that while some low-income households use bread to feed poultry, others without poultry and higher income families, simply throw away their extra bread. When a subsidy puts a commodity's price near zero and when there is an ample supply, then the rational consumer will not "invest" in waste avoidance. Given that much or even most of Egypt's wheat is imported, the broad situation succinctly illustrates the distortions that can result from government intervention.

Some alternative solutions to the malnutrition problem were mentioned in the previous section. The U.S. food stamp system was studied by project members as a possible alternative to food subsidies. Stamps could be better directed at target groups. Single prices would exist for each commodity rather than the current subsidized and black market rates. People would be given more freedom of choice and greater satisfaction while meeting their nutritional needs.

The main problem with food subsidies seems to be that the government, in order to provide cheap food mainly to urban poor, has put controls on farmgate prices received for some crops and prescribed compulsory deliveries and/or allotments. The result is severe distortions in the allocation of resources.

All research shows that the achievement of food security must be approached in several ways. On the one hand, changing the cropping pattern to minimize risk of agricultural sector foreign trade deficits can make a substantial contribution. But, also, investments in post-harvest handling and processing are necessary to complement production policies.

ALLOCATION OF DEVELOPMENT RESOURCES

Agriculture is still the largest sector in the Egyptian economy, contributing about a quarter of the gross domestic product and employing almost two-fifths of the total labor force. In the past decade, however, the agricultural sector has received only 7–12% of total public investment. In addition, the discriminatory pricing policies oriented to benefiting urban consumers and other sectors of the economy at the expense of the agricultural sector are drawing resources out of agriculture. Taxes or implicit taxes paid by agriculture exceed the subsidies received by agriculture, implying a net capital outflow from agriculture to other sectors of the economy. Decisions concerning the allocation of development resources, both between the agricultural and other sectors of the economy and among alternative investment programs within the agricultural sector affecting the long-run development of the agricultural sector in Egypt have been the concern of several research activities.

The Mechanization, Irrigation Evaluation, Lakes Development, and Biogas Evaluation projects made substantial contributions to determining the optimal allocation of development

resources. Additional study of these important issues was accomplished by the Rural Labor Supply, Livestock, Cotton, Citrus and Policy Analysis research projects.

Agricultural intensification, generally directed at Egypt's traditional farmers, aims at achieving a more favorable output-to-input ratio with respect to each input, but particularly in Egypt's case, to land. In the attempt to extract more output from limited resources there is a temptation to shortcut the process and adopt ready-made capital-intensive technology imported from developed countries. More appropriate for Egypt, however, would be a small-scale industry which manufactures small, relatively inexpensive but improved farm inputs, as well as equipment for marketing and processing.

One way the government has tried to help farmers to intensify production is to provide input subsidies. In spite of costly subsidization of fertilizer and pesticide prices, the gap between what is needed and what is available is increasing rapidly. Farmers tend to defeat governmental plans, for example, by putting subsidized inputs intended for cotton on other crops. One study showed that allowing free trade in fertilizer could reduce its (black market) price and then fertilizer use might expand by some 40–50%.

Input subsidies of capital equipment may have caused another serious distortion: under-utilization of inexpensive abundant labor. Here, however, is room for serious debate as some in Egypt believe there is actually a "labor shortage".

Several commodities are of such importance to the development of the Egyptian agricultural sector that special research effort, including a number of papers, workshops and conferences, was directed to these several more specialized areas: cotton, citrus, livestock, and poultry.

Cotton has been an important crop in Egypt since the early 1800s. Although Egypt's cotton represents only a small portion of the world's total, Egypt has been a principal supplier of extra-long staple (ELS) cotton and historically has enjoyed some degree of monopoly power, receiving premium prices for ELS. Also, cottonseed provides about 90% of Egypt's edible oil, and cottonseed cake is an important livestock feed.

Lately, however, premiums for ELS have fallen sharply. Cotton exports are way down and stocks are accumulating rapidly. It seems that as the world's blending technology has improved fewer end uses require ELS. Meanwhile, the domestic cotton spinning industry has been fraught with problems: machinery is obsolete; there has been underinvestment in replacement or new equipment; high-cost ELS has been used to weave coarse and medium yarns. Efficiency would call for either import of shorter staple cotton or improvement of yarn quality, but equipment obsolescence precludes the latter. Researchers on the cotton project had some difference of opinion about how to improve the situation. Some felt that despite government production and pricing policies that have implicitly taxed cotton farmers very heavily, Egypt may still have a comparative advantage in cotton were farmgate prices raised to give farmers proper incentives. The question of whether or not there still exists a specialty market for ELS needs to be clearly answered. If not, then Egypt should switch completely from ELS to higher-yielding long varieties. Since Egypt cannot even supply its own textile industry adequately, some higher yielding varieties should be grown even if there still is a market for ELS.

Experiments with short staple, short season cotton should continue, since these varieties are land saving in that they mature much earlier than other varieties as well as saving on other inputs. Also, high yields would better cover labor and other fixed costs of production.

Demand for *oranges* for both domestic use and export exceeds supply, encouraging further development of varieties with better yields. A special effort is being made with 'Navels' and 'Valencias'. Policymakers must however be made aware of the long time lag involved in the supply response of a perennial crop. Even with no exports, the expanding population means greatly increased demand for oranges, but rigorous price ceilings have reduced grower incentives, thus thwarting increased supplies. Farmers should be provided with better outlook information, better price incentives, and assistance in improving their productivity. Of course, a reduction in the population growth rate would greatly reduce the severity of the adjustment problem.

Increasing population and increasing per capita incomes have greatly increased the demand for *livestock and poultry products*. Demand exceeds domestic supplies with imports filling the gap, raising prices beyond the reach of many. Meanwhile, there is a serious

deficiency in animal protein, particularly among the young and rural poor. In response to the situation, the government has intervened on many fronts.

Analysts of the Economics Sub-Project, after studying the situation, have made several recommendations. First, the dominant role of the traditional small crop-livestock farm in Egypt should be recognized by policymakers. Eighty-two percent of Egypt's milk comes from these farms, mostly from water buffalo. Small farms manage to sell from one-fourth to one-half of their milk production and have been shown to be more efficient, lower-cost producers than commercial dairies.

Given the agricultural pricing system, it is not surprising to find traditional farmers decreasing area in cotton and wheat and increasing area in feed and fodder. There are also other reasons for keeping livestock and processing livestock products on small farms. Livestock activities absorb much of the surplus family labor (mainly women), increase family incomes, and provide vital human food nutrients. In spite of the efficiency of Egypt's traditional farms, the productivity of the nation's dairy herd is low by international standards. This is largely a consequence of lack of improved genetic stock, shortage of summer fodders, lack of access to veterinary services and medicines, and the continued use of milk animals for power. Opinions vary on the seriousness of this last point. One estimate was that if milk animals were no longer worked, Egypt could end imports of milk products; another study felt that estimates of the opportunity cost of lost milk production were too high. At any rate, researchers felt that with sufficient attention to the above four points, Egypt might realistically regain a comparative advantage in milk production.

As the rural population continues to grow, intensive livestock production on small farms will continue to increase, unless the government allows crop prices to rise to international levels, thus greatly changing farmers' incentive structure. Also, it remains to be seen whether Egypt's traditional farmers will keep their formerly dual purpose animals in the face of mechanization.

A second recommendation is that the production of milk, as a relatively inexpensive source of animal protein, should be emphasized over meat. While some meat comes from traditional farms, it is more typical for farm animals to be acquired by cattle feeders who finish and market the animals. Egypt's credit policy has been weighted in favor of short-term loans for these cattle feeding operations even though Egypt has a greater comparative advantage in milk production.

The government subsidizes frozen boneless meat imports, but supplies are not sufficient to meet demand at such low prices; rationing is by queues. Those who can afford it buy better quality domestic meat at quadruple the subsidized prices of imports. Red meat prices have escalated, particularly since 1980, and domestic meat production is increasingly dependent on feed imports. The third recommendation is that the processing and allocating system for livestock feed concentrates is badly in need of reorganization. The current system is for the Ministry of Supply to import yellow maize and distribute it at subsidized prices—first, to public companies who make feed mixes; second, directly to commercial feedlots and dairies; and finally, to village cooperatives which make about one-fourth of the total available to farmers. Once prepared by the public company, feed concentrate is distributed at greatly subsidized prices by a quota system with first priority going to state farms and certain specialized producers, second to commercial feedlots and dairies, and last to small farmers. ADS researchers pointed out that those small farmers with the lowest priority have 90% of Egypt's herd and receive only 35% of the feed concentrate. A shift in the emphasis of the feed concentrate distribution policy is called for so that milk production in Egypt's traditional farms is encouraged.

Under government subsidization, the number of units producing *broiler poultry* has increased greatly. It is thought that the policy may be keeping inefficient producers in the industry, and that without the subsidy there would be many fewer units with much larger flocks. One estimate found that net farm income of broiler producers was ten times the average Egyptian income and that 80% of broiler income was represented by subsidy.

Production of white meat is more efficient than that of red meat with meat from poultry costing about one-half the price of domestic beef. White meat production is on an increasing trend and there is a possibility of Egypt's becoming self-sufficient in poultry. The official

An issue addressed by several ADS economics projects is what constitutes optimal use of resources, and what policy options are open to the government to encourage such use. It is not surprising that questions in uses of land and water continue to be of primary importance in Egypt. A fish farmer is seen here measuring the depth of his pond. Using land in this way often yields higher returns than the alternative of cropping.

Photo: Eric Gustafson

strategy is to encourage consumers to substitute white for red meat, but there may be a limit to substitution willingness.

LAND AND WATER RESOURCE USE

On account of the extremely limited and constrained land base and the complete dependence on Nile water for irrigation, policies concerning the allocation of land and water resources in Egypt deserve special treatment.

Three projects were concerned directly with land and water resource use questions: Land and Water Allocation, Irrigation Evaluation, and Lakes Development. In addition, the Policy Analysis activity attempted to treat land and water allocation problems in an integrated policy framework.

The principal policy decision confronting the Egyptian MOA with respect to Lakes Manzala, Burulus, Edku and Maryut is to determine the relative desirability of developing

these northern Delta lakes as fishery resources rather than reclaiming the land for agricultural production. The northern lakes fisheries are considerably more productive than the historical data suggests, and improved fishery management practices could further elevate yields. The high value of the fisheries that will be lost if the lakes are drained and the relatively poor or mixed results of the reclaimed agricultural areas are pursuasive arguments against significant further reductions in the lake area.

The most productive parts of the fisheries appear to yield net revenues per feddan comparable to those of agricultural production on neighboring farms, despite the current inadequate fisheries management practices. The public reclamation of the lakes has had mixed success due to the poor soils, high salinity, and inadequate irrigation supplies in the areas. Because the most productive fishing areas coincide with the lake bed most productive of agricultural crops when converted to land, the social costs of sacrificing the fisheries for agricultural production are significantly greater than the private costs and call into question the economic value of permitting continued private reclamation efforts.

Another research team constructed a regional and intertemporal computer model of land and water use by the agricultural economic sector. The resulting model was run under alternative export price scenarios. The effect of increasing crop export prices on land and water scarcity values was analyzed in addition to examining the efficiency of regional water and land allocations. Policy analysis of the diversion of water for Sinai desert irrigation and the regional allocation of crop security constraints was also performed by the model. The main accomplishment of this project is to have an ongoing regional intertemporal model of the Egyptian agricultural sector that is capable of analyzing future policy questions if kept updated.

A more detailed summary of the research findings and policy recommendations of the whole body of research carried out under the Sub-Project is presented later in this report.

EDUCATIONAL AND TRAINING ACCOMPLISHMENTS

Since the primary goal of the ADS Economics Sub-Project has been to promote the professional development of the Egyptian agricultural economics community in order to improve the capabilities of the Ministry of Agriculture for evaluating and implementing agricultural sector development programs, it is difficult to separate training activities from the research activities. However, every effort has been made to create an atmosphere of scholarly pursuit, lively debate of the issues, and economic and technical awareness in our promotion of seminars, guest lectures, short-courses, workshops, short-term and long-term training at the University of California, visits to international meetings, and so forth.

EDUCATION AND TRAINING

The Sub-Project has sponsored three doctoral students at the University of California. Their studies were incomplete at the termination of the ADS contract, hence they will complete their doctorates under direct USAID sponsorship.

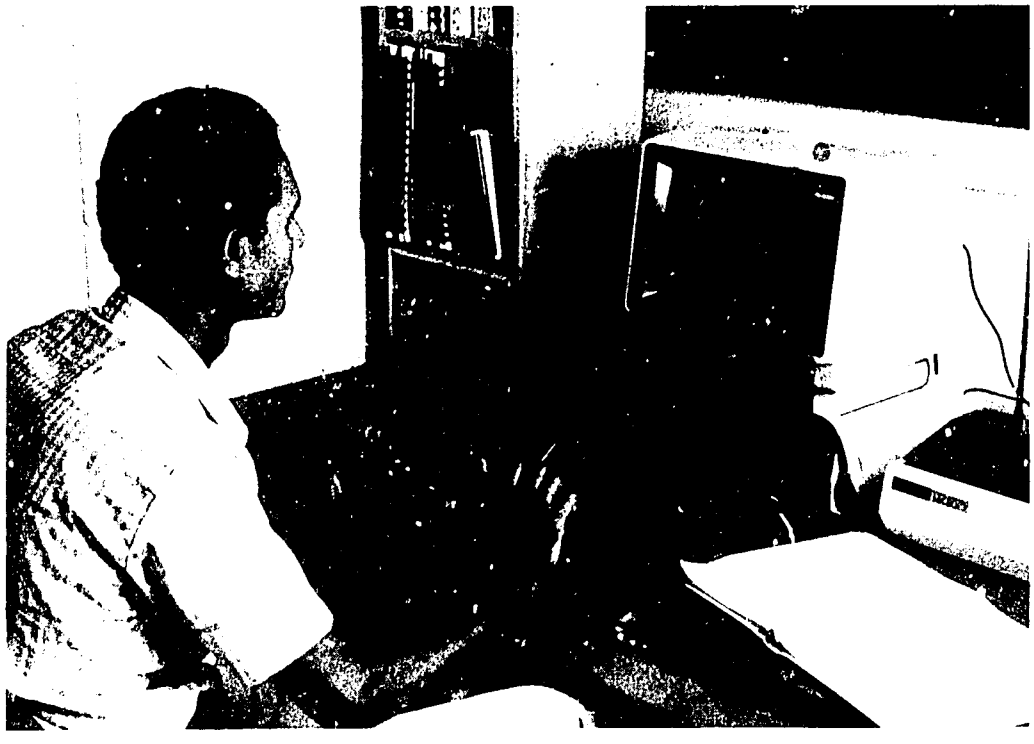
Ten post-doctoral researchers sponsored by the Economics Sub-Project, each spent one year at the University of California focussing on upgrading their professional skills by taking course in contemporary research methodologies and techniques and engaging in supervised research projects.

Short-term training visits by Egyptian counterparts to the University of California have been a major component of the Sub-Project's training and educational program.

There were a total of 70 Egyptian short-term training visits to work with their UC counterparts. Numerous planned short-term training visits were cancelled in 1982–83 due to the severely constrained budget of the Sub-Project. Included in these were visits by seven Egyptian colleagues to attend professional international economics meetings.

A most valuable educational activity sponsored by the Sub-Project has been the special "English for Economists" courses taught by a faculty member from the American University in Cairo. With approximately 70 Egyptian colleagues participating, "English for Economists" was taught each year of the project using course materials adapted from actual ADS Economics Working Papers that had been developed by research team members.

During 1982–83, a weekly training seminar on the ADS Apple computer was held for Egyptian colleagues. The project acquired software for statistical, linear programming,



Training has been a major component in all ADS projects. The Economics Sub-Project purchased an Apple computer and has trained MOA and university economists in its use. *Photo: Nadir Hashem*

graphic, tabular, and financial analyses, along with word processing software, for use by the researchers. The weekly seminar provided "hands-on" computer experience for more than 25 Egyptian participants during the year.

WORKSHOPS AND SEMINARS

An integral part of the educational program designed to promote policy discussion was the dissemination of research activity findings. To accomplish this objective, the Sub-Project held ten Economics Policy Workshops in Egypt with international participation (Appendix). The Minister of Agriculture addressed all but one of these Economics Policy Workshops and each was attended by more than 100 participants. Workshop papers and proceedings were widely distributed in Egypt. Issues discussed in these workshops included agricultural mechanization, agricultural marketing, migration and mechanization, the promotion of horticultural exports, agricultural policy, the future of cotton, mechanization issues, livestock economics, food price policy and subsidies, and labor migration in Egyptian agriculture.

SEMINARS AND MINI-WORKSHOPS

Throughout the project ADS researchers were encouraged to present their work in seminars and lectures to establish a regular forum for the presentations of findings and discussion of analytical and policy issues. More than 40 seminars and lectures were presented by UC and Egyptian participants between January, 1981, and May, 1983. In addition the Sub-Project sponsored six one-day mini-workshops or training sessions, covering horticulture post harvest problems, citrus marketing, survey techniques, research proposal preparation, the applications of micro-computers, and consumption and nutrition in rural Egypt. Average Egyptian participation in these mini-workshops and training sessions was more than 70 economists.

AGRICULTURAL ECONOMICS LIBRARY

Modest efforts have been made to build up the quality of the agricultural economics library and reference materials available in Egypt. Most of the materials purchased were

specifically contributing to the agricultural economics research being done in the Sub-Project.

ECONOMICS WORKING PAPERS

ADS participants have been encouraged to produce and disseminate their research findings in the Economics Working Paper Series. At this writing the series has 183 papers. Complete sets of the 183 working papers have been deposited in about 20 Egyptian libraries, with additional sets deposited with USAID and other international agencies in Egypt. More than 13,000 copies of ADS Economics Working Papers have been distributed to individuals and institutions in Egypt. Since termination of the project over 40 additional research papers have been prepared and all are being distributed by the authors.

FUTURE DIRECTIONS

Valuable long-term policy-relevant research for the Ministry of Agriculture and significant professional development of the Egyptian agricultural economics community have been accomplished by the ADS Economics Sub-Project in its three years of operation. Future research and training programs must build on this strong beginning.

The strengths of the ADS Economics Sub-Project have been many. First, the Sub-Project has been the only institution that has consistently supported the long-term research needs of the MOA. Second, the Sub-Project has promoted the professional development of the Egyptian agricultural economists, both within the MOA and in the Egyptian universities. Third, the Economics Sub-Project has emphasized the institutional development within the MOA by enlisting virtually all MOA economists to participate in collaborative training and research activities and providing an organization for focussing on long-term research needs of the Ministry.

Many of the research activities sponsored by Economics Sub-Project have unanalyzed data and research work in progress that will require additional months, if not years, to complete. In addition, most of these activities have unfinished research agendas. A continuing program of agricultural economics research on the problems of the development of the agricultural sector in Egypt is required. Such a continuing program can usefully build on the ADS experiences. Long-term research, professional development for economists, and MOA institutional development are the broad objectives still needing to be served. A flexible and adaptable format and formula is required to meet the Ministry's needs in the light of contemporary policy questions and the progress made by the ADS Economics Sub-Project.

THE IMPACT OF PRICING ON LAND AND WATER ALLOCATION

Development and administration of natural resources in Egypt are the responsibility of the government through the Ministry of Agriculture. If agriculture is to continue as the stabilizing sector of the economy, the question of sub-optimal resource allocation needs to be examined. The misallocation of scarce land and water resources due to conflicting objectives have led to serious economic problems.

Focussing on land and water allocation, along with cropping patterns, this project has used computer modeling to reveal some of the effects on the agricultural sector of shifting from a government-administered price system toward a free market.

ACCOMPLISHMENTS

CHOICE OF MODEL

A programming model was selected as the most suitable instrument for exploring resource allocations because of the spatial nature of production and its implications for interregional specialization. Programming models are normative, and it is usually the case that models of agriculture purport to change regional production patterns. In the agricultural decision making process, a recursive element is inherent because decisions for a particular period are influenced in part by previous ones. Also, decisions are continuously being amended due to updated information, a feature which could be easily incorporated in a recursive program (RP) which was chosen by the project in preference to a simpler linear program. Furthermore, in an RP the parameters of a multi-period model can be adjusted in response to the previous solutions. That feature is particularly useful for accommodating technological change in the models. Probably the foremost advantage of RP over LP is due to inclusion in the factors affecting farmers' decisions of some nonpecuniary elements. By relying on the measurement of previous reaction to conditions similar in principle, but not necessarily in magnitude, one can specify the range within which the response is likely to happen. This is the spirit of RP as represented by the flexibility restraints.

The research team succeeded in constructing a recursive linear programming model as the vehicle for investigating land and water allocation. In addition the model was applied to estimating the potential gains that would be likely to accrue from a higher degree of regional crop specialization. The effects of alternative pricing policies for the four main controlled crops was also examined using the model.

The yield entries were obtained from Ministry of Agriculture estimates of average yields and may contain a sampling error or departure from "time" yields. Water coefficients were generated by aggregating several sources reporting water, wages and water requirements. This data, reported per crop, per person, or per area, was processed into a per feddan basis.

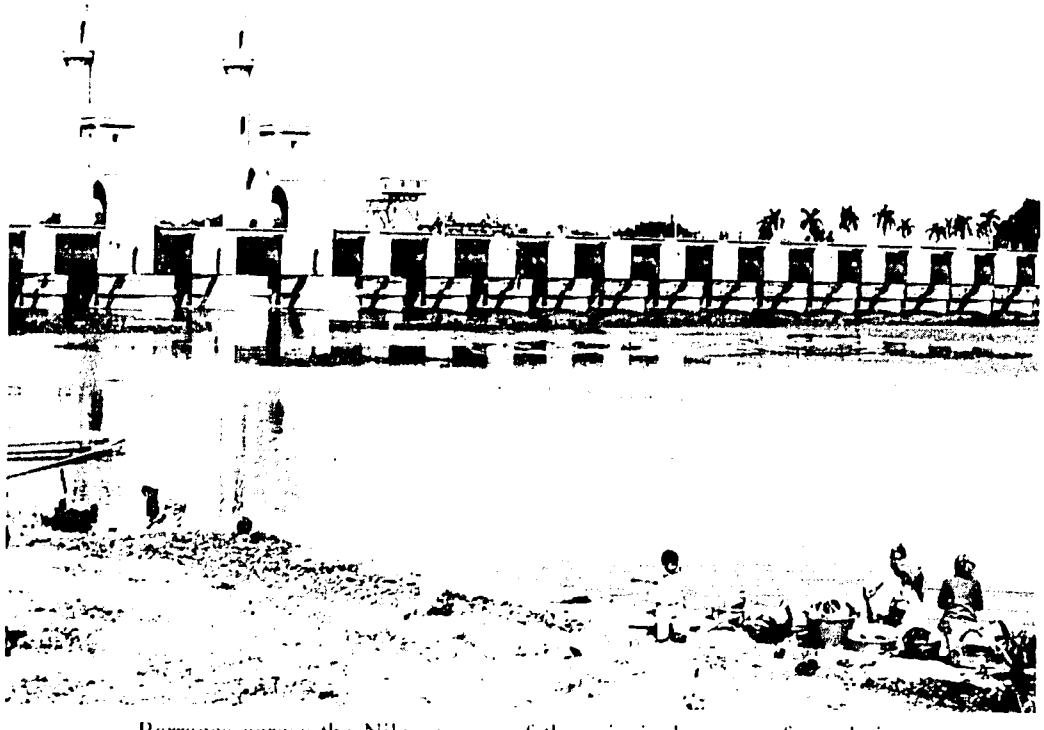
The regional recursive linear programming model measures several parameters both at the national and regional levels. These are agricultural net revenue, crop production, demand for inputs, and resource valuations. The formulation of the model makes it possible to assess the two main goals of the exercise. First, net revenue is maximized subject to water supply by region, land productivity by governorate, the availability of purchased and nonpurchased inputs, crop rotations, regional governmental and public policy, behavioral constraints, and the current technology. The second objective was to gauge the system's reaction to several proposed changes over time, such as price and nonprice intervention, regional specialization, resource policies, and deteriorating land quality because of rising water tables.

The model passed through several stages of building and testing before it arrived at its current form. The first stage in model building was the design of the structure in such a way that future augmentation would be possible. The overall system was to be put together to achieve the end objective of creating an experimental vehicle which would aid in analyzing the agricultural sector, and then investigating the effects of any postulated changes. The model provides estimates of the values of resources, the cost of some policy actions, and identifies resource and input use under current conditions.

The basic model uses the Day flexibility coefficients on crop acreages on a regional basis. Within the three regions, crops are allocated to governorates according to their comparative advantage. The bounds serve as the effective limits on the optimization process and thus ensure that we are "close" to reality.

In making any comparisons between the model results and the actual cropping pattern, the model will give some indication of comparative advantage in crops among governorates through the dual values on the bounds and crop activity rows. Although the model does in principle reflect the influence of administered prices and production plans and targets, it will not necessarily reflect every aspect of public policy at governorate level.

One should also note that allocations not only reflect margins of net returns, but also the pattern of resource use and marginal productivity differences. So an estimate of productive efficiency *vis a vis* national requirements can be obtained for input use. The salient inputs are land, water, labor, fertilizer, animal power, and machinery.



Barrages across the Nile are one of the principal means of regulating water flow, and hence a key to provision of year around irrigation.

Photo: John Rowntree

Table 1. **Value Added Estimates in Egyptian Pounds (Nominal prices)**

Year	*Original*	*Price System*
1974	569,847,870	NA
1975	585,404,350	1,204,509,879.98
1976	619,620,230	1,195,245,297.67
1977	705,843,400	1,539,412,085.38
1978	745,976,690	1,969,818,151.48
1979	1,167,382,600	2,315,067,399.36

The Price System was run recursively for the years 1975–79, using prices which are higher than the actual prices for the period. Table 1 lists the objective function values for the sequence of Price models, and for the historical (henceforth referred to as Original) equivalent. The figures are aggregate values added resulting from crop production in current Egyptian pounds (LE).

The 1975 and 1979 years are the only ones to be discussed in detail for several reasons: (1) they are the opening and closing years of the sequence (although most of the results for the other years will be presented, but not discussed in the same detail); (2) 1975 is the first year, so no recursive error build-up is included; (3) 1979 is the last year, so it should include the effect of any accumulated error, and the effect of successive optimizations; (4) 1979 is also the most recent year to be analyzed and as such is important to our discussions; (5) as far as model validation is concerned, these two years should be sufficient; and (6) it allows us to determine the various characteristics of the 1975 solution (such as allocational inefficiencies), and then by studying 1979 we should determine the pattern of change.

Running the Price System consisted of changing the prices of the four major crops: cotton, wheat, rice, and sugar cane.

Table 2 shows the international and local prices for these crops, together with the tax implied by the price differentials. The table shows that the tax has been declining, but a detailed look will show that a large part of the decline is due to the drop in international prices, and thus the typical farmer is still faced with the problem of insufficient incentives. In the face of that reality, the margin between both prices was halved (i.e., reduce the inputed tax by half). Table 3 gives the new prices and the percentage change over existing prices.

The net return estimates listed in Table 1 are in nominal prices and include the effects of various factors such as inflation, the effect of the optimization process, and the price effect on the various model parameters. To be able to separate these effects, we ran a sequence of models called Day System which is identical to Price System except that it uses the actual prices in the objective function. Computing the objective function value (aggregate net returns) for all three systems (Original or historical, Day System, and Price System), using 1979 average crop prices would remove the effect of inflation. We would then be left with the other two factors. The difference between

Table 2. **International and Local Prices for Major Crops 1975–1979**

Crop	1975	1976	1977	1978	1979
Cotton					
International Price	84	70	96	73	73
Local Price	28	34	36	37	47
Tax Percent	200	106	166.6	97.3	55.3
Rice					
International Price	259	154	107	143	135
Local Price	40	50	57	65	67
Tax Percent	547	208	87.72	120	101.5
Wheat					
International Price	28.2	17.5	14	15.1	12.1
Local Price	6.9	6.5	7.0	8.9	8.9
Tax Percent	300	170	100	70	36
Sugar Cane					
International Price	22.07	16.4	11.17	11.6	10.0
Local Price	7.53	8.4	8.03	9.0	10.0
Tax Percent	194	96	40	28	0

Notes:
1. International prices are adjusted for transportation processing, etc.
2. All prices are in Egyptian pounds per unit of net product (i.e., sugar cane prices are for the sugar equivalent) based on the appropriate conversion factors.
3. The tax figure is the difference between both prices represented as a percentage of local prices.
Source: Computed from MOA and FAO statistics.

the Day and Original Systems represents the effects of optimization within the flexibility constraints, and the difference between the Price and Day Systems represents the effect of higher prices. The aggregate crops net returns have been recalculated using the 1979 national average price for each crop, and the new values are presented in Table 4.

Comparison of the totals in the table reveals that the Day System's aggregate net returns in real terms for 1975 was only an improvement of 0.02% over the Original figure, compared with 12.82% when measured in current prices. For 1979, the Day System's estimate in current prices was 43.46% higher than the Original estimate, whereas when evaluated in real terms, the difference became 13.93%. The difference is not all due to deflation or the actual effect of optimization, but is also due to the fact that for every crop the weight used is an average for that crop, whereas in the model the net return valuations are computed for each crop/governorate combination and thus have a wider variance. Nevertheless, we can still say that these results show that in aggregate terms restructuring the production process within the flexibility constraints did not show large efficiency gains in real terms. The inputed costs of some of the constraints will be examined later. However, if we view the situation from a dynamic context (over several years), we find that the agricultural system will take a few years to adjust. For example, the improvement due to higher prices in 1975 is marginal (0.9% comparing the Price System to Original) when

Table 3. **New Prices Used in Policy Years**

	1975	1976	1977	1978	1979
Cotton					
Price	56	52	66	55	60
Change percent	100	33	83	49	28
Rice					
Price	113	102	82	104	101
Change percent	183	105	44	60	51
Wheat					
Price	14	12	10.5	12	10.5
Change percent	103	85	58	35	18
Sugar Cane					
Price	14.8	12.4	9.6	10.3	10.0
Change percent	97	48	20	14	0

Notes:
1. All margins were halved except for rice and wheat in 1975 where the new price is based on 33% of the difference plus the old price.
2. These prices are only averages for the whole country but the actual price scenario figures vary between governorates.

measured in real terms, compared to a striking 105.6% using current prices, which even when adjusted for the effect of optimization (to give us the effect of higher prices) yields differences of 0.87% and 92.78%, respectively. Or in other words, on the surface the picture looks rosy with

Table 4. **Adjusted Net Returns, Using 1979 NR Figures**
LE × 10^4

CROP	*1975*			*1979*		
	Original	*Day*	*Price*	*Original*	*Day*	*Price*
Cotton	24040	23455	24868	21353	16351	15993
Rice	6032	5260	6850	5970	5191	7263
Wheat	1562	1341	1366	1552	1051	1054
Peanuts	467	540	451	455	586	891
Lentils	155	155	131	59	59	42
Beans	1616	1823	1318	1642	1896	1175
Barley	130	93	93	139	106	74
Garlic	662	842	834	721	639	1290
Sugar Cane	3905	4121	4121	4435	3718	4115
Flax	231	161	161	290	181	177
Sesame	274	249	236	312	213	232
S. Sorghum	1383	1601	1528	1162	1459	1488
N. Sorghum	52	66	66	33	78	60
Maize	4950	6429	5337	5197	5582	3692
W. Onions	1938	366	289	168	387	318
S. Potatoes	1898	2820	2863	2973	7663	10615
N. Potatoes	1999	2108	2109	2691	4206	4206
W. Tomatoes	3133	3361	3361	3840	5610	10642
S. Tomatoes	985	1148	933	1087	1799	1676
N. Tomatoes	3314	3271	3271	2461	6247	6247
W. Vegetables	2820	3259	3131	3801	10917	20413
S. Vegetables	3122	4145	4145	3940	8791	9862
N. Vegetables	2884	3086	3086	2875	4700	4700
Long Berseem	25995	20213	20213	25995	27464	19498
Short Berseem	1461	1422	1422	1461	1212	1274
Fruits	6155	5967	5967	7331	6861	6688
Oranges	3130	2985	2967	3743	3386	3341
Melons	11099	12462	13462	11784	13947	33801
S. Onions	117	247	247	201	637	257
Total	113777	114010	116307	117684	134087	171102

Notes: N = Nili, W = Winter, S = Summer

a doubling of agricultural returns by changing some prices, but in real terms the initial benefits are substantially lower than some other unconstrained studies have estimated. One should only expect a real shift in returns to the tune of 10–13% in response to higher prices in the first year of change. At the end of several years, when the prices have been brought closer to the equilibrium values, we can expect the real change to be about 30% (compared to 95.67%). Again, the price effect alone is 31% and 52.21% (real and current, respectively). The situation could be summed up as follows: if a reorganization is made such that we can allocate production within regions to achieve a more efficient pattern and also to reorganize such that the more optimal crops are emphasized, then we can expect an improvement in aggregate net returns of about 0.02% in the first year, but over time the change becomes 14% at the end of the fifth year of pursuing such a policy. Additionally, if we use higher prices for the four major crops, we can expect an increase of about 0.9% in the first year, which rises to 30% at the end of the fifth year. More dramatic gains in reallocation of production may result if interregional shifts in key crops is permitted. This substantial institutional shift is not examined in this set of results.

So far, only total figures have been discussed, but examination of the net returns when disaggregated by crop will show what the effects would be in a more detailed fashion. These effects could be broken down further into acreage effects (i.e., the change in area and production) and price effects (the effects of higher prices in an accounting sense). First, we can look at the price effect before and after deflation by the 1979 weights. We already examined the deflated net returns in Table 4, and the undeflated results are presented in Table 5.

These results are instructive, since for example one could easily be misled into thinking (indeed as several analysts have done) that by doubling the cotton price, its aggregate net return would rise from 82,509,187 LE

(Original 1975 net revenue [NR]) to 238,546,690 LE (Price 1975 NR); but if we reevaluate these figures using the 1979 NR as weights, the change is only from 240,407,270 LE to 248,688,530 LE, that is, a change of only 3.4% compared to a nominal increase of 189.11%. For rice, the nominal increase is from 39,383,857 LE to 236,845,585.9 LE, while in real terms it is only from 60,322,242 LE to 68,501,174 LE in response to a price change of 183%. Doubling the price of wheat still doesn't seem to make any difference since the adjusted net revenue (NR) actually drops from the original adjusted 15,626,180 LE to 13,699,653 LE, while in nominal terms the Original is 45,415,009 LE and the Price 1975 NR is 130,591,360 LE. Also, doubling the price of sugar cane caused the real NR to change from 39,059,000 LE to 41,219,011 LE, whereas the nominal change was from 34,598,299 LE to 92,724,178 LE.

For 1979, the effects of the Price change at the end of the five year phasing-in is also affected by the fact that the original NR valuations include the effects of several actual price increases. Thus, for the four major crops under investigation, their Price 1979 prices are the last stage in narrowing the gap between local and international prices, while for Original 1979, this is also true, although to a lesser extent, since Original 1975 does not include any higher prices while in 1979 the actual prices were higher in real terms.

Table 5. **Price System Net Returns (LE × 10^4)**

Crop Code	*Crop*	*1975*	*1979*
1	Cotton	23854	21083
2	Rice	23684	13177
3	Wheat	13059	602
4	Peanuts	215	871
5	Lentils	500	172
6	Beans	1593	1446
7	Barley	396	204
8	Garlic	257	1465
9	Sugar Cane	9272	3228
10	Flax	226	338
11	Sesame	161	370
12	S. Sorghum	1292	412
13	N. Sorghum	58	14
14	Maize	3942	3114
16	W. Onions	527	893
17	S. Potatoes	2455	13841
18	N. Potatoes	1703	6360
19	W. Tomatoes	3616	12688
20	S. Tomatoes	3076	8354
21	N. Tomatoes	2902	9701
22	W. Vegetables	1618	24530
23	S. Vegetables	3089	15305
24	N. Vegetables	1355	5644
25	Long Berseem	6037	19498
26	Short Berseem	678	3352
30	Fruits	4934	10079
31	Oranges	2437	5514
32	Melons	7238	49000
35	S. Onions	263	236
	Total	120450	231506

For cotton in 1979 we find that at first glance the net returns of the Price model are 210,837,290 LE which is approximately equal to the Original 213,533,430 LE, while after deflation the Price estimate becomes 159,938,650 LE. Rice also drops from the 131,770,498 LE estimated by Price 1979 to the adjusted figure of 72,637,346 LE while the Original estimate is 59,702,574 LE. The Original figure for wheat is 15,529,135 LE, which when compared to the adjusted figure of 6,026,659.5 LE in nominal terms is a reduction to 10,549,753 LE. Sugar cane also dropped from the Original 41,154,875 LE. Note, however, that the totals for 1979 showed an increase in both nominal and real terms from 1,176,842,600 LE to 2,315,067,000 LE and 1,711,022,900 LE, respectively, which is largely the effect of the acreage increase in the crops with unaltered prices, such as peanuts, garlic, summer tomatoes, nili tomatoes, winter vegetables, summer vegetables, nili vegetables, melons, and summer onions. For 1975, in addition to the real increase in net revenue brought about by increasing the prices of the major crops (except cotton which marginally dropped), the following crops also increased: lentils, barley, flax, nili sorghum, winter onions, summer potatoes, winter tomatoes, summer tomatoes, oranges, and summer onions. The changes in these crops for 1975–79 are not due to the cross price effect since when no price changes are made (as in the Day models), the list of crops for which net returns have actually increased is mainly due to the effect of optimization. Thus, for 1975, the list is: peanuts, lentils, beans, garlic, sesame, summer sorghum, nili sorghum, maize, nili potatoes, winter vegetables, summer vegetables, nili vegetables, and melons. For 1979, the price effect is attributed to: lentils, beans, winter onions, maize, long berseem, melons, and summer onions.

Many other policy results were obtained from the model, but brevity demands excluding their discussion from this final report. The additional results concern the allocation efficiency of current land and water allocations, the impact of water diversion to irrigate the Sinai desert and the improvement of regional crop security constraints. The empirical results are published in the working papers cited in this report.

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RURAL LABOR SUPPLY

Egypt is traditionally considered a textbook example of a labor surplus economy. Egyptian agriculture must provide food for a rapidly growing and increasingly affluent population. Historically, agriculture has also provided more than one-third of total employment, responding flexibly to changing macroeconomic conditions by releasing labor in economic upswings and absorbing it during downturns. The Rural Labor Supply Project has investigated the structure and function of rural labor markets, and in particular the relationship between agricultural policies and changes in rural labor markets, and the impacts of their current trends on Egyptian agriculture in the 1980s.

During the 1970s, the demand for food in Egypt increased much faster than the supply because of rapid population growth (2.5% annually), rapid GNP growth (8% per year), and because agricultural policies subsidized the consumption of several staples but failed to encourage their production. The Egyptian government wants to reduce the food gap that widened in the 1970s because imported food, which accounts for 43 to 51% of the total consumption of nine basic commodities such as wheat, corn, and sugar, soaks up scarce foreign exchange and increases economic uncertainty as the cost and availability of food supplies on international markets fluctuate. However, the government wants to close the food gap without either upsetting urban consumers by abruptly reducing or eliminating food subsidies, or disrupting traditional agriculture so much that rural emigration is increased still further. Many believe that a "labor shortage" constrains Egypt's attempts to close this food gap. The policy response has been to implement subsidies to encourage the mechanization of agriculture by 1990.

The *raison d'etre* of the Rural Labor Supply Project was to investigate the nature and extent of labor shortages in Egyptian agriculture in order to evaluate the mechanization subsidy policy. In the initial phase of the project background research and a survey of farmers and farmworkers were used to generate information on the nature of seasonal labor demands and seasonal labor supplies in Egyptian agriculture. The second phase of the project investigated the impacts on the rural labor market of migration from agriculture to urban areas and abroad.

THE FARM LABOR MARKET

Egyptian agriculture consists of several million farms that average two feddans each and employ a total of 4.2 million workers, 36% of the workforce. Since 1961, average farm size has been declining because the Agrarian Reform law limited ownership to 50 feddans per person and Muslim inheritance laws normally lead to a division of land between an owner's children at death. About two-thirds of the cultivated area in Egypt is in farms smaller than five feddans, and the average size of the largest class of farms is only 17.5 feddans. In addition to owned farm land, at least one-third of all farm land is rented, usually for cash.

Most small farmers grow several crops and produce livestock. Under normal crop rotation schemes, a Delta farmer would grow cotton, wheat, maize, and berseem (normally two crops per year) as well as raise livestock and poultry. During the 1970s, livestock production increased more than twice as fast as crop output, reflecting the incentives provided by controlled crop prices and uncontrolled livestock prices. Even small farmers hire some labor, not to tend livestock but for use primarily during the labor-intensive phases of crop production. Traditionally, landless workers (45% of the farm population in the early 1970s, and perhaps 25% today) have provided the corps of prime-aged male workers who did most of the heavy hand-work done by hired workers.

The demand for hired farmworkers in Egyptian agriculture is seasonal, peaking during the May–June harvest of field crops and again in October for the cotton harvest. Daily wages vary by month, by task, by sex, and by age, but seem to average about LE 2–3 for male workers during the May–June peak and dip as low as LE 1 for women and children during the off-season. Since women do a considerable portion of all crop labor (perhaps one-third) the average daily farm wage is considerably lower than the peak daily wage paid to prime-aged males.

In the 1970s, Egyptian farmers began to complain increasingly of labor shortages. Their complaints had two themes: prime-aged male workers were more difficult to find, and those workers who were available demanded higher wages, more perquisites, and shorter hours. In order to evaluate the validity of the farmers' complaints, we first investigated measures of the changing size of the labor force and changes in wage levels. From this we were able to assess the magnitude of labor shortages and whether they were traceable to changes in the demand for labor, the supply of labor, or both.

The size and wage measures used to evaluate the farm labor market are not completely reliable. In particular, labor force data severely underestimate women's participation in the farm work force. It appears to be true that the farm work force did decline in size, but the major decline appears to have occurred among prime-aged, landless workers. The substantial increase in real wages in the 1970s was most pronounced during those months when farmers needed male workers to complete traditional male tasks such as land preparation and heavy hand-harvesting. Since wage costs have risen while government price policies or imports held down the prices received by farmers, the wage cost share of production for most major crops has increased, accentuating the profit squeeze in Egyptian agriculture.

DEMAND OR SUPPLY?

Rising real wages could be traceable to an increased demand for hired workers or a decreased supply of such workers or both. On the demand side, farmers planted more labor-intensive commodities and increased their cropping intensities in the 1970s, but such changes were more than offset by the mechanization of plowing, land-leveling, and other changes in production methods. Similarly, increased farm fragmentation could increase the demand for labor because survey evidence from Sharqiyya indicates that small farmers use more hired labor per feddan than do large farmers. However, this phenomenon appears to vary by region, and is not common in Giza or Minufiyya Governorates, for example. Our overall conclusion is that there have not been substantial increases in the demand for hired farmworkers that would explain the sharp rise in real farm wages after 1973 throughout the agricultural sector. The change in wages was discontinuous, while demand changed slowly and evenly.

If demand-side factors cannot explain rapidly rising real wages in agriculture, the explanation must lie on the supply side, where causes for the discontinuous rise are easy to spot. The most obvious cause of the discontinuity in the supply of rural workers was the availability of jobs abroad after 1973. The construction boom in the Arab oil exporting countries is responsible for the current employment of one to two million unskilled and semi-skilled Egyptians, and this external demand for Egyptian labor has pulled workers directly from agriculture, and has further reduced rural labor supplies by creating vacancies in the urban jobs abandoned by Egyptians who go abroad.

Emigration is a plausible explanation for the discontinuous wage rise, but other policies and trends also contributed to the reduced pool of farmworkers in the 1970s. The spread of educational opportunities to rural areas and the government policy of guaranteeing jobs to graduates encouraged young people to obtain an education instead of committing themselves to do agricultural work. Although survey data show that illiteracy remains widespread in rural Egypt, this is much less true for young men than for either women or older men. However, many hired workers, especially part-timers, are young and often students. The evidence suggests that spreading education is reducing the pool of full-time, hired agricultural workers. Further, literate workers who remain in agriculture demand and receive a higher wage.

Increasingly profitable alternative activities have also reduced the supply of labor offered by small farmers who were formerly important participants in the hired labor market. This is much less common now: in our sample there was a less than 10% chance that a farm holder had hired himself out for farm labor as a secondary occupation. Numerous on-farm activities provide alternatives to these farmers becoming hired labor. First, small farmers can and do enter the land-rental market. They farm land that they have rented very intensively; their cropping intensities were well above those of larger farmers, using *more* hired labor, *more* machine hours, and *more* of other inputs. In addition, small farmers now devote much of their time to livestock production (Table 1). This is true for men as well as for women and children. The rapid growth in urban incomes, the subsidization of staple foods, and the protected livestock market have created a growing internal market for livestock products. Small farmers have sought to supply this demand. Thus, agricultural price policies, which raised Egyptian livestock prices some 50 to 100% above international prices, contribute to labor shortages by encouraging small land owners to devote their time to livestock production instead of doing wage work.

The farm labor changes wrought by emigration and price policies are magnified by the poor operation and segmentation of many rural labor markets in which some jobs are reserved for men, some for women, and some for children. Such imperfect substitutability among types of labor aggravates "labor shortages" and helps to explain why adult male wages rise above trend during the May–June peak but not during the September–October peak. Women and children do much of the cotton harvesting in September and October. Their availability holds down adult male harvesting wages, but women and children do much less land preparation or wheat harvesting, both of which are typically done in May and June.

Poor wage and job information, when combined with this segmentation, assures that some jobs and workers are not matched simply because attitudes and information impede the normal functioning of the farm labor market.

Our survey found evidence that rural labor markets do not clear during the off season. We asked unemployed

Table 1. **Crop, Livestock Labor for Farm Family, by Farm Size Class**

	Crop Hours	*Livestock Hours*	*Total*	*Per Cent Crop*	*Per Cent Livestock*
All Farms	231,406	148,647	380,053	61	39
0-1 Feddan	15,160	31,794	46,954	32	68
1–3 Feddan	64,784	51,273	116,062	56	44
3–5 Feddan	33,776	24,393	58,169	58	42
5–10 Feddan	29,797	23,593	53,390	56	44
10+ Feddan	87,885	17,594	105,479	83	17

and underemployed rural workers what their reservation wages were, and we asked farmers what wage they paid for specific tasks. We learned that the mean reservation wage of workers was less than the wage that farmers reported paying, indicating that workers are available at going wages but unable to be matched with employers. Further research on precise causes of this poor labor market performance and on the appropriate policy responses would be very useful. It appears that the Egyptian government can no longer rely on traditional private arrangements to match farmworkers and farm jobs, that it must begin to actively expedite the matching of farm jobs and farmworkers, perhaps by establishing clearing houses for farm jobs in each village.

The net effect of these changes is a farm labor supply that exhibits a very low elasticity with respect to rising wages: a 1% increase in wages does not bring forth a 1% increase in the supply of farmworkers. Therefore, the impact on the wage rate of the reduction in the pool of hired farmworkers due to migration, spreading education, and profitable on-farm activities, is magnified. In sum, our survey evidence points to supply rather than demand factors to explain the alleged labor shortages in Egyptian agriculture.

The supply factors noted above best explain the discontinuous rise in real wages after 1973–74. The single most important explanation for the labor shortage appears to be the emigration of prime-aged landless workers from agriculture. But the pool of workers willing to do wage labor on a daily or seasonal basis is also reduced by the combined effect of a number of other factors: the indirect effects of price policies on labor supply; spreading education and government job guarantees that encourage people to pursue an education rather than do farm work; and labor market segmentation in the face of very poor labor market information. However, the resulting "labor shortages" are task and season specific, indicating that the optimal mechanization response should be targeted to overcome these limited labor bottlenecks. The evidence indicates that Egypt is paying a very high price in foreign exchange and possible irreversible changes in agricultural production methods because it has adopted a broad shotgun mechanization policy in order to overcome selective labor bottlenecks. This conclusion is reinforced by the fact that crop-price policies and massive food imports hold down farm-gate prices, thus exacerbating farmers' problems and complaints. These problems will not be solved by indiscriminate mechanization.

Table 2. **Distribution of Labor Time by Operation and Category of Worker.**

	Hired Labor			*Family Labor*		
Operation	% Male-time	% Female-time	% Child-time	% Male-time	% Female-time	% Child-time
Plowing	4.7	0	0	2.8	.3	.8
Scrape, Ridge	1.1	0	.1	1.8	.4	1.4
Scraping	1.0	.1	0	1.3	.6	.7
Planting	6.2	16.5	3.8	6.0	8.2	4.3
Irrigation	11.7	–	.3	37.3	19.2	33.4
Fertilizer Applica.	7.1	5.5	3.9	11.0	15.1	13.8
Hoeing	20.1	.1	1.1	5.5	1.5	.7
Harvesting	21.7	55.8	28.4	10.6	23.4	17.5
Threshing	4.0	1.1	.2	2.1	2.9	2.1
Separating	4.3	1.3	–	2.1	2.1	1.1
Maize Sep.	.2	4.9	–	.8	4.9	1.9
Manual Pest Control	5.9	–	56.0	3.6	6.1	7.0
Transport	5.7	5.3	.8	7.1	9.8	4.1
"Other"	10.4	9.3	5.4	7.9	11.0	11.4
Percent of Total Time for Each Category	32.0	15.0	53.0	63.0	15.0	19.0

EMIGRATION

Egypt has traditionally supplied skilled teachers and civil servants to the oil exporting Gulf nations and to Libya. Manpower statistics are not completely reliable, but it appears that in the early 1970s at least 500,000 skilled Egyptian workers and their families were living and working abroad. After the four-fold increase in oil prices in 1973–74, the OPEC nations embraced massive development strategies that required the rapid construction of basic infrastructure, housing, and a variety of manufacturing and service facilities. Given their small indigenous populations, the aversion to manual work by many citizens and the reluctance to employ local women, the OPEC nations decided to import massive numbers of alien workers. Egypt contributed at least 2 million unskilled and semi-skilled workers, especially in construction, where it is estimated that about half of all Egyptian construction workers emigrated in order to earn wages that are about 10 times higher than those prevailing at home.

Construction wages within Egypt have traditionally been at least double those for hired farmworkers. As urban construction workers went abroad, landless rural workers were pulled into the cities to replace them. When the demand for construction workers abroad was especially strong in the late 1970s, rural workers could go almost directly from agriculture to a foreign construction job. Thus, emigration directly and indirectly reduced the availability of able bodied male workers willing to do farm work on a daily or seasonal basis.

The Egyptian economy benefits from remittances of $2 to $3 billion annually from Egyptians who work abroad, as well as the return of a more skilled work force. Egyptian manpower planners, aware of these benefits, talk of exporting even more unskilled and semi-skilled workers during the 1980s. In this strategy, the continued emigration of Egyptian workers dovetails nicely with the complete mechanization of Egyptian agriculture.

However, our research indicates that Egypt may not be able to achieve its manpower export goals. As major construction projects abroad are completed, and as the preference for Asian workers grows, a reverse migration back to Egypt appears likely. If Egypt has already mechanized its agriculture, it may face the major tasks of satisfying workers who are accustomed to high wages abroad.

Egypt's agricultural sector has historically been the "shock absorber" of the nation's labor market, releasing workers during booms and reabsorbing them during economic downturns. This feature is being permanently altered by mechanization. Complete mechanization, as envisioned by national plans, would end it completely. Given a population growth rate of more than 2.5% per year, the burdens of employment creation for other sectors may well be extremely heavy in the years ahead.

Even as Egyptian workers remain abroad, our research indicates that Egypt is not reaping maximum advantage from its *laissez-faire* emigration policy. First, remittances are not used to create permanent jobs that have high multipliers within Egypt. Instead of investing in new factories or making agricultural improvements, remittances are more likely to fuel land speculation, to be spent on housing or imported consumer durables, or to purchase taxis or trucks and increase urban congestion. In addition to the inefficient use of remittances, the emigration of skilled construction workers has lowered overall productivity in the domestic construction industry by creating labor shortages and labor bottlenecks, especially for skilled workers. Employers are reluctant to train new workers because they fear that they will soon depart for jobs abroad. In addition to remittance and labor shortage problems, it is sometimes difficult to reintegrate returning workers and to prevent recruitment abuses.

Emigration clearly opens a window of opportunity for the Egyptian economy. The pressure of domestic unemployment is lessened and a new source of foreign exchange can provide the means to finance economic development. However, experiences abroad and in Egypt demonstrate that job-creating development does not follow automatically as a result of selective emigration. Egypt will have to develop an integrated agriculture, labor, and migration policy if it is to maximize the benefits of foreign job opportunities.

CONCLUSIONS

This project has investigated one aspect of Egypt's agricultural economy: how well does the rural labor market match farmworkers and farm jobs? We found that the matching process is imperfect, and that labor market imperfections may be sending false signals to Egyptian policy makers who then devote too much of Egypt's scarce resources to eliminating the need for farmworkers in agriculture.

In particular we showed that there are no *general* labor shortages in Egyptian agriculture. Instead, farmers' complaints about labor shortages must be interpreted as a response to the increased difficulty of finding prime-aged male workers who are available and willing to do farm work for wages on a daily or seasonal basis. However, we found that farmers have already mechanized many of the tasks for which such workers are required, so that further subsidized mechanization would begin to eliminate the jobs of women and children, who still do a substantial amount of Egypt's farm work and who do not participate in the emigration of male workers that lies at the source of the labor shortage complaints. In short, we believe that Egypt has specific labor shortages, and that the optimal mechanization policy is one that targets mechanization subsidies to overcome these specific labor bottlenecks. The Rural Labor Supply Project also documented the existence of numerous labor market imperfections that prevent farmworkers from being matched efficiently with vacant farm jobs. We believe that the Egyptian government could remove some of these imperfections by establishing a network of job information centers that would serve as a clearing house for rural employers and workers. Such a low cost information strategy could help to overcome many of the current labor shortage complaints.

One of the most important contributions of this project was its documentation of the indirect effects of government

policies on the rural labor supply. For example, government efforts to assure educational opportunities appear to be sound, but the government policy of guaranteeing jobs to graduates unnecessarily subtracts workers from the farm labor pool and adds them to an already bloated Egyptian bureaucracy. Similarly, massive food imports and a policy of subsidizing staple food supplies by requiring farmers to grow certain acreages of such commodities for delivery to the government at less than world market price, squeeze farmers' profits and encourage small farmers to devote their time to livestock, which fetches above world market prices, instead of doing wage labor for other farmers. Egypt will have to be more sensitive to the *indirect* effects of current policies if it is to avoid such unintended consequences of policies meant to promote other goals.

Four policy recommendations follow from our analysis:

- Egypt needs a more focussed, task-specific, less subsidized mechanization effort. There is no need for a *general* mechanization subsidy;
- current crop and livestock price policies should be modified to change farmers' incentives;
- better farm labor market information systems should be developed to utilize efficiently the available labor supply;
- Egypt should use tax and subsidy policies to steer remittances into productive investment.

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PRICE POLICY AND TRADE

Egypt has adopted a number of policies and practices, such as price controls, taxes and subsidies on inputs, and compulsory planting rules, that have caused divergences between "free market" prices and the actual prices consumers pay. These "price distortions" influence the amounts of production and consumption, the techniques of production, distribution of income, volume of exports and imports, tax revenues, saving and investment, and virtually every aspect of economic activity.

This project has studied the effect of price policies on Egypt's exports, imports, and the trade balance and has evaluated the effects of these price policies and of any distortions which may affect output, growth rates, increased exports and reduced imports.

A principal objective has been to provide a clear, straightforward exposition of the economic analysis underlying policy recommendations. The technical analysis of price distortions has long been worked out in the economics literature, both in general and for the case of particular countries. What seemed to be needed was a clear exposition of Egyptian circumstances—an explanation that would be in a form accessible to policy-makers.

One paper produced by the project, "The Basic Economics of Egyptian Agricultural Price Policies," is essentially a statement of the economic efficiency gains flowing from the use of market prices to guide the allocation of resources. It is an application of the principle of comparative advantage. One of its conclusions is that the total value of agricultural output in Egypt (at world prices) could be substantially increased by removing price divergences in both outputs and inputs of the agricultural sector.

A second paper, "Treating Berseem as a Traded Good in the Calculation of Social Re urns," is an extension of an earlier study by the Ministry of Economics in which the profitability of the major agricultrual products had been calculated at international prices for comparison with the calculations made at the distorted domestic prices. However, for some crops such as berseem the domestic price was used because there is no world market price quoted for berseem. The authors attempted to supply a proxy international price for berseem by converting its nutrient values into an equivalent in major animal foods such as maize and cotton-seed meal. Prices of the latter products were substituted for the farm price of berseem. Although the price adjustment was substantial for the year chosen, the change did not much affect the rank order of social profitability of the major agricultural crops.

A third paper, "Egyptian Agricultural Price Policies and the Balance of Payments," has three main purposes: (1) to describe the dramatic changes that have occurred in Egypt's balance of trade and payments during recent years, (2) to consider the role of agricultural price policies in causing those changes and thus determining the present balance of trade, and (3) to consider the effect of changes in agricultural prices on the balance of trade and payments.

Man carrying bread (*aish baladi*) through the streets of old Cairo. *Photo: Turid Reid*

It is shown that the balance of trade has changed greatly from its traditional structure in recent years. Merchandise imports now exceed merchandise exports, and agricultural exports—once the mainstay of Egypt's external balance—now account for only a small fraction of total current account transactions.

Using a few major crops as examples (rice, wheat, cotton), the influence of price distortions on the volume and value of exports and imports was examined. It was shown that, using plausible elasticity coefficients, the influence on trade is very substantial.

The final conclusion was that Egypt would benefit substantially from a removal of price distortions: The value of output would rise; the trade balance would improve.

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FOOD SECURITY AND AGRICULTURAL PRICE POLICY

Agricultural price policy is a key economic and political issue in Egypt today. Manipulation of agricultural prices affects the whole price system including the level of real wages, profits, and rents. In turn, it affects the personal distribution of income, the structure of consumption, and the nutrition of the population. The conflict between insuring the welfare of poor consumers through cheap food policies and agricultural production incentives is one of the most difficult dilemmas to resolve. Other conflicts include the trade-off between food self-sufficiency and foreign exchange earnings, and between food subsidies and non-inflationary public budgets.

The objective of this project has been to assess the microeconomic, macroeconomic, and income distribution effects of alternative agricultural price policies on the achievement of food security for Egypt. It has aimed at determining the cost of food self-sufficiency, the degrees of risk in achieving food security objectives implied by alternative policies, and the economic trade-offs among alternative policies.

ACCOMPLISHMENTS

STRUCTURAL CHANGE AND INCOME DISTRIBUTION IN RURAL EGYPT, 1976–1982

The issue of farmers' responses to policy and rural income distribution has been addressed using two approaches. First, a statistical approach was used which analyzed the situation in 1976 and compared it to the situation of the same farmers in 1982. This took advantage of the 1976 Farm Management Survey and represented the first large-scale and systematic use of this source of information. In addition, a resample was taken in 1982 of a subset of the farmers which was used for purposes of comparison. Second, the information gathered was used for the formulation of models to simulate farmers' responses to the policy environment under the different scenarios of 1976 and 1982. The two approaches together make for a better understanding of the dynamics of change in the Egyptian countryside over the last decade.

The results of the analysis of the situation in 1976 can be summarized in several points. First, the distribution of income in rural Egypt in 1976 resembled that of land, one of the most unequal in the world. Second, the unequal distribution of income fortunately does not have negative impact on productivity; yearly intensity of land use is not less on larger farms than on smaller ones and yields of particular crops are independent of farm size. Third, the cropping pattern does not vary significantly across farm sizes. With yields, intensity, and cropping patterns fairly constant across farm sizes, the per-feddan productivity was not found to be statistically different across farm sizes. However, sharecropping relations do affect productivity negatively but not overwhelmingly so. Thus, the issues of productivity and income distribution or economic equity are somewhat more disassociable in rural Egypt than in the rural sectors of other less-developed countries. Fourth, marketing and utilization patterns do not differ significantly across farm sizes. This, together with the idea that farm size is not a determinant of cropping patterns, suggests that larger farmers are not as likely illegally to escape the negative government interventions as has been argued by some proponents of decreased government intervention. It is probable however that they feel the negative effects less than small farmers because their larger marketed surplus allows them to take greater advantage of the free market. This is not to say that intervention should be encouraged. But arguments against it have to be based on facts other than its supposed backfiring due to the large farmers' tendencies to avoid the controls. The most important factor influencing productivity was regionality. In the absence of detailed information on soil quality and other environmental factors, it is difficult to say whether these regional differences are institutionally or ecologically determined. It would be a worthwhile future task to determine whether these differences are institutional, and to the extent they are, a duplication of the effective institution in the areas currently lacking them would be a clear policy recommendation

When compared to the 1976 data, the data gathered in 1982 from a subset of the original farmers show an improvement in income distribution. The income of the smaller 40% of the farmers in the sample increased by about 150% while that of the larger farmers increased by approximately 20%. With an increase in prices during the same period of roughly 80–100%, small farmers are seen to be keeping up with inflation while the larger ones fall behind. This increase in income for the smaller farmers is due to four factors. First, the amount of land controlled by the smaller farmers in the sample has increased. Even if this is neglected as a peculiarity of our sample, the second factor—an increase in productivity—cannot be denied. Yields have increased in all crops due to better seeds, increased use of fertilizers, and other factors. The most important impact, however, comes from the labor market. Wages for off-farm work have increased by about 200%. If one considers that smaller farmers tend to derive about 30% to 40% of their income from the labor market, that this proportion has been increasing, and that larger

farms tend to be net users of hired labor, it is clear that the labor market has worked highly in favor of the smaller farms in Egypt over the last decade or so. This has largely compensated for the negative impacts of government policies.

The simulation of farmers' responses to policy changes is based on a 1976 and 1982 risk-sensitive linear programming household model for small and large farms. This allows the identification of bottlenecks peculiar to different economic groups so that economic policies can be designed with specific groups in mind and their relevance and internal consistency can be assured. Through the model, circumstances of subsistence requirements, production-consumption interdependencies, differential technology, duality of input and output markets, seasonal price variations, and risk, as well as the various government interventions, have been investigated in detail. The first set of data used was the 1976 Farm Management Survey, East Delta subset. The second was the 1982 Updating Survey for two villages in the same zone. Family Budget Survey data were used to support data on household consumption. Risk was incorporated into the model using an absolute deviation approach by simply incorporating the total negative gross margin deviation (calculated for a 10 year period at the governorate level) of the cropping plan as a constraint and running parametric tests.

The various simulations revealed some important features of farmers' responses to government policies. First, removal of government interventions at the most general levels tends to favor the cultivation of cotton and rice but more so the latter. It also tends to favor the smaller farmers because, since the larger farmers have greater total marketed surpluses, they do not feel the burden of the government procurements as much as the smaller farmers. Second, the livestock subsector is of tremendous importance in influencing the farmers' cropping decisions. Securing sufficient livestock feed seems to play a key role in determining cropping patterns and, indirectly, consumption patterns. The areas planted to wheat, maize, and berseem, all of which contribute to fodder supplies, are the most sensitive. Third, improvement in labor market conditions results in increases in income above and beyond that derived from the sale of labor itself, as the income from these labor sales helps the farmer solve critical cash-flow problems. As larger farmers had little surplus labor for the labor market to begin with, increasing absorption capacity of the non-farm sector has helped, and could help further, to reduce the degree of income inequality among farmers. Increases in wage rates would evidently have the same effect. Fourth, the pattern of household consumption changes as a result of alterations in the household cash-flow situation which, in turn, is affected by government credit policy. An improvement in government credit policy seems to have more of an impact on consumption than on cropping patterns: farmers can use government credit to substitute for the sale of some products in order to finance the production of others. The decreased need to sell products results in an increase in consumption. This effect is more marked for the small farmers than for the larger. Fifth, farmers' responses, especially those of small farmers, are affected by risk. Even though it may seem that Egypt is as close as one could come to an agriculturally riskless country, the simulations showed that farmers do in fact take risk into account in their decision making.

AGRICULTURAL SUPPLY RESPONSE

Growth rates of the Egyptian agricultural sector have been falling in the past two decades. In the 1970s, especially when the rest of the economy was growing at high rates, per capita agricultural production declined, leading to a great deal of policy concern. The need for a comprehensive assessment of the effects of alternative policies on the growth of the agricultural sector has been felt for quite a while. This task has been the main aim of this project.

Past studies of the role of agricultural policies in the performance of the sector have focused on supply responses of individual crops. Usually, the supply responses to prices have been significant, and the conclusion has been drawn that prices of crops should be raised in order to enhance total agricultural production. Unfortunately, this result is based upon inappropriate models and suffers from the fallacy of composition. The main problem with these studies is that crop-by-crop estimations do not capture the full cross-effects of the expansion of individual crops, and hence, leads to inconsistencies when aggregated.

In order to quantify the overall effects of government policies upon the growth of the agricultural sector, the research undertaken in this project has used a model based on the systemwide approach to the theory of the multiproduct firm developed by Laitinen and Theil (1978). This model has enabled us to assess the impacts of technical change and of particular price policies on the aggregate agricultural production.

Such a project, however, is quite data intensive. Fortunately, most of our data requirements were available through the Egyptian Ministry of Agriculture. The data set obtained from this source contains information on areas, yield, prices, costs of production of 22 crops, and their by-products for the 25 governorates of Egypt, extending, with some missing values, from 1955 to 1979.

Based on a preliminary organization of the data, a relatively large model was specified which related the log-changes in outputs to the log-changes in product prices properly discounted for input prices. The cropping ratio (i.e., the ratio of total cropped area over total physical area) was taken as proxy for technical change in the agricultural sector and was also included in the model. In Egypt, increases in the cropping ratio have been, to a large extent, the results of further availability of water and improvements in irrigation and drainage systems. Thus, this ratio was assumed to be exogenous for the production decisions of individual farmers.

Since the available data did not allow the estimation of a system with 22 products, the crops in each governorate were classified into seven groups. The first five major crops of each governorate were classified separately, while the rest of the crops were aggregated into two composite

categories. Also, since the number of observations for each governorate was small, 14 governorates which had more complete data and could be paired were chosen for the estimations. These governorates cover the majority of agricultural land in Egypt. The criteria for choice of pairs were proximity and similarity of agronomic conditions and of agricultural production structures. These seven pairs are: Beheira/Kafr el-Sheikh, Daqahliya/Domyatta, Gharbiya/Sharqiya, Minufiya/Qalyubiya, Beni Suef/Minya, Asyut/Sohag, and Qena/Aswan. The model specified for each pair is slightly different depending on the cropping pattern of the two governorates.

The first and most important result was that the aggregate supply response to a proportional increase in all agricultural product prices is quite low: in any of the regions considered, the increase in the aggregate agricultural production is likely to be less than 2.5% if all output prices are raised by 10%. This low supply response shows that the sluggish growth of Egypt's agricultural sector cannot be explained by the low aggregate level of its product prices. This result also reflects the importance of the natural constraints that the sector faces—the first and foremost being the limitation on the physical area of arable land.

The second result depicts the importance of activities which relax the binding constraints on agricultural production. It was found that increases in the cropping ratio were quite significant in explaining the growth of the aggregate output in the regions, with an elasticity of about 0.07. However, if increases in the cropping ratio are interpreted as increased availability of land, then the "marginal productivity" of land is less than one. This result implies that additional utilization of land has diminishing returns, i.e., there are fixed factors which have not been extended simultaneously with the land utilization rate. Identification and development of these factors may have important implications for factor productivities in the agricultural sector and for the total output.

The third result shows that technical changes which lead to increases in the cropping ratio do not have the same effect on all crops; improvements in the irrigation and drainage systems have favored summer crops and have been detrimental to cotton and sugarcane. The winter crops have also benefited from this technical change to some extent because they precede the summer crops on land. Thus, the expansion of berseem, which in the past has been explained by its profitability, may also have occurred because more land has been made available in winter as the cotton area shrunk in favor of maize, rice, sorghum, and other summer crops. This effect is probably as important as relative price changes in explaining the reluctance of Egyptian farmers to plant cotton.

The fourth result concerns relative price changes. Given the present system of rotations and controls, an increase in the relative price of any traditional food crop, i.e., wheat, rice, and maize, is likely to enhance the aggregate agricultural output as well as the production of the crop itself. In other words, such a price rise increases the "weighted" output of the traditional crop more than it reduces that of the others. Cash crops, such as potatoes, tomatoes, and berseem, on the other hand, do the opposite by draining resources out of the production of other crops while contributing little to the aggregate volume of output. This assymmetry is probably the consequence of the frequent controls and constraints which affect the allocation of the fixed factors in favor of the traditional crops while holding their prices low. Removal of these constraints or adjustment of relative prices in favor of traditional crops should have favorable effects on agricultural production.

Finally, our results show that despite regional similarities, differences among them became important when the effects of policies on particular crops are being considered. The relationship between wheat and maize provides an example. In Lower Egypt, maize usually follows wheat in the three-year rotation system since planting time of rice conflicts with the harvesting time of wheat in early summer. Thus, increases in the area of wheat lead to greater maize production. However, the opposite happens in Middle and Upper Egypt where in the summer sorghum is grown instead of rice. In these regions, wheat is usually followed by sorghum, thus competing with maize for land. In any case, such effects are most noticeable among Lower, Middle, and Upper Egypt regions.

PRICE INTERVENTIONS AND AGRICULTURAL PERFORMANCE

Agricultural production and the distribution of food in Egypt have been subject to extensive governmental interventions. Since 1971, the country has moved toward an increasingly open free-market economy and many controls and subsidies have been relaxed. Yet, popular pressures for the perpetuation of these interventions (such as the 1977 food riots) and a piecemeal approach to policymaking, have resulted in a highly complex and heterogeneous policy package. At the producer level, some physical variables are controlled (land quotas, forced deliveries of products, and input allotments) while others are free (uncontrolled crops and inputs); some prices are set by decree while others are market determined. Consumers also face a dual economic system with many commodities subsidized, while others are sold on partially or totally free markets. The results have been numerous inconsistencies in the policy package leading to unintended consequences: a rapidly growing gap between consumption and production, rapidly increasing food imports, and an escalating public budget and foreign-exchange costs for food and agriculture. Yet quantitatively, if not always qualitatively, malnutrition among Egyptians has been virtually eliminated in spite of very low income levels in a large part of the population. The challenges for Egypt are to stimulate production, to reduce the food gap, and to improve food security while preserving the nutritional benefits of intervention policies.

We identified some of the inconsistencies in the current policy package by studying the movements and distortions in five key prices, namely, the prices of food grains, meat and animal products, animal feed, machinery, and the level of agricultural wages. The results show that partial and uneven area and price controls among farm activities reduced the profitability of crops relative to that of livestock.

The results have been (1) a shift in land use from production of staple food toward that of animal feed; (2) a shift in livestock use from draft animals toward production of meat and milk; (3) rapid mechanization to substitute for animal power; and (4) yet minimal—but potentially extensive—displacement of labor by machinery. The conclusion is that a new integrated policy package needs to be devised to eliminate these imbalances by explicitly taking into account the trade-offs identified in this study.

The price policy for rice was studied in detail since rice is an important commodity still characterized by extensive governmental intervention. In the period 1978–1982, forced deliveries captured nearly 50% of production at a price less than half the world market price. The consumers' subsidized price was only 22% of the world market price, and the residual free-market price was 62% of the world market price. The key questions here are what would happen to price levels, to farm incomes, to consumer welfare, and to the cost of governmental food subsidies if forced deliveries for domestic consumption were removed. We assumed that the government would continue to procure 15% of the total output for export (the 1976–77 level) but that the rest would be freely bought and sold on the domestic market. Based on 1976–77 Farm Management Survey data, the conclusion of the present study is that the system of forced deliveries with residual free-market sales can, in fact, benefit farmers under some combinations of free-market price, subsidized consumer price, and forced delivery price. This is due to the fact that the residual free-market price is pushed above the equilibrium free-market price without procurement (except for export). Under some price combinations, the gross revenue from the combination of forced deliveries and residual free-market sales is greater than the gross revenue from free-market sales without procurement. In these cases, however, the scheme of price control is regressive as larger farmers, with a greater share of output sold on the residual free market than that of small farmers, derive benefits from high residual free-market prices while small farmers do not have enough marketable surplus after forced deliveries to do so. Particularly when the residual free-market price is either too high (more than three times the subsidized consumption price) or too low (less than twice that price), farmers are hurt and would fare better under a fully free domestic price alternative after procurement for export.

Forced deliveries of wheat were eliminated in 1976, but they still exist on rice and many other commodities for the sake of "food security" of urban and landless rural populations. We analyzed the impact that removal of forced deliveries on rice would have on farm income and marketed surplus. The results suggest that maintenance of forced deliveries is not important for food security. Removal of forced rice deliveries during the 1979–1981 period would either increase the marketed surplus by 2%, if forced deliveries are set as a share of output, or decrease it by less than 3% if set as a lump sum tax. In either case, the effect on marketed surplus is so small that the scheme is irrelevant for extracting food from farmers' control. This is because farmers' incomes, from sources other than rice quotas, dwarf the positive income effect of forced rice deliveries on the marketed surplus.

Forced deliveries serve mainly as an income redistribution mechanism whereby the cost of subsidizing rice consumption is shifted to farmers. If forced deliveries for domestic consumption are removed, farm income will increase by about 10%. The tax on producers relative to the world market price will still be large but reduced by 17%. Part of the cost of subsidizing rice to consumers is now shifted from producers to the government. With forced deliveries, 80% of the consumer subsidy was paid by producers and the remaining 20% by government. Without forced deliveries for domestic use, farmers still pay 66% of the subsidy and government, the remaining 34%. Here, too, we conclude that the Egyptian government can still manage the rice subsidy program at a limited cost if rice export revenues can be preserved. Egyptian rice farmers would be modest beneficiaries of this liberalization process without substantial detrimental effects on any other segments of Egyptian society.

AGRICULTURAL POLICY AND MACROECONOMIC LINKAGES

Research on this topic is still in progress and we are reporting here the preliminary results of work on construction of a social accounting matrix (SAM) for Egypt which emphasizes the agricultural sector and policy simulation in a computable general equilibrium model.

The preliminary model for which results are reported here has 306 equations. All the left-handed variables in the model are taken as endogenous (total of 246) and this leaves us with 60 more degrees of freedom. In factor markets, we fixed wage rates and capital and land endowments so that labor demand, return to capital, and land rents can be determined endogenously (total of 60 variables). Wage rates are fixed nominally to take into account the fact that the public sector (which dominates in industry) does not index labor rentals in the short run. The wage rate in both closures of the model is chosen as the numeraire. Capital is fixed sectorally because capacity does not respond to change in demand in the short run. Land endowments are fixed as the total amount of arable land. In two sectors in which government controls are strictly enforced (cotton and staple food), land is also fixed sectorally. In the two other agricultural sectors, there are substitution possibilities for land among those two sectors.

The effects of policy changes on the macroeconomy are dependent on the type of closure chosen and on the value of the parameters of the model. Depending on how domestic and foreign constraints are binding, the policy goals of growth and equity may or may not conflict. *Ceteris paribus*, there will not be a conflict if labor is not a binding constraint.

If the supply of labor is elastic, the problem of origin and amount of savings has an important impact on the income multiplier. Any policy redistributing income towards the government or increasing the foreign deficit will lower the multiplier. Conventional fiscal policies have

a positive impact on the economy as long as the foreign deficit is not of concern. The government may want to target subsidies and other instruments toward certain sectors to obtain more expansionary results. Even food price increases may not hurt the urban population since the additional income earned by the rural income groups and their effective demand will increase total real income. Increasing the price of cotton is even more beneficial to farmers, and there are second-round effects for the urban groups which do not lose much in terms of real purchasing power. By contrast, crop failures are detrimental to everybody, although the urban population loses less since food can be imported at fixed prices. As long as there can be unlimited borrowing, there is no problem.

If on the other hand labor supply is inelastic, an increasingly likely situation if migration keeps on tightening rural labor markets, the macro picture looks very different. Policies redistributing income towards the government or increasing the foreign deficit will increase the level of investment. Reduced subsidies, for instance, increase government savings and foster investment if there is full employment. Agricultural price increases shift the distribution of personal income toward rural groups, reduce savings, and thus result in contraction. Moreover, such price increases reduce imports (or increase exports) by increasing domestic production. If foreign reserves are unlimited, investment might be a better use of resources for the country rather than using them for the production of food at an increasing marginal cost. In this case, even crop failures can be a blessing for growth since the government borrows abroad to pay for food imports which it sells domestically capturing the price differential! The government thus captures the income that the rural population has foregone because of crop failure and can spend it on investment projects. The urban population in this case would be better off as a result of increased demand, while food is provided by imports at unchanged prices.

EGYPTIAN FOOD SECURITY

Food security has been an important policy concern for Egypt although it has never been clearly defined. This has given rise to diverse interpretations and recommendations. The aims of this project have been to define food security and to specify appropriate production, reallocation and trade policies to achieve it.

The research approach of this project has, for the first time, considered explicitly the risks that Egyptian agriculture faces both domestically, in terms of yearly yield variations, and in the world market in terms of fluctuations in commodity prices. Both of these factors affect the agricultural balance of trade and, hence, the aggregate national balance of payments.

Food security was defined as the ability of Egypt to consistently satisfy domestic food requirements either through domestic production or trade. This ability, in turn, was specified in terms of a criterion that involved the expected value of agricultural foreign exchange earnings and the variance of these proceeds, while assuming that domestic food requirements are always satisfied. This criterion can be justified both theoretically by invoking the theory of international trade under uncertainty, as well as empirically, since it guarantees food supplies at minimum international opportunity cost and risk.

The basic premise of this research has been that consumption and production policies at the national level could be looked at separately. While food security per se involves first a national decision and commitment about food consumption levels, the consistent satisfaction of these goals necessarily involves separate decisions about the Egyptian production structure. This is a fact that has been altogether neglected in discussions of food security both at international as well as national levels. However, in the medium and long run, it is the ability of Egypt to produce the right commodities in the proper amounts that will ensure adequate income to satisfy domestic consumption requirements and also minimize exposure to international risks.

The research has designed and implemented a fairly large model of the Egyptian agricultural sector. The objective that was maximized considered the expected value as well as the variance of the agricultural foreign exchange earnings under the assumption of fixed, and always assured, availabilities of domestic food commodities. The model included three regions, Lower, Middle, and Upper Egypt, and separate physical and technological constraints for each region. The products considered included all the major cultivated crops and livestock, which was included both as a producer of meat and of traction power, as well as a consumer of domestic and imported feedcrops and crop residues. The constraints pertained to (1) monthly land and labor use for each product and region, (2) water availability, (3) protein, starch, and roughage requirements for livestock, (4) traction power from tractors and animals, (5) rotational land-use constraints for vegetables, and (6) sugar processing capacity limitations.

One of the basic results obtained was a frontier (namely, a set of efficient or best points) of expected value and standard deviation of agricultural foreign exchange earnings under different assumptions about aversion to risk of Egyptian policymakers. It was shown that the current agricultural production structure could be represented by a point considerably inferior and, hence, very inefficient compared to the efficient frontier. This result still holds even if a different frontier is constructed that assumes that the current government area controls are indeed effective in placing a lower bound on cultivated land. The inevitable conclusion is that there is considerable room for changing the production structure and thus improving both the foreign exchange earnings as well as diminishing their fluctuations.

The second basic set of results pertains to the composition of crops that should be grown to achieve food security. The results of the policy experiments are quite startling. If it is assumed that Egyptian policymakers can accept fluctuations and instability in the foreign exchange earnings, then the model results show that Egypt should concentrate its agricultural production on a few relatively remunerative cash crops like cotton, tomatoes, onions, oranges, and berseem. Incidentally, very similar results have been

reached by a World Bank report (Cuddihy, 1980) that did not consider risk at all, as well as by other researchers that investigated Egypt's comparative advantage under conditions of certainty.

If however, Egyptian policymakers are assumed to be very adverse to international instability, then the model results are quite different. Under these conditions, it is shown that Egypt should deemphasize the production of the cash crops mentioned above and concentrate its production on more basic food commodities, namely, maize, rice, sugarcane, wheat, and livestock. This result is very robust under a large number of sensitivity experiments in which many of the model's parameters and constraints were varied widely. It is also consistent with the view of several Egyptian policymakers. The best solution depends on the particular preferences and attitudes toward risk of Egyptian policymakers, but the results have clearly illustrated the alternative choices.

A third major result of the research is that self-sufficiency in basic grains for Egypt is technically and physically infeasible in the near future even if new technology improves the yields of crops considerably. Any pretension to this goal should therefore be abandoned and replaced by one more feasible.

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FOOD CONSUMPTION IN RURAL EGYPT

One of the criteria by which the success of the government's food security policy must be judged is the adequacy of consumption among the people. While this implies evaluation of food policies by estimating their direct effects on nutrition through increasing the quantity or quality of food consumption, their indirect effects through changing the levels of farm production and income must also be taken into account. The mutual interdependence between these direct and indirect effects needs to be incorporated into any framework which seeks to evaluate policy. For example, programs which increase the quantity or quality of the labor supply may increase farm production. Programs which increase farm production such as credit opportunities, input subsidies and price policies for the crops which farmers produce, have a bearing on income and, therefore, on nutrition. There is thus both a need to study the interacting effects of the government's agricultural policies on consumption patterns within the rural household, and to develop a means of predicting likely consequences of policy shifts. In order to explore the effects of government policy on the nutrition of the rural population, this project developed a predictive model based on consumption patterns of rural households. The project was conceived as a three-stage process. First, existing data on dietary habits and beliefs, nutritional status, food intake, consumption of commodities other than food, crop production, other production activities, asset holdings and other demographic and socioeconomic characteristics of Egyptian landholding peasant households, were gathered and analyzed. To complement this data, to expand it where necessary and to provide more recent information, two surveys, the Farm Household Survey and the Case Studies, were conducted. Second, a theoretical model of the poor *fellahin* household as an economic decision unit was specified, then validated by comparing its empirical solutions with observed patterns. Third, the model was used to generate solutions which reflected the consequences of hypothetical changes in policy.

ACCOMPLISHMENTS

THE FARM HOUSEHOLD SURVEY

The 56 villages for which data were available from the 1977 Egyptian Farm Management Survey were classified into five agronomic zones. Briefly, the first zone contained villages located in the north Delta governorates (14 villages). This is the rice zone with approximately 27% of the cropped and 50% of the total cultivated area devoted to rice. Villages located in the middle Delta governorates (14 villages) are in the second zone, characterized by adherence to traditional crops which vary in relative importance from year to year, with no single extensive crop. The third zone included the villages located in the southern part of the delta and the northern part of Middle Egypt (11 villages around Greater Cairo). This zone is characterized by the relatively high percentage of land devoted to fruits (13%) and vegetables (50%). The fourth zone included the villages located in Middle Egypt (7 villages), also characterized by traditional crops. The fifth zone included villages located in Upper Egypt (10 villages), where about 23% of the total landholdings are devoted to sugar cane.

For purposes of this study a survey was conducted on ten villages randomly selected as a representative sample from the five zones. The number of villages selected in each zone depended on the number of landholders holding five or fewer feddans in the zones. Four villages were selected from zone 1, two from zone 2, two from zone 3, one from zone 4, and one from zone 5. The sample may be characterized as a multistage random sample of rural Egyptian households. Observations were randomly selected to be representative of the different size classes of landholders but special emphasis was placed on those holding less than five feddans. The number of observations for each of the villages was proportional to the number of landholders holding five feddans of land or less in the zone.

The major part of the data used in the analyses to be described in this report was gathered from the ten representative rural Egyptian villages in the period from April 1, 1981, through March 31, 1982. Two hundred forty-nine landholders' households, or approximately 25 households chosen at random from each village, were interviewed repeatedly with a minimum of six visits paid to each household.

Specifically, data were collected from the household on the following matters:

- demographic characteristics of household members and family structure;
- size of landholdings and type of tenure;
- cropping structure;
- farmers' options concerning cropping structure, institutional constraints, policies, and programs;
- plant production (quantity and value) and its allocation for home consumption (human and animal), market sales (obligatory delivery and free market);
- input costs (quantity and value) of on- and off-farm costs of plant production;
- animal production and work;
- sources and costs of animal feed (quantity and value) during different seasons;
- farm household assets, including average price of land;
- annual family budget including off-farm income;

- risk and uncertainty in farming operations;
- family labor balance sheet (on- and off-farm labor);
- loans and credit, inputs (in cash and in kind) and technical assistance;
- daily consumption of different food items;
- monthly consumption of the main food commodities (purchased and home-produced);
- farmers' opinions on how to increase their production and income, and how to improve their nutritional level (open-end questions).

Interviewers asked what was eaten in the past 24 hours when gathering data on food consumption. One month for which food consumption data was gathered was August, one was October, so as to reflect seasonal variation in food patterns. A proportionate number of households was interviewed on each day of the week and each week of the month so that different daily or weekly food patterns would not bias the observations.

Additional information needed to complete and check information from a farm household questionnaire was collected at the village level. Directors of the cooperative societies, the village bank, members of the village council, and agricultural supervisors were interviewed to collect the data concerning:

- village infrastructure and basic information about the village;
- landholding structure and land tenure system on the village level;
- cropping structure and land allotment rules for the agricultural years 1980–81 and 1981–82;
- average price of agricultural land and its rental value versus official and free market values;
- prices of different inputs received from the formal and informal sectors;
- farm gate prices for the principal crops grown in the village available from different marketing channels;
- input deliveries supplied by the cooperatives and other suppliers;
- resale of inputs and subsidized commodities;
- credit facilities, their costs, terms, and sufficiency;
- food prices (subsidized, rationed, and free market prices).

Data were gathered by enumerators from the Egyptian Ministry of Agriculture working under the direction of Dr. Mohamed A. El-Shennawy, the Egyptian Team Leader for the entire project. The sample was designed by Dr. Afaf Abdel Aziz Mohamed.

Additional data used in the analyses came from an intensive survey of 54 households in two Egyptian villages conducted in 1982. Data in the latter survey were gathered on virtually every aspect of the household's activities. Specific questions dealt with the health status of household members, births and deaths and reasons for deaths of children in the household, and social factors affecting food consumption and food habits. Dr. Marzouk Abdel Rahim Aref and Dr. Isis Nawar planned and conducted the latter survey.

THE MODEL

A model was constructed which specified production and consumption activities undertaken by a peasant household in order to maintain family life (Benito and Lane, 1983). The purpose was to depict the economic activities of the farm household in Egypt and the relationship between these economic activities and nutrition. Since the farm household makes interdependent decisions concerning production and consumption, and since consumption depends on household assets and the income generated by on-farm and off-farm activities of all household members, the model specified: the allocation of land, household members' labor, animal power, and mechanical equipment among income-generating and consumption activities; the household's allocation of the farm's produce to home-consumption and the market; the household's allocation of labor to on-farm and off-farm activities; the net cash flow available for purchases of commodities other than food and credit payments, and the energy and protein consumption of household members.

The household was assumed to have a lexigraphic utility function, reflecting the household's behavior in acting in accordance with its priorities, first meeting requirements for energy and protein before consuming additional food or other commodities. The farm was assumed to have a Leontief-type production function. A linear programming algorithm was used in the numerical solution of the model.

The model was validated using data from Manshaat El Gamal, a typical village in the northern Nile Delta. A comparative static analysis involving parametric programming was used in order to estimate: the labor surplus response to wage rates; the labor surplus response to mechanization; the relationship of household income to consumption, energy intake, protein intake and relative prices of food; and the demand response to changes in the prices of cereals, beans, lentils, and poultry.

The major findings that have emerged from our work, and which are reported here are based on solutions generated both by the model and empirical analyses.

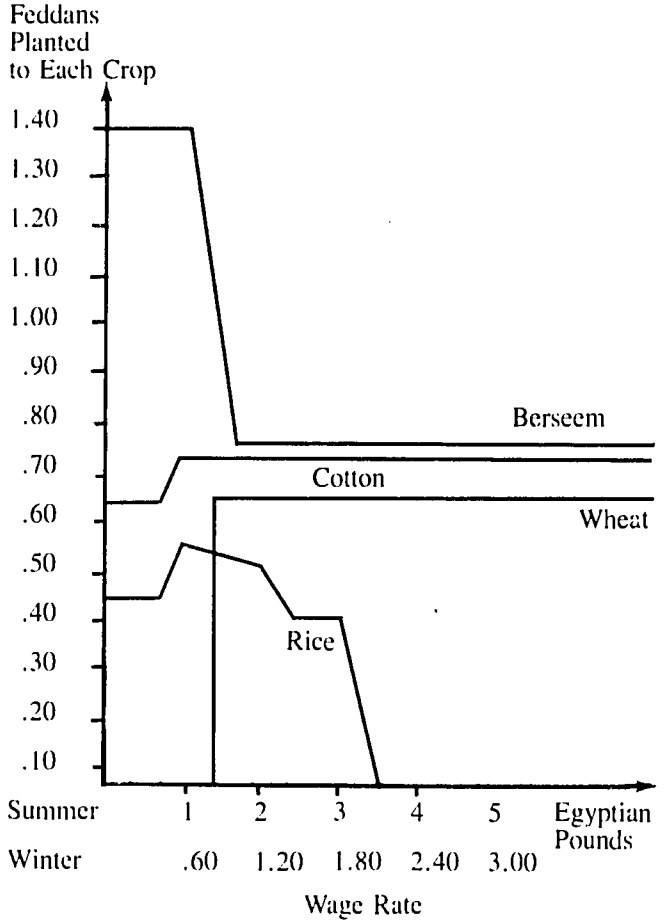
MECHANIZATION AND WAGE RATES

A positive relationship was found to exist between surplus labor supplied to the market and wage rates. Although wage rates are higher during the summer season, it is more profitable for the family to supply labor during the winter season due to the high opportunity cost of family labor on the farm during summer. Only for very high wage rates will the family prefer to sell part of its labor during the summer season. Figure 1 shows changes in cropping patterns as a consequence of changes in wage rates.

Access to mechanization was simulated by change in the rent for mechanical power using values from zero to 2.50 LE. As one would expect, if new activities within the household are not available, mechanization increases the supply of surplus family labor. At the same time the use of animal power on the farm decreases.

The likely impact of mechanization on cropping patterns is most interesting. *Ceteris paribus*, higher rates of mechanization will likely induce increases in food crops at the expense of cash crops. Indeed, for low mechanization loads, wheat is not a profitable crop and berseem tends to be substituted for it.

Figure 1
Cropping patterns as a Function of Wage Rates.



PRICE AND INCOME ELASTICITIES

Price and income elasticities for groups of foods, energy, and protein were generated by the model. Those for grains, i.e., wheat and rice, are 0.08 and 0.39, respectively in the Delta. The demand for grains is relatively inelastic with respect to price. Beans, lentils, and poultry have higher price and income elasticities (Table 1). Income elasticities are higher for commodities other than food and higher for protein than for energy (Table 2). Consequently, an increase in income will increase consumption of nonfood commodities more rapidly than food (the income elasticity of nonfood is 1.4). Under the price structure prevailing in 1981–82 there is very little incentive to change the composition of the typical diet insofar as protein was concerned. Household members will probably continue to consume vegetable proteins rather than animal proteins.

SOURCES OF FOOD SUPPLY AND FOOD CONSUMPTION PATTERNS

Findings indicated that food rationing is the major factor which offsets variability in consumption levels among different income classes or landholding classes. Accordingly, vegetable oils, tea, and sugar, all subject to food rationing, were characterized by the highest degree of similarity and quantity consumed among all the sample observations. Other foods of minor importance in food rationing such as broad beans and lentils, show a higher degree of variability. Food consumption patterns and habits differ from one region to another in rural Egypt and are mainly associated with availability which in turn is largely determined by production patterns. Prices and income are not predominant determinants of consumption levels in rural areas. However, the relative importance of consumption of food produced on producers' farms has noticeably diminished in the last few years. This is particularly evident in the case of products subject to price subsidies, such as wheat, since producers can benefit from the subsidized price in purchasing their needs and thus devote large portions of their produce to the feeding of animals. Nevertheless, in spite of regional variations in consumption levels, farm-produced foods are responsible, along with food rationing, for establishing more equitable consumption patterns among landholders with different farm sizes.

On the other hand, even though farmers producing animal products have a high propensity to sell most of their production and keep little for their own consumption, they constitute the majority of animal product consumers.

ZONAL VARIATION OF FOOD CONSUMPTION

The per capita share of consumption, as indicated earlier, is strongly connected with cropping patterns. Thus in the first zone (the rice zone) rice consumption was almost four times that of the next highest share for the other zones. A similar trend was evident with other food crops. The vegetable zone, which is also a high income zone consisting of villages in the neighborhood of cities, was characterized by a relatively high level of consumption for vegetables, fruits and animal products. Consumption in Upper Egypt (fourth and fifth zones) also reflected cropping patterns. Maize consumption was almost nil, and rice and potato consumption were somewhat less than a quarter and one-third, respectively, of the levels prevailing in the Delta zone.

Differences between zones in consumption of processed or rationed goods such as sugar and vegetable oils were insignificant. There is some tendency among farmers to purchase their wheat flour needs from the market, taking advantage of price subsidies, while selling their total production of wheat at higher prices.

SEASONAL VARIATION OF FOOD CONSUMPTION

Although the time lapse between the visits carried out in July-August and those in October-November was rather short, some variation was detected either due to seasonal differences or to the irregularity of consumption of some food items. Fruit is an example of a food whose consumption level varies seasonally. The major item in this category of consumption during the first period was watermelon which was in large quantities, but was out of season in the following period.

Cereals, as necessary foods, and rationed items, such as sugar, showed the most stability in consumption level from season to season. Tomato consumption was very stable in all seasons. Such a finding may be explained by the fact that tomatoes are grown year-round and they are used in many recipes as well as being eaten fresh.

The differentiation of seasonal or daily consumption patterns apparently increased with size of landholdings

Table 1. **Price and Income Elasticities for a 3-Feddan Landholding Household in the Northern Nile Delta**

	Grains	*Beans and Lentils*	*Poultry*	*Household Income*
Grains	− .08	− .02	.02	.39
Beans and Lentils	− .01	− .28	.04	.42
Poultry	− .02	− .03	− .25	1.05

Source: Parametric Estimation from Farm Household Survey Data, ARE Ministry of Agriculture, University of California, Davis, 1981–1982.

Table 2. **Income Elasticities for Food, Energy, and Protein for a 3-Feddan Landholding Household in the Northern Nile Delta for 1981–1982**

	Intercept	*Household Income Coefficient*	*Elasticity*	$\bar{R}^2$
Grains (wheat flour and rice)	993	.37	.39	.99
Beans and Lentils	65	.03	.42	.93
Poultry	−9	.02	1.05	.70
Other Foods	366	.08	.28	.99
Other Commodities	−144	.87	1.14	.99
Energy	4,798	1.44	.34	.99
Protein	14.898	7.02	.45	.99

Source: Parametric Estimation from Farm Household Survey Data, ARE Ministry of Agriculture, University of California, Davis, 1981–1982.

which may be regarded as a proxy for income and wealth. Greater variety in food consumption is to be expected and is characteristic of households with higher economic status.

CONSUMPTION LEVELS RELATED TO SIZE OF LANDHOLDINGS

The bulk of the daily diet consisted of cereals, consumed at reasonably high levels. Legumes and animal products were consumed in only minor amounts. Similar levels of consumption of cereals were found among the different landholding classes, as might be expected with a necessity food. Fruit consumption, observed during the first visit, varied only slightly with size of landholdings. That might be due to consumption of watermelons, the summer season's major item, which are usually consumed in large quantities by different income classes in Egypt, and are relatively cheap when in season.

Differences in consumption levels between holders of less than one feddan and holders of larger parcels were clearly observed. Per capita consumption of milk and red meat were in the range of 10–16 grams/day and 10–14 grams/day respectively for holders of less than one feddan, and in the range of 40–60 grams/day and 30–80 grams/day for holders of large parcels. Wheat and maize showed a substitutable relationship, as did red and white meat.

SEASONAL VARIATIONS IN WAGE RATE, LABOR USE AND FOOD PRODUCTION

The reservation wage rate, which is the rate below which the supply of labor to the outside market is zero, is much higher for summer labor than for winter. At 1976–77 prices the summer reservation rate was about LE 2.50 per day, and the winter reservation rate about LE 0.30 per day.

These changes in wage rates affect the cropping pattern of small landholders. For example, under the present technological conditions, farm gate prices, and credit rationing, there is an inverse relationship between wage rates and production of berseem and rice; the relationship with the production of wheat is a direct one. In contrast cotton production is not related to changes in wage rates, because of institutional constraints.

The pattern of land and labor use, as well as the crop pattern prevailing in the Delta rice zone among small holders (less than three feddans with an average of 1.5 feddans) are largely explained by response to output and input prices under resource constraint and land allotment

restrictions. As might be expected, allocations of family labor between on-the-farm and off-farm activities respond to changes in rural wage rates and vary seasonally.

ANIMAL PROTEIN CONSUMPTION

The influence of various factors on the animal protein consumption of households was analyzed with the ratio of animal protein to total protein consumption as the dependent variable. This ratio is a good measure of the nutritional well-being of household members and is generally lower than desired in Egypt.

It was found that family size, age of head of household, area of residence, the number of feddans managed, and the number of cows and buffalo in the village, all had significant effects on the proportion of animal protein consumed. Large families cannot afford to make animal protein as important a part of their diet as can smaller families with the same levels of income. Villages around Cairo are relatively more prosperous than those in other parts of the country and hence have a higher animal protein ratio. Older household heads tend to preside over families with higher ratios reflecting their generally more secure economic position relative to younger families. Land area managed is positively correlated with greater command over resources (full income, including home-produced commodities) and therefore with animal protein consumption. Variation in total food consumption levels, however, is not consistent with variation in landholdings since many with smaller landholdings have off-farm income which brings their total incomes above those with larger landholdings. Raising levels of animal protein consumption requires raising incomes, increasing the stock of cows and buffalo so that more small landholders have them, and changing Egyptian food habits. Where there are cows and buffalo, more milk is drunk. Providing credit to lower-income landholders to permit them to buy cattle and buffalo and making animal feed more readily available at lower prices should, along with nutrition education, help increase the proportion of animal protein in diets.

Our research has led us to the following conclusions which we state as hypotheses that require corroboration by expanded surveys. We hypothesize that, in general, the Egyptian farm household tries to maximize income and concomitant utility in relation to output possibilities, available inputs, available time and resources, bureaucratic frustrations, and wage rates for their own and hired labor. Off-farm income is important for the rural Egyptian landholding household, often more important than farm income. Based on our survey, provision of adequate calories was not a problem, and only in a few cases was consumption of animal protein unacceptably low. We reiterate however that nutrition problems are group specific: the group most at risk is young children recently weaned. It should be noted we did not survey the rural landless nor did we have information on the intra-family distribution of food, and it is possible that at-risk categories might show up here on closer examination.

Food rationing, food subsidies, and the government food distribution system are effective in rural areas in keeping food consumption levels relatively equal. Since the demand for wheat and wheat flour is relatively inelastic and bread is a major component of the diet, the removal of this subsidy would probably have serious repercussions.

When prices increase, particularly for animal products, an increased proportion of these products is marketed, and there is a danger that nutrition levels may decline as a result. Farm households prefer cash to their own home-grown or-produced food in order to buy commodities other than food. When more crops can be marketed on the open market, farmers prefer cash crops to food crops, again posing a threat to adequate nutrition. The traditional Egyptian diet in rural areas has deficiencies which have not generally been remedied despite rising incomes.

If accepted, our conclusions would lead to a policy of continuation of the present subsidies on bread and wheat flour, beans and lentils, and, perhaps, cooking oil, for the time being, but with a phasing out of rationing and subsidies on any other food products. In addition there should be a separate policy focused on nutrition education and public health. These changes would need to be coordinated with other policy changes if detrimental side effects are to be avoided. In particular, the phasing out of wheat flour and bread subsidies, and the rationing and subsidies on beans, lentils, and cooking oil would lead to economic hardship and inequity in the absence of an incomes policy and an improved private marketing system. Two other ADS projects, the Marketing Project and the Prices and Subsidy project will also have outputs that affect thinking on these issues.

We have only initiated the work that has to be done if the costs and benefits of the present food policy in the rural areas of Egypt are to be assessed. An analytical model has been established and can now be adapted to meet the needs of a variety of investigations, such as the consumption patterns and nutritional status of rural landless households. Our original plans were to identify the most effective agricultural and nutrition intervention programs for the improvement of the nutritional status of the rural poor. Though nutritional deficiencies have been identified, we have not yet completed the analyses required to accomplish our objective fully. But, more importantly, we find nutritional status is more a problem among the landless than among landholders, and survey material on this group is needed. More information about food security and nutrition programs and how they affect those most at risk also should be gathered in order to provide the government with a more complete picture upon which to base policy.

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EXPORT MARKETING POTENTIAL FOR VEGETABLES

With a limited area of land for cultivation, it is imperative to Egypt's economic well-being that maximum use be made of this resource. One potential approach to capitalizing on the comparative advantage of its warm winter climate and geographical location, is production and export of fruit, vegetables and flowers to Europe and other Near Eastern countries. Foreign exchange earnings from these high value crops applied, for example, to purchase of imported staple foods, are likely to result in a net gain for Egypt over and above the value of food crops that could otherwise have been grown. Before this can be accomplished however research is needed to determine which vegetables or flowers can be exported profitably with prospects of long term markets, and what is required to exploit the opportunity. This project has been designed to provide the framework for formulation of policy on this issue.

The possibility may also exist for processing certain vegetables for domestic use or export to Near East countries. Were processing economically feasible it would contribute to the reduction of fluctuations in supplies and market prices, reduce waste, and help meet nutritional needs. This study has determined the economic feasibility of such processing given the market potential.

ACCOMPLISHMENTS

Initially work centered on the production and export feasibility of fresh tomatoes. Domestic supply and demand for fresh and processed tomatoes were included in the scope of research because domestic factors affect potential export supplies. Possible export markets considered in this study were the European Economic Community (EEC) and Near East countries. Underlying demand and supply forces were investigated in an attempt to define the structural form of the multi-country trading network, a necessary step in constructing an economic model with which to evaluate the effects of factoral changes.

Studies were conducted on market channels and demand for tomatoes in the Netherlands, Germany, France and the U.K. Analysis of the data from these EEC markets as well as data obtained on the supply of tomatoes from competing countries (Spain, Morocco, and the Canary Islands) showed that:

- the demand for fresh winter tomatoes is price elastic and large expansion in Egyptian exports would not significantly affect market prices in West Germany, France and the U.K.;
- competitive supplies of tomatoes from the Canary Islands and Morocco will likely not expand further due to climatic factors and higher returns available from competitive products such as cut flowers;
- Spain will expand tomato supplies upon becoming a member of the EEC, but the increase in supplies will go mainly to France, leaving Egypt with good markets in West Germany and the U.K.

An EEC trade model was constructed using the demand functions for West Germany, France and the U.K., and the supply functions for Spain, Morocco, and the Canary Islands. A reactive programming routine was used to investigate the effects of changes in economic factors on equilibrium prices and the network of trade flows. The various scenarios investigated were related to Spain's entry into the EEC and the effects on supplies from Spain.

Research on vegetable markets in Near East countries indicated that competition from other Mediterranean countries for Near East markets is increasing due to (a) transport cost advantages compared to Egypt, (b) national policies in other countries (such as Jordan, Greece, and Lebanon) to promote exports to Near East markets, and (c) better developed export facilities in other Mediterranean supplying countries.

Also, Near East countries themselves are vigorously promoting domestic production, sometimes at high cost. However, tomato exports to Arabian countries have been affected by the war in Lebanon. Further research indicated that large multi-national trucking firms located principally in Lebanon experienced difficulty in moving produce from Turkey, Lebanon and Iran to Gulf States, so, in order to increase the use of their trucks, they developed relationships with Egyptian exporters. While a few of them went into partnership with Egyptian exporters, most merely accomplished the transportation function. The produce is picked up usually at Cairo airport (since quality inspection is accomplished there), in 18-22 ton refrigerated trucks. Trucks are driven to Suez, loaded onto ships, travel to the Gulf of Aqaba, are unloaded there, and are driven to the various Gulf States. The trip costs about $175 per ton and takes some three days in transit, compared to $270–$360 per ton by plane. Such transportation arrangements appear to make Egyptian tomato exports to Gulf States feasible, but several problems remain, including:

- insufficient supplies of tomatoes cause delays in accumulating loads and often delay shipments;
- the produce is heterogenous in quality, being assembled in small lots from individual farmers;
- contracts with farmers at fixed prices cause the exporter to bear substantial risks of loss from price fluctuations;
- special packaging is required for truck shipment, is costly and not always available;
- ships are sometimes unavailable or are not of the type to allow use of refrigeration equipment while on board;

- regulations in some countries restrict free routing of supplies.

A comprehensive analysis of domestic supply and demand relationships was conducted to furnish data and understanding complementary to research on overseas markets. This entailed a survey of retail and wholesale handlers in Cairo, conducted at regular intervals during 1982. Data on prices, margins and facilities were obtained and analyzed. About 100 retailers in 10 areas of Cairo were interviewed twice monthly between December 1981 and May 1982. Areas of differing income levels and environment were selected on a judgmental basis. Average quantities handled daily for the 100 retailers were 190 kgs. of tomatoes. Average purchase at wholesale price plus transport to the retail establishment was 9.9 LE per 100 kgs. Most retailers obtain their produce at Rod El-Faraq market, the remainder being purchased at secondary city markets. Transport to retail establishments is accomplished at secondary city markets. Transport to retail establishments is accomplished by donkey-cart (21%), pick-up trucks of 1–1½ tons (68%) and larger trucks (11%).

Data on acreage, yields and prices for summer, Nili and winter tomatoes, by governorates, were obtained and supply functions were estimated.

A study of tomato processing facilities in Egypt was initiated to determine costs and profit margins for tomato paste and juice. Although demand for tomato paste in Egypt is expanding rapidly, it was determined that imports cost only about half the cost of processing in Egypt, and output prices are fixed at about half the cost of production. Consequently, it is difficult to recommend expansion of processing facilities.

A survey of vegetable retailers and marketing margins in Cairo indicates that the farmers' share of the retail price of tomatoes is only 44.3% on the average, the wholesale margin is 8.2% and the retail margin is 47.5%. The average volume handled daily by retailers is only 180 kilos. The high retail margin is due partly to small scale and partly to the fact that a high proportion of the tomatoes must be sold at discounted prices due to deterioration of quality caused by poor handling. Domestic prices are subject to large price fluctuations in relatively short time periods. The marketing system suffers from lack of facilities and inefficient handling procedures. There is considerable re-shipping from the Cairo wholesale market back to consumer markets in producing areas, and excessive loading and unloading.

Research at Rod El-Faraq and El Nozha wholesale markets on seasonal variation in prices and quantities of tomatoes and the size distribution of handlers (Rod El-Faraq market only) was accomplished. These data were used to estimate wholesale demand functions and indicated near-competitive pricing behavior with price elasticities of demand around −0.9. Demand expands somewhat in April and declines somewhat in July. Reduced supplies in April cause the price to rise significantly. Prices respond closely to variations in market supplies, and prices seem to be well aligned geographically, judging from average monthly price data.

In summary, these studies on the characteristics of producers and exporters of tomatoes in Egypt revealed several major constraints on export potential:

- lack of infrastructure such as packing plants, refrigeration, and transportation, causes quality loss, excessive marketing costs and erratic export supplies;
- exporters are small, lack facilities and practice frequent entry and exit from the industry, creating an unstable environment for exporting. Government regulations on exports also reduce incentives for investment in facilities;
- a new variety of tomato durable enough for ocean travel is desirable, since it is not economical to ship by air.

Research on cut flower export potential centered on identifying the demands in EEC countries. West Germany is the largest importer, with over 26,000 tons of carnations, 12,000 tons of roses and 6,000 tons of chrysanthemums during the November to May period. The Netherlands is the principal supplier, but Kenya, Columbia, Israel, Italy, and Spain also supply substantial quantities. Glass-house production in Germany provides about 10% of the total flower market supply.

The flower market is a worldwide network of supplying and consuming countries connected by air shipments. Demands by individual countries for individual flowers are price elastic. An OLS regression analysis of West Germany's monthly data indicated price elasticities −2.2, −2.3, and −2.7 for carnations, roses and chrysanthemums. Egypt's greatest potential in cut flower exports is probably in cut chrysanthemums.

A survey of cut flower producers and exporters in Egypt indicated that the export of cut flowers is a very small industry composed of approximately ten private producers and El Nil Company. Currently gladiolus is the principal flower exported (69% of total exports) and is growing in importance relative to other flowers, but only 414 tons of gladioli were exported in 1981. Lebanon and Russia are the biggest customers, and Lebanon re-exports much of the imported Egyptian flowers. Very small quantities of flowers are exported to Western Europe, primarily to the Alsmeer auction. Roses are the second most important flower exported (29% of total exports) and tuber roses are third (9% of total exports).

The varieties of gladioli grown in Egypt are primarily white varieties, a color not preferred in Western Europe; they sell better in the domestic market. The difference in preferences for color and type between Western Europe and Egyptian consumers makes it difficult to establish coordination of production for both markets.

Flowers are shipped by air to the various markets. Cost of airfare for flowers in 1982 was 33 piasters per kilo to France, 38 to Holland, and 35 to West Germany. The cartons required for shipment cost 3.05 LE per carton.

The export of cut flowers operates under certain restrictions imposed by a Commodity Board, made up of representatives from various Ministries, as well as some producers. The Board sets minimum export prices for each type of flower (including minimum prices for each

grade or quality in the case of gladioli and roses). The minimum prices are set at the beginning of the season and remain unchanged throughout. The Board may also allocate export targets to different markets and to different exporters, although the very small size of the industry makes this role meaningless. Such allocation only plays a meaningful role if there are excess supplies. The Board also issues licenses to export, and once a license is issued it is only good for 24 hours. Hence, if an exporter intends to develop a continuous supply of shipments he must continually be obtaining new licenses.

It makes very little economic sense to place restrictions or regulations on an infant industry—particularly one requiring heavy capital investment and facing considerable risk of price variation. High risk activities must carry correspondingly high profit potential if capital is to be attracted for investment. The government should remove all restrictions which affect the flexibility and profit potential for the producers and exporters.

POLICY IMPLICATIONS

General Recommendations

If Egypt is to develop a viable export industry for tomatoes and cut flowers substantial changes must be made in the present marketing system. This includes new physical facilities (such as packing plants and refrigeration facilities) as well as marketing institutions.

It would be advisable to develop markets in Arabian countries first, and Western European markets second, when marketing facilities are better developed.

Restrictions and constraints on the export industry imposed by the government must be eliminated or at least relaxed. This includes the practice of fixing minimum export prices at the beginning of the season, and the required remittance of foreign currency to the Central Bank. Such constraints reduce the flexibility for producers and exporters to pursue normal business operations and retard the development of the industry. Export of horticultural products is risky and requires large capital investment. Such industries normally can develop only if given sufficient flexibility and substantial profit incentive. Commission houses in importing countries are reluctant to accept shipments at guaranteed prices, no matter how low the minimum price may be, particularly when quality variations in shipments are substantial. Although such restrictions may have the intent of aiding the export of horticultural products, they actually have the opposite effect.

Public companies such as El Nil and Wadi could play a more useful role in stimulating exports by a vigorous program of vertical integration with farmers, the selective construction of adequate handling facilities, and vigorous development of contracts in overseas markets. Government constraints, which are the same as for private companies, should also be relaxed.

Specific Recommendations

Development of Export Markets

Markets for tomatoes, other vegetables and cut flowers in Arabian countries can be developed if transport costs can be reduced. Transport by refrigerated truck combined with container-type ships is probably the most feasible method at present, and has, in fact, recently been used by international trucking firms operating out of Lebanon. A similar system should be developed in Egypt for movement of produce to Arabian countries. Packing plants and pre-cooling facilities are a necessary part of the "cold chain" and should be developed.

Export of tomatoes to Western European markets would require the same type of facilities but cut flowers can be air-freighted.

Packing plants are even more necessary for exports of tomatoes because the high quality and uniformity requirements of EEC markets cannot be satisfied without machine sizing and quality cannot be maintained without pre-cooling prior to shipment.

Processing of Tomatoes in Egypt

Tomato paste is currently available for import from Italy, Spain, Portugal and Greece for substantially less than the cost of processing in Egypt. Also the output from processing plants in Egypt is priced at substantially less than the cost of processing. Although it may be desirable from a food strategy point of view for Egypt to process some tomatoes it is doubtful that such processing capacity should be expanded at present. Since processing machinery and packaging materials must be largely imported, the costs to the Egyptian economy for expanding capacity would be significant, and probably not warranted until import supplies begin to diminish. The present inefficiency in domestic marketing channels for tomatoes and other vegetables indicates the desirability of experimenting with alternative marketing channels. Due to lack of market alternatives and price information in producing areas, farmers often ship to Cairo only to find the commodities re-shipped back to consuming markets in producing areas. An experimental program of constructing auction markets (possibly accompanied by packing plants and refrigeration facilities) in selected producing areas appears warranted. Wholesalers would be present at these markets and the first stage of assembly could be accomplished there, with the result that movement to markets would occur in larger lots at less cost and with reduced spoilage. The possibility of building one or two additional wholesale markets in principal cities should be studied as a method of reducing congestion and increasing competition at the central market level. The markets would be located so as to minimize transport difficulties for arriving produce.

Cut Flower Exports

Preliminary findings from research on cut flower markets indicate that chrysanthemums and gladioli have the greatest potential for large volume shipments to EEC markets. Competition from other countries is less severe for cut chrysanthemums in the winter season because present supplies from West Germany and Holland rely on high-cost glass-house production. The development of chrysanthemum production in Egypt could possibly result in a sizeable industry. Competition in carnations is severe

from Columbia, Kenya, Spain and Israel, and roses are supplied from Canary Islands, Israel, Spain and other countries. Export of cut flowers to Arabian countries seems feasible, since flower consumption in those countries is increasing and quality standards are not so exacting as in the EEC. Live plants and foliage are rapidly expanding markets and should be investigated further.

The Need for Further Research

The research conducted under this project has identified several topics which need additional study. These are:

(1) to determine an efficient structure of local packing houses for assembling, packing, grading, and cooling tomatoes for export and domestic use. The study should identify the number, scale and location of packing plants in producing areas;

(2) to determine efficient alternative marketing channels for fresh vegetables, such as the location and facilities needed for auction markets in producing areas. These would provide alternative markets for producers, and would avoid congestion and cyclical over-supplies on the Cairo wholesale market, would improve market information to producers and wholesalers, and would alleviate the problem of re-shipment of vegetables from Cairo back to consuming markets in producing areas. A feasibility study for better situated wholesale markets in Cairo and Alexandria is also desirable;

(3) to examine the feasibility of exporting other vegetables to Western Europe and Near East markets;

(4) to explore the feasibility of exporting to Near East markets given the changes which have occurred due to the war in Lebanon. The present study has provided a framework for pursuing this but limitations on time and resources precluded a complete analysis;

(5) to investigate the feasibility of exporting winter tomatoes to Eastern European countries—principally Russia;

(6) to assess the feasibility of exporting live plants and foliage. These are expanding markets in Western Europe and seem to be more profitable than cut flowers.

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FARM MECHANIZATION AND PUBLIC POLICY

The Egyptian government's policy of agricultural mechanization and the demand for farm machinery stem partly from the rising real wages in rural areas and partly from labor shortages. However, several other factors may be influencing the demand for machinery. For example, the uncontrolled price of livestock products or fuel subsidies may have more to do with the demand for tractors than increased wages. Social factors may be as important as economic factors in influencing the tightness of labor markets. If indeed genuine labor-related bottlenecks exist which hamper improved yields and higher valued cropping patterns, then failure to take advantage of modern mechanical technology under these circumstances would make it difficult for the agricultural sector to continue to maintain its contribution to the Egyptian economy.

In fact, however, little is known about the interaction of economic policies, farm size, credit availability, and acreage requirements on the demand for machines. The most appropriate government policies regarding support for mechanizing agriculture cannot be determined until much more information is available concerning the social and economic impacts of task-specific mechanization.

The specific objectives of this project have, therefore, been: to study the derived demand for mechanical technology under alternative assumptions about the structure of prices and markets; to examine the interaction between the farming system, cropping and employment patterns, and task-specific mechanization; to examine the impact of price distortions of land, fuel, livestock and other factors on the type and rate of mechanization; and to analyze the impacts of ownership patterns and factors affecting the emergence of hire-markets on the demand for mechanization in Egyptian agriculture.

Pursuing these objectives has required an analysis of both the demand and supply of mechanical technology. The methodology used to pursue these objectives was necessarily eclectic: on the demand side, both econometric and programming techniques were used, and on the supply side, resource constraints dictated that the results have been simple tabulations of the surveys carried out among the relevant respondents.

ACCOMPLISHMENTS

DEMAND CONSIDERATIONS

In looking at the determinants of the demand for mechanization, several elements can be distinguished. There is, for example, the question of an appropriate measure of the opportunity costs of animals when these are used both for power and for livestock products. Obviously the greater the trade-off between the two, the greater the benefits that would accrue from the introduction of mechanical technology. Quantitative measures of the impact of using animals for both work and milk are difficult to obtain, but Dyer (1981) has provided estimates based on cross-sectional data collected at Zagazig University. Although not without problems, the resulting analysis strongly suggests that previous assumptions about the effects of work on animal products output have been significantly overstated.

A second econometric study of the determinants of the demand for mechanization was undertaken with data drawn from the 1977 Farm Management Survey carried out by the Ministry of Agriculture (Dyer & Imam, 1981). In the case of yields, an analysis of covariance was used in which a Cobb-Douglas production function with dummy variables for each type of mechanization was fitted to cross-sectional data. The generalized form of the model can be written as:

$$Y = a + bP + cI + dN + eM = fH = gF = hS$$

where all variables are logarithmic except the dummy variables and:

Y = yield in ardebs per feddan
P = dummy variable for type of plowing
I = dummy variable for type of irrigation
N = chemical fertilizer in kg/N
M = organic fertilizer
H = hired labor in man days
F = family labor in days
S = size of the field in feddans

As Table 1 indicates, the results of the estimates were not terribly good with generally low R^2's and insignificant coefficients. However, in several cases, there appear to be higher yields associated with mechanization (maize in Upper Egypt and cotton in Upper and Lower Egypt). These findings are buttressed by informal interviews with farmers who singled out these two crops as being the recipients of special attention while seedbeds were being prepared.

The quantitative work did not support various hypotheses regarding the effect of mechanization on timeliness of planting and cropping intensities. However, the study noted that the data constraints were such that the resulting partial analysis may have missed some of the more important contributions of mechanization to improvements in the overall farming system.

The major part of the work on the determinants of demand was devoted to a linear programming model of farming systems in the Central Delta. The general formulation of the model followed familiar lines but it was characterized by a high degree of disaggregation. As noted above, most of the mechanization debate has focused on the issue of timeliness of operations and consequently,

Table 1. Covariance Analysis on Yield, Upper Egypt

		Plowing Technology			*Irrigation Technology*									
	Intercept	Animal	Mech.	None	Animal	Mech.	Gravity	Nitrogen Fertilizer	Manure	Hired Labor	Family Labor	Field Size	No. Obs.	R^2
Wheat	6.34*	-0.01	-0.20	0	0.34*	0	–	0.09		0.0	-0.01	0.08	72	0.24
	(13.34)	(0.14)	(1.39)		(4.00)		–	(0.99)		(0.17)	(0.16)	(1.48)		
	6.15*	0.42	0.47	0	-0.38	0	-	0.10	-0.09	-0.13	0.38*	0.12	18	0.75
	(6.92)	(1.60)	(1.55)		(1.23)		–	(0.70)	(0.73)	(1.06)	(3.67)	(1.05)		
Maize	3.71	0.03	1.05	0	0.32	0	–	0.40		0.19	-0.02	0.20	35	0.50
	(1.93)	(0.09)	(2.00)		(1.56)		–	(1.39)		(1.09)	(0.19)	(1.88)		
	4.68*	-1.01*		0	1.04*	0	–	0.01	0.15	0.15	0.32*	0.43*	10	0.97
	(2.92)	(2.74)			(3.91)		–	(0.04)	(1.12)	(0.51)	(3.42)	(4.43)		
Sorghum	6.37*	0	-0.15	0	-0.03	0	0.06	0.16		-0.12	-0.04	-0.08	46	0.05
	(7.69)	(0.01)	(0.28)		(0.15)		(0.14)	(0.90)		(0.98)	(0.37)	(0.40)		
	11.46	-0.51	-2.20	0	-0.02	0	0.58	-0.15	0.04	-0.72	-0.65	0.47	13	0.31
	(1.12)	(0.27)	(0.36)		(0.01)		(0.21)	(0.13)	(0.01)	(0.44)	(0.48)	(0.29)		
Sugar-	2.23*	0		0	0.07	0	0.19*	0.09		0.13*	0.08*	-0.02	38	0.59
cane	(6.04)	(0.03)			(0.38)		(2.46)	(1.51)		(2.98)	(2.32)	(0.52)		
Cotton	3.70*	0.07	0.50*	0	0.58*	0	0.15	0.42*		-0.08	0.08	0.13	21	0.87
	(5.11)	(0.59)	(2.42)		(3.29)		(0.58)	(3.71)		(1.37)	(1.43)	(1.66)		

* - significant at 5% level

Note - number in parentheses is T-statistic

limits on resource availability have been broken down into semi-monthly constraints for eight of the most critical agricultural months. Each resource, e.g., land, water, labor, etc., was actually composed of 20 resource constraints representing the crop year. These detailed time periods in turn allowed a more realistic modeling of the crop activities—each crop had planting dates at semi-monthly intervals over the relevant season.

The model was disaggregated to include a variety of technological choices. Separate activities were developed to represent the purchase and operations of indivisible durable capital investments—buffalo, cattle, *sakias* (water wheels), pumps, tractors, threshers and *norags*. Such a formulation permits modeling experiments that embody different assumptions about the presence or absence of hire service markets.

The model can be written as follows:

Maximize:

$$Z_j = c_{ij}C_i - u_{ij}U_i - p_{ij}P_i - l_{ij}L_i - m_{ij}M_i - b_jB - e_jE - d_jD + a_{ij}A_i$$

where:

Z_j = value of objective function j
C_i = area in feddans of crop i
c_{ij} = net revenue per feddan from crop i
U_i = hours (or days) utilization of lumpy input i
u_{ij} = variable cost of utilizing lumpy input i
P_i = units of lumpy input i purchased by the farm
p_{ij} = annualized fixed cost of lumpy input i
L_i = person-days of type i hired casual labor
l_{ij} = daily wage rate of type i hired casual labor
M_i = persons of type i hired permanent labor
m_{ij} = annual wage rate of type i hired permanent labor
B = tons of broadbean sold
b_j = price per ton of broadbean
E = tons of feed concentrate purchased
e_j = price per ton of feed concentrate
D = liters of diesel fuel purchased
d_j = price per liter of diesel fuel
A_i = units of livestock activity i
a_{ij} = net revenue of livestock activity i

The results of maximizing the net revenue of crop and livestock enterprises subjected to constraints on land, labor, capital, water, etc., encompass a number of policy issues.

Economic *vs.* Financial Returns

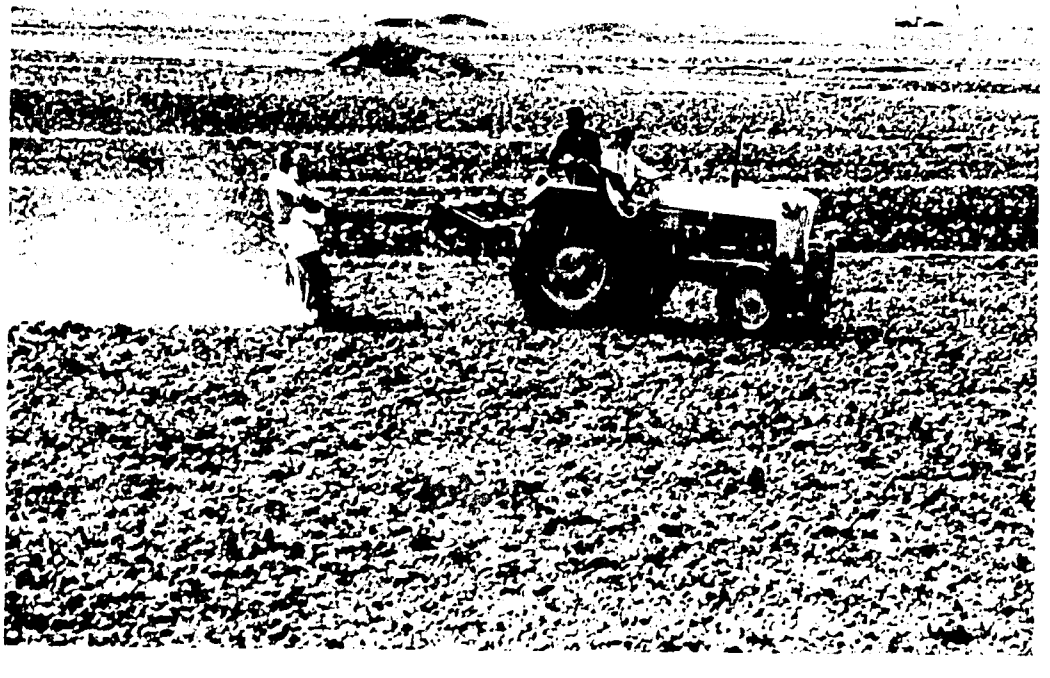
The solution was evaluated at both economic and financial prices. As might be expected, there were substantial differences in the value of the objective function. However, when financial prices without government acreage constraints determined the optimal solution, it was substantially different than the allocations of revenues that has been historically observed. This finding suggests that while there may have been significant leakage in the government's efforts to control crop acreage, the procurement programs have had some effect on acreage planted. To this extent, benefits from proposed price reforms that rely on changes in the cropping pattern between financial and economic prices may be overstated.

Choices of Technology

Table 2 compares the choice of mechanical technology under financial and economic prices. As expected, the financial solution showed a greater dependence on mechanical inputs than the economic solution. The results were immediately evident from the role of livestock in the two solutions. In the economic solution, cattle continued to be important because of their ability to supply both dairy

Table 2. **A comparison of the choice of mechanical technologies expressed as farm capital in which net revenues are maximized for a three feddan farm (assuming all technologies to be available)**

	Financial Solution			*Economic Solution*		
	Quantity	Capital LE	Stock %	Quantity	Capital LE	Stock %
Tractor	0.0153	37	4.2	0.0117	28	6.8
Thresher	0.0153	3	0.4	0.0117	2	0.6
Winnower	0.0216	3	0.4	0.0189	2	0.7
Pump	0.1819	52	5.8	0.0976	28	6.6
Cattle Cow	0.0892	16	1.9	0.7061	134	31.6
Buffalo Cow	1.8764	459	50.7	0.2668	65	15.4
Sakia	0.0696	10	1.2	0.2463	36	8.7
Norag	0.0	0	0.0	0.0756	1	0.3
Other Livestock		322	35.6		124	29.4
Total		906	100.0		425	100.0



Egyptian agricultural practices are often no different than they were a hundred years ago, as this picture of land leveling shows. But mechanization is increasing rapidly—especially tractor plowing—and is encouraged by sector policy. The ADS Mechanization Project has been studying mechanization, its impacts and efficiencies and the relation to an alleged labor shortage resulting from the migration of Egyptian labor to European and neighboring countries. *Photos, Eric Gustafson*

products and the power for the *sakia* and the *norag*. In the financial solution, livestock continued to be important, but animals were represented almost entirely by milk buffalo.

Estimation of the Rates of Return

The five types of technology that were considered were (1) a 65-horsepower tractor used for tillage only, (2) the tractor used for tillage and harrowing, (3) the tractor used for tillage, harrowing and ridging, (4) a tractor-powered drum thresher with a handpowered winnowing machine, and (5) a 7-horsepower diesel pump set. The model was run with and without the technology to calculate the rate of return. For the tractor, rates of return were calculated for its use in tillage, harrowing and ridging separately. Each rate of return is for that operation alone, without including the benefits for the other tractor operations.

Three different rates of return were calculated for each type of technology. The two of policy significance are the financial and economic rate of return under second-best assumptions, i.e., financial prices in the objective function. This formulation resembles most closely what is normally done in benefit-cost analysis. The third rate of return, to be used as a comparison, is the economic rate of return in the first-best world when international prices are used in the objective function.

The three rates of return for each technology calculated for four farm sizes are presented in Table 3. The importance of examining the differences in farm sizes lies in the effect of different resource endowments on technology choice. At the extremes, the one feddan farm can meet its labor demands almost entirely with family labor, and the ten feddan farm cannot hire sufficient labor to fulfill demands, driving shadow prices for labor above the market price.

A comparison of the results in Table 3 shows how the tractor-tillage is both financially and economically profitable, with rates of return above 10%, but that tractor-harrowing and-ridging have high financial rates of return with much lower economic rates of return. The similarity in all three rates of return for tractor-tillage is particularly striking. It is obvious that both the farmer and economy are benefiting from the mechanization of tractor-tillage, with second-best economic rates of return varying from 37 to 322%, depending on the degree of labor shortage.

The second-best economic rates of return for tractor-harrowing are negative infinity for all but the five feddan farm, despite the fact that financial rates of return are all above 20%. The case for tractor-ridging is similar with second-best economic rates of return all being minus infinity while the financial rates of return are above 15%.

Table 3 also illustrates that the combination thresher and winnower is a highly profitable technology; financial rates of return are above 75% for all farm sizes. The sensitivity of this technology to the wage rate is evident from the second-best economic rates of return that are negative for the one feddan farm but increase to 767% on the ten feddan farm. This is because the dual values of man labor during the wheat threshing season for the non-thresher solution are zero for the one feddan farm and LE 18.4 per day for the ten feddan farm, which is virtually the highest opportunity cost of labor in any of the many solutions. It is also more than ten times the normal wage rate.

The importance of farm size reflects the fact that mechanization of threshing and winnowing induces large labor savings. Furthermore, these labor savings are realized at the most labor-constraining periods in the year, late May and early June. All three measures of rate of return increase dramatically as the size of farm increases.

Rates of return for mobile pumps in Table 3 pointedly demonstrate the difference between pumps and the thresher technology investigated in the last section. The rates of return for pumps were little affected by farm size. The introduction of pumps saves only marginally on labor use, and in addition, these labor savings are spread across the entire cropping cycle with no concentration in the critical labor-short periods.

The second-best rate of return is always negative for the mobile pump which reflects the fact that the pump consumes heavily subsidized diesel fuel. Therefore, because of no significant labor savings, the economic rate of return is very low despite the high financial rates of return.

The broad conclusion that emerges from the foregoing demand analysis is that in Egyptian agriculture, indirect effects, i.e., effects other than the immediate results of changes in relative factor prices, play an important role in explaining the demand for mechanical technology in Egypt. Of particular significance in the Egyptian case is the demonstration that a number of apparently unrelated policies, such as fuel subsidies, livestock concentrate subsidies, cotton and rice taxes, all tend to work in the same direction, namely the substitution of machine for animal power.

SUPPLY CONSIDERATIONS

Phase II of the Mechanization Project focused primarily on learning about conditions on the supply side, specifically on the supply of machinery services (Imam and Khalil, 1983). Time and resources did not permit a quantitative analysis of the economics of providing machines to Egyptian agriculture.

Hire Service Arrangements

Tractor hiring services were found to be widespread. In an initial farm management survey in Sharkia Governorate, 90% of the land preparation was done with machines. In southern Egypt, the percentage may be somewhat less, but the overall use of tractors for plowing has increased substantially.

Most of the effective hire service activities are being carried out by private individuals. Cooperatives have been hampered not only by the lack of machines, but by the lack of repair and maintenance facilities. Because the machines are often "down" when they are needed, they are not relied upon to provide machine services. This in turn leads to underutilization and an inability of the cooperative to recover the capital cost of the machine, even though it has been purchased at subsidized prices.

Table 3. **Rates of Return for Mechanical Technology**

Farm Size (Feddans)	*Financial* Rate of Return Second-Best	*Economic* Rate of Return Second-Best	*Economic* Rate of Return First-Best
	TRACTOR-TILLAGE ONLY		
1	101.7	37.7	111.1
3	91.8	47.1	147.1
5	120.3	128.9	109.6
10	377.1	322.0	327.0
	TRACTOR-HARROWING ONLY		
1	23.0	*	*
3	89.9	*	−28.6
5	306.2	18.8	8.8
10	66.7	*	19.5
	TRACTOR-RIDGING ONLY		
1	15.4	*	*
3	72.0	*	*
5	214.0	*	−22.6
10	16.2	*	−10.3
	THRESHER AND WINNOWER		
1	76.7	−6.5	141.6
3	124.0	8.0	186.7
5	244.8	440.3	276.6
10	1089.4	767.4	1080.5
	DIESEL MOBILE PUMP		
1	39.0	*	−28.4
3	38.6	*	−7.8
5	50.5	−12.4	−1.0
10	66.5	*	15.8

*The internal rate of return is minus infinity because the cash flow contains all negative entries.

Based on a farm management survey, farmers who have purchased tractors think that the prices of machines are too high. Even though credit and fuel are subsidized and tractors have been made available at favorable exchange rates, apparently the taxes on agricultural crops are sufficient to raise questions in farmers' minds about the desirability of purchasing tractors.

With respect to the cooperative sector, machine services are offered at a lower cost. Cooperatives rent tractors for land preparation and provide the services of sprayers, threshers and mobile pumps, all at subsidized prices. However, the driver and technicians who work with this equipment are government employees and hence not motivated to use the equipment intensively. Thus, when it comes time to replace the machines, the hire service fees have not been sufficient to buy new tractors.

Repairs and Maintenance

The availability of spare parts and the prices charged make maintenance and servicing a problem. Repair shops are to be found in most of the medium and larger towns in Egypt but not in the villages. Distributors in Cairo are at least several hours by bus from these small shops and hence private repair facilities must sometimes wait several days before someone can go to the city to pick up the necessary parts. (In a few cases where tractors have been purchased under barter arrangements, there are literally

no spare parts available and tractors may go unrepaired for months.)

High prices in spare parts are also the result of hoarding by distributors and dealers. Because the flow of parts is uneven, anyone who can stockpile may, in times of acute scarcity, dictate the prices. The response of local industry has been to manufacture some of the critical spares. However, variable quality on finely machined parts and competition from large construction jobs renders local manufacturers an unreliable source of spares.

Service and maintenance are also particularly difficult for cooperatives since every decision must be referred to a higher administrative authority. The result is that tractors are frequently broken down during critical periods.

Mobile Pumps

Substantial numbers of low-lift pumps are coming into the local markets from Europe, Japan and India. The problem is that the environmental conditions under which they must work, i.e., dirty water and dirty fuel, cause frequent breakdown. The simpler domestically produced pumps are more durable, but are heavier and less mobile.

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PRICE POLICY AND FOOD SUBSIDIES

Egypt is faced with serious food problems since demands on production of food commodities cannot keep up with demands due to the high population growth rate and a rising standard of living. If the discrepancy between population growth and growth of agricultural output continues Egypt must increase food imports each year just to maintain per capita consumption. Indications are that this situation is unlikely to be self correcting unless there are radical changes in the policies that price and allocate agricultural products. For over two decades the government has intervened in the pricing and distribution of basic foodstuffs in order to achieve welfare objectives. These policies, in the form of heavy subsidies on several food commodities and fuel, are a significant burden on the government budget.

The existing subsidy policy has become highly controversial. Defenders believe it is anti-inflationary and contributues to raising the standard of living of Egyptian consumers, that it protects Egyptian consumers against price and income fluctuations that may occur if domestic prices were left free to follow world price movements, and that it is an important means to redistribute real income from high to low income consumers.

Opponents of the policy argue that government intervention in the form of subsidies creates relative price distortions and prevents efficient resource allocation. The increasing subsidy payments create budget deficits which may be inflationary, and the importance of the policy as an income distribution vehicle is exaggerated since the subsidy goes to rich as well as poor consumers.

The major objective of the study was to analyze and evaluate the efficiency and equity effects of existing price and distribution policies for some major subsidized and rationed food commodities. The study was divided into three main research tasks which sought to examine the impact of the existing pricing and distribution policies of major subsidized food items. These tasks were:

1. to analyze the effects of subsidy policy on the welfare of producers and consumers;
2. to determine the effect of existing policies on consumption and distribution;
3. to examine the economics of law enforcement as related to food policy.

The principal inquiry concentrated on prototypes representing three groups of commodities: a) subsidized and strictly rationed commodities (e.g., sugar, food oil, tea, and rice); b) subsidized and semi-rationed commodities (e.g., beans, lentils, frozen meat, poultry, and flour); and c) subsidized and unrationed commodities (e.g., bread).

ACCOMPLISHMENTS

A WELFARE ANALYSIS OF PRICE POLICIES FOR WHEAT, RICE AND BROAD BEANS

Wheat and wheat flour are both heavily subsidized by the Egyptian Government in order to keep bread prices low. Based on 1979 figures, we have estimated subsidies for consumers of native bread made with flour, milled at an 82% extraction rate. The subsidy for domestic wheat per ton was 35.1 Egyptian pounds (LE), while for imported wheat, it was 48.7 LE. The estimated subsidy for wheat converted into flour in Egypt was approximately 112 million LE in 1980–81. In addition, the subsidy on imported flour captured by consumers of wheat products was estimated at 129 million LE. The total subsidy of approximately 241 million LE is, however, considerably less than that calculated by the Ministry of Supply of approximately 555 million LE. Three reasons appear to explain much of the difference.

1. The Ministry of Supply believes a much larger quantity of wheat was used to produce native bread than does the Ministry of Agriculture. We utilized data from the Ministry of Agriculture.
2. The Ministry of Supply apparently used the CIF commercial import prices for both imported wheat and imported flour, whereas our study used the average prices on imports which include quantities imported under various concessionary programs.
3. In the case of the flour subsidy, the Ministry of Supply used the price of 67.8 LE per ton for flour going to consumers, whereas we use a more representative price of 76 LE per ton that users of flour pay.

The price and subsidy policy misallocates resources in two ways: (1) subsidizing wheat consumption by offering wheat and wheat products to consumers at prices below the cost to the economy of acquiring these supplies (demand-side welfare losses) and (2) paying producers of wheat lower prices than the cost of importing wheat (supply-side welfare losses). In Table 1 the demand-side welfare costs are shown at various assumed price elasticities of demand and the supply-side costs at various assumed elasticities of supply. If the upper end of the ranges of elasticities of demand and supply are assumed to be valid the total welfare costs are about 237 million LE, or about 5.4 LE per capita annually that could have been captured in increased living standards.

Rice is extremely important in the Egyptian diet and this study has explored patterns of rural and urban rice consumption, shown how producers' prices are established and analyzed the price and rationing policy for rice, both for its welfare implications and its effect on economic efficiency. Because a free market for rice exists in the

Table 1. **Welfare Costs of Wheat and Wheat Products at Various Ammended Price Elasticities**

Assumed Price Elasticities of Demand	*Demand-Side Welfare Loss (million LE)*	*Assumed Price Elasticities of Supply*	*Supply-Side Welfare Loss (million LE)*	*Total Social Welfare Cost (million LE)*
−0.50	177.740	0.66	59.456	237.196
−0.50	177.740	0.50	41.344	219.084
−0.35	133.153	0.25	18.344	151.497
−0.10	41.749	0.10	6.873	48.622

rural areas, it was necessary to divide the economy into rural and urban areas for purposes of analysis.

The total cost of procuring, milling, and distributing rice was estimated for three different levels of rice quality for 1981–82. These figures are 153.97 LE, 158.85 LE, and 162.51 LE per ton, respectively. Consumers pay 50 LE per ton for low quality rationed rice, 140 LE per ton for high quality rice when it is available, and 400–500 LE per ton of high quality rice that is sold to larger restaurants and hotels. Estimates of the welfare loss associated with price and subsidy policies for rice are given in Table 2. If elasticities are at the high end of the ranges, welfare losses annually are only about 7 million LE, much less than for wheat. The reason is probably the free market for rice that exists in rural areas. Here both producers and consumers trade in rice at prices that do not depart significantly from world market levels. This free market greatly mitigates the welfare losses

Broadbeans are both heavily subsidized and rationed in Egypt. Additional quantities are also sometimes available on the ration book and are referred to as "semi-rationed." This commodity is also imported in large quantities and the farm price on quota deliveries is held far below world market levels. This study has focussed on estimating the subsidy received by consumers, as calculated in the Ministry of Supply, and has analyzed the social welfare cost

Table 2. **Welfare Losses for Rice at Various Assumed Price Elasticities**

Supply-Side Losses	
Assumed Price Elasticity of Supply	*Welfare Loss LE*
0.10	370,000
0.25	944,000
0.44	1,667,000
0.50	1,900,000
0.75	2,913,000

Demand-Side Losses			
Assumed Price Elasticity of Demand	*Welfare Loss LE*		*Total Rural and Urban Loss LE*
−0.12	urban	268,000	893,000
	rural	625,000	
−0.31	urban	677,000	2,254,000
	rural	1,577,000	
−0.59	urban	1,042,000	3,945,000
	rural	2,903,000	

$350

of the pricing and trade policies (Table 3). In 1980–81 demand-side welfare losses were 3.82 million LE and supply-side losses were only 0.111 million LE at elasticities that appear most valid. As with rice, these are not large losses and are as small as they are because of free markets in beans. These losses could be reduced further if quota prices to producers were raised to world market levels and if import restrictions were eliminated.

DISTRIBUTION OF CONSUMPTION IN THE URBAN AND RURAL AREAS IN EGYPT

The Family Budget Surveys in both 1964–65 and 1974–75 indicated that per capita expenditures by households were substantially higher for urban than for rural areas. Per capita food expenditures were also higher for urban than for rural areas in absolute terms, but as a percent of total expenditures they were higher for rural than for urban areas. In both areas real per capita total expenditures and real per capita food expenditures increased from 1964–65 to 1974–75.

A study undertaken by this project has examined the effect of family size (economies of scale) on per capita food expenditure. Statistically significant differences were found in expenditure elasticities: (1) between urban and rural households and (2) between families of different sizes. A major finding of the study was that average per capita expenditures decrease as family size increases.

The increase in real per capita total expenditures and the consumption quantities of a given commodity were used as criteria of whether a commodity was a superior or inferior good. Wheat, corn, rice, whole beans, fresh meat, poultry, fish, milk, white cheese, butter, oil, sugar, coffee and tea were superior goods in both areas. Sorghum, granulated beans, granulated lentils and local cheese were inferior in urban areas, whereas only sorghum was inferior in rural areas.

Table 3. **Welfare Costs of Broad Beans for Various Assumed Elasticities of Supply and Demand**

Supply-Side Welfare Loss				
Elasticity of Supply		*Assumed Free Market Price to Farmers*		
		500	400	235
.25	LE	2,364,000	697,000	476,000
.50		4,432,000	1,309,000	952,000
.75		6,402,000	1,891,000	1,462,000
Demand-Side Welfare Loss				
Elasticity of Demand				
−.10		LE	1,871,000	
−.22			3,447,000	
−.50			10,244,000	
−.75			16,449,500	

The distribution of per capita total expenditures and per capita food expenditures was measured as GINI coefficients. Both distributions were more unequal in urban than in rural areas. GINI coefficients were also utilized to reveal the concentration consumption of individual commodities measured in physical rather than in value units.

Commodities which were subsidized and rationed (sugar, tea, vegetable oil, and rice) have low GINI coefficients, meaning that the distribution of consumption tended to relative equality, as was the case also with those commodities which were subsidized but not rationed (wheat flour, bread). Commodities which were subsidized and sometimes rationed (beans, lentils, beef) had GINI coefficients that tended to be low in urban areas but much higher in rural areas. The major unsubsidized and unrationed food items surveyed tended to have high coefficients in both urban and rural areas (especially fresh beef, poultry, eggs, milk, coffee and cheese).

The conclusion seems to be clear that the subsidy and rationing policies are associated with commodities that are more equally distributed in consumption than those commodities that are not rationed and are not subsidized. There is also evidence that the subsidized commodities are more readily available in urban than in rural areas and thus the policy discriminates against rural consumers.

UTILIZATION PATTERN OF PRIMARY SUBSIDIZED FOOD COMMODITIES IN EGYPT

This study attempted to quantify empirically some unintended consequences of the food subsidy policy that until now have been largely anecdotal and somewhat speculative. These unintended uses included utilization as livestock feed of a number of foods intended for human consumption. Economic inefficiency or waste results from this practice, however, because the costs to the nation of supplying these foods are generally higher than the costs of supplying equivalent animal foods. The specific quantities that were diverted from human consumption in the sampled areas are not known, and the remaining task should be to actually measure these inefficiency costs.

Included with animal feeding in the survey was the term "waste." As a concept, it is somewhat difficult to deal with in an economic framework. Most would agree that it has something to do with the difference between quantities acquired for consumption (by either humans and/or animals kept for income or recreation) and quantities actually consumed by them. This difference will be greatly affected by the investment of time and real resources in handling, transporting, storing, refrigerating, and otherwise managing stocks of commodities. There will be a relevant margin for all these activities where an economically rational person will invest limited time and real resources to the point where marginal benefits equal the marginal opportunity costs of the resources. The price of the commodity is highly relevant to the choices of these margins. If the price has been reduced through subsidy to the point

where it is nearly zero and amounts are not constrained by rationing or supply unavailability, then there are no incentives to invest in avoiding waste. It will be less costly to simply buy more of the commodity than to invest in conservation. Much of what is called "unintended" use or "waste" results from rational decisions of utility-maximizing choosers as they react to relative prices and resource constraints facing them. It is also clear that this phenomenon is an important component of increased price per capita consumption of subsidized commodities.

The percentage diversions of subsidized foodstuffs to unintended uses in the sampled areas were:

Wheat	7.18%
Flour	5.10%
Balady Bread	6.10%
Fino Bread	3.06%
Rice	7.20%
Beans	24.42%
Sugar	no measured unintended use

It is important to understand clearly the true opportunity costs of unintended use for the economy as a whole. Significant quantities of wheat, flour, and beans are imported, and commercial imports cost the Egyptian economy the world price converted to Egyptian pounds at the parallel exchange rate. Thus, if unintended uses of wheat, flour, bread, and beans could be reduced, the saving to the economy must be evaluated in terms of saved foreign exchange.

As the government of Egypt wrestles with the question of how much to subsidize these commodities, it must take into account the costs of these unintended uses. Much attention has been given to the allocative effects of subsidy on the consumption side: the increase in per capita consumption, the increasing dependence on imports, and the implications for food security. Added to this list of legitimate concerns is the fact, demonstrated by this study, that not all benefits claimed for the subsidy policy in terms of human nutrition are valid. Significant allocative losses are also occurring because of rational diversions of subsidized foodstuffs to animals and waste.

This study also contributes to our understanding of the *equity* of the present subsidy, rationing, and distribution system. We have attempted to identify precisely the acquisition sources of subsidized commodities for high and low income classes in the rural and urban areas sampled. Even at highly subsidized prices, it appears that consumers of beans are not getting their monthly allotment of one kilogram under the rationing system. There appear to be no similar problems with rice and sugar.

This analysis also reveals that there is a great disparity between urban and rural areas in the availability of subsidized commodities from the government retail cooperative shops. Apparently, rural citizens do not have access to these stores to the same extent as urban citizens. Instead, they must rely more on free markets in rural areas where prices are considerably higher. This is a highly perverse income distribution policy since on average rural people are substantially poorer than urban people. If the primary justification of a subsidy policy is to redistribute income from rich to poor, or even to support poor people with cheap food, then failure to implement fully the policy in rural areas where the poorest people live seems to defeat the objective of the policy.

Free markets are playing an indispensable role, contributing both efficiency and equity benefits. The reasons are obvious: traders can improve their satisfaction by exchanging their endowments of commodities at mutually beneficial terms. Since a more efficient allocation of resources occurs as all traders make themselves better off, free markets should be encouraged in every possible way.

A free market is not an equitable substitute for a subsidy policy, however. Subsidized commodities, if they are to exist at all, should be made available to all equally or at least where they are most needed. After initial allocation, a "white" market where endowments can be freely exchanged could improve efficiency since consumers have highly diverse preferences and income and wealth constraints.

THE ECONOMICS OF ENFORCING AGRICULTURAL LAWS IN EGYPT

The current agricultural and food price policy in Egypt has distinct pervasive characteristics. Retail prices of major food commodities are kept low for equity reasons. The government tends to assure availability of major agricultural commodities either for domestic markets or for export earnings. In order to assure supplies that the government deems to be "needed," a land rotation is forced on the Egyptian farmers, and most of the major food and export crops are marketed through the cooperative marketing system under government control. To maximize export earnings and to reduce the burden of subsidies on the government budget, the government tends to keep farm prices for these commodities below world levels and to require farmers to deliver quotas on some crops. Policy instruments such as these are implemented through laws and ministerial rules.

Enforcing agricultural laws is a crucial prerequisite for policy implementation designed to change the behavior of economic agents to a more socially preferred type. Optimal private behavior may differ, however, from optimal social behavior of the individual. Laws and administrative rules are invoked to reduce the perceived discrepancy between optimal private and optimal social behavior, and punishment for violators of these laws, in the form of fines or imprisonment, is the shadow price of the social importance of the law. The cost of obeying the law is different for each economic agent and will depend upon age, family size, farm size, dependence on off-farm markets, income and wealth, diversification, risk preference, market information, etc. This study examined the farmer's choice pertaining to obeying or violating major agricultural laws and rules. Mandatory quota delivery and obligatory land allotments were chosen as examples of the rules and regulations that can be violated, making the violator liable to punishment.

The farmer's choice between two discrete alternatives, namely to violate or obey the law, was examined. A sample

of 81 farmers for rice and 79 farmers for cotton were interviewed. The sample included 36 farmers violating the mandatory rice quota delivery regulation and 34 farmers violating the mandatory cotton area allotment regulation. Violators of the rice quota delivery rule tend to have less total landholding, less owned land, a lower number of land pieces, fewer cattle, and consume less rice than nonviolators. Farmers violating the rice quota delivery regulation tend to be those located near the village markets. They have more information regarding free market prices. Also, violators of area cotton allotment tend to be the poorest among sampled cotton producers. They have less owned land and fewer cattle than nonviolators. Sampled cotton area violators also tend to be located nearer to the village markets than the nonviolators.

Maximum likelihood estimates were obtained for the probit and logit models specified in this study to examine factors affecting the farmers' decision to violate these laws. Model estimates indicated that the probability of violating the rice quota delivery would increase by about 12–13% for a one kilometer increase in the distance to the market. Also, this probability would increase by about 1% for each 10% increase in the percentage of required rice area from total landholdings. Increasing the number of land pieces would tend to decrease the probability to violate the mandatory rice quota delivery regulations by about 12–13%.

The probability of violating mandatory cotton area allotments tends to increase by only 1% for a one feddan increase in landholdings and tends to decrease by about 18–20% for a one kilometer increase in the distance to market. Increasing expected government prices would tend to decrease the probability of violating mandatory cotton area allotments by about 10–20%.

Apparently, violation of the law and concomitant payment of fines is very pervasive and would seem to justify further analytical work that attempts to measure the social benefits and costs of having rules and regulations that are so widely violated.

FOOD CONSUMPTION AND DISTRIBUTION: AN OVERVIEW

A review of several ADS working papers on food consumption and distribution in Egypt established several significant points. Based on expenditure elasticity estimates, all but a very few goods were classified as superior, sorghum being one notable exception. A policy to lower consumer prices of certain of these superior goods by means of subsidies is one way of increasing consumers' incomes and thereby increase their nutrition levels.

The GINI coefficient analysis established rather clearly that those commodities which are subsidized and/or rationed are more equitably distributed across income classes, particularly in urban areas. For these commodities, the goal of an equitable distribution seems to be close to being accomplished.

The question is, however, at what cost to the economy? Is it even possible that everyone in Egypt, including the urban poor, whom the policies tend to favor, would be better off without the subsidies? Although certain benefits clearly have been achieved in nutrition, the costs should be fully assessed in order to determine if society may in fact be worse off than it would be without these policies. The redistribution of income from the wealthy to the poor by means of well-intended government intervention may result in the poor actually being worse off. How can this be so?

1. Subsidies have rapidly increased the consumption rate of particular commodities. If consumers value resources going into the supply of these chosen commodities less than if these resources had been used to produce a preferred commodity, their standard of living is thereby lowered.
2. The government's favoring consumers over producers has led to producer disincentives, lower domestic production, and a greatly increased dependence on imports. So long as domestic production costs are below import prices the nation's scarce resources are being squandered in choosing importation to meet demand.
3. Price subsidies have had some unintended consequences, including waste of the subsidized commodity because it is so cheap.
4. Although food policy may be intended to benefit the poor, in fact, rich and poor alike, particularly in urban areas, participate in the programs.
5. Enforcement of any system of quotas, rationing, and price fixing is costly for the government to maintain. Resources going into such enforcement might have been used in other ways making everyone better off.
6. Subsidies of basic foods have created excess demand for these items leading to chronic shortages, consumer queues, hoarding incentives, and other costly phenomena.
7. Meanwhile, as other sectors of the Egyptian economy are growing, agriculture is stagnating. This imbalance created by artificial and capricious policy, reduces the efficiency in the entire economy.

It is one matter to discuss these various dangers of the system, but it is quite another to provide quantitative measures of the magnitude of the welfare loss to society. Much needs to be done in this area. Only a few studies have attempted to provide quantitative estimates of the loss associated with subsidy programs for wheat, rice, and broadbeans. Better data and better estimates of the price elasticities of supply and demand for the particular commodities are needed to estimate more accurate measures of the welfare losses involved. It would then be possible to make even more definitive statements about whether the policy favoring equity is "worth it" in terms of efficiency losses to the economy.

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THE ECONOMICS OF EGYPTIAN LIVESTOCK PRODUCTION

Livestock production currently accounts for about one third of Egypt's total agricultural output when the value of animal power and manure are included. Animal products provide some 10% of the energy and 15% of the protein in Egyptian diets. Pushed by increases in population, as well as in consumer income, per capita and total consumption of red and white meats and milk expanded dramatically during the past decade. Increased demand caused prices for livestock products to rise during the 1970's an average 12–14% per year compared with 11% increases which were registered for crop prices. Expansion of production did not match increases in consumption and, as a result, imports rose sharply. During the decade, the country's level of self-sufficiency declined for all three of the major livestock product groups.

Although Egypt did make gains in per capita consumption of livestock products during the 1970's, at 17.2 kg of meat and 51.4 kg of milk per capita, intake is still low by international standards. While the average Egyptian diet may be adequate in terms of energy availability, protein intakes are low and distribution within the population is uneven. Animal protein intake is very low among the rural population, particularly the poor and the young.

ECONOMIC CONDITIONS

The livestock sector has enjoyed substantial economic protection in recent years in the form of high prices for livestock products and subsidized inputs. Prevailing domestic prices for livestock products are higher than world prices. In 1981, for example, the cost of delivering imported meat to retail was LE 1.45 per kilogram whereas the retail cost of locally produced beef was more than LE 2.50 (Soliman, 1982). At the same time, it cost the Egypt Milk Company about 15 piastres per kg to reconstitute milk from imported powder, while the wholesale price of domestically produced milk was almost double that amount.

The second aspect of protection derives from subsidies on feed and other livestock inputs. According to analysis based on a survey of 32 broiler farms conducted in 1981, for example, subsidies averaged LE 12,653 per farm which accounted for almost 80% of their profits. Similarly, implicit and explicit subsidies on the feed mix processed by public sector companies for feeding cattle amounted to just over LE 100 per ton in 1980 (Soliman & Ibrahim, 1983a).

Economic analyses indicate that Egypt has a comparative advantage in producing milk and poultry (Soliman, El-Zaher & Fitch, 1983), but not in red meat production (Soliman, 1982). Given certain technical improvements to increase productivity, it seems quite possible for Egypt to become self-sufficient in milk and poultry. Improved productivity could also alter the prospects for red meat production.

LIVESTOCK IN THE EGYPTIAN FARMING SYSTEM

In Egypt, livestock production is closely integrated with crop production. It is estimated that about 90% of the animals are held in the traditional farming sector where they rely not only on berseem clover but also on substantial amounts of crop residues and by-products, particuarly wheat and rice straws. Livestock in turn, provide significant inputs to crop production in the form of power and manure. Farm surveys show that animal work accounts for 27% of the total value of livestock output and manure for 13%.

Small farms are much more intensive in their livestock production than large farms. The 1976 Farm Management Survey showed that 65% of all animal units are held on farms of three feddans and less, and that smaller farms are more efficient at raising livestock than larger farms. Farms of three feddans and less were found to have net returns of LE 190 per animal unit, compared to LE 111 for 3–5 feddan farms and LE 35 for 5–10 feddan farms (Soliman, Fitch & El-Aziz, 1982).

Utilization of family labor, which is relatively abundant on small farms, helps to explain why small farms specialize in livestock. Surveys show that, on average, farms devote some 44% of their labor to livestock production, but that on farms of one feddan and smaller 73% of labor is for livestock. Women play a predominant role, particularly in milking and milk processing. On farms of three feddans and smaller, women provide more than 40% of the livestock-related labor, and more than 70% of the milk is processed into products such as cheese, butter and ghee.

Milk

The surveys show that milk and milk products account for 35% of the value of the livestock products at the farm level. Thus, the primary role of large animals in the Egyptian farming system is for milk production. The water buffalo is the main milk animal, yielding an estimated 65% of all milk produced.

It is estimated that 82% of the milk produced in Egypt comes from the traditional farm sector. Seventeen percent comes from commercial buffalo herds located on the peripheries of urban areas. These units, known as "flying herds," are composed of animals which are bought from farms in more remote areas; there is usually no system for breeding or replacement of cows from within the flying herds and the cows are normally sold for slaughter after one lactation. There are a few large scale state farm and

Cattle on smallholdings are providers of milk, meat, and power for plowing and irrigation. Tethered here close to the homestead, they are fed their ration of berseem, cut daily from nearby fields.

Photo: Harry Jurey

joint venture dairy herds in Egypt, but these currently account only for about 1% of the milk produced.

Comparative advantage in milk production lies mainly in the buffaloes held by traditional farms. Given the 1200 kg per lactation which these animals produce (average from farm surveys), milk can be produced at a cost which is about equal to the 15 piastre cost of imported milk. The relatively low cost of producing milk in traditional farms appears to derive not only from low labor costs and access to certain amounts of inexpensive feeds and crop residues, but also from the value of the joint products (work and manure) which are derived from animals in this sector. Thus, if yields from the Egyptian dairy buffalo can be increased, this type of milk production could be very attractive for the Egyptian economy. The economics of producing milk from native cattle are least attractive of all, however, due to extremely low yields (about 750 kg per lactation). It is possible that these yields could be increased by crossing with exotic breeds.

Although the buffaloes in commercial dairy herds were found to have higher milk yields (1565 kg average per lactation) than buffaloes on traditional farms, they were found to produce higher cost milk than buffaloes on the traditional farm. This was attributed to both higher feed costs and less efficient feed use. Nor were the economics of larger scale dairy cattle herds found to be impressive. In a survey of a large herd of Friesians, it was reported that the cows averaged 4,100 kg per lactation. The economic evaluation showed that labor and investment costs were quite high, however, with the result that this milk is more expensive to produce than milk from the buffalo on the traditional farm.

Although milk produced by traditional farms does appear to be less expensive than milk from larger herds, the problems associated with marketing and processing such milk cannot be denied. Survey data showed that even the smallest farmers market a significant portion of the milk which they produce albeit much of it in the form of white cheese, butter and ghee. While the processing of this milk in the household provides a productive outlet for available family labor, it presents severe sanitation problems. Improvements are required in village level technology and facilities for marketing and processing milk.

Red Meat

Egypt's system of red meat production depends on the traditional farming sector for almost all of its animals. For this reason, meat production is really a by-product of the traditional sector dairy industry. Several hundred thousand head of calves are slaughtered directly for veal each year, most of them before weaning, with little or no finishing (Fitch & Soliman, 1981). Larger farms feed out some animals to heavier weight, and there are numerous feedlots which specialize in fattening animals. Typically, these lots are not very large and feed no more than 10 to 50 animals at a time.

The finding that Egypt does not have a comparative advantage in red meat production is based upon analysis of costs of feeding not only domestic animals but also imported feeder animals. Indications were that there is even less advantage to finishing the imported live animals

than the domestics (Soliman, 1982). These findings imply that, given the costs and feeding response which are currently attained, it would be cheaper for Egypt to import more red meats than to continue to produce so much locally.

The current program for importing live feeder animals for finishing in Egypt is perplexing in view of the half million or so young buffalo calves which are slaughtered each year before they reach weaning age. Farmers find it more attractive to sell these animals than to maintain them on the rich, high valued buffalo milk. To take advantage of this type of animal would require making milk replacer available at the village level and training farmers in its use. The economics of such a system require careful evaluation. This should be investigated as an alternative to importing either meat or feeder animals.

Current daily rates of gain are only about 0.8 kg per animal in typical Egyptian feedlots, compared to 1 to 1.4 kg in countries with successful feeding industries. Furthermore, dry matter conversion ratios appear to be too high in Egypt. Recent experimental feeding trials have improved feed response somewhat, but not sufficiently to warrant too much optimism.

Poultry

Poultry production is more concentrated in larger scale production units than either milk production or beef feeding. Currently, more than half of the broilers produced in Egypt come from modern, confined units, and almost half of the chicks produced each year come from modern hatcheries (Soliman & Ibrahim, 1983b).

Poultry, like milk, provides a relatively inexpensive source of animal protein. Analysis of producer surveys shows, however, that Egypt's comparative advantage in this sector rests upon large scale production. Until now, the system of subsidizing poultry feed and production credit has made it attractive for smaller scale producers to operate, but these smaller firms tend to be economically inefficient and would not be profitable, given their current technical performance, if they were required to pay the full international costs for inputs.

Again, however, there are opportunities for technical improvement. Surveys of 32 broiler production units disclosed average feed conversion ratios of more than 2.5 kg per kg of liveweight gain whereas international standards would be closer to 2 kg per kg of gain. Furthermore, mortality rates in excess of 6% were reported, which is at least 50% higher than that attained in countries with highly developed broiler industries.

POLICIES AND PROGRAMS AFFECTING LIVESTOCK PRODUCTION

In an effort to deal with livestock production problems and run-away prices, the government has developed a number of programs and policies. These include the processing of feedstuffs, importation of feedstuffs, subsidies on feeds and credit, production and processing of livestock products in public sector companies, importation of livestock products for sale at subsidized prices, maintenance of a livestock insurance program, controls on meat prices, conduct of research, and provision of limited amounts of free veterinary and technical services (Soliman, Habib and El-Azim, 1983).

Feed Production

Government companies were organized to process livestock feeds in the early 1960's. The initial objective of this program was more complete utilization of cottonseed cake produced by public sector ginning mills. This was combined with molasses, bran, and other locally available by-products to form a balanced ration. Eventually, government mills produced not only a variety of feeds for beef and dairy animals but also various poultry feeds. Public sector production of concentrates for large animals grew at an average annual rate of 13% between 1960 and 1980, amounting to production of more than a million tons by 1980 (Soliman & El-Azim, 1983).

Total national production of poultry feed mixes reached 544,000 tons by 1981 and 75% of this was produced by public sector companies. In 1977 the private sector share of poultry feed production was less than 5%, but this increased to 25% in 1981. Private sector production is heavily concentrated in broiler feeds, while public sector companies produce most layer feeds. Feeds produced by the private sector do not benefit from subsidized inputs to the same extent that public sector feed production does.

Production and availability of feedstuffs was augmented, starting in 1974, when the government began to import yellow maize. This was utilized as a mix ingredient for both livestock and poultry feeds, as well as for direct distribution of both livestock and human consumption. By 1980, imports of yellow maize reached 1.3 million tons, of which more than two-thirds was used as poultry and livestock feed (Soliman & Ibrahim, 1983a).

Feed Subsidies

Feed concentrates and yellow maize are both distributed at subsidized prices by the government. In the case of the concentrates, much of the subsidy is an implicit one since the government mills are supplied with low price cottonseed cake and other by-product ingredients by other government companies. Maize which is imported at world prices is supplied to the feed mills (and to a limited number of direct feed users) at subsidized prices. In 1981, the supply price was LE 65 per ton, compared to an import cost of over LE 100 per ton when calculated at the free market exchange rate.

In 1980, the government was selling its livestock feed mix at LE 38 per ton whereas the mix had a value of LE 139 per ton if the ingredients were valued at their world trade prices. This implies implicit and explicit subsidies of LE 101 per ton. Assigning values on the same basis, the total subsidy for the government mix rose from LE 13 million in 1970 to LE 127 million in 1980 (Soliman & El-Azim, 1983).

Feed Distribution Policy

Through quotas and other allocation procedures, the livestock feeds produced by government mills are allocated

heavily in favor of larger farms and meat production. The proportion that went to feedlots increased from 35% in 1977 to 73% in 1980. The average feed subsidy for a dairy cow in a large joint venture dairy herd was estimated at LE 304 in 1981, compared to LE 18 in subsidy for the concentrate fed to a traditional dairy buffalo farm in the same year (Soliman & El-Azim, 1983).

Credit

Credit for livestock and other food-security related activities is currently provided at an annual rate of interest of 6%, compared to a market rate of interest of about 14%. More than 90% of the livestock credit is for short-term loans, and of this about 95% is for beef feeding.

Thus, in credit as well as in feedstuffs and related subsidies, the distribution is heavily in favor of large farms and meat production. Since the studies reviewed here tend to indicate that meat production is relatively inefficient in Egypt and that smaller farms are more efficient producers than large farms, it would appear that these resources are being allocated to the least efficient types of production.

Meat Price Controls

The government has attempted to impose price controls for some livestock products, particularly red meats. The controls are applied to retail outlets, to wholesale carcass prices and to fed live animals, but not to feeder calves. Thus, when the government attempted to enforce the controls in 1980, a feedlot operator would have operated at a loss by selling his fed animal at the controlled price if he had purchased the calf at the free market price (Soliman, 1982). Under these circumstances, it is difficult to enforce the price control. Another factor which complicates enforcement of price ceilings stated on a per kilogram basis is that most livestock sales yards in Egypt do not have scales.

Imports

The Ministry of Supply imports meats and dairy products to bridge the gap between consumption and production and most of the imported commodities are delivered to the market at subsidized prices. Studies show that it is possible to import good quality meats at a cost well below prevailing domestic prices without any subsidy. However, there are some obstacles to this

Since the government sells the meats which it imports at subsidized prices, increased imports weigh heavily on the budget and this causes the Ministry of Finance to limit the funds which are made available for imports. Currently, meat is sold at 68 piastres per kg through the cooperative stores, compared to an imported cost which is more than double that amount, and compared to the prevailing free market price which is almost five times that amount (Soliman, 1983).

There are no explicit laws which prohibit private imports, but only about 15% of the meat which Egypt imports comes through private channels and this is mainly for the hotel and tourist sector. There is a limitation on the margins which private traders may earn and this seems to inhibit private trade. Furthermore, private importers are required to procure the major part of their foreign exchange at the free market rate which increases their cost of operation.

Limited cold storage facilities probably hinder both public sector and private imports. Studies of the economic feasibility of expanding cold storage are required (Soliman, Habib & El-Azim, 1983).

Public Sector Production

Various public sector companies have been established over the past two decades to produce meat, milk, and poultry. Currently, these companies account for about 25% of broiler production. Cattle and buffaloes held in government herds are estimated to constitute no more than 2 to 3% of the national herd. Typically, products from these public companies are sold through the government's system of cooperative stores at lower prices than prevail on the free market. Currently, the differential in prices is small for poultry but substantial for red meats.

While dairy herds belonging to state farms and other public organizations account for less than 1% of milk production, the government-owned Egypt Milk Company is a major processor of milk and milk products for sale in urban areas. It has nine processing plants located throughout the country. Currently about half of the company's output is based on reconstituted imported powdered milk, much of which is received on concessional terms from the EEC. The Milk Company has difficulty in procuring sufficient quantities of locally produced milk because it cannot afford to pay a competitive price. It is required to sell the products which it makes at lower prices than domestic products which are available on the market. For example, a litre of milk produced by the Milk Company sells for 20 piastres at retail, compared to two to three times that much for locally produced milk.

TECHNICAL CONSTRAINTS AND OPPORTUNITIES

While there are obvious constraints to improved livestock production, there are also numerous opportunities for improvement, particularly in feed production, feeding response, genetic base, and improved technical services.

Green Fodders

The problem with shortage of green fodder in the summer months has long been recognized. Current experiments with elephant grass and various forage sorghums are encouraging but as yet incomplete. Not only must the feasibility of producing these fodders on a wider scale be tested, but they must also be compared in terms of response in feeding trials under realistic farm conditions. Finally, the acceptability of the new crops to farmers must be examined along with economic cost-benefits and impacts on the cropping pattern (Soliman & Fitch, 1983).

Enhancement of By-Products and Wastes

There are a wide range of opportunities for increased utilization of crop by-products and wastes. One new system, which entails treating straw with anhydrous ammonia,

Traditional resource use: Persian water wheels (*sakia*) operated by cattle are seen irrigating fields by raising water from the network of delivery canals. The use of cattle for this purpose has been an issue addressed in several of the ADS economics projects. *Photo: Harry Jurey*

is currently being tested by the Animal Research Institute through the FAO-supported Beef Project at Nobaria. Though still under development, the feeding trials for this process, which improves digestibility and nutrient availability, are encouraging and appear to be economically feasible in some circumstances.

Another system for by-product utilization is already in commercial use by a feed processing plant in Zagazig, Sharkia Governorate. This plant has a new, highly automated process which grinds rice husks to which molasses and urea are added. The selling price for this new feed is LE 92 per ton.

Feed Subsidies: An Obstacle

Feed subsidies are a factor which is frequently cited as an obstacle to developing new feedstuffs. For example, under the current system the general purpose concentrate livestock feed produced by the government is sold at an official price of LE 38 per ton whereas the equivalent cost price in world trade is LE 138 per ton in 1980. Thus, there was an implicit subsidy of LE 100 per ton. The problem which this presents to expanding feed production is that it is risky for entrepreneurs to invest in non-traditional feed processing facilities with per ton costs higher than LE 38. Cattle feeders would naturally continue to attempt to secure the government feed at LE 38 and would only use the newer, more expensive feeds as a last resort. Thus, the potential investor always faces an uncertain market for his new feed, and this serves to discourage investment.

Distribution and Quota System

With an artificially low price on the concentrate feed, there is always more feed demanded by feeders than is available. This means that the government must utilize a priority distribution and quota system. Not only does this system result in a very active black market, it also produces a seemingly irrational distribution pattern. For example, although Egypt's traditional farms which produce the cottonseed (the major ingredient of the government concentrate) hold more than 90% of the country's animals, they received only 16% of concentrates which were distributed in 1980. This system not only seems unfair, it is irrational in the sense that it denies resources to the most efficient producers.

Another problem with the current feed distribution system is that the availability is erratic and unreliable. Even those quotas which are due farmers are often not fully available and frequently do not arrive on time. This can be particularly damaging in the case of milk production where the interruption of balanced feeding can cause the premature termination of a lactation. Discontinuities of feed supply in broiler production can be equally damaging.

Genetic Improvement

Egypt's dairy animals, in particular, could benefit from genetic improvement. There are currently a number of improved gene pools available in the country. There are experimental herds of foreign milk animals and of locally improved dairy buffaloes on several of the MOA's experiment stations as well as on university farms. There are also herds of good quality on state farms, joint ventures and large privately owned dairy farms. The problem is that, as yet, no viable system has been devised to upgrade the traditional farming herd with genetic stock drawn from these various pools. The existing system for artificial insemination is fraught with technical problems such as poor processing, unreliable refrigeration, and uncertain

delivery. To date, artificial insemination must be considered a failure. Many farmers who were interviewed had not even heard of the artificial insemination program, and those who had heard of it or had used it did not feel that the system, as it stands, is workable.

Technical Support and Services

The problem with artificial insemination (AI) is but one aspect of a broader problem. Egypt has, at best, a very weak system of veterinary services, medicines, technical information and training available to support livestock production at the village level. Although there are some 4,000 farm villages, there are only 200 specialized livestock service units to serve these. This number would appear to be woefully inadequate to meet Egypt's livestock production needs.

Surveys were conducted asking farmers their views on livestock production programs, problems and needs. With respect to technical support, most farmers claimed that the long distance to the nearest veterinary services unit was a problem, yet many did claim to have benefitted from these services. Half of those interviewed claimed that there was no nearby unit for artificial insemination, and it was clear from their comments that they did not have enough exposure to AI to judge its effectiveness well. There is still a strong preference to use bulls for breeding purposes (Soliman & Zaki, 1982a,b).

Less than half of the livestock producers claimed to have benefitted from the government livestock insurance program. Although technically the rules have been changed to permit small herd owners to get insurance, few farmers with fewer than five cattle said that they were able to obtain the insurance. Larger farms were found to benefit more from the insurance program, from the concentrate feed distribution program and from the credit program. Perhaps for these reasons, larger farmers more than small farmers are found to engage in livestock fattening.

Most farmers interviewed were in agreement on the need for more concentrate feeds, and relatively few were in favor of increasing the area they devote to berseem production. Although there was very little awareness of possibilities for improved summer forages, this option was of more interest in the development of marketing facilities for their livestock products, whereas larger farmers did not think this to be important.

It is a basic fact that Egypt's livestock herd is widely scattered among a large number of small farms, with one or two buffaloes or cows per farm being the norm. In developing a technical support system which will adequately serve a large number of villages and a large number of farmers with small herd sizes, Egypt is not likely to find viable examples among the relatively advanced western countries. India, on the other hand, is a country with herd size and distribution circumstances similar to those of Egypt. India has developed a system of specialized village milk production and processing cooperatives which may be of interest to Egypt. It is worth noting that the Indian system has managed to incorporate technical support services, including artificial insemination, which seem to work.

Impacts of Mechanization

The current strategy of agricultural development assumes that spreading mechanization will liberate livestock from farm work, which in turn will either increase milk and meat production or will permit a reduction in the number of farm animals. Livestock surveys indicate, however, that about 80% of animal work is for transportation, which current modes of mechanization seem unlikely to affect greatly. While there was no evidence that animal work used to operate *sakias* (water pump) reduces milk production, animal draft power used for plowing was found to have a significant negative impact. Thus, it is mainly further mechanization to liberate animals from the plow which is likely to have a favorable impact on livestock production in the form of increased milk output (Soliman, 1983).

Statistical Data Base

Statistical knowledge of Egypt's livestock situation has been limited. Estimates of herd size have been based upon trend projections from surveys taken in 1968 and 1970. Slaughter statistics have been incomplete because they cover only those animals slaughtered in government supervised slaughter houses. This situation hopefully will change with the up-to-date information which will be available from the 1982 Census of Agriculture and with current statistics to come from the MOA's Data Collection and Analysis Project.

In the past, given the lack of a good data base, it has not been possible to monitor or predict livestock production accurately. In particular, there has been no system of following or predicting the effects of livestock population cycles on meat production, and decisions to import meat and livestock products have operated independently of the production situation. Without doubt this factor contributed to the meat crisis in the summer of 1980 when prices rose unexpectedly and the government decided to implement a temporary ban on the slaughter of livestock so as to insure adequate supplies for the Courban Bairam Feast.

It is possible with available econometric procedures, operating from an improved statistical data base, to monitor and predict livestock production with fair accuracy. The MOA would do well to implement some form of econometric modelling of livestock herd growth and meat and milk production on a continuing basis, not only to permit better import planning but also to help generate a better understanding of the forces which drive Egypt's dynamic livestock economy.

Prior to this project, relatively little economic information existed about livestock production in Egypt, nor had there been any extensive review or analysis of the various government programs and policies which affect the sector. In particular, there was no current farm level information on production costs or on farmers' perceptions of production problems. Most analyses of livestock production problems relied upon aggregated secondary data.

Given this situation, it is tempting to say that the major accomplishment of this project was in the collection and

assembly of economic data about livestock production. In fact, substantial amounts of data were collected and made available in ADS-Egypt Working Papers and other publications. Not only was the livestock data from the 1977 Farm Management Survey—hitherto collected but not used—sorted out and organized into a report which provided a detailed description of livestock production in the traditions of the Egyptian farming sector (see Soliman, Fitch & El-Aziz, 1982) but a number of purposive surveys were conducted to focus on particular issues related to beef feeding, milk production, and broiler production. To avoid relying upon old cliches and possible misconceptions, farmers were asked to state their opinions and cite problems with livestock production and related government policies.

However, the project accomplished much more than just collecting data. The data were analysed with respect to economic efficiency and comparative advantage, as well as from the perspective of government policy. Particular attention was paid to feed subsidies and credit.

FUTURE RESEARCH PLANS

To date, the research has indicated that production of milk and dairy products hold particular economic promise. It is therefore suggested that research in this area be continued.

While cost of production data strongly suggest that milk produced by traditional farm buffaloes is Egypt's least expensive domestic milk source and that milk produced by modern Friesian herds is relatively expensive, these conclusions were based on a limited sample. Furthermore, cost information on cross-bred cows was not available. Recently, data has been obtained on some other Friesian and traditional herds, but some limited additional field work will be needed to secure cost and productivity information on cross-bred animals. All of this information needs to be analyzed and combined to present a more robust statistical picture and to offer cost comparisons of the different systems and animals available for milk production.

More information is needed on the disposition of milk once it is produced. Data collected in the 1981 livestock survey needs to be examined to determine how the proportion of milk which is processed in the farm household changes, not only with farm, herd, and family size, but also with differing access to market outlet facilities. Access to state-owned *vs.* private milk purchasing (collection) facilities will need to be analyzed for its impact on the decision to process on farm or sell liquid milk.

The decision of whether to consume products in the farm household *vs.* selling off-farm is also an issue that needs to be examined. For this, the marketable surplus of milk and milk products could be analyzed with respect to various factors such as farm size, herd size, and access to different marketing opportunities. The marketing agents and channels for liquid milk and various home processed dairy products could then be compared for different villages and regions. Based on survey data in conjunction with national surrogate statistics on milk processing, current patterns of processing and consumption can be established.

More research is needed to learn why milk yields vary. The relationship of milk yields to quantity and timing of availability of concentrates and summer forages, as well as to organizational and management factors, warrants further investigation. Based on measurement of response from available survey data, the impacts of alternate feed policies and distribution options also merit examination.

RECOMMENDATIONS

Based on the studies presented and the discussion at the workshop, it is possible to distill a number of policy recommendations.

(1) Egypt needs a more clearly defined strategy for livestock production. Such a strategy would recognize the dominant role which the small, traditional farmer plays in livestock production, and it would expand and improve the technical services which are meant to improve his productivity. Foremost among these would be improved artificial insemination services, veterinary services, medicines, and feed inputs organized to reach the village level. Improved availability of feeds during the summer months is also essential.

(2) A second element of the livestock strategy would be to place more emphasis on milk production. Milk is a low cost source of animal protein that is needed in rural areas. Improved, more hygienic village-level processing technology for handling milk, separating cream, churning butter, and making cheese is needed, as are improved marketing facilities.

(3) The Government should reconsider and reorganize its system for processing and allocation of feed concentrates. The distribution of these feeds at low, subsidized prices discourages the development of new domestic feed sources, while the current allocation and quota system tends to favor less efficient producers.

(4) While Egypt appears to have a comparative advantage in broiler production, this industry is currently propped up by heavy subsidies. This may have been justified in order to get this industry started, but now that it has begun to take off consideration should be given to establishing a timetable for phasing out the subsidies. In the absence of this, inefficiency will be protected. It is possible that smaller scale producers would be forced out of business if the subsidies were eliminated. However, there are technical inefficiencies in the industry which can be reduced or eliminated if producers are given the economic incentive to do so. Reduction of inefficiency could permit even smaller scale producers to survive.

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COTTON MARKETS AND GOVERNMENT POLICY

Choices made by Egyptian planners for production and marketing of the country's cotton crop involve some of the most critical and complex decisions in the Egyptian economy. Indeed, cotton policy can only be seen as an interaction of multiple objectives and constraints. First, cotton occupies about 20% of cultivated land and cotton prices thus represent a major determinant of agricultural sector income. Second, cotton pricing decisions are important to the government treasury. Despite increased earnings from the Suez Canal and oil, lint cotton exports account for 20–25% of foreign exchange earnings. Since producer prices have remained less than half of export prices, cotton contributes to government revenues. Finally, cotton policies are of key concern to the industrial sector and urban consumers. The expansion of the domestic spinning industry has comprised a major component of industrial growth during the past two decades and the objective of low consumer textile prices has depended largely on the prices of cotton lint.

This project has assessed the economic efficiency and price responsiveness of domestic production, the economic efficiency of domestic spinning, and the price behavior of the international cotton lint market. The results of these studies were utilized to examine the efficacy of Egyptian government interventions in the cotton market. Three areas were of particular interest: produce price policy and acreage restriction, consumer price policy and allocations of cotton to domestic spinning mills, and price-fixing policies for cotton lint exports.

In addition to determination of the efficiency costs and benefits of particular policies, this project attempted to explain how the various objectives and policies for production, processing and export interact. Only if these interactions are understood can agricultural planners develop a range of options and analyze the prospects for change. The importance of this can hardly be overemphasized since cotton revenues more than cover the cost of all subsidies to agriculture.

ACCOMPLISHMENTS

SUPPLY

Social and private profitability analyses were performed using the domestic resource cost method on twenty cotton production technologies. The analyses varied principally in location, irrigation techniques (draft animal *vs.* diesel pump), land preparation (draft animal *vs.* tractor) and staple length of cotton output. Most of the principal conclusions can be illustrated by the eleven technology types described in Table 1. These variants were chosen to isolate the effects on private and social revenues of the principal technological changes occurring in Egyptian agriculture, i.e., the rapid displacement of animal power, the effects of regional variations in labor and land costs and water requirements, and the effects of tradeoffs between staple length and yield.

Recent increases in labor demands from other Middle Eastern countries and in the demand for rural education have resulted in rising wage rates for both adult and child labor, and labor has become a key resource constraint. The data in Table 1 illustrate the limited impact of the new technologies on labor input requirements. All the techniques are highly labor-intensive, reflecting the prominence of labor requirements for the tasks of pest control (collection of egg masses), harvesting and packing. Input substitution among the techniques occurs between different types of capital inputs (machinery for animals) and types of tradable inputs (fuel for feed). Studies of capital-labor substitution await the introduction of mechanized harvesting and further increases in the use of chemical and biological forms of pest control.

Yields vary inversely with respect to staple length, although regional variations in the yield of each staple length appear more significant than variations across staple lengths. This result is not surprising given the use of a single variety under a wide range of environmental conditions. Solar radiation and temperature are the most important differences in this regard, reflected by the substantial differences in water requirements between Lower, Middle and Upper Egypt. Yields are generally lowest in Middle Egypt, where 'Giza 75' is the dominant long-staple variety. Lower Egypt grows the same variety but with 50% higher yields. In Upper Egypt, 'Dendera' is the dominant long staple and yields are comparable to those of 'Giza 75' in Lower Egypt. Yields for the short staple variety are the most uncertain. Experiment station trials are difficult to assess. Yields have shown significant variation from year to year and experiment trials have changed cultural practices, length of growing season and staple length in a simultaneous rather than a stepwise fashion. The yields chosen for this study are comparable to American yields and are probably conservative estimates.

Summaries of the results of the study of costs and returns associated with different production systems are presented in Table 2. Each production system includes costs of ginning and transportation to Alexandria, the point of exportation. The results for private profitability suggest below-market returns to domestic factors in two of the three draft power technologies (lines 1 and 4), and in medium-long staple production (line 9). These numbers underestimate farm-level returns, as all post-farm costs are absorbed by the government at no charge to spinning mills. Nevertheless, all of these technologies offer lower returns than mechanized technologies and longer staple lengths, and

Table 1. **Description of Alternative Technologies of Cotton Production, 1980–81.**

Governorate	*Preparation Technique*	*Irrigation Technique*	*Requirement (m^3)*	*Labor Input Mandays*	*Labor Input Boydays*	*Input (Days/ Feddan)*	*Length of Output*	*Yield (Cantars/ Feddan)*	*Alternative Crop/ Rotation*
1. El-Daqualiya	Draft	Draft	5220	51	96	34	ELS	6.04	berseem-rice
2. "	Tractor	Pump	"	53	90	7	ELS	6.34	"
3. "	Tractor	Pump	"	57	105	7	LS	8.21	"
4. Menoufia	Draft	Draft	5220	57	111	36	LS	8.02	Berseem-Rice
5. "	Tractor	Pump	"	60	106	10	LS	8.42	"
6. Beni-Suef	Tractor	Pump	7550	64	103	7	SS (Acala)	8.00	Broad Beans-Soybeans
7. "	Tractor	Pump	6040	58	83	5	LS	5.50	"
8. El-Minya	Tractor	Pump	6040	43	83	5	LS	5.50	Broad Beans-Soybeans
9 "	Tractor	Pump	"	57	92	5	MLS	6.56	"
10. Sohag	Draft	Draft	7350	53	113	39	LS	7.73	Broad Beans-Maize
11. "	Tractor	Pump	"	55	104	4	LS	8.12	"

Table 2. **Private and Social Costs and Returns to Cotton Production and Ginning, 1980–81 (LE/mt lint)**

	Private				Social			
Technology	*Revenue*	*Tradable Inputs*	*Domestic Factors*	*Profit*	*Revenue*	*Tradable Inputs*	*Domestic Factors*	*Profit*
1. El-Daq. (D-D-ELS)	1012	286	815	−88	2162	345	1249	568
2. " (T-P-ELS)	1012	265	742	5	2162	376	1139	646
3. " (T-P-LS)	978	211	636	130	1996	300	942	754
4. Menoufia (D-D-LS)	978	288	798	−109	1996	345	1136	514
5. " (T-P-LS)	978	237	706	34	1996	338	1004	654
6. Beni-Suef (T-P-SS)	609	230	512	−133	1303	338	620	344
7. " (T-P-LS)	978	291	648	38	1996	428	802	765
8. El-Minya (T-P-LS)	978	284	650	44	1996	427	954	615
9. " (T-P-MLS)	709	286	579	−156	1914	408	834	672
10. Sohag (D-D-LS)	978	274	656	48	1996	310	917	768
11. " (T-P-LS)	978	272	611	94	1996	357	840	798

thus the results are consistent with observed patterns of change in production technologies and staple length. The presence of positive private profitabilities reflects the effect of increases in producer prices in 1979 and 1980 and correspond with a marked reduction in farmer attempts to avoid the acreage allocations dictated by the central and local governments.

The social costs and returns to each technique are presented in the last four columns of Table 2. The difference between private and social costs and returns reflects the impact of market imperfections and government-induced distortions. The most prominent distortion is in the output category, as domestic lint prices are held to less than half of their world-market values. Interestingly, the degree of protection varies somewhat across staple lengths. Nominal protection coefficients on output are 0.47, 0.49, 0.37, 0.47 for ELS, LS, MLS and SS, respectively, indicating that MLS is particularly heavily taxed. The negative private profitability of the MLS system results principally from this tax.

Tradable input costs are somewhat subsidized, as seeds, fuel, fertilizer and pesticides are provided at prices below world market levels. Domestic factor costs are about 50% lower than their opportunity costs. This difference reflects the availability of subsidized credit and restrictions on land rental rates. Market interest rates ranged from 69%, depending on the type of loan, while the opportunity cost of capital is estimated at 11%. On average, capital costs were about 30% below their opportunity costs. Land rental rates are restricted by law and further distorted by the maintenance of low prices for alternative crops relative to their world-market levels. The opportunity cost of land is based on the returns to alternative crop rotations (described in Table 1) rather than the return to specific crop. This procedure was necessary because of the long growing season for cotton and consequent overlaps with the alternative crop calendars. Rental rates represented only one-fifth to one-half of their opportunity costs.

Labor costs account for about one-half of the social cost of domestic factors and are even more prominent in the private cost calculations. Market wages are assumed representative of the social opportunity cost of labor. Off-farm demand from other Middle Eastern countries appears to play a significant role in the labor market in most areas. In addition, regional wage rate data for adults suggests that the labor market is spatially well integrated. Wage rates appear to vary inversely with respect to the distance from Cairo, reflecting increased competition for labor. The wage rates for children show variations of 100% among regions (from 45 to 90 piastres per day in 1980) which are substantially greater than the variation in adult wages. This result probably reflects differences in local labor supply conditions, as children are not generally able to migrate.

The social profitabilities of all systems are positive. Domestic resource cost ratios vary between 0.5 and 0.7, and are generally in agreement with the findings of previous studies. Regional differences are not pronounced. Tractor-pump technologies are superior to draft animal technologies, reflecting the technological superiority of mechanized capital equipment to animal capital. Long-staple cotton offers higher profitabilities than other staple lengths, and Egyptian planners have efficiently exploited relative comparative advantages among staple lengths as MLS and ELS acreages have been decreasing in favor of LS plantings.

The large net social profitabilities indicate the sacrifices of national income that would result from further reductions in cotton acreage in favor of import substitutes, such as wheat. The introduction of short-staple cottons may be a way to minimize the income losses from such a substitution policy. Although profitabilities appear lower for shorter staples on a weight basis, the American cottons have a growing season which is nearly two months shorter than the longer staple lengths (nine *versus* seven months). If a winter wheat crop can be grown in a five month period, short-staple cotton-wheat rotations may be technically feasible. Furthermore, the yields for short-staple cotton are conservatively estimated. A 50% premium for short-staple yields relative to long-staple yields is common in U.S. cotton production systems, and similar achievements in Egypt would cause social profitabilities per unit area to be equal across staple lengths. In this case, substitution could occur with zero opportunity costs. These results point to the need for further agronomic research to define the technological potential of the short staples.

Cotton represents a source of foreign exchange and government revenues, and the ability of the government to tax cotton production is constrained both by domestic production costs and by world prices for lint. Estimates of acreage responses at the governorate level demonstrated the ability of Egyptian producers to substitute among crops in spite of acreage allocation decisions by the governments. A more subtle response of producers to output price changes involved adjustments in yields. The correlation between producer price increases and record cotton yields during the 1979–81 period suggests these responses are substantial. The responsiveness of yields is statistically confirmed in earlier data for the 1964–79 period. Estimates of yield response for the different staple lengths which range from 0.1 to 0.6, are based on estimates of profitability. Since 1% increase in cotton price will increase profitability by more than 1%, these measures understate the yield elasticity with respect to output price changes.

These supply estimates suggest that, for most regions and staple lengths, total output is elastic with respect to changes in domestic cotton prices. Therefore, Egyptian planners could increase total foreign exchange revenue through increases in domestic cotton prices. Since output increases proportionally more than domestic price, aggregate returns to the government from subsequent export sales would more than offset the domestic price increase. This calculation presumes that increased exports do not force down export prices, a conclusion supported by the market integration analysis described below.

DEMAND

While planners may not be fully aware of the potential foreign exchange gains from changes in domestic price

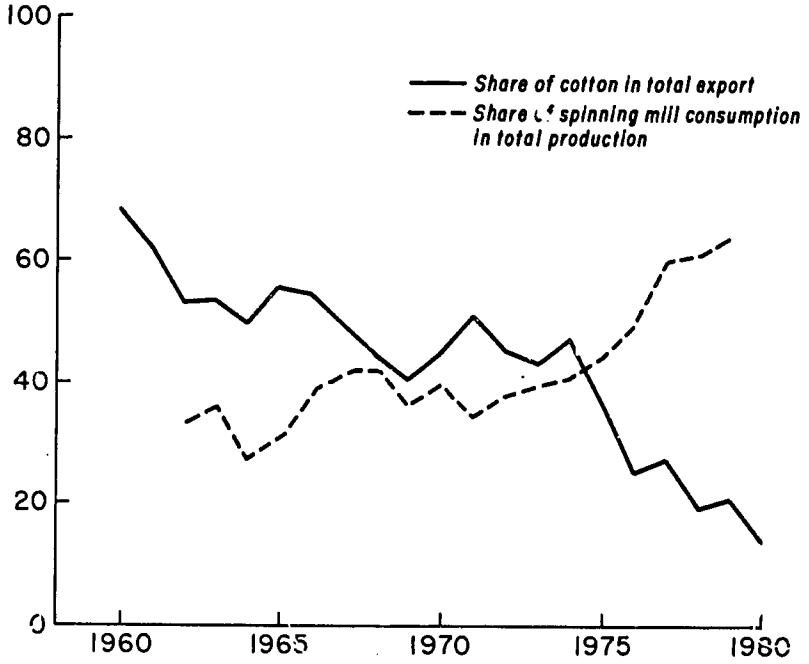

Figure 1

policy, the presence of a domestic spinning industry is of particular importance in understanding the current constraints on cotton policy. Figure 1 documents the trends in exports and spinning mill consumption during the 1960–80 period. Cotton's importance in total export revenues has declined steadily in the last two decades as earnings from the Suez Canal, petroleum exports and emigrant remittances have increased. Export volumes of cotton declined in absolute terms as well. By 1980, export volumes were only 44% of their 1960 levels. This trend reflects the growth of the spinning and weaving sector during the 1960s and 70s, as spindle and loom numbers nearly doubled. Cotton and yarn processing represent the largest industrial employer, engaging about 30% of the industrial sector labor force (300,000 employees). Although total cotton production increased in absolute terms over the 1960–80 period (from 320 to 400 thousand metric tons), spinning mill consumption increased more rapidly. By the end of the period, mills accounted for more than 60% of total utilization.

The explanation of current cotton producer price policies thus depends primarily on the role cotton prices play in determining domestic spinning costs and textile prices. Since 1973, mills have been required to purchase cotton at farm-level prices thus giving the spinning sector an interest in the formulation of agricultural prices. This concern is further increased by constraints on the prices for yarns and fabrics which are held well below world market levels in order to subsidize domestic consumers.

To assess the importance of cotton prices to the spinning industry, private and social costs and returns were estimated for ten of the largest spinning mills. These mills account for about two-thirds of total spinning capacity. Results of the cost-benefit analyses for nine of the firms are provided in Table 3. Firms demonstrate large differences in operating efficiencies. Five of the firms had negative private profitability in 1981 and thus required operating subsidies from the government. Since capital equipment is allocated to public sector firms without charge, at least some of this subsidy was an implicit rather than explicit transfer. Cotton represents the main input costs, accounting for 43% to 69% of total costs. The shares are particularly low for the three most unprofitable firms (lines 6, 8 and 9) and suggest that inefficiencies may be concentrated in the use of non-cotton inputs. For the other two firms, the cost share of cotton is substantially higher, reflecting general inefficiencies in the utilization of all inputs.

Comparison of private and social cost data indicate the magnitude of consumer subsidies for outputs and the constraints on firm profitability which would arise from increases in cotton lint prices to world market levels. Nominal protection coefficients on total firm output vary from 0.60 to 0.84. The variation is caused by inter-firm differences in the composition of outputs. Coarser yarns for the production of popular cloth are the most heavily subsidized, while finer yarns are sold at prices closer to f.o.b. levels. Cotton input subsidies amount to about 50% of f.o.b. values. In all firms, attempts to raise cotton input prices to mills would require major increases in output prices. In six of the nine firms, output prices would have to increase beyond world market levels in order to sustain positive private profitability.

In sum, the data of Table 3 show that changes in government policies toward agriculture must first address the plausibility of increased textile prices to consumers or else make provisions for increases in direct subsidies from the treasury to yarn and textile manufacturers. Current policy represents a way of maintaining low prices to final

Table 3. **Private and Social Costs and Returns for Spinning Mills, 1981 (million LE)**

	Private					Social				
		Intermediate Inputs					*Intermediate Inputs*			
Firm Number	*Revenues*	*Cotton*	*Other*	*Domestic Factors*	*Profit*	*Revenues*	*Cotton*	*Other*	*Domestic Factors*	*Profit*
1.[a]	16.94	10.27	0.68	4.05	1.94	25.09	20.47	0.92	4.05	0.65
2.[a]	10.54	5.06	0.45	2.85	2.14	14.81	9.61	1.40	2.85	0.95
3.[a]	8.15	6.76	0.46	2.54	−1.61	13.68	12.70	0.68	2.54	−2.24
4.[a]	13.80	9.62	0.85	4.08	−0.75	20.72	18.26	1.33	4.08	−2.96
5.	46.33	20.71	2.88	11.55	11.19	59.13	40.41	3.11	11.55	4.06
6.	19.93	10.70	1.48	12.74	−4.99	32.07	20.32	2.27	12.74	−3.26
7.[a]	25.24	13.02	0.92	7.34	3.96	29.96	24.41	1.77	7.34	−3.56
8.[a]	17.72	11.20	1.84	6.35	−1.67	26.24	21.24	2.73	6.35	−4.08
9.	37.05	22.26	2.30	14.60	−2.11	52.62	41.87	3.83	14.60	−7.68

Notes: [a]Calculations based on data for six months.

consumers without imposing a direct burden on the government treasury. As with most other domestically-produced agricultural products, producers provide a substantial share of the subsidy to final consumers.

Finally, subsidies will be needed even if spinning mills are able to produce yarns equal to current qualities from shorter staple cottons. World prices for 'Acala' cottons are about 65% of Egyptian long staple cottons and substitution of 'Acala' for long staple would eliminate the cotton subsidy requirement for only one of the firms. Yarn quality represents an important caveat to this type of substitution, however. Egyptian mill equipment is older than that of most textile producers, and Egyptian spinners produce relatively coarse yarns for a given staple length of cotton input. Barring major changes in technical efficiency, attemps to spin yarns from shorter staple lengths will result in increased costs due to slower spinning and higher yarn breakage rates. Thus, the substitution of shorter staple lengths will not necessarily reduce the magnitude of subsidization required by spinning mills.

Cotton lint exports represent the alternative to domestic utilization. While export volumes have declined over the past decade (from 300 to 120 thousand metric tons), Egypt still accounts for about half the world exports of extra-long staple cotton. During most of the post-war era, planners have associated these large market shares with market power and pursued an independent pricing policy. Prices are established by the six government-owned export companies based on annual visits to the principal export markets and judgments about world textile market conditions. Payments are usually made in convertible currencies; barter trade with the centrally-planned economies was deemphasized after the early 1970's. Once established (usually in November), export prices are never lowered. Rather, prices increase by 1%–2% each month to reflect storage costs and to induce early placement of orders.

The reliance on price-setting policies rather than auctions or other market-clearing practices presumes that the market demands for Egyptian cotton are largely independent of the market demands for other staple lengths. In this case, changes in the supply of ELS can be expected to influence prices and the elasticity of international market demand becomes an important parameter in the determination of optimal production patterns. A number of developments over the last two decades, however, suggest changes in the economic relationships between the markets for different staple lengths. The emergence of synthetic fibers and advances in spinning technologies indicate that the ELS market may not be independent of the markets for other staple lengths. In this circumstance, the demand curve for ELS cotton can be considered infinitely elastic. Decreases in ELS production, for example, will not result in higher prices for ELS varieties but instead will cause increased use of shorter staple fibers or synthetics in the manufacture of yarns traditionally dependent on ELS varieties.

The linkage between markets for different qualities was examined. The pattern of relationships among staple lengths suggests a transitive sequence of adjustment rather than a pattern in which the prices of all staple lengths adjust simultaneously. Within the year, short staple prices are linked to medium prices, medium staple prices are linked to long staple prices, and long staple prices are linked to extra-long. But the adjustments between short and extra-long and medium and extra-long prices appear less complete. Only three of the six short-extra long and nine of eighteen medium-extra long coefficients are significantly different from zero. Complete adjustment of prices among these categories may require more than one year.

An hedonic price analysis, which examines the price of cotton in terms of its quality characteristics, was used

Cotton has long been a crop of major importance to the Egyptian economy. Correct government pricing of the various grades is a key to providing appropriate signals to growers and to prompt sales thru avoiding stockpiling as seen here. Several ADS economics projects have investigated policy options on pricing of cotton. *Photo: John Rowntree*

to test for the stability of discounts and premiums for staple length over time (Monke & Petzel, 1981).

The first implication of these results is that, in the long run, the world market for cotton can be considered a single market with respect to staple length. Few end uses exist for which ELS fiber is uniquely required and the marginal elasticity of substitution across qualities appear sufficiently large to present long-run changes in the relative prices of different staple lengths. The pattern for price adjustments within the market may involve a time lag however, with the initial impetus for price changes determined by changes in the demand for particular end products. Increases in demand for medium staple products will eventually effect ELS demand and prices as manufacturers are forced to buy increasingly longer staple cotton with which to make their products. Initial increases in ELS demands will ultimately affect medium staple prices in a similar manner. The rate at which changes in demand occur will be influenced by mill-level variations in managerial ability, vintage of capital stock, and costs of alternatives in the production process.

The specifications of a global demand supply model provide insight into the long-run prospects for the cotton market and for prediction of the price effects of expanded Egyptian production. Empirical models of international commodity trade usually view international markets as components of total production and consumption. Output and consumption within each country are assumed to be determined by international prices with excess demands or supplies being imported or exported. However, such approaches ignore the presence of quantitative controls on trade and are therefore inappropriate for the analysis of trade in many primary products. Cotton is an especially good case in point as cotton production is dominated by less-developed countries (LDC's) and centrally planned economies (CPE's) whereas exports are largely determined by the decisions of state trading monopolies. With quantitative restrictions on trade, domestic prices bear no necessary relationship to international prices, the result being that movements in world prices are not particularly useful in explaining global consumer and producer behavior.

A second complication arises from cotton's role as an intermediate input. Spinning mills are the principal consumers of cotton, although small amounts are utilized by other industries such as pharmaceuticals. The production of yarns involves a number of forward decisions such as the determination of fabric colors and patterns, yarn counts, and fiber blends. These decisions are usually made in consultation with apparel and household furnishing wholesalers and manufacturers, and orders are usually taken for the delivery of fabricated goods in a future period. Cotton consumption decisions by spinning mills are thus made in advance of actual purchases so that, as with production, expected prices again determine economic behavior. The model assumes: that the demand for cotton in world price-responsive countries is a function of the expected own-price, the expected price of substitutes, income, and trends in tastes and technology; that current production depends upon the expected own-price and the prices of substitutes; and that the expected price by the stockholder is a function of past prices. The model divides the cotton market into price responsive and non-price responsive countries which implies that the price-responsive countries will adjust in the short-run to the actions of price-exogenous countries through adjustments in inventories, and in the long-run via adjustments in levels of production and consumption. The output of the model indicates that:

- total world supply is inelastic with respect to world price changes even in the long run;
- own-price elasticity is −0.27 (a value similar to that found in other studies) but in the long run, consumption appears to be price-elastic, with a point of estimate of −1.69;
- and, that current prices are dependent on inventory adjustments in the price-responsive countries. The estimated elasticity (calculated at the point of means) is −0.54, based on an average stock change of 1.98 million mt.

In sum, the international market analyses suggest that substantial expansion of Egyptian cotton exports is not likely to cause significant declines in export prices. Egypt's share of the total world market for cotton is only 4% and the long-run elasticity of demand of −1.7 implies that a return to export levels of the early 1970's would be readily absorbed by the price responsive countries in the international market. In additon, income elasticities of 0.5 and population growth imply that the demand curve will continue to demonstrate significant outward shifts, and long-run price levels appear likely to remain at their level of the 1970–80 period. Thus, decisions by planners to reverse the trends of increased domestic utilization and reductions in cotton acreage will increase foreign exchange earnings of the economy at a constant rate.

In the short-run, however, Egyptian planners may have some latitude for price manipulation of the Egyptian LS and ELS varieties; however, effective use of this needs to be linked to price forecasts. Accordingly, the final component in the demand analysis was the selection of a methodology for forecasting cotton prices. A pricing model was developed consistent with the demand characteristics already identified, as well as with supply considerations and with the dynamics of speculative markets. Cotton market transactions are often made with a view towards resale at a later date or, in what amounts to the same thing, stocks of cotton are withheld from the market in anticipation of higher future prices. As a result of these speculative transactions, today's price is in large part determined by what tomorrow's price is expected to be. To capture these speculative effects, the cotton pricing equation reflects the influence of stocks of raw cotton on hand and the effects of future demand and production costs. This equation forecasts future demand by using other forecasts of world income, price of substitutes, and world cotton production. These forecasts permit us to predict cotton prices one year into the future.

Table 4 summarizes the results of econometric estimates of the demand for Egyptian ELS exports. The dependent variable was the number of bales of Egyptian ELS exports to all market economies. Exports to the CPEs were excluded on the assumption that their demands were likely to be less price responsive and/or based on bilateral trade agreements whose terms are not necessarily reflective of hard currency export prices.

Variables used to explain Egyptian ELS exports are: income in consuming countries, Egyptian export prices, and prices of competing fibers. The proxy used for income

Table 4. **Estimates of Demand Functions for Egyptian ELS Cotton**

Equation 1

$$\ln Q_t = -1.24 \ln P_{t-1} + 1.5 \ln Y_t + 0.83 \ln S_t$$
$$\quad (5.1) \qquad (7.0) \qquad (7.7)$$

$R^2 = .722$ SE = 0.19683 DW = 2.102

Equation 2

$$\ln Q_t = 3.25 - 1.24 \ln \frac{P_t}{L_t} \; 0.44 \ln Q_{t-1}$$
$$(3.6) \quad (3.7) \qquad (2.5)$$

$R^2 = .565$ SE = 0.24599 DW = 1.885

Q_t = 1000's of bales of ELS exports to market economies
P_t = real dollar fob price of Egyptian ELS exports
Y_t = real dollar income in importing countries
S_t = real dollar price of polyester fibers
L_t = real dollar U.S. farm price of 1 1/16" middling cotton
(t statistics are reported in parentheses)

in consuming countries was total OECD real gross domestic product in dollars. Prices of competing fibers included the dollar price per pound of polyester fiber delivered to US mills and the US farm price in dollars of middling 1 3/16" cotton fiber. All prices were deflated by the OECD gross domestic product implicit price deflator to obtain real dollar prices. Income and polyester price data were for the calendar year while export volume, export price, and US 1 3/16" price data were for the crop year beginning August 1 of the comparable calendar year and extending through July 31 of the following calendar year. As a result, income and polyester price data refer to a period which lags seven months behind export volume and cotton price data.

The equations reported in Table 4 have quite different implications for the price responsiveness of export demand. Equation 1, with lowest standard error, implies that exports are totally unresponsive to export prices within the crop year. The results indicate that export demand responds to prices in the preceding year. The point estimate of the elasticity of demand to lagged prices is 1.24. Equation 2 reveals a similar point estimate of the elasticity of demand but to current rather than lagged prices. Export demand also depends heavily on lagged export demand, which implies an additional distributed lag response to price changes over time. With a lagged export coefficient of about 0.44, the elasticity of export demand after one year increases to 2.21.

These estimates can be used to identify the reduction in ELS export prices needed to avoid ELS stock accumulation during the 1977–78, 1978–79, and 1979–80 crop years. These required price reductions are then compared to the net social cost of growing ELS cotton to determine whether production of cotton in those years exceeded the socially profitable level. Columns 1 and 2 of Table 5 show actual LS and ELS export prices. Columns 3 and 4 identify the world prices which make the domestic resource cost (DRC) equal to one in the least efficient producing regions.

Table 5. **Comparison of ELS Export Prices Required to Eliminate Stock Accumulation to Actual FOB Export Price and World Price which Makes DRC = 1 (LE/MK)**

Year	*Actual FOB Export Price Lagged*		*World Price for which DRC = 1*		*Required % Change in ELS Exports to Market Economies*
	(1)ELS	(2) LS	(3) ELS	(4) LS	(5)
77/78	67.09	54.24	45.11	41.91	3.81
78/79	51.51	43.99	45.11	41.94	9.84
79/80	95.13	84.23	80.62	74.98	73.24

Year	% Change in Export Price Required to Control Stock Accumulation *In Year of Accumulation*	*After One Year*		FOB Export Prices Required to Control Stock Accumulation *In Year of Accumulation*	*After One Year*
	(6)	(7)		(8)	(9)
			Equation 1		
77/78		−3			65.03
78/79	Not Possible	−8		Not Possible	43.66
79/80		−59			39.00
			Equation 2		
77/78	−3	−2		65.06	66.42
78/79	−8	−5		47.44	50.49
79/80	−59	−40		39.15	63.42

Column 5 indicates the percentage change in exports to market economies required to avoid accumulation of ELS stocks. These percentages assume that only exports to market-oriented economies will change in response to export price changes. If, for example, Eastern European export volume also responds to price changes, the "required" price changes reported in Columns 6 and 7 are overstated.

With Equation 1, price reductions affect demand with a one year lag. In such a case, policymakers would either have to anticipate potential stock accumulations one year in advance and make price adjustments at that time or, alternatively, adjust prices in the year in which stock accumulations occur and then hold in inventory the excess amount for one year until price adjustments have time to eliminate the stock accumulations. Columns 6 and 7 for Equation 1 indicate the reduction in f.o.b. ELS export prices would have offset stock accumulation after one year. Only in 1979–80 would price reduction have resulted in a price below that which makes ELS cotton production socially profitable. Equation 2 demonstrates results which are similar qualitatively, although the larger demand elasticity suggests less drastic price cuts.

For several reasons, these results are likely to overstate the size of the price changes required to eliminate stock accumulation. First, only the demand from market economies is considered, while exports to nonmarket economies represent about 50% of total Egyptian ELS exports. Second, the price elasticities come from a sample which reflects dependence upon a relatively unchanging set of customers for the bulk of sales. One should not be surprised to find that unusually large changes in Egyptian prices will evoke larger and faster demand responses than those measured here as occasional buyers will be attracted to the market. Third, this approach considers a very short time horizon. The optimal solution to an inventory problem usually includes adjustment over more than one (or even two) periods. Finally, the stock levels reflect the cumulative effect of errors in setting market-clearing prices. By 1980, stocks had grown substantially larger than export sales and thus unprecedented price cutting would be required to get traditional customers to absorb the increase.

CONCLUSION

The performance of the cotton economy in Egypt has been largely determined by government policy. Efficient

resource allocation has not been a principal objective in the determination of production patterns as interest in foreign exchange revenues, urban industrialization programs and low consumer prices for textiles have dictated low prices for cotton producers. While consideration of nonagricultural interests is necessary to delineate the objectives of cotton policy, the reliance on lint prices as the primary instrument with which to achieve objectives can only be understood by consideration of the self-interest of government. From the perspective of the government treasury, increases in domestic producer prices have two unfavorable effects. First, increases in prices reduce the profitability of export sales. Second, increases in lint prices force increases in consumer textile prices unless government increases direct subsidies to the spinning industry. Given the constraints on government revenues and the substantial costs of other commodity subsidy programs, attempts to change price policies require major shifts in the objectives of policy as well as the financial capacity to pursue these objectives. At the same time, however, planners have not been able to ignore entirely output prices at the farm level. Even with the use of forced area allocations, supply response appears to be price-elastic as farmers vary yields and ignore mandatory area controls to some extent. Thus policymakers are required to offer positive private profitability at the farm level.

The dominance of nonefficiency objectives in the formulation of cotton policy suggests that agricultural planners have little room for independent manipulation of prices and maximization of agricultural sector incomes. Income gains which result exclusively from agricultural policy are likely to be limited to improvements in varieties, such as short staple cottons, and the development of more efficient production technologies which can profitably substitute capital for labor. Mechanized harvesting techniques are probably the more important in this regard. Even in these cases, however, decisions by planners on foreign exchange allocations for equipment purchases and the response of the spinning industry to shorter staple lengths may remain critical constraints to change in the agricultural sector.

The piecemeal approach to cotton policy and the resulting constraints on domestic price policy miss significant potential gains to the Egyptian economy. Domestic supply and international market demands both appear price-elastic, and increases in producer prices and expansion of exports would increase both aggregate foreign exchange earnings and net tax revenues for the government. These revenues could then be used to provide direct subsidies to textile consumers and at least partially replace the indirect textile subsidies provided by cotton producers. Economic policy has largely ignored these potential changes, as particular interest groups do not see benefits from change, and central planners ignore the transfers which could compensate particular groups. The changes described above are simultaneous but, if implemented without central coordination, compensation of potential losers will not take place. Like many other agricultural commodities, significant changes in cotton policy remain dependent on changes in objectives and policies in other sectors of the economy.

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THE EFFICIENCY OF THE EGYPTIAN FARM

The Farm Efficiency Project undertook to measure the structure of farm-level Egyptian agricultural technology and to evaluate the effects of agricultural policy on farm-level resource allocation and productivity. Recognizing that joint production is an important characteristic of Egyptian production technology, a major goal of the project was to assemble data and develop a multiproduct econometric production model for policy analysis.

ACCOMPLISHMENTS

SURVEY OF AGRICULTURAL POLICY AND AGGREGATE DATA FOR MAJOR FIELD CROPS, 1960–1980

A major goal of the research activity was to evaluate the effects that agricultural policy has had on productivity and resource allocation. An important first step towards that goal was to survey the major policies which affected agricultural production. In addition, it was necessary to survey the available aggregate data to learn about major trends in productivity, input use, and prices. For this purpose, policy surveys and data were assembled for major outputs by governorates as well as for all Egypt. Additional detailed data were available for fertilizers, pesticides and seeds. Detailed data on production, consumption, imports and exports of these inputs were collected. Price, yield and area data were assembled for major products. Detailed data were assembled and policies analyzed for rice, wheat, maize and cotton.

Analysis of Rice Technology, Farmer Rationality, and Agricultural Policy

Research in Phase I of the activity investigated the structure of Egyptian rice technology in the important East Delta region and used these findings to draw some preliminary inferences about policy questions. The econometric model was based on a homothetic translog cost function. Estimates of this model allowed us to test the technology structure and to estimate input demand elasticities. These elasticities provided important information about the price responsiveness of Egyptian farmers and about various agricultural policies.

Agricultural Policy and Farmer Rationality

Egyptian agricultural policy emphasizes output regulation through intervention in product and input markets and enforced crop rotation. Such policies imply that the central decision-making agency, the MOA, can make better resource allocation decisions than farmers themselves. This view contradicts much agricultural development literature which, beginning with T.W. Schultz's work, has found farmers to be economically rational and efficient. Economic theory implies that economically rational farmers make input decisions as a function of the opportunity cost of inputs. Therefore, to test farmer rationality, we estimated the cost function with free (or black) market prices of inputs rather than much lower government-administered prices.

To illustrate, we considered nitrogen fertilizer distribution. In 1966, Agricultural Law No. 53 gave the MOA monopoly power to distribute fertilizers for each crop at subsidized prices. During the period 1973–78, the nitrogen quota per feddan was about 31 kilograms. For other major field crops, similar quotas were applied—38 to 62 kilos for wheat and maize and 46 to 62 kilos for cotton. To investigate the economic effects of this policy, consider the standard theory of derived demand. Each farmer's fertilizer demand is a function of local technical and economic conditions. Theory predicts that the fertilizer use of economically rational farmers will vary. Some farmers will use more fertilizer than the quota if they can acquire it, and others will use less, so there should be economic incentives for farmers to trade fertilizer in a black market. Indeed, an active fertilizer black market exists in Egypt. Survey data show that the average government price per kilogram of nitrogen was about 0.15 Egyptian pounds (LE). This was only about 57% of the average black market price. Economically rational farmers thus base their fertilizer allocation decisions on this price which is the opportunity cost of fertilizer.

The Homothetic Translog Cost Function

The empirical model used to study the structure of East Delta rice production was a homothetic translog cost function. Rice production data came from the 1976–77 Farm Management Survey conducted by the Egyptian MOA. Our sample covers the East Delta region which comprises the Sharkia, Dakahlia, and Domiatte governorates.

The model was specified with prices for hired labor, mechanical power, animal power, and nitrogen and phosphate fertilizers. Acreage under cultivation, family labor input, and two regional dummy variables were included as fixed factors. Farmers' acreage decisions are constrained by exogenous factors such as the government-administered crop rotation system. The family labor variable perhaps should not be a fixed factor. However, without more information about the opportunity cost of family labor, we could not estimage a separate input demand function for it, and we treated it as fixed.

The model's parameters were used to calculate input demand elasticities (Table 1). These estimates imply substantial price-responsiveness by farmers. All significant own-price elasticities are negative as implied by economic theory. Only the machinery elasticity is small and positive but has a large standard error. The elasticities of inputs

Table 1. **Output Compensated Input Demand Elasticities Based on the Translog Cost Function for East Delta Rice, Egypt, 1976**

	Equation:				
	Hired Labor	*Animal Power*	*Mechanical Power*	*Nitrogen*	*Phosphate*
Prices:					
Hired Labor	−.730	.142	.020	.428	−.462
	(.602)	(.344)	(.090)	(.555)	(.552)
Animal Labor	.485	−.907*	−.049	1.081*	3.314*
	(.361)	(.434)	(.069)	(.484)	(1.481)
Mechanical Power	.101	−.243	.014	−.148	−.552
	(.472)	(.344)	(.100)	(.534)	(2.385)
Nitrogen	.317	.762	−.021	−1.684**	−1.565
	(.407)	(.484)	(.075)	(.592)	(1.852)
Phosphate	−.101	.694*	−.023	−.464	−1.232
	(.341)	(.310)	(.099)	(.549)	(.741)
Fixed Factors:					
Land	.229**	−.174**	−.072**	.274**	.358**
	(.049)	(.043)	(.029)	(.093)	(.114)
Family Labor	−.122**	.109**	.019	−.107	−.183**
	(.030)	(.028)	(.019)	(.061)	(.073)

Note: Standard errors in parentheses.
*Significant at 5 percent.
**Significant at 1 percent.

with respect to fixed factors show a consistent pattern. *Ceteris paribus*, increased rice acreage is associated with increased use of hired labor and fertilizers, and reduced animal and mechanical power input. Increased family labor use is associated with an opposite pattern of input use. These results show that family labor substitutes for hired labor and is complementary to animals and machinery. Such complementarity is consistent with the established patterns of labor use. Typically, family members tend animals and operate machinery, especially when they are family owned.

Implications for Agricultural Policy

We argued above that economically rational farmers would use nitrogen fertilizer as a function of the black market price, a hypothesis clearly supported by our estimates of the elasticity of nitrogen and phosphate fertilizer demand. Another piece of supporting evidence is the distribution of fertilizer per feddan for farmers in our sample. Histograms of the data show that while the average is near the govenment quota, many farmers use either more or less fertilizer, as theory predicts they would, as a function of local economic and technical conditions. Thus, if farmers were to follow the government's quota, most of them would be producing with a fertilizer input level which would be both economically and technically inefficient.

The fact that farmers deviate from the government quota might be viewed as evidence that fertilizer is being efficiently allocated. However, the free market in fertilizers is an illegal one, and although farmers manage to allocate fertilizer to other crops or trade it in their villages, intervillage and interregional fertilizer trade appears to be very limited. This suggests that the quota and distribution system does reduce the efficiency of fertilizer use in the aggregate.

Further evidence of the fertilizer distribution system's inefficiency comes from a comparison of domestic and world fertilizer prices. A free-trade policy in fertilizer would lead to equality between domestic and international prices, with farmers using fertilizer up to the point where the value of the marginal product equals the world price. However if trade were restricted and the country were a net importer of fertilizer, the domestic market price would rise above the world price. This latter scenario accurately describes Egypt. In 1977, the world price of nitrogen fertilizer was about 0.2 LE/kg at the official exchange rate, as compared to the subsidized price of 0.15 LE/kg at the government cooperatives. The fact that the quantity of fertilizer was severely restricted is evidenced by the average black market price which was 0.27 LE/kg in the East Delta, and by prices as high as 0.40 LE/kg in some villages. Combined with the high price elasticity of nitrogen demand, these prices indicate quantity was restricted far below the free-trade equilibrium.

The cross-elasticities of demand show strong substitution between hired labor, animal power and fertilizer. These relationships can be explained partly because hired labor and animal labor are used to produce and apply manure. Therefore, an increase in the wage rate or the cost of animal power gives farmers an incentive to substitute nitrogen for manure. If less family labor is used to apply chemical fertilizer than manure, then family labor and fertilizer should be negatively associated. The elasticities of both nitrogen and phosphate with respect to family labor are negative with relatively small standard errors. There is evidence supporting this relationship. These results suggest that increased fertilizer availability will reduce the fertilizer price, encourage farmers to substitute purchased fertilizer for manure, and cut back on hired labor and animal labor.

Recently there has been an unprecedented increase in rural wages which can be linked with increased outmigration of Egyptian workers in response to wage rates in the nonagricultural sector in Egypt and other Middle Eastern countries. The current debate over an appropriate policy for the resulting labor shortage in Egyptian agriculture includes the question whether or not the government should continue or expand its program of subsidizing farm mechanization and whether or not the shortage is a long-run phenomenon.

Our estimates of demand cross-elasticities show a very small and statistically insignificant substitution between labor and mechanical power input. There also is some evidence of complementarity between family labor and mechanical power. These results reflect the way in which mechanical power is used in rice cultivation. The two forms of mechanical power are tractors for land preparation and pumps for irrigation. Substituting mechanical power for animal power in these operations does not greatly reduce human labor input. However, the increased productivity attainable with improved land preparation and irrigation increases the labor demand in planting, cultivating and harvesting.

Another factor contributing to the low measured own and cross-elasticities for mechanical power is the nonprice rationing system determining mechanical power use. Tractors and pumps are both privately owned and provided by government cooperatives in each village. There is an open rental market for them at prices generally above the subsidized cooperative price. However, in many villages the primary source of tractors and pumps for farmers who do not own them is the village cooperative. According to survey data, government cooperatives supplied 89% of the tractor horsepower available in the 11 villages in our sample.

Therefore, it is not clear whether the low degree of input substitution and price elasticity are characteristic of the technology or are due to the nonprice rationing system. If labor and mechanical power are not readily substitutable with the existing technology, increased mechanization of the kind currently in use will not relieve the labor shortage problem. Assuming the labor market change is permanent, the government's efforts should be to introduce new mechanical technology which can substitute for labor in critical operations where more labor is needed. For rice and most other field crops, the critical operations which are still largely unmechanized in Egypt are planting and harvesting.

While it may be sensible for the government to subsidize research, development and diffusion of appropriate new mechanical technology, it is not clear that it should directly subsidize mechanical inputs at the farm level. Rational farmers in Egypt will respond to wage rate increases by demanding more machinery just as U.S. farmers have. It is reasonable to argue that Egypt would benefit from a change in agricultural policy to phase out the government supply system for mechanical technology and to encourage a private supply system.

The 1981–82 Production Survey: Comparison to the 1976–77 Farm Management Survey Data

A random sample of 10 East Delta villages in Sharkia, Dakahlia, and Domiatte governorates was drawn and 150 farmers were randomly selected in those villages. The survey was carried out in the summer of 1982 to obtain production and price data for the previous season's major field crops. Comparison of these data to that collected for the 1976–77 Farm Management Survey in Egypt revealed some important technological changes. One is a marked increase in fertilizer use in all crops but cotton. Average nitrogen use per feddan on rice, wheat, corn, and cotton was 32, 42, 53, and 48 kilograms according to the 1976–77 survey. In contrast, the 1981–82 survey shows the corresponding values to be 66, 63, 94, and 71 kilograms, which represents on average a 68% increase in nitrogen use. This increased availability of nitrogen seems to explain the decrease in black market fertilizer trade. In 1981–82, farmers reported buying on average only about 6% of their fertilizer in the free market (which is in fact a black market). In contrast, the 1976–77 data showed that on average about 10% of the nitrogen used was obtained in the free market. Yields showed changes corresponding to fertilizer input. Rice and cotton yields each increased about 26% from 1976 to 1981, whereas wheat increased 14% and corn increased 17%.

The total hours of mechanical power and hired labor used per feddan were about equal in the two surveys. However, there was a significant change in machinery ownership. The 1976 data showed that 89% of total tractor horsepower available was owned by the government cooperatives. This information was not collected in the 1981–82 survey, but we did collect data on hours of mechanical power from privately owned and rented (either from the government cooperative or private owners) equipment. Depending on the crop, these data show that 30 to 60% of the mechanical services came from machinery owned by the farmer who used it. Since part of the machinery rented is also privately owned, this means that in 1981, at least 30% or more of the mechanical equipment in use was privately owned. This represents a substantial increase in privately owned machinery from 1976.

There were also major changes in relative prices from 1976 to 1981, most notably the price of hired labor which

Table 2. **Output Compensated Own-Price Input Demand Elasticities for Based on Estimates of the Single-Product Homothetic Translog Cost Function East Delta Region, 1981–82**

	Crop			
Input	*Wheat*	*Corn*	*Rice*	*Cotton*
Hired Labor	−.240	−.669	−.008	.184
	(.121)	(.144)	(.187)	(.126)
Mechanical Power	−.491	−.775	−.792	−.919
	(.078)	(.132)	(.132)	(.141)
Nitrogen	−.586	−.918	−1.036	−.775
	(.208)	(.225)	(.496)	(.314)
Phosphate	−.408	−.590	−.175	−.159
	(.619)	(1.200)	(.280)	(.647)
Animal Labor	−.584	−.997	−.302	−1.023
	(.197)	(.169)	(.203)	(.252)

Note: Standard errors in parentheses.

increased 200–300% relative to other inputs. This increase reflects the labor shortage problem, which was due to the outmigration of agricultural labor to the nonagricultural sector in Egypt and to other Middle East countries where much higher wage rates prevailed. It is remarkable that in spite of these dramatic relative price changes, hired labor input did not decline relative to most other inputs except nitrogen. One goal of the research was to explain why this occurred.

The homothetic translog cost function defined above was specified with prices for hired labor, mechanical power, animal power, nitrogen and phosphate fertilizer. Acreage under cultivation, family labor, and regional dummy variables were included as fixed factors for all crops. The cotton model also included a variable measuring the value of pesticides applied.

Table 2 summarizes the own-price input demand elasticities implied by the estimated translog cost functions. Like the analysis based on the 1976–77 Farm Management Survey data, the elasticities imply farmers respond rationally in input price changes. Like the previous analysis, the cross-price elasticities based on the 1981–82 data also showed that hired labor and mechanical power are not strong substitutes for each other. Overall, the results of this analysis supported the above policy analysis based on the 1976–77 rice data.

MULTIPRODUCT ANALYSIS OF SUMMER FIELD CROP TECHNOLOGIES

The agricultural technologies in Egypt and many parts of the developing world are multiproduct in nature. For the most part, only normative linear and quadratic programming models have been used to evaluate agricultural policy questions in a multiproduct framework, and such models presuppose knowledge of the technology structure. We developed a multiproduct translog profit function model to characterize the structure of summer field crop technologies using the 1981–82 survey data described in the above section. We used the estimates of input demand and output supply functions based on this model to evaluate current agricultural policy questions. In addition, we compared the multiproduct technology estimates of input demand elasticities to those presented above produced by the single-product model. This comparison provides an example of how the assumptions of single or multiproduct technologies affect estimates of the technology structure.

Since the parameters of the translog model do not have a direct economic interpretation, they were used to calculate the demand and supply elasticities (Tables 3 and 4). We note the following properties of these estimates. First, all own-price input demand elasticities are greater than one in absolute value, indicating substantial input price responsiveness. Second, all own-price output supply elasticities are positive and approximately 1 and 2 for rice and corn and 3.75 for cotton, indicating a marked difference in supply response across crops. Third, inputs are generally complementary as indicated by the negative signs of the cross-price input demand elasticities. Fourth, the elasticities of output with respect to input prices are negative, but their magnitudes vary across crops. Fifth, input demand is increasing in output prices, but the effects are much greater for corn and rice than cotton. Sixth, the cross-price supply elasticities show all three outputs are complements, although corn and rice are much stronger complements than cotton. A final result of interest is that cotton supply responds significantly to rice and corn prices but not *vice versa*.

Policy Implications of the Multiproduct Analysis

The estimates of input and output response in Tables 3 and 4 provide a basis for analysis of the wide spectrum of government policies. Egypt has a long history of intervention in agriculture, including input markets, production

Table 3. **Input Demand Elasticities Based on Multiproduct Translog Profit Function for Corn, Rice, and Cotton, 1981 East Delta**

	Inputs				
Prices	*Hired Labor*	*Mechanical Power*	*Nitrogen*	*Phosphate*	*Animal Power*
Hired Labor	−3.495	−2.109	−2.490	−3.096	−3.550
	(.398)	(.415)	(.510)	(.996)	(.711)
Mechanical Power	−1.493	−2.381	−1.271	−1.242	−2.531
	(.294)	(.401)	(.330)	(.535)	(.582)
Nitrogen	−.583	−.421	−1.654	−1.755	−.792
	(.119)	(.109)	(.359)	(.774)	(.208)
Phosphate	−.042	−.024	−.102	−.955	−.035
	(.014)	(.010)	(.045)	(.270)	(.018)
Animal Power	−1.257	−1.265	−1.196	−.921	−1.334
	(.252)	(.291)	(.313)	(.462)	(.790)
Corn	2.818	2.807	3.006	2.102	3.561
	(.626)	(.679)	(.826)	(1.164)	(1.676)
Rice	3.0244	2.304	2.572	.405	3.906
	(.520)	(.725)	(.647)	(1.255)	(1.123)
Cotton	.57311	.612	.307	.702	.051
	(.215)	(.250)	(.222)	(.272)	(.533)

Note: Standard errors are in parentheses.

and output markets. The Nasser, Sadat and Mubarak governments inherited and further developed policies aimed at taxing agriculture through a system of price policies, production quotas and cropping rotation. Farmers are required to grow mandated acreages of crops such as cotton, rice and wheat. All or part of their output must be sold to the government at low prices which are below those of market equilibrium or world market prices.

The own-price supply elasticities in Table 4 suggest that these price policies, and especially the cotton price policy, have had a substantial negative impact on production. It should be emphasized that these elasticities were estimated subject to given acreages, so the measured supply response is due to allocation of other resources in response to price changes. The cotton supply response also is due to late planting. The practice became common as the government price policy reduced the incentive to produce cotton, and berseem (which precedes cotton in the rotation) became increasingly profitable due to higher livestock prices.

Time series data show that after the marked yield increase in the mid-1960's, due to the introduction of fertilizers, pesticides and mechanization, cotton yields continuously declined despite increased availability of the new technology. Our results suggest that the yield decrease is explained at least in part by the policy-created price disincentives and the high degree of cotton supply response, which is high even with controlled acreage.

The importance of price policy to overall agricultural productivity is suggested by the complementarity between

Table 4. **Output Supply Elasticities Based on Multiproduct Translog Profit Function for Corn, Rice, and Cotton, 1981 East Delta**

	Outputs		
Prices	*Corn*	*Rice*	*Cotton*
Hired Labor	−2.527	−2.512	−3.469
	(.562)	(.432)	(.558)
Mechanical Power	−1.782	−1.355	−3.028
	(.431)	(.427)	(.460)
Nitrogen	−.631	−.501	−.689
	(.173)	(.126)	(.135)
Phosphate	−.0256	−.004	.004
	(.014)	(.014)	(.009)
Animal Power	−1.130	−1.148	.366
	(.532)	(.330)	(.490)
Corn	2.105	3.4195	2.796
	(1.392)	(.811)	(1.139)
Rice	3.692	1.083	5.210
	(.876)	(.929)	(.859)
Cotton	.081	.645	3.752
	(.393)	(.275)	(1.509)

Note: Standard errors in parentheses.

cotton, rice and corn shown in Table 4. This complementarity is explained by cotton's long growing season which encompasses the rice and corn seasons. Cotton also requires large inputs of human labor, animal labor, and mechanical power which are complementary to the other field crops. The evidence suggests that the agricultural policy based on low output prices to farmers has had significant adverse effects on resource allocation to the productivity of the major field crops. Table 4 also shows that the rice and corn prices have a large and positive and significant effect on cotton supply, but the cotton price has much smaller effects on rice and corn production. An explanation for this phenomenon can be deduced from Table 3 and is consistent with informal interviews with farmers. Due to the cotton price policy, farmers do not want to grow cotton, and Table 3 shows that, indeed, input demand responds marginally to the cotton price, in contrast to rice and corn. Farmers use means such as late planting as well as input reallocation to regulate cotton supply. Since corn and rice are less heavily taxed, farmers adjust input use in response to corn and rice prices. Because those inputs complement cotton production, cotton supply responds in turn to corn and rice prices.

In Table 3 the elasticities of input demand with respect to output price show that price policies have differential impacts on input use. The rice and corn prices have a substantial effect on labor demand. This means that increasing these prices would markedly increase the demand for labor and, hence, the wage rate. This is an important consideration for policy makers in view of the so-called labor shortage of recent years. Consequently, the average agricultural wage increased several fold relative to other input and output prices from 1976 to 1981 in the East Delta region.

Our data also show that, relative to mechanical power or animal labor, the human labor in 1981 was no less than in 1976 despite the dramatic wage rate increase. The cross-price input demand elasticities in Table 3 provide the explanation: human labor *complements* both animal power and mechanical labor: there are no substitutes for human labor with the existing technology. Thus, the only option available to farmers as wage rates increase is to reduce output and to bear the high labor costs. This situation has been especially damaging to farmers because the government has increased output prices to compensate for the increased cost of production. Table 4 shows that wage rate increases did indeed induce farmers to reduce output substantially.

Our field observations indicate that the lack of input substitution shown in Table 3 is reasonable. Since widespread mechanization began in Egypt in the 1960s, the emphasis has been almost exclusively on large (60–70 h.p.) tractors and small to medium size irrigation pumps. These relatively large tractors are useful only for a limited number of farm operations, primarily plowing, powering threshers, and transportation. These tractors, as well as the irrigation pumps, replace primarily animal labor. Planting, transportation, fertilizing, weeding, pest control and harvesting still require large amounts of human and animal labor input.

Egypt's mechanization policy has been, and continues to be, based on government subsidies for import of these large tractors which are available as rentals from village cooperatives or purchase through government channels. No private tractor industry is allowed. The evidence presented above overwhelmingly suggests that this policy has led to an inflexible technology, and that continuing this policy will not solve the labor market problems. In our view, appropriate policy is to allow new mechanical and biological technology to be introduced or developed which will save labor in the highly labor-intensive operations. Recent experience shows a massive wage increase did not significantly alter factor proportions with the existing technology. As long as the government forces the existing technology to be maintained, it seems unlikely that much reduction in labor requirements will be induced through technical change. Therefore, farmers will be induced to save on labor by distorting cropping patterns, seeking alternative production such as livestock, or reducing proportion and turning to nonagricultural production.

Major conclusions of the farm efficiency project's research are as follows:

1. Egyptian farmers respond *rationally* to economic conditions, i.e., they are *price responsive;*
2. There is an active black market in fertilizers caused by governmental rationing. The black market price has been 50–100% above the cooperative price;
3. There appears to be no economic rationale for the crop-specific fertilizer quota policy. A general fertilizer subsidy and a free-market for fertilizers would increase allocative efficiency;
4. Fertilizer availability was severely restricted in 1976–77, and nearly doubled by 1981–82. Nevertheless, the black market price remained well above the cooperative price. The estimates of fertilizer demand elasticity imply a free trade policy, which would increase the availability and lower the black market price, would greatly increase fertilizer use and agricultural productivity;
5. There is very little possibility of substituting mechanical power for human or animal labor with the existing technology. Evidence for this is provided by estimates of input demand elasticities, and by the fact that farmers used the same labor input relative to other inputs in 1981 and 1976 despite a tripling of labor costs relative to those of other inputs;
6. In view of (5), there is clear need for a change in the mechanization policy. Small, not large, tractors are needed, along with other biological research to develop technology which requires less human labor input in critical operations such as planting, cultivating, and harvesting; and
7. Cotton, corn and rice supply response was found to be high (supply elasticities of 2 for corn and rice, 4 for cotton) even when acreage is held constant. This means farmers are responding to relative output price variations rationally. This finding also shows that the

Modern mechanized pumps are being used increasingly to replace traditional irrigation methods based on animal or human effort. Questions concerning the economic efficiency of using large numbers of diesel engines such as that seen above is one of the subjects of ADS research.

Photo: Eric Gustafson

existing price policies, which hold these crop prices low, are reducing agricultural productivity. Thus, the existing price policies may be a major cause of the low productivity growth in Egyptian agriculture.

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IMPROVEMENT IN AGRICULTURAL COOPERATIVES

For over 50 years the Egyptian government has promoted cooperatives as part of its rural development strategy. Varied results and changes in Egyptian conditions justify a reevaluation of policy on cooperatives.

The purpose of this project was to assess the role and performance of agricultural cooperatives in Egypt *vis-a-vis* national planning goals and the stated interests of cooperatives. Specifically, the project sought to: (1) identify key factors conducive to cooperative success at the national, regional, and local level and within each of several different types of cooperatives; (2) identify types of cooperatives suitable for the new lands; (3) recommend ways to evaluate and enhance cooperative performance; and (4) compile a library and data bank on agricultural cooperatives for Egyptian use in teaching, research, and planning.

The project approached its objectives initially by a comprehensive literature survey followed by the design and preparation of conceptual methods and instruments for evaluating the role and performance of a representative sample of cooperatives. This involved preliminary surveys to test and fine tune the approach, followed by a main survey based on the preliminary findings. A comprehensive set of annual budget sheets, covering cooperative incomes and expenditures, was processed for computer research. General findings on cooperative roles were written into reports, and a statistical analysis of cooperative performance was completed in the summer of 1983. The library and data bank from the project are in place for further research and analysis.

ACCOMPLISHMENTS

LITERATURE REVIEWS ON COOPERATIVES

Land Reclamation Cooperatives in Egypt

Dr. Abdul Hameed Sharshar headed a review of the history, structure, and function of these cooperatives which operate under the aegis of the General Agency for Land Reclamation and Development. During the period 1952–1972 Egypt reclaimed nearly 330,000 feddans of land under the Agrarian Reform Law. Reclaimed Land and Settlement Cooperatives were formed to cultivate this land and by 1980, there were 177 village and 15 regional "land" reclamation cooperatives. To date, however, very little has been written about these cooperatives, but there is the general impression from the data collected that their performance is better than other production cooperatives in Egypt.

Agrarian Reform Cooperatives in Egypt

Dr. Mohammed Ramadan El Shohnah headed this team which reviewed the literature covering their historical evolution beginning in 1952. The report also provides specifics on the structure and size of Agrarian Reform Cooperatives. In 1980, there were 65 regional cooperatives, 684 local cooperatives, with 361,000 members and an approximate worth of 2 million LE. They are administered by the General Agency for Agrarian Reform, and their organization is similar to that of the local, district, and regional cooperatives of the voluntary sector cooperatives (discussed in the next section).

The Agrarian Reform Law was the primary foundation for agricultural and credit cooperatives established by the revolution of 1952. Immediately following Law No. 178, the maximum area of land that could be owned by one family was 100 feddans. As large holdings were partitioned, the number of small land owners increased. Nearly 1 million feddans were requisitioned and 900,000 feddans were redistributed to 418,000 families. The Agrarian Reform Law stipulated that an agricultural cooperative society will be formed by those who have acquired requisitioned land in their own right and who do not possess more than five feddans in the same village. In addition, crop rotation programs were introduced. At the time this report was prepared there was relatively little known about the performance of the Agrarian Reform Cooperatives, though this review indicated that they were active in providing credit, marketing assistance, machinery, and technical help in crop and livestock production.

The Agricultural and Cooperative Credit (ACC) System in Egypt

Dr. Faris Shaker conducted this overview of voluntary sector (ACC) multipurpose cooperatives, which differ from those in areas developed by agrarian reform and land reclamation cooperatives. Altogether, Egypt recorded 5,165 agricultural cooperatives with 3 million members in 1976. The multipurpose ACC system alone covered 4,170 cooperatives and 25 million members in 1976. In addition to a review of the legislation on and programs for ACC members since the 1952 revolution, Dr. Shaker assessed the constraints facing the ACC system in Egypt. Basically, his review shows a lack of understanding of cooperative principles by the membership, weak enforcement of mandated responsibilities (e.g., crop rotations, provision of social and marketing services, etc.), mismanagement of cooperatives, and inadequate financial support for cooperative activities.

Specialized Cooperatives in Rural Egypt

Drs. Fawzy Abdel Aziz El Shazly and Refugio I. Rochin outlined the role and operation of specialized cooperatives in Egypt administered by the Under Deputy Secretary of

Agriculture for Cooperative Affairs (in the Ministry of Agriculture). There are eight types organized by product group: (1) potato, (2) onion, (3) rice, (4) oil crops, such as peanuts and sesame, (5) sugar cane, (6) vegetables and fruits, (7) cotton, and (8) textile products, such as cotton fiber. Specialized cooperatives began in 1969 and provide primarily marketing services.

The review focussed on the cooperatives for potatoes and showed their importance in providing potato seed as well as storage and export of this product. The authors argued that potato cooperatives have not achieved their potential for economies of scale and still face relatively high administrative costs and inefficient storage. They may, however, have helped stabilize product prices and in some years, have paid attractive dividends to potato growers.

An Historical Analysis of the Cooperative Movement

Dr. Ibrahim Moharrum reviewed the origins of Egypt's cooperatives back to 1870. This review provides a backdrop against which the national movement of cooperatives can be assessed--the British occupation, the role of National Party Leader Moustafa Kamel and Sultan Hussein's influence (circa 1910), and the earliest cooperative laws of 1923 and 1927. The legal, cultural and religious (Islamic) roots of cooperation (such as the tradition of *zequer*) were also examined. A second phase of government support for cooperatives began in 1952, and Dr. Moharrum traced the rise, fall and reactivation of the Central Agricultural Cooperative Union, Egypt's major federation for farm cooperatives. Prospects for the Cooperative Law of 1980 were also assessed by Dr. Moharrum.

Cooperative Credit Programs for Small Farmers

Dr. Rochin and Ms. Solomon prepared a compendium of recent studies and reports on cooperative credit efforts for small farmers in LDC's. This "state-of-the-art" report covers (1) the role of small farmer credit cooperatives, (2) common ideologies and features, (3) group lending as a cooperative tool for agriculture development, and (4) economic and financial policies of credit cooperatives. Useful insights are provided on the manner in which credit can be diffused to numerous small farmers and still be relatively cost effective. Over 20 countries were represented in the selections. The reports have been copied and installed in the ADS library in Cairo where they will serve as a valuable reference to Egyptian students of credit cooperatives.

Case Studies of Agricultural Production Cooperatives

This case study review by Stoft focuses on the production cooperative as a small farm development tool. Case studies were from California, Israel (the Moshav and Kibbutz), Tanzania (the Ujamaa), and Zambia. The several meanings of cooperation in these different countries were defined and synthesized from the literature to derive a practical concept of a "production cooperative" which could be used in the Egypt Project. For each case study, the principles governing production cooperatives were examined as were their goals, structure, ability to create jobs, improve resource use, increase income, and educate members. This "state-of-the-art" review's main contribution was in structuring a set of issues and tools to be used for measuring the performance of production cooperatives in Egypt.

Agrarian Reform Cooperatives and Community Development Programs

The goal of this review, conducted by Filiz Temel, was to understand the importance of cooperatives and community development programs in improving the living conditions of people affected by land reform. The three countries studied—Mexico, Taiwan, and Egypt—offered a wealth of information and interesting contrasts. Among the conclusions, Temel notes that: "In Egypt, the supervised cooperatives introduced under land reform have come to be regarded as one of the most successful parts of the reform. Taiwan and Egypt appear to have recognized the fundamental problem of peasant psychology. They began resolving it through local organizations in which the peasant can participate as a member of a group. Reforms in both Egypt and Mexico required that all land reform beneficiaries form a cooperative society among themselves. But Mexico's rural organizations acquired political functions before they became service oriented, and their political role may be seen as an obstacle to their capacity of growth and change." (Temel, 1982)

FIELD SURVEYS

The Mini Survey

A mini-survey of 1,000 interviews was conducted to gauge the relative strength of participation in the cooperative at the village level before and after the new elections under Law No. 122 (1980). All persons interviewed knew about the existence of the agricultural cooperative in the village; three-fourths knew about the new election law. Seventy-nine percent of the respondents mentioned that there was no meeting held for reestablishing the cooperative, a requirement of Law No. 122, but 21% mentioned that the meeting was held by the general assembly. Seventy percent of the respondents knew about members' new election of the board of directors.

One indirect result of the survey was that interest was stimulated among those interviewed in participating in future elections as mandated by the new law. In a few places where the nominations for board positions were already closed, the villagers demanded that they be reopened because they were apparently uninformed about the new election procedure.

The Main Survey

From this abundance of preliminary work, two sets of evaluation criteria were developed for the main survey of Egyptian farm cooperatives: economic and social. The economic criteria served to evaluate cooperatives in terms of member income, employment, management, marketing, credit, mechanization, assets, and liabilities. The social criteria covered general attitudes, participation, cohesion,

solidarity, education, and training. Both criteria focused on questions regarding cooperative membership, voting behavior, crop rotation plans, the delivery of services, and in general, cooperative performance in fulfilling social and economic roles.

The project team also collected general information from board members, supervisors (*mushrifs*), and regional and national leaders of the four types of cooperatives, in addition to interviewing cooperative members at the village level. The survey, conducted in three governorates—Sohag, Beheira, Gharbia—recognized four types of agricultural cooperatives: Credit cooperatives, Agrarian Reform Cooperatives, specialized cooperatives, and land reclamation cooperatives. The number of persons interviewed is summarized in Table 1. Member responses to the survey questions are summarized below.

GENERAL FINDINGS ON COOPERATIVE PERFORMANCE

Characteristics and Attitudes of Egyptian Cooperative Members

Individual cooperative members were interviewed on topics covering personal characteristics, relative wealth, and cooperative involvement. The findings were tabulated by Grossman and Rochin, and a preliminary analysis reveals the following features. The overall mean age of those interviewed fell within the 40–60 years range, encompassing 62.1% of the respondents. Ninety percent were married and slightly over 50% reported they were illiterate; 36% stated an ability to read and write. Only 30% attended high school or beyond. For income, most farmed, and less than 3% said they had a nonfarming occupation. However, there were many who did not answer the question about off-farm employment. The mean size farm is 3.5 feddans, in line with the national average. Relatively few own capital equipment. The average respondent has been a cooperative member for 16 years, but 12% indicate membership of five years or less. About 55% attend meetings regularly while another 20% only participate sometimes. Less than 10% never attend cooperative meetings, but relatively few have voted in the last cooperative elections held since 1980. Approximately 42% said they ran unsuccessfully for membership on the Board of Directors. Another 41% did not think that candidacy applied to them: they said they were generally unqualified or were satisfied with other candidates. Approximately 95% of all members indicated that they have never considered leaving their cooperative: less than 1% said they were unaware of this option.

Multipurpose Credit Cooperatives

A. ***Crop Rotation.*** Results indicated a discrepancy between members' reported participation in decision-making process and their responses concerning the suitability of crop rotation practices on their land, with 85% mentioning participation, yet 80% disagreeing with the present rotation. Perhaps there was misunderstanding about the meaning of "participation." Since most only attend meetings without becoming involved in discussing the plans, education and encouragement toward greater involvement was recom-

Table 1. **Agricultural Cooperative Study, Egypt. The Numbers of Cooperatives, Interviews, and Budget Sheets Collected**

Cooperative		*No. of Cooperatives*	*Members*	*Member of Board of Directors*	*Managers*	*No. of Annual Budget Sheets***
Types	Level					
Multipurpose	Local	24	1,295	157	24	120
	District	4	—	29	4	16
	Central	3	—	32	3	15
	*Federal	1	—	13	1	4
Agrarian Reform	Local	14	505	90	14	70
	District	2	—	20	2	10
	*Federal	0	—	17	0	5
Land Reclamation	Local	7	165	49	7	27
	District	0	—	0	0	4
	*Federal	1	—	0	1	5
Specialized	Local	11	104	58	11	39
	Central	1	—	—	1	10
	*Federal	2***	—	28	2	—
TOTAL		70	2,069	493	70	325

*Federal: on the national level.
**Cover years 1977–1981 inclusive. The budget sheets are based on secondary data about the cooperatives surveyed in the study.
***Potatoes, vegetables, and fruits.

mended. Another discrepancy was found between members' and boards of directors' satisfaction with the existing crop rotation. About 85% of the members reported dissatisfaction with the present rotation, while 94% of board members indicated satisfaction. Concerning the existing system for administering penalties on members who violate the required crop rotation, about 59% agreed and about 35% disagreed with the present system for punishment.

B. ***Cooperative Marketing of Agricultural Crops.*** About 62% of the respondents mentioned receiving bad quality product packaging materials; 88% received their packages late. Existing marketing centers appeared unsuitable for 76% of respondents because of distance and type of roads. Seventy-eight percent mentioned difficulties in their dealings with marketing centers as a result of the complicated procedures. Eighty-five percent of respondents were satisfied with the crop weighing process, while 62% were dissatisfied with crop grading process. Fifty-one percent of member respondents were dissatisfied with incomes derived from marketing crops cooperatively, while 89% of board members were satisfied with cooperative marketing of crops.

C. ***Cooperative Credit and In-Kind Services.*** Ninety-three percent of members faced difficulties in getting loans from sources other than the cooperative or the village bank. Fifty-three percent mentioned that the cooperative is not the only channel for governmental service to farmers, a result which might be interpreted as indicative of farmers' lack of knowledge about the existence of governmental service in the village. Over 84% of respondents were satisfied with the value, quality and timing of loans delivered. Fifty-nine percent indicated that they preferred the cooperative as a source of loans rather than the village bank. Ninety-three percent of respondents mentioned they would face difficulties getting their in-kind services if there was no cooperative in their village. The majority of respondents (89%) were satisfied with seed quantity, 57% were satisfied with seed quality; 66% were satisfied with fertilizer quality; and 46% with fertilizer quantity. The majority of respondents were satisfied with the delivery time for seed, fertlizer and loans. It was observed that a main problem for managers was official procedures and dealings with village banks. They preferred dealing with cooperatives over the village banks.

D. ***Machinery Service.*** The credit cooperatives provide their members with some mechanical services such as plowing, threshing, irrigation, and pest control machines. The results revealed that the majority of respondents were dissatisfied with the machinery service provided by the cooperative.

E. ***Social Services.*** The survey showed that contributions of money, building mosques, construction of roads, and illiteracy programs were the most common social services provided, but only a small percentage of respondents were aware of such services. About 78% of respondents mentioned that the cooperative had no role in developing production techniques and practices. It was observed that most members of boards of directors wanted their cooperative to be involved in developing awareness among members about cooperation. There is, however, a shortage of cooperative training programs since less than one-third of the cooperatives have held such programs.

Agrarian Reform Cooperatives.

A. ***Crop Rotation.*** It is known that the success in planning a suitable crop rotation depends on the involvement of cooperative members in the decision-making process. About 93% of interviewed members reported participating in planning their crop rotation, and 91% agreed with the present rotation. Further, 81% applied the planned rotation, and 61% agreed with the penalty system for violation of the required crop rotation. Thus, the majority of respondents of Agrarian Reform Cooperatives seem satisfied with the present system of planning crop rotation.

B. ***Cooperative Marketing of Members' Crops.*** Over 90% of the members interviewed were dissatisfied with the quality and delivery of packaging materials they got from their cooperative. Concerning the location of marketing centers, about 88% of the interviewees indicated that the location is not convenient; about 92% indicated they had difficulties in their dealings with marketing centers because of the complicated procedures that must be followed. Seventy-eight percent of interviewees were dissatisfied with the product weighing process; 61% with the grading process; while about 54% mentioned that time before receiving crop prices is too long. All in all, about 52% of the members interviewed were dissatisfied with their incomes from marketing their crops cooperatively.

C. ***Cooperative Credit and In-Kind Services.*** About 99% of members interviewed agreed with the importance of the cooperative as a source of loans since they face difficulties in getting loans from other sources. Ninety-one percent of respondents were satisfied with seed quantities and 94% with insecticide quantities, while about 56% mentioned that the quantity of fertilizer is insufficient. Concerning the quality of in-kind services, the results showed that 96, 90, and 92% of the members interviewed were satisfied with seed, fertilizer, and insecticide quality, respectively. About 98% were satisfied with the time of delivery for seeds, 80% for chemical fertilizer, and 84% for insecticides. Thus, it appears that attitudes toward cooperative credit services are generally favorable.

D. ***Machinery Services.*** About 82% of the members interviewed were satisfied with the number of machines in their cooperative, while about 59% were satisfied with the quality and kind of machines available to them. About 64% mentioned that they can get the machines whenever they need them, while 69% indicated dissatisfaction with the estimation of working hours for machines they rent from the cooperative. This result suggests that greater control should be administered by the board of directors over machine services.

E. ***Social Services.*** The cooperative contributes toward the following social activities: building mosques and religious institutes, road construction, illiteracy programs, housing services, medical services, consumption services, diffusion of cooperative information among members, and training programs.

Specialized Cooperatives

A. ***Crop Rotation.*** The majority of the members interviewed participated in the decision-making process in planning crop rotation in their villages, and the present crop rotation was suitable for about 71% of those interviewed. About 95% of the board members interviewed concurred. Although about 93% of the members interviewed violated the required crop rotation, 84% agreed with the importance of administering the present system for the violation of crop rotation.

B. ***Cooperative Marketing of Members' Crops.*** About 69% of members interviewed mentioned that they got packaging material for product marketing whenever they need them and they feel satisfied with their quality. About 77% of interviewees indicated that marketing center locations are convenient. About 73% of these marketing centers are located in the interviewees' villages. About 71% of respondents seem satisfied with cooperative marketing procedures. Seventy percent of respondents were satisfied with the processes of weighing and grading for their crops, but about 73% complained about receiving their crop prices late. About 69% were satified with their income derived from the cooperative while 98% of Board of Director members interviewed were satisfied.

C. ***Cooperative Credit and In-Kind Services.*** Ninety-three percent of the members interviewed mentioned that they would face difficulties getting loans if it were not for the cooperative. About 20% of the managers interviewed stated that the most important problem facing the specialized cooperative was the shortage of capital, and that the monetary position of these cooperatives should be strengthened.

All members interviewed agreed with the importance of the specialized cooperative as a main source for production equipment and facilities. Ten percent of members interviewed mentioned that the following services their cooperative offers play an important role in increasing their income: insecticide service, 41%; fertilizer, 36%; seed, 10%; and feed, 3%. But about 20% of the board members interviewed indicated that the quantity of fertilizer is insufficient, and 7% mentioned there is shortage of feed. These responses are consistent with the opinion of 18% of the managers interviewed. Thus, the suggestion is to increase the quantity of fertilizer and feed, keeping prices low, with control of the delivery system.

D. ***Machinery Services.*** Thirty-four percent of the members interviewed receive machinery services from their cooperatives, and these services are instrumental in increasing their income.

E. ***Social Services.*** Ninety percent of the members receive social services from their cooperative such as building mosques and religious institutes, medical services, electricity projects, and consumer services. About 10% of the board members of the specialized cooperatives indicated the desire for their cooperative to be involved in building schools and youth clubs.

F. ***Educational and Cultural Services.*** About 84% of the members interviewed indicated that they knew about innovations in agriculture from their cooperative. Also, 75% mentioned that they have had chances to read the agricultural bulletins and magazines which come to their cooperative periodically. Meanwhile, about 6% of the managers interviewed recommended that cooperatives be more involved in developing educational programs for their members.

G. ***Human Facilities.*** The number of the employees in most specialized cooperatives seems about right according to 82% of the managers interviewed, although the other 18% thought the cooperatives to have excess capacity in labor. Concerning the process of hiring employees, 66% of the managers interviewed agreed with the present method, and 73% mentioned that they participate in a selection process. One-half suggested the importance of training programs for employees to increase their awareness of cooperative principles, treasury work, and agricultural equipment operation.

About 79% of the managers interviewed wanted to stay with their cooperatives; 7% wanted to have different jobs within the same cooperative. About 90% of the managers mentioned that the majority of the specialized cooperative employees want to stay with their cooperative because they feel secure and most are settled in the same village. As a result, employee transfers are few and infrequent.

H. ***Work Procedures.*** Although all specialized cooperatives surveyed open their doors during official work hours, most of the members interviewed complained about access to the cooperatives' employees during work hours. About 41% of the members did not find anyone responsible to whom they could complain about careless employees. Although 84% knew how to check their accounts, 99% of the respondents felt that the procedures are very complicated.

I. ***Material Facilities.*** Twenty-nine percent of the specialized cooperatives surveyed own their buildings; 71% rent. Most thought the buildings suitable with enough storage. Ninety percent thought the furniture in the cooperatives to be inadequate and in bad condition.

Land Reclamation Cooperatives

A. ***Crop Rotation.*** The results about members' participation in the process of planning crop rotations revealed that only about 39% of the members interviewed participated in the decision-making process, and 56% did not agree with the present rotation. However, all members of the boards of directors agreed with the present crop rotation, since most of them participate actively in planning.

B. ***Cooperative Marketing.*** About 86% of the members interviewed found the quantity of packaging for marketing acceptable, but about 77% were dissatisfied with the package quality.Eighty-five percent of the interviewees indicated that marketing center locations are inconvenient. About 81% were satisfied with the procedures for marketing crops cooperatively, but 45% were dissatisfied with the grading process, and 53% complained of receiving their crop prices late. Seventy-six percent of members were satisfied with income from marketing their crops coop-

eratively; about 87% of the board of directors members interviewed were also satisfied.

C. ***Cooperative Credit and In-Kind Services.*** About 83% of the members interviewed mentioned that they would face difficulties in getting loans if they had no cooperative. About 97% of interviewees were satisfied with the amount of loans they got from the cooperative, and 65% were satisfied with the delivery time of loans.

Three-fourths of the members interviewed were satisfied with the amount and quality of seed, and 93% were satisfied with the delivery time. However, 86% were dissatisfied with the weighting process for seed; it was suggested that this process be supervised by board members. Seventy-one percent of the members interviewed were dissatisfied with the amount of fertilizer, but 90% were satisfied with its quality. Sixty-six percent were satisfied with the delivery time, while 90% mentioned that the packaging was inadequate. Therefore, it is recommended the amount of fertilizer be increased, and more consideration be given to packaging and delivery time.

Sixty-six percent of the interviewees were satisfied with the amount of insecticides; 88% with their quality. Fifty-five percent found the time of delivery unacceptable, and all disagreed with the weighting and distribution processes.

D. ***Machinery Services.*** About 95% of the members interviewed and all of the board members were satisfied with the number and quality of machines available in their cooperatives. All indicated that they can get the machines whenever they need them.

E. ***Social Services.*** About 40% mentioned that the social services offered are insufficient. Benefits include building mosques, religious and educational institutes. About 85% of the members interviewed mentioned the importance of the cooperative as a source for knowing about innovations in agriculture.

STATISTICAL ANALYSIS OF ECONOMIC PERFORMANCE

The main survey sought answers to 227 questions administered to well over 2,500 respondents. Joseph Grossman (1983) developed a statistical procedure for analyzing the massive amount of data collected. With 2,503 usable questionnaires, the data set was reduced to 80 variables on the basis of Pearson-product moment correlation coefficients, cross-tabulations, chi-square analysis and principal components analysis. Factor analysis was then used to estimate an hypothesized performance model and to condense the data into 12 performance variables, or factors. Three way analysis of variance and multiple regression analysis was applied to examine the influence of member age, education level, wealth, length of membership and cooperative type on these performance factors.

Results

Results of this analysis indicate members clearly judged the economic performance of their cooperatives to be deficient. "They believe cooperatives are badly managed, administratively inefficient, performance of boards of directors is poor, credit and inputs provided by cooperatives have a low marginal value and the income received for members' crops marketed by the cooperatives is insufficient. Furthermore, members fail to understand the critical concepts of cooperation and democratic values. Thus, members place minimal value on their membership in the cooperative." (Grossman, 1983).

Additionally, the problem of low income received for crops marketed by the cooperative was empirically linked to poor, inefficient management. Member age emerged from the regression analysis as a clearly significant factor in perceptions towards cooperative performance. The attitudes of the 40–60 year-old group were consistently stronger and generally more negative, expressing greater dissatisfaction with the economic performance of cooperatives than older and younger members.

As member wealth increased (measured by land holding size and number of animals owned), so does the conviction that the cooperatives performed poorly. However, understanding of cooperation and democratic values also improved with increasing wealth, as did value placed on membership in the cooperative.

While member level of education was not a consistently significant factor in this analysis, literate members' views differed from their illiterate counterparts; they felt the boards of directors performed poorly, they placed lower value on cooperative membership, and yet participated more in meetings of the general assembly. Illiterate members utilized services more than their educated peers, yet felt greater dissatisfaction with income received for their crops.

As length of membership in cooperatives increased, participation in meetings of the general assembly decreased as did income received for crops marketed by the cooperatives.

Multipurpose cooperative members were least critical of the economic performance of cooperatives, while specialized members displayed the most negative attitudes of all. Wealth appeared to exert a very strong influence on multipurpose members: dissatisfaction with the economic performance of cooperatives grew with increasing wealth.

POLICY CONSIDERATIONS

Results of the Cooperative Improvement Project suggest dramatic change must transpire if the role and economic performance of agricultural cooperatives is to improve. The general findings and, in particular, the statistical analysis by Grossman (1983) revealed inadequate provision of credit and inputs coupled with lack of alternatives as a major weakness of the cooperative system. If the cooperative system does not improve, then serious attention must be given to expanding private enterprise roles in the input and credit supply system.

Inadequate payment for crops planned and marketed by cooperatives suggests the need to install more efficient cost saving devices in cooperatives or higher crop prices in the market.

Attention must be paid to the large percentage of illiterate members in the development, education and extension programs for cooperative members. The strong willingness

of cooperative members to utilize educational cooperative services suggests an accessible origin for change, and thus a means by which to improve the cooperative systems.

Additional inspection of the cooperative system is necessary in order to pinpoint the exact sources of many of these complex problems. Furthermore, once identified, the support of government as well as cooperative administration, boards of directors, management and membership must be solidified if improvements are to be made.

Recent changes in the election laws regarding cooperative management (*mushrif*) occurred while this project was being conducted. While it is too early to gauge the impact of cooperative member control over the selection of management as opposed to government appointment, there is a definite need to examine the impact of this innovation, especially given the high disregard for management noted in the main survey.

If the cooperative is to be a cohesive unit, its members must have a solid understanding of the tenets of the organization. Lack of understanding of cooperation and democratic values can undermine the entire system. The issue of whether voter apathy can be attributed to (1) lack of understanding of cooperation, (2) disrepect for the system, or (3) the belief that control of the cooperative rests with the government has been beyond the scope of this project. Yet, voter apathy needs to be closely examined in order to find ways to improve member participation in the election process and the performance of the cooperative.

Despite numerous negative implications about cooperatives, derived from the project, it is still apparent that the extensive network of cooperatives plays a unique and critical role in Egyptian agriculture. The supply of inputs and credit for agriculture are based on cooperatives. The crop rotation system is administered by cooperatives as well as the marketing of outputs. Extension and education programs offered by cooperatives reach deep into rural Egypt, offering an organized outlet to facilitate change as technology and priorities develop over time. For now, the final verdict on cooperative performance cannot be made without additional study and evaluation.

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ECONOMIC CONSTRAINTS TO POULTRY PRODUCTION

Few would question the importance of the poultry industry in Egypt: it is capable of highly intensive production on limited land area and can provide the high-quality protein deficient in the diets of so many. The failure of the Egyptian poultry industry to keep up with expanding domestic demand for eggs and white meat raises the question of how government policies currently affect the industry. This project was undertaken to add to the existing meager information base so as to provide data and analysis necessary to assist the Egyptian government in forming policies which would improve the allocation of resources in the poultry subsector. It is believed by many that Egypt has the potential for self-sufficiency in poultry, yet poultry product imports have increased dramatically. Much information, however, is needed before it is known whether poultry self-sufficiency is a realistic goal or even whether significant expansion in the industry is a possibility.

The needs are twofold: to identify constraints to the expansion of the domestic industry and to develop a poultry data collection and market reporting system upon which successful formulation of poultry development policy must rest. Because Mathtech (funded by USAID and under contract with the Egyptian Ministry of Agriculture) has done research in the area of commercial poultry enterprises, this project concentrated on gathering information in three other areas: poultry marketing, the economics and location of village hatcheries, and rural flock demographics.

Marketing Survey

1. To provide the foundation for the development of market stabilization policies.
2. To systemize the collection and analysis of price and quantity data in the urban poultry market.
3. To determine the production, purchasing, and marketing practices of commercial, layer, and broiler producers in the private sector.

Village Hatcheries Survey

1. To identify the population size, characteristics, and spatial distribution pattern of the native hatcheries in Egypt.
2. To observe the seasonality in number of eggs set, fertility, hatchability and chick mortality in the hatcheries.
3. To observe the seasonality of operation and supply of the native hatcheries, especially with respect to regional differences.
4. To identify the channels of possible constraints faced in the marketing of the native hatchery chicks which may lead to production uncertainty.
5. To identify monetary constraints which may limit productivity.
6. To construct profit functions, on the basis of output and cost function information collected, which will allow the determination of the opportunity cost associated with the inability of the hatchery to operate at full capacity or with the use of inferior (i.e., diseased or infertile) eggs.

Rural Flock Survey

1. To establish the population size and distribution pattern of chickens in rural Egypt.
2. To determine factors associated with decreased meat and egg production in the rural flocks.
3. To determine the economically optimal strategy for removing these production constraints in the rural flocks.

For each of the three areas of investigation, separate populations were chosen. For each, a stratified random sample was taken based on production capacity of the operation and geographic location. Data sources used for the determination of sample consisted of the (1) Department of Statistics of the Institute of Agricultural Economics (IAE); (2) Department of Marketing, (IAE); (3) Central Agency of General Mobilization and Statistics, Ministry of Supply (MOS); and (4) various departments of agriculture at the individual governorate level. The use of a stratified random sample increased the precision of the results, minimized costs and efforts of the sample selection, simplified the collection of data, and increased the homogeneity within each stratum.

MARKETING IN THE COMMERCIAL LAYER AND BROILER INDUSTRIES

Samples of the layer and broiler industries covered a period of 12 months from April 1982 to April 1983. Although Mathtech recently conducted a very comprehensive survey of government-owned broiler and layer operations, this survey consisted only of nonhousehold producers within the private sector. Population information, categorized by operation capacity, was provided by the General Agency of Poultry (GAP) within the Department of Agriculture which has a branch within each governorate. From this, a stratified random sample located in 15 governorates for each of the two sectors was selected: in the broiler sector, 75 operations were chosen and 78 in the layer sector. These numbers represent approximately 3% and 15% of their respective industry's populations. Currently, all of the questionnaires (about 180 for each industry) have been completed. The data are being entered into the

computer and will be analyzed initially using descriptive statistics.

Stratified Random Sample of the Broiler Industry

Data available concerning the broiler farms differ greatly according to source. The General Poultry Company (GPC) is generally considered the most accurate source of data on the present-day Egyptian broiler industry. To establish a new broiler or layer farm, a license to produce must be obtained from the GPC. However, once this permit is given, the GPC does not continue to monitor the poultry farms. In fact, the only relationship which the GPC maintains with the farms is the provision of subsidized feed and chicks. Some farms continue to receive their allocation of subsidized goods after having discontinued poultry operations. These farms may sell their permit (for feed and chicks) to other producers who are either short of the commodities or wish to maintain a guaranteed flow of the goods. Or, alternatively, the former poultry producer may utilize the feed in an alternative livestock sector.

Because of this lack of correspondence between GPC licenses and actual producers, a follow-up study in the private sector only was made to determine the location, actual size, and number of continuing operators. Based on the farm capacity data collected, i.e., the number of birds capable of being raised on a particular farm, the sample was stratified by flock size into ten groups from less than 25,000 to greater than 225,000.

Survey results showed that almost all—98% of the 2,630 farms—could be classified as small farms with an annual capacity of less than or equal to 100,000 broilers. Of these, 77% could be considered very small with less than 25,000 broilers raised per year. Only 1.3% was of moderate capacity (101,000—200,000 broilers per annum) and only 0.3% had a capacity of more than 200,000 broilers per year. Using these results, the private-broiler population was stratified by size and a random sample of the population selected.

Results of the initial survey of the commercial, private layer industry in Egypt showed that 64% of the 540 could be considered small in layer capacity (300–3,000 layers), 34% as moderate to large (3,001–10,000), and the remainder (2%) as very small (less than 300). A significant percentage (28%) of the 182 moderate scale farms were located in the Giza Governorate, in close proximity to the large Cairo market. Also, Giza was the site of 39% of the 33 largest private layer operations in Egypt. Of the small to very small operators (1000 layers) comprising nearly two-thirds of the total farms in this sector, one-half were located in Al Minea Governorate.

Village Hatcheries

The village hatchery survey was also conducted from April 1982 through April 1983. The completed questionnaires are currently being translated into English. As with the marketing questionnaires, they will be taken to the University of California at Davis and entered on the computer for initial descriptive data analysis.

Eighty (from a population of 775) villages hatcheries from nine governorates were selected by random sample. Enumerators visited these hatcheries monthly for a period of 12 months.

Rural Flock Survey

A poultry census to use as a basis for determining the population composition from which a rural flock survey sample might be drawn has not been taken since 1961. An attempt to update the information using regression analysis to link the 1961 rural flock population with cropping area, cultivated area, cereal area, agricultural population density, and rural population was not successful. The rural flock sample, therefore, was based on stratification of the country by agricultural zones: East Delta, Middle Delta, West Delta (all in Lower Egypt), Middle Egypt and Upper Egypt. Fifteen districts were selected from the five zones according to the estimated poultry population (based on the 1961 census) of the respective zones.

Once the governorates and districts were selected, suitable villages believed to be representative of the district were selected, each with an enumerator. In each of the villages, the leader of the cooperative was identified through whom 70 households were selected which he felt would be willing to participate in the study and provide accurate information. With a suitable introduction from the elder to the individual participants, the enumerators were greatly aided in acquiring accurate information. The bias introduced by such a method was thought to be small compared to the wealth of information obtainable by the systematic selection process.

All of the data have been collected, and the information has been translated into English. The data are at the University of California, Davis, being coded for the computer, and initial descriptive statistics are being computed. Fifteen districts are to be analyzed for a period of 12 months each (November 1981–October 1982), making a total of 180 district-months.

Although much of the data in the three main surveys gathered are still in process and analysis is far from complete, certain preliminary results from other information collected can be summarized.

SURVEY OF IMPORT OF CHICKS

Imported chicks may be categorized into four groups: broiler, layer, broiler-breeder and layer-breeder. Between 1977 and 1980 the total number of imported chicks quadrupled from 2.2 million to about 9 million with a peak occurring at 14.1 million in 1979. Most imported chicks are broilers—from 1977–79, 97% were broilers; 92% in 1980. These figures, 13.9 million broiler chicks in 1979 and 8.3 million in 1980, contrast sharply with the 2 million imported in 1977–78.

The 1980 value (2.6 million LE) of chick imports was down only slightly from 2.8 LE million spent in 1979. This slight decrease, in spite of the major decrease in import numbers, was due to substantial increases in the prices (e.g., a 50% increase in the broiler chick price). The total value of imported chicks increased from 276,800 LE in 1977 to nearly 2.6 million LE by 1980, almost a tenfold increase.

As with the quantity of chicks imported, broilers represented the major expenditure—89% of imported chick value in 1979; 75% in 1980. Layers and breeding chicks represented the second largest proportion—9.5% of the total for 1977–80. Layer chicks were in third position with 6 to 9% of import value during the same period.

From 1977–1980, there was a constant price increase for broiler chicks (0.11 LE to 0.24 LE). The price of layer chicks reached a maximum in 1979 (0.71 LE) fell to 0.61 LE in 1980, still 35% higher than the 1977 price (0.45 LE). The price paid for broiler chicks has been relatively erratic. There was approximately a 25% drop in price, from 1977 to 1978 (1.07 LE to 0.82 LE); the price rose again in 1979 and remained relatively constant in 1980 (1.36 LE and 1.40, respectively). The price paid for layer-breeder chicks increased dramatically from 1977 to 1979 with the 1978 price nearly double that of 1977 (1.37 LE and 0.79 LE). Prices continued to increase in 1978, reaching 1.93 LE in 1979. (No purchases were reported in 1980.)

Geographical Distribution of Chicks Imports

The geographic distribution of imports of broiler chicks was found to vary widely from year to year. Greece was dominant in 1977 when it supplied Egypt with about 88% of its imported chicks. Israel and the Netherlands predominated in 1980, with Israel supplying about 46% and the Netherlands 38%.

Imports of layer chicks were concentrated in seven countries during the 1977–1980 period, but the relative importance of each country differed from year to year. In 1977, the United Kingdom and the Netherlands were the only exporters of layer chicks to Egypt with approximately equal shares with imports from the Netherlands fluctuating sharply during this period—reaching a maximum of about 92% in 1978, falling to only 11.5% the following year.

The flow of import trade of breeding-broiler chicks is very different than that of the layer industry. The Netherlands was the sole exporter to Egypt of broiler-breeding chicks in 1977, but its share fell dramatically to 2.5% in 1979. Meanwhile, West Germany's share increased from 5.3% in 1979 to 62.2% in 1980.

Seasonal Pattern of Price Fluctuations for the Imported Chicks

Available data indicate that prices of imported chicks have a seasonal pattern for both broilers and layers, but no seasonal pattern was observed for import prices of breeding chicks given irregular supplies. Layer chick prices fluctuated more sharply than broiler chick prices, reaching a maximum of 1.01 LE in March, with a seasonal fluctuation of 162.7%. Broiler chicks prices reached a maximum value of 0.24 LE during September with a seasonal fluctuation of 126.4%. Layer chick prices were at a low of 0.50 LE during May with a seasonal fluctuation of 80%, while broiler chick prices reached a minimum value of 0.14 LE during January with a seasonal fluctuation of 75%.

Import of Feed Concentrates

It is well known that Egypt faces a shortage of feed and concentrates as a result of limited resources (mainly cultivated land) and competition for these resources between food and feed production. Thus, expansion of the poultry industry appears to be heavily dependent upon the availability of feed, primarily via imports. Current sources of feed differ according to price, credit and commercial facilities offered by the exporter. During 1981 the value of feed imports for poultry amounted to an estimated 32.4 million LE.

The major imported feed commodity purchased for poultry consumption during 1981 was soybean cake. Fifty-three thousand metric tons were purchased at a cost of more than 14 million LE or 43% of the total imported poultry feed expenditure (32 million) in 1981. Major exporting nations of this commodity to Egypt were the United Kingdom with 55% of the 52.75 metric ton total and Israel with 34%. There were major differences in prices charged for soybean cake. In fact, Israel charged a rate approximately three-fourths that of other exporters, 231 LE per metric ton, contrasted with Italy at 305 LE; France, 300 LE; United States, 296 LE; and the United Kingdom, 281 LE.

The second most important feed ingredient imported by the Egyptian poultry industry in 1981 was fish powder. The 23,072 metric tons imported amounted to 26% of the total poultry feed import for that year. Imports from the Netherlands, Denmark, Norway and the United Kingdom accounted for more than one-half of the total. The monetary value of this import was approximately 10.3 million LE, or nearly one-third of the import poultry feed expenditure. As with soybean cake, the price of fish powder varied greatly according to source, with Israel again offering the lowest price (76.40 LE/m. ton), far below that offered by other nations whose prices ranged from 416.42 LE (Italy) to 552.72 LE (the Netherlands). Although the price offered by Israel was attractive, it was only able to supply Egypt with less than 10% of its fish powder requirements.

The third major poultry feed ingredient imported by Egypt (according to value) was feed concentrates, accounting for almost 13% of the total poultry feed import expenditures in 1981. The major exporting nation of this commodity to Egypt was Israel which provided 21% of the supply. Denmark provided 18%; Italy, 17%; France, 14%; the Netherlands, 13%; and West Germany, 9%.

The fourth ingredient comprising a significant amount of the poultry feed import expenditure was feed additives, with a value of about 9% of the total at 3.0 million LE in 1981. Forty-four percent of this value was provided by France (1.3 million LE), while Italy (20%), West Germany (11%), and the United Kingdom (11%) brought the combined contribution of these nations to nearly nine-tenths of that purchased by Egypt. The feed additives component is by far the most diverse with respect to its composition, and comparisons of the price offered by the various exporting nations are difficult. However, variations in price depend in an important way on transport distances and on quality of the additives.

AN ECONOMIC EVALUATION OF NORTHERN LAKES DEVELOPMENT

The Lakes Development Project was designed to prepare research reports leading to a cost/benefit analysis of alternatives for the development of the northern Nile Delta lakes. The primary concern was to determine where, when, how, and to what extent the lake areas could be profitably reclaimed for agricultural uses. The study therefore involved investigations of the topography, history, and fishing yields of the lakes; the water availability for fisheries or agricultural development; the successes and failures in past reclamation efforts; and a myriad of other factors entering into the determination of their optimal use.

The importance of this issue lies in Egypt's need to make maximum use of all potentially arable land. The large shallow northern lakes occupy approximately 325,000 feddans, equivalent in area to about 5% of the nation's cultivable land.

Project research staff observing workers at El Zawia Government Fish Farm as they transfer fish fingerlings from a nursery pond to the 500 feddan rearing pond. The fish ponds are excavated from reclaimed marshland south of Lake Burullus, which is of little value for agriculture but suitable for rearing fish (carp, mullet, and tilapia) for urban markets.

Photo: Turid Reid

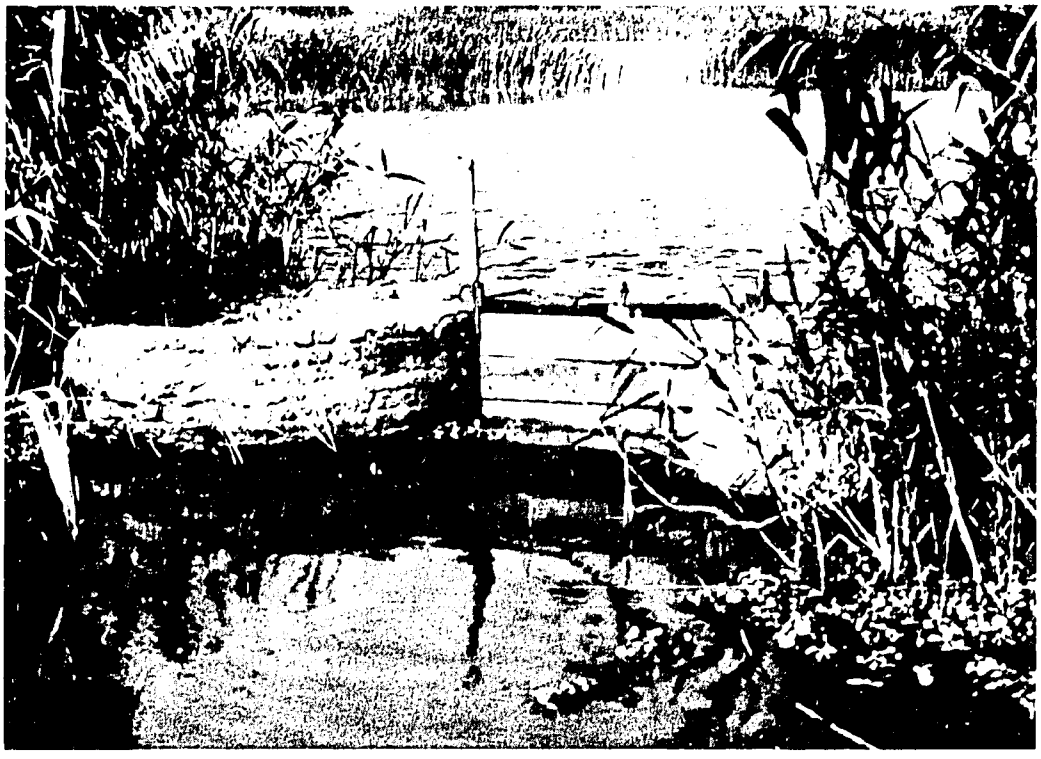
ACCOMPLISHMENTS

Initial studies involved a review of the lakes' history, water quality, the evolution of the fishing industry, and past reclamation experiences. Original estimates were made of the past and present lake areas based on an analysis of topographical maps and Landsat satellite images. Potential developments affecting the fisheries were investigated and attempts made to explain the changes in the species composition in the lakes' fish catches following the construction of the Aswan High Dam (Reid and Rowntree, 1982).

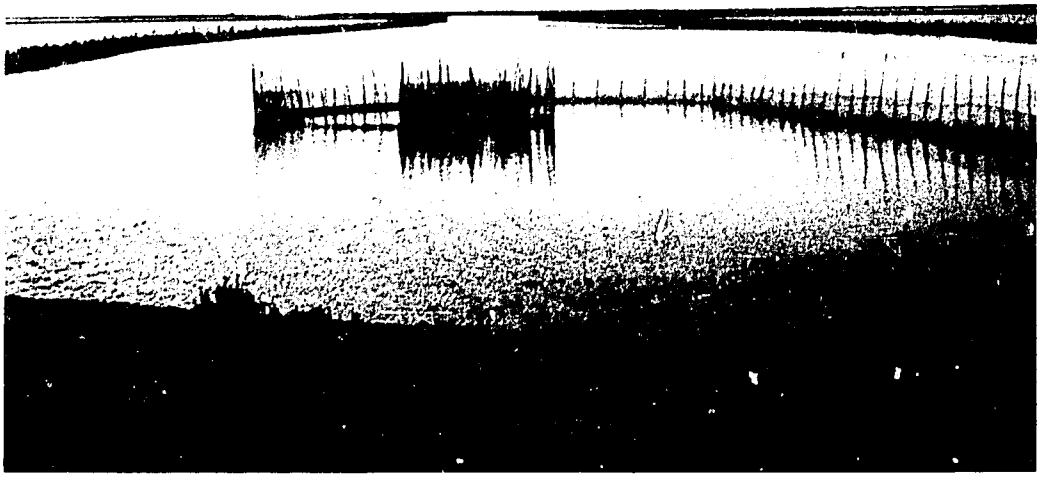
The current (1981) lake areas available to open water fishermen were calculated. Lake Manzala has an open water lake area of 166,480 feddans; Lake Burulus has 114,520 feddans; Lake Edku, 27,470 feddans and Lake Maryut, 16,240 feddans. The study concluded that the fished area of these lakes had been reduced in area by about 26% between 1953 and 1981. Public and private land reclamation efforts were primarily responsible.

Comparisons were made between fishing and agricultural production, income generation, and employment to compare alternative uses of the lake areas either as fisheries, or as cultivated reclaimed land. The output, income, and employment generated by the fisheries are not only important in their own right, but also because they represent part of the opportunity costs of reclaiming the land for agriculture.

While agriculture is commonly superior to fishing in terms of income and employment generated on a per feddan basis, this does not apply to the specific use of these lakes. First, the net advantage to agriculture is usually so small that it does not justify the investment costs of reclamation. Second, agricultural yields on reclaimed lake areas have proven to be significantly lower than yields on the old lands, which are often used as a basis for comparison with yields from fisheries. Third, even selective reclamation of the lake areas has problems, since sacrifice of parts of the lakes may have detrimental impacts on aspects of the lake environment vital to sustaining productive fisheries, such as water flow, spawning grounds, and fingerling nursery areas. Fourth, while the fisheries thrive on agricultural and urban drainage waters, there appears to be inadequate supplies of sweet water to accomplish the leaching necessary for reclamation processes, and later on, for irrigation of the reclaimed land. Thus there are severe constraints on further profitable reclamation from these lakes.



The *Hosha* method of fishing in lake margins involves sectioning off an area by a sluice gate, illustrated here, and pumping out the water to leave behind the stranded fish. This is a practice that is officially discouraged since it fails to discriminate between mature and immature fish and destroys potential future stock. *Photo: John Rowntree*



The *Taweeta* fishing technique, common in the Northern Lakes, is an effective but illegal method used in waters about one meter deep. This method relies on fish being driven deeper and deeper into a net arranged in a spiral shape. The common use of illegal fishing methods raises the issue of the need for management of these fisheries if they are to reach their potential yields. *Photo: Nadir Hashem*

A study on fish yields in the northern Nile Delta lakes (Rowntree, Reid, and Abou-Auf, 1983) estimates the actual 1982 fish yields from the four northern lakes. Historical data on fish yields, seasonal yield patterns, species composition, and landing sites have been analyzed, and fish yields for 1982 estimated from the data of a survey conducted with boat captains in November–December 1982. The fish yields projected from the survey data were 91% greater than the expected 1982 historical projection. A review of the data collection and reporting methods used by the various Egyptian government agencies involved in managing and monitoring the lakes suggests that they are inadequate for policy and management requirements. Recommendations were made for improving the data base to meet these needs.

The importance of good fisheries management practices for attaining high productivity was evident. While the fisheries on lakes Manzala and Maryut are the most productive, largely due to their natural features and the influx of nutrient rich wastewater from Cairo and Alexandria respectively, the fisheries on all lakes suffer from low yields as a result of inadequate management. One of the most important developments has been the spread of "*hosha*" fishing (Reid, Rowntree, El Kholei and Abou-Auf, 1983) which occurred rapidly and widely in Lakes Manzala and Burullus during the periods of hostility with Israel between 1967 and 1973 when traditional controls broke down. *Hosha* is a method of fish capture which involves enclosing an area of lakeshore by dykes, periodically pumping out the water from the enclosure and harvesting the fish by nets at the pump intake. The use of this fishing method, technically illegal, holds great promise for the fisheries as well as presenting a great challenge.

Potentially, unchecked expansion of *hosha* could increase the fishing intensity on the lakes to the point of depleting the fish stocks and destroying the fisheries. It has been argued by those who oppose the legalization of *hosha* that because *hosha* are constructed along the shoreline, the shallow, vegetated, protected areas favored as nursery grounds by fingerlings are eliminated. Since the capture method does not discriminate between different size classes, the fingerlings end up being sold for animal feed instead of maturing for human consumption.

There are great possibilities, however, for controlling and managing *hosha* to Egypt's advantage. The Ministry of Agriculture has already recognized some of this promise, for it has begun to license some operators on an experimental basis. Financial and technical aid are offered to these *hosha* operators if they will switch from a pure capture to a modified *hosha*-fish farm technique in which they hold and feed the fish.

Hosha is often more than a fishing technique; in many cases it is a prelude to private reclamation efforts on the edges of the lakes. It is important therefore that extensive study of *hosha* and its potential impact on the fisheries be undertaken to establish a clear policy on its use, and to determine how best it should be managed.

Land such as this can be reclaimed from the shallow lakes and developed for agriculture. The land is where Lake Edku used to be; its level has been raised some five feet above the former water line, an expense justified by the high prices received for truck crops.

Photo: Eric Gustafson

In addition to a purely economic analysis, a study of the sociology of fishing communities was conducted to explore the social effects of investing in fisheries development versus cultivation on reclaimed land. The data from extensive surveys of two communities conducted to answer these questions is currently being analyzed in Cairo.

An additional study, still in progress, is examining the feasibility of development of fish culture in the immediate vicinity of these lakes.

Past reclamation experiences from lands that were formerly lake bed or lake-associated marshland were reviewed and surveys of farmers on public land reclamation projects were undertaken to explore the reasons for the success or failure of these schemes. This work is continuing and will result in recommendations to guide any further reclamation plans.

There remains much unfinished work on the research agenda of this project, as well as on particular analyses of survey data already collected. When survey analysis is complete, all the elements should then be available for integration into a general social benefit-cost framework, which could be valuable for guiding policy makers in planning and investment decisions that will lead to the optimal development of the northern Egyptian lakes. It is clear from the work already undertaken and completed that the northern lakes are much more productive of fish, employment, and incomes than has been suggested by the historical data. Public and private directions are currently leading towards sacrifice of the northern lakes fisheries at great cost to Egypt. There are strong indications that protection and further development of the fisheries' potentials in the northern lakes will be highly socially profitable for Egypt. However, further research is necessary to explore the problems of fisheries development, and hence provide policy guidelines.

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ECONOMIC EVALUATION OF POSTHARVEST LOSSES

This project is closely related to ADS horticulture research, and provides an economic evaluation of postharvest losses for selected commodities. The aim was to explore the cost effectiveness of alternative improvements in handling, packaging, processing, distribution and marketing, as well as to investigate the feasibility of different market coordination schemes.

ACCOMPLISHMENTS

ESTIMATES OF MARKETING LOSSES

The horticultural Postharvest Project estimated losses according to technical standards utilizing five categories of quality. Losses were estimated by separate samples at each level of the marketing system, but since some products classified as unmarketable still had a value, their study did not estimate economic losses.

This project has used two approaches to study economic losses in the marketing system. The first involved administering a questionnaire at the farm, wholesale, and retail levels, where respondents were asked questions concerning losses, damaged products with no value which were thrown away, and damaged products sold at reduced prices. The second approach involved a case study which followed a sample of each commodity (potatoes, tomatoes, and grapes) from the grower to the retailer. The impact of various containers on average losses was also considered.

The survey results revealed significant economic losses in the marketing channels, but these were lower than losses based only on technical standards.

Potatoes: In a survey of four villages, losses of potatoes at the farm level averaged 5.2%. Average physical losses (no value) at the wholesale and retail levels were 2.2% and 1.4%, respectively. Damaged potatoes sold at reduced prices averaged 1.5% at an average discount of 38% at the wholesale level, and 4.4% at an average discount of 50.2% at the retail level. Economic losses for potatoes in this sample averaged 5.2% at the farm level, 2.8% at the wholesale level and 3.6% at the retail level.

Tomatoes: Physical losses of tomatoes at the farm level averaged 10.8% in the sample villages. Average physical losses (no value) at the wholesale and retail levels were 5.2% and 11.6%, respectively. Damaged tomatoes sold at reduced prices averaged 16.8% at an average discount of 36.8% at the wholesale level, and 3.9% at an average discount of 35.5% at the retail level. Economic losses for tomatoes averaged 10.8% at the farm level, 11.4% at the wholesale level and 13.0% at the retail level.

Grapes: Physical losses of grapes for the sample averaged 4.5% at the farm level. There were negligible physical losses (no value) at the wholesale level and an average of 7.4% at the retail level. Damaged grapes sold at reduced prices averaged 7.0% with an average discount of 31.9% at the wholesale level, and 6.3% at an average discount of 41.8% at the retail level. Thus, economic losses for grapes averaged 4.5% at the farm level, 2.5% at the wholesale level and 10% at the retail level.

While the survey provides a measure of economic losses at various levels in the marketing channel for each commodity, it probably overlooks some losses and thus understates total losses. The case studies provide a measure of total losses by following a given lot of product from the farm through the retail level. Members of the horticultural team who accompanied the economics team in the case study included Dr. Sharara (potatoes), Mr. Hassan Ahmed (tomatoes), and Dr. Kamla (grapes).

The case study found a total loss in the marketing channel of 17.6% for potatoes, 43.2% for tomatoes and 28.0% for grapes. Losses by level for each product are shown in Table 1.

Case studies of the impact of sorting and containers on marketing losses were conducted for each of the three commodities.

Potatoes: Three sizes of sack—25, 50, and 75 kilograms—are commonly used for potatoes. Losses in the marketing channel tend to be inversely related to package size: Losses for the 25 kg sack were 21.3%, decreasing to 17.5% for 50 kg sacks and 16.3% for 75 kg sacks. Based on a price of LE 108.50 per ton the value of the losses are LE 23.11, LE 18.99 and LE 17.68 respectively.

Tomatoes: The relationships between four different containers and average losses both with and without sorting at the farm level were investigated. Average losses between the farm and retail level without sorting ranged from 34.1% for green plastic boxes (25 kg) to 28.2% for palm rib crates lined with perforated carton (Table 2). However, examination of losses which occur when the tomatoes are sorted at the farm indicate that much of the variation in losses for unsorted fruit may be due to quality differences.

Sorting at the farm level reduces marketing losses by removing unmarketable fruit before shipping. While this offers potential cost savings in transportation, it is not practiced because the pricing system does not adequately discriminate between differing quality levels.

Grapes: Most grapes are packaged and shipped in either carton boxes or palm rib crates. For Banati grapes, losses were 4.28% in the carton box and 17.85% in palm rib crates. While the carton box reduces losses, its higher cost (45 versus 15 piasters) may discourage its use. Under 1982 price conditions, the value of the grapes saved by use of a carton box compared to palm rib crates was 17

Table 2. **Marketing Losses for Tomatoes Related to Container Type, With and Without Farm Sorting**

Container	*Not Sorted*	*Sorted*	*Costs of Package and Transportation*
	—Percent Marketable—		
Palm Rib Crates	70.6	81.1	LE 13.34
Lined Palm Rib Crates	71.8	81.3	17.50
Blue Plastic Boxes (20 kg)	71.6	82.5	12.00
Green Plastic Boxes (25 kg)	65.9	85.1	10.25

piasters, but this was at a cost of 30 piasters. Widespread use of carton boxes will require higher prices for the improved quality observed.

Table 1. **A Summary of Losses Occurring in the Marketing Channel by Level and Commodity for the Case Study**

Level	*Percentage Loss of Commodity*		
	Potatoes	Tomatoes	Grapes
Farm	11.89	8.96	15.10
Wholesale	1.47	17.89	6.90
Retail	4.18	16.30	6.00
Total	17.54	43.15	28.0

POTATO STORAGE PRACTICES

This study examined storage practices and experience with both home (*nowlat*) and refrigerated storage of summer crop potatoes in a sample covering the important potato production districts. The 164 producers included in the sample spanned a wide range of farm sizes and levels of potato production.

A total of 143 respondents (87.2% of the sample) indicated that they stored summer potatoes to use as seed for their nili crop. Just over 61% of these same respondents also stored summer potatoes for sale on the local market to take advantage of price movements. Four respondents who did not store seed potates did store potatoes for the local market. A total of 97 (66.4%) respondents stored some of their crop in home *nowlat* storage, 52 (35.6%) utilized refrigerated storage, and 24 (16.4%) used *nowlat* storage located in the village. The respondents who stored the largest amounts of potatoes tended to use a combination of *nowlat* and refrigerated storage. Respondents reported that they stored 54.8% of their summer potato crop, and of this amount 34.7% was stored for seeds and 65.3% for sale on the local market.

Respondents reported that the potatoes they stored were sold at the farm gate (17.6%), at a village market (15.3%), at a wholesale market (55.8%), or through a middleman or broker (11.8%). Those respondents with small quantities tended to sell at the farm gate or village market and the producers with large quantities tended to use middlemen or brokers.

Length of storage of potatoes for the local market varied from 1.5 to 4 months with 26.3% of the respondents storing 48.4% of the potatoes for 1.5 to 2.5 months, 41.4% of the respondents storing 36.9% of the potatoes for three months, and 32.3% of the respondents storing 14.7% of the potatoes for 4 months. Respondents reported price increases for stored potatoes ranging from LE 15 to LE 130 per ton with an average of LE 50.09 per ton. Average price increases during the storage period were: 1.5 to 2 months, LE 47.92; 2.5 to 3 months, LE 65.41; and 4 months, LE 32.08. The price pattern observed, with prices decreasing from 3 to 4 months, is probably explained by both supply-demand relationships and decreases in quality during storage.

The capacity of home *nowlat* storage facilities ranged from 2 to 150 tons with an average of 13.5 tons. Reported construction costs averaged LE 24.86 per ton of capacity. Storage costs ranged from LE 2 to LE 10 per ton with an average of LE 5.58 per ton. Costs remain fairly constant regardless of length of storage, and there are no economies of size for home *nowlat* storage. The capacity of village *nowlat* storage ranged from 3 to 250 tons with an average of 32.2 tons. Average construction costs were LE 24.59 per ton. Storage costs ranged from LE 2.5 to LE 9 per ton with an average of LE 4.10 per ton. Costs of storage did not increase with length of storage, and there are no economies of size.

Costs of storing potatoes in refrigerated storage ranged from LE 18 to LE 45 per ton with an average of LE 28.17 per ton. Transportation costs to move potatoes to refrigerated storage averaged LE 2.95 per ton and did not appear to vary with distance. Refrigerated storage costs did vary with length of storage. They averaged LE 23.33 for 3 months and LE 33.10 for 4 months.

Respondents listed sales prices of stored potatoes by end use. The prices of *nowlat* stored potatoes sold for seed ranged from LE 90 to LE 200 per ton with an average of LE 148.16 per ton. The prices of *nowlat* stored potatoes sold for local consumption ranged from LE 100 to LE 140 with an average of LE 116.37 per ton. Refrigerated

potatoes were not sold for local consumption. Prices of refrigerated potatoes sold for seed ranged from LE 130 to LE 210 with an average of LE 167.87 per ton.

There is a significant difference in storage waste between *nowlat* and refrigerated storage. Average waste in *nowlat* storage increased from 8.4% for 2 months storage to 9.4% for 3 months to 12.6% for 4 months storage. Average waste in refrigerated storage increased from 1.4% for 3 months to 2.3% for 4 months storage.

Losses during the storage period are significantly lower for refrigerated than for *nowlat* storage but costs are much higher. Many producers find refrigerated storage difficult to justify on an economic basis when only waste and storage costs are considered. Under typical conditions, the price of potatoes would have to be very high to justify the extra expenditure for refrigerated storage. However, if there are price differentials due to quality differences, as survey results indicate, then refrigerated storage can be justified. Seed potatoes stored in refrigerated storage were priced an average LE 19.71 per ton higher than seed potatoes stored in *nowlat*. Using average costs and loss experience for 3 months storage reveals that returns would be LE 10.70 per ton greater in refrigerated storage than *nowlat* storage. The examples utilized indicate that there may be economic advantages from expansion of refrigerated storage facilities but that these advantages depend on the loss experience of individual producers and price movements during the storage period. Further work on quality and price differentials by type of storage by production district would be helpful in formulating plans and recommendations.

GRAPE STORAGE

Two varieties of grapes, 'Banati' and 'Romi', were stored for one and three months to investigate storage losses, storage costs, and return from storage. The results of this study summarized below reveal that refrigerated grape storage is both technically and economically feasible.

Losses of 'Banati' grapes increased from 2.5% after one month of storage to 18% for three months storage. Losses of 'Romi' grapes increased from 1.3% after one month of storage to 23.0% after three months of refrigerated storage.

Farm level prices of 'Banati' grapes during the picking season averaged 25 piasters per kg. These prices increased to 85 piasters per kg after one month storage and further to 125 piasters per kg after three months storage. Average farm level prices of 'Romi' grapes were 19 piasters per kg during the picking season. These prices increased to 85 piasters per kg after one month of refrigerated storage and further to 100 piasters per kg after three months.

After subtracting the value of losses and storage costs, net revenues from storing 'Banati' grapes in refrigerated storage were 12.3 piasters and 33.8 piasters per kg for one and three months, respectively. Returns from refrigerated storage of 'Romi' grapes were 24.9 piasters and 20.2 piasters per kg for one and three months, respectively.

A test of grape storage on the vines (delayed picking) for a period of three months was performed with some farmers from Minia. Losses were quite high, 45%, but the price increase which occurred did provide a net return. Researchers, however, believe that grape storage on vines has very limited commercial application because of both losses and decreased quality.

Urban vegetable markets provide opportunity for further deterioration in product quality. The project on Evaluation of Postharvest Losses has examined the cost effectiveness of alternative improvements in market practices.

Photo: Eric Gustafson

MARKETING CHANNELS AND COSTS

A village survey indicates that there is significant variation in market outlets utilized by producers. The variation by commodity is illustrated by data in Table 3.

A breakdown of the consumer pound shows that the farmer's share varied from 42% for potatoes to 48% for grapes (Table 4). The wholesalers' share varied from 16.1% for tomatoes to 17.4% for grapes, while the retailers' share varied from 34.6% for grapes to 40.9% for potatoes. Shares at the various levels do not seem to be related to perishability, but shares at the wholesale level do vary with total value. Shares and value do not appear to be related at either the farm or retail level.

PRICE-QUALITY RELATIONSHIPS AT ROD EL-FARAG AND EL-NOZHA MARKETS

This statistical study was restricted to grapes, potatoes and tomatoes for El-Nozha market. It utilized monthly data for 1972–1981 and weekly data (1979–81) for Rod El-Farag, using ordinary least squares methods (OLS) for relating prices to quantities sold and certain shift variables. Several linear functions were fitted for each product. The results computed were reasonably similar. Each indicated a negative price-quantity function with an upward price trend during the 10-year period studied.

The price-quantity function moves upward over time for all three products and also shifts from month to month. The monthly shift for grapes is a substantial and fairly steady decline during the main marketing season, June–September. The price-quantity function for potatoes is about LE 12 per ton below the annual average during the first six months of the year. Its level increases steadily to a premium of LE 30 in November and drops sharply during the next two months. The pattern of monthly shifts for tomatoes is rather irregular. When equations are fitted for shorter time periods, say four or five years, the shifts take on a more systematic pattern.

HOUSEHOLD CASE STUDY

A survey of household purchasing practice, prices paid, and losses for potatoes, tomatoes and grapes was administered to 40 households in Cairo and 70 households in Alexandria. The sample was not random, and thus the results cannot be generalized. The results do, however, provide an indication of losses occurring and of factors which may be related to losses at the household level.

Survey results indicate that losses ranging from 10% to 20% can occur when products are stored temporarily in the household prior to consumption. Household losses may relate to household storage practice, but they may also be due to marketing and pricing practices. It appears, as one might expect, that product quality is adjusted to stay within the administered price structure when market prices exceed administered prices. Survey responses indicate that households which purchased products at administered prices experienced higher losses than those that purchased at higher than administered prices.

This case study emphasizes the importance of considering losses at the household level when calculating losses in the marketing channel. It also illustrates some of the inefficiencies which can be introduced into a marketing system by administered prices. Educational programs directed toward reducing household losses may be worthwhile.

Table 3. **Percentage Distribution of Market Outlets Utilized by Potato, Tomato and Grape Producers in Sample Villages**

Market Outlet	*Potatoes*	*Tomatoes*	*Grapes*
		—Percent—	
Farm Level	10.1	47.7	73.2
Village Market	–	–	–
Governorate Market	1.9	1.3	8.8
Wholesale Market	32.5	50.0	18.0
Export Market	55.5	1.0	–
Total	100.0	100.0	100.0

TOMATO PROCESSING

A study of the tomato processing industry found a number of problems related to administered prices, product distribution, processing costs, and quality. There are two public sector food processing companies, Kaha and Edfina, which produce tomato sauce. During the period 1977–1980, tomato sauce accounted for an average of 16.5% of their total production. Private sector companies have not processed tomatoes since 1977.

Table 4. **Shares of the Consumer Pound Going to Farmers, Wholesalers, and Retailers for Potatoes, Tomotoes, and Grapes**

	Potatoes		*Tomatoes*		*Grapes*	
	LE/Ton	*Percent*	*LE/Ton*	*Percent*	*LE/Ton*	*Percent*
Farmer	76.24	42.12	79.10	47.37	205.07	47.99
Wholesaler	30.77	17.00	26.90	16.11	74.27	17.38
Retailer	74.00	40.88	61.00	36.52	148.00	34.63
Retail Price	181.01	100.00	167.00	100.00	427.84	100.00

Administered prices for tomato sauce restrict the price which firms are willing to pay for fresh tomatoes. This leads to problems of raw product availability and quality. During the three-year period 1979–1981, the average price paid for processing tomatoes was LE 49 per ton. At the same time, the average price in the Rod El Farag market, one of the sources of processing tomatoes, was LE 94.90 per ton. The companies complain about shortages of raw product, operate at about 53% of capacity and have only worked 75 days per year. This low level of plant utilization results in high average fixed costs per unit processed. Raw product quality also has an adverse impact on costs. The solid soluble content of tomatoes processed has averaged 4.5 to 5% while international standards are in the 7 to 8% range.

The public sector companies have also experienced distribution problems and, as a result, have accumulated inventories which average 35% of production.

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AN EVALUATION OF BIOGAS TECHNOLOGY

Agricultural crop residues are currently being used in rural communities either for feeding livestock or for burning in inefficient stoves. An estimated 13.6 × 10^6 tons of crop residues are currently used for cooking and heating, a large portion of which (estimated at 9 × 10^6 tons) could be saved for animal feed if alternative fuel sources could be used. The shortage of animal protein for human consumption, an important problem in the Egyptian agricultural sector, could be alleviated by increased livestock production resulting from animal feed made available by the introduction of biogas technology.

Animal wastes, like crop wastes, perform an important function as energy sources in rural communities. About one-third of the animal dung produced is dried and burned for cooking and heating. In 1975 about 10% of the nation's energy needed for cooking and heating was provided by animal wastes. The remaining dung is added to the soil as fertilizer. Burning these waste materials thus withdraws important nutrients from the production system and represents a loss of potential organic fertilizer which might instead be used to increase soil fertility.

The process of biogas generation from crop residues, animal droppings and human habitation wastes has attracted the interest of scientists worldwide because of the numerous benefits realized from it: it provides a clean and convenient fuel for cooking; manure remaining after obtaining the biogas is of higher quality, richer in nitrogen and carrying fewer pathogens and parasites as compared with the traditionally prepared manures; it conserves alternative fuels, e.g. kerosene; crop stalks and straw which are otherwise burned as fuel are saved for use as fodder and for silage. Rough estimates in pilot studies suggest that the installation of biogas digesters in Egyption farming could:

1. save about 9.3 × 10^6 tons of crop residues currently burned as fuel which could then be used to increase animal production by over 100%;
2. provide a quality heating and cooking fuel which is renewable and which would triple the current production of energy;
3. provide a use for other wastes such as bird droppings and human wastes—thus reducing health hazards; and
4. double the amount of plant nutrients and organic manure returned to the soil.

The main objective of the Biogas Technology (BGT) Project has been to conduct an in-depth study of the feasibility and impact of widespread adoption of BGT in Egyptian farming. The project has integrated data from on-going lab work and field experiments with digesters with an extensive survey of sources and uses of energy in Egyptian farms and households. The expected end product was assessment of physical impacts on the farming system, the costs and benefits to Egypt, the distribution of impacts, and assessment of the prospects for adoption of this technology.

ACCOMPLISHMENTS

The project embarked on a number of related research activities.

1. An examination in the lab and infield units of various biogas technologies potentially appropriate to small-scale on-farm use in Egyptian farming communities—including design features, costs of construction, input and output studies (optimum and actual field use by households), design of auxiliary devices (burners, etc.), operating procedures, and fertilizer studies.
2. An examination of current patterns of energy, residues, and fertilizer use in Egyptian farming derived from a 300 sample survey of farm and households from seven farming regions in Egypt. The survey collected over 500 pieces of information per sample on all farm input and output relationships, household socio-economic characteristics, sources and uses of all energy including traditional off-farm (kerosene and butagas) and on-farm sources (crop residuals, dung cakes), uses of fertilizer (chemical and manure), animal inputs and production, household health information and other data.
3. A study of the adoption potential (saturation level and speed of adoption) for BGT, beginning with a survey of 120 individuals consisting of actual adopters and non-adopters. Answers to questions of willingness to adopt are correlated with characteristics of farmers such as age, education, role in community, exposure to media, cosmopolitaness, and contacts with extension agents.
4. An analysis of the socio-economic impacts of widespread BGT in agricultural communities, incorporating information from the survey, data from lab and field experiments, and cost data from experimental units.

The impact study examined:

a. existing patterns of energy use across small, medium and large farms, concentrating on the use of crop residues and dung cakes in particular;
b. the role of fertilizers (chemical and animal) in existing farm systems to determine the potential for substitution using biogas sludge in place of chemical fertilizers;
c. the potential for substitution of existing energy sources in cooking, heating, water boiling, etc. with biogas energy, analyzing the value of crop residues saved as potential fodder and of dung cakes saved as potential fertilizer;
d. health effects of safer utilization of crop and animal wastes;
e. complete cost/benefits of typical farm and household systems in several farming regions and across

three farm sizes to determine feasibility and payoffs of BGT;

f. the overall benefits of BGT to Egypt as a whole, focussing on where geographically and what farm sizes might produce highest payoffs, what increased production (crop and animal) might result, what other impacts might be expected.

By August 1983 all data gathering activities from survey work had been completed, data keypunched and two-thirds of it entered into the computer to begin analysis. There is an enormous amount of very high quality data in this survey according to our preliminary logical tests, and ultimately of much potential use for understanding many aspects of farming systems in Egypt—including cropping patterns, production function studies, soil inputs to crops, fertilizer studies and animal production—in addition to the particular parts we are focussing on.

Data for field and lab work on fertilizer benefits of digester sludge have been compiled and summarized. One surprising result has been the discovery that the economic return to the added fertilizer amounts to perhaps two-thirds of the returns produced by the use of biogas-technology. In addition, field experiments suggest a strong residual effect on the soil and crop yields from using biogas manure.

Prelimininary results are available from the analysis of only about one-third of the collected data. Due to the delayed start of this project, much work still remains to be done. The researchers require 6 to 12 more months before the full analysis of the data will permit predictions of aggregate impacts and an overall evaluation of the feasibility of using biogas digesters in Egyptian agriculture. The work so far has been very promising.

ECONOMIC EFFICIENCY AND RESOURCE USE ON THE EGYPTIAN FARM

Previous studies of farm efficiency in Egyptian agriculture have emphasized selected single commodity input-output relationships rather than the examination of the performance of whole farms as undertaken in this current study.

The economic efficiency of Egyptian farms is conditioned by different technical, social, institutional and economic factors. Soil characteristics, farm technology, cooperatives, research, extension and government programs, farm size, and capital intensity, among other factors, are expected to have an effect on farm efficiency and resource use. The purpose of this study is to examine relative efficiencies of Egyptian farms under different environmental and economic conditions. The identification of factors that affect farm efficiency will be beneficial to both farmers and policymakers.

Findings of the study will have important bearing upon the possible adjustment process which might result in the development of more efficient farming units in Egypt. Information about the factors that influence efficiency would be helpful to decision makers in Egypt in different ways. For example:

1. Determination of the optimal cropping patterns in the zones under study and the impact of these on the production of major crops have a strong bearing on the availability of foreign exchange;
2. A study of the relation between size and efficiency provides helpful information for policy makers in determining optimal size of farms to be established in the "new lands," which are to be distributed to college graduates or individual operators;
3. The relation between new technologies (e.g., rural electrification, new varieties, new cultural practices, etc.) and efficiency helps evaluate their potential impact on agricultural production and farm efficiency.

This study, initiated in January, 1982, had three major objectives identified for study over a proposed three year project life. The first objective was to measure efficiency of different farm sizes in selected agronomic zones based on an extensive sampling of farms. The second objective was to identify factors which constrain profitability and economic efficiency, including cropping patterns, farm size, managerial ability, technological innovations, factor costs, infrastructure, and institutions. The third objective was to evaluate current governmental policies with respect to economic efficiency and to assess possible policy alternatives. At the time of project termination, only the first of these objectives had been pursued. The findings are summarized below.

ACCOMPLISHMENTS

EFFICIENCY OF DIFFERENT FARM SIZES

The project was designed to be implemented in two phases, involving the application of economic efficiency analysis to two quite different sets of data.

During Phase I, conducted during the first half of 1982, the Egyptian team collected data from the Farm Management Survey for 8 villages in the vegetable zone and 15 villages in the rice zone. The collection of data had two purposes: 1) to familiarize all participants with the process and content of the previous survey, and 2) to provide UC Davis collaborators with the opportunity to examine that data set for congruence with data requirements of the several analytical approaches under consideration. The data set was processed and analyzed to test concepts and procedures for use when Phase II survey information became available. Phase I also served to identify more precisely the data needs to be filled in the Phase II survey effort. An additional facet of Phase I carried on by both UC and Egyptian team members was an extensive survey of the literature including studies within Egypt, in other developing countries, and other empirical studies of farm efficiency. The latter efforts contributed to several team working papers.

Phase II of the project involved collection of a specific set of farm data and was to include analysis and interpretations.

Data Collection

Building the data base was accomplished in three distinct tasks:

1) Delineation of the population and drawing the sample;
2) Preparation of the interview schedule; and
3) Collection and tabulation of survey data.

Delineation of the population and drawing the sample

The basic study unit is the Egyptian farm. However, because of the apparent heterogeneity in agricultural activities, it was decided to work with farmers who specialized in certain enterprises. Consequently, our survey population is focused on farms in the rice and vegetable zones.

The rice zone consists of six governorates. These governorates, in the order of their share of national rice area, are Dakahlia, Kafr El-Sheikh, Behira, Sharkia, Gharbia, and Domietta. The area planted with rice in these governorates in 1980 ranged from about 25% of the summer crop area for Gharbia to 66% of the total summer crop area for Domietta. The six governorates in the rice zone produced about 2.4 million tons (about 97% of the national production of rice in 1980).

Several criteria were employed in selecting sample governorates: a) the percentage of national rice area contributed by each governorate; b) the percentage of the national rice value contributed by the governorate; and c) the relative share of the rice area to the governorate's summer crop area. Combining these criteria resulted in the selection of four governorates; Beheira, Kafr El-Sheikh, Dakahlia, and Domietta, which, combined, constituted 70% of the national rice area and contributed 72% of the national rice output in 1980. The rice area in each of these governorates accounts for more than 35% of the governorate's summer crop area.

Applying similar criteria, one district was selected from each of the four governorates. Within each district the selection of villages proceeded in two steps. In the first step, the five villages showing the most intensive summer rice cultivation within each district were selected. In the second step, the five tentative sample villages were reduced to two, following evaluation in terms of a) an infrastructure index (constructed to reflect availability of rural institutions and facilities), and b) the level of mechanization. These criteria were applied in a way that ensured the sample reflected extreme variation in village infrastructure and levels of mechanization.

The selection of sample farms within villages proceeded as follows:

a) Large size holdings (greater than 10 feddans) occur with rather low frequency. In each sample village, ten holders were randomly selected. If the total number of large holdings was ten or less in the village, all holders were selected in the sample.
b) For each of the other size of holdings, holders were selected randomly and in proportion to the number of holders in each size class (less than 1 feddan, 1–3 feddans, 3–5 feddans, and 5–10 feddans). The total sample size was targeted for 30 farms in villages with less than 1,000 total holdings; otherwise a total of forty was sought.

The vegetable zone is not as concentrated as rice, and is dispersed over much of Egypt. The top four governorates in terms of the area planted with vegetables each year are Behira, Giza, Sharkia and Kalubia. Almost one half of the national vegetable area is located in these four governorates. Using criteria involving a) the governorate's relative share of the value of vegetable production with respect to the value of national agricultural production, and b) its relative share of vegetable area as a proportion of the national area in vegetable production, two governorates were selected for this study: Giza and Kalubia. Each of the selected governorates has more than 33% of its area cropped in vegetables.

Similar criteria were used in selecting districts, and the selection of villages was based on their relative share of area cropped in vegetables, their infrastructure, and their level of mechanization. As with rice, an objective was to select villages reflecting extremes in village infrastructure and mechanization levels. Sampling of farms within villages proceeded as described for the selection of rice farms.

Preparation of the Interview Schedule

The interview schedule prepared to collect survey data from farm operators was designed to elicit responses about the farming operation and related aspects. Basically, the schedule included questions intended to secure data on:

a) the farm family in terms of size, age, and sex composition, educational level, occupations, etc.;
b) the farm enterprise in terms of size, tenure, cropping pattern, present investments in farming, and farm credit, etc.;
c) crops grown during the agricultural year 1981–82 in terms of area, production inputs (seeds, fertilizers, insecticides, machinery/equipment use, manual and animal labor, and land rent), output, and product disposal;
d) animal production enterprises, in terms of inputs and outputs;
e) family income from various sources (including non-farm);
f) the managerial ability of the farm operator in terms of level of aspiration, contact with local organizations, internal management, technological competence, and cooperative relations; and
g) personal and social characteristics of the farm operator, including urban contact, mass media exposure, level of living, modernity, social participation, and contact with extension agents.

Collection and Tabulation of Survey Data

Personal interviews with farm operators in each of the two farming areas were conducted in two interview sessions. In the initial session respondents were asked about the structure of the farm, the farm family, farmer enterprise, family income and managerial ability as well as production data for winter crops. In a later interview, respondents provided information about the personal and social characteristics of the operator, as well as production data for summer and nili crops.

After the second interview, responses were summarized and processed for statistical analysis. Nine summary tables were designed to incorporate the data needed for analysis. The tabulated farm survey data were then transferred to Davis where a computer program was developed to examine the internal consistency of the data. Discrepancies were clarified in a series of exchanges between the US and Egyptian counterparts. Simultaneously, the Egyptian team undertook related analyses involving examination of managerial characteristics of the sampled farm operators, an activity which is expected to be useful at a later stage in explaining efficiency differences among farm units. The Egyptian team also undertook a separate analysis using a linear programming model to explore optimal cropping patterns and resource allocation.

The data file now being analyzed contains 1908 variables for each farm. Among them, 1705 are crop production variables of 35 crops, 45 are livestock production variables, 20 are managerial ability variables, and the rest of them pertain to other variables such as tenure, investment, credit.

DATA ANALYSIS

Five estimation techniques applied to technical efficiency studies have been examined. Farrell's deterministic non-parametric frontier approach provides definitions and a computational framework for both technical and allocative inefficiency. Aigner and Chu's deterministic parametric frontier approach specifies a Cobb-Douglas production frontier by constraining all firms to be on or below the frontier. Both approaches use mathematical programming to estimate technical efficiency. The non-statistical property of the above mathematical programming approaches led to the more recent development of deterministic statistical frontiers, stochastic frontiers, and the dual approaches. The computer algorithms of all estimation methods (except that for a dual approach) have been acquired, modified if necessary, and tested. Currently, we have two algorithms applying Farrell's approach, both linear and quadratic programming algorithms to estimate deterministic parametric frontiers, one algorithm to estimate deterministic statistical frontier, and two algorithms to estimate stochastic frontiers.

Preliminary analysis has used only a subset of the total data base discussed previously. It contains 115 observations from four villages in the rice zone:

Governorate	*Village*	*Number of Observations Used*
Dakahlia	Meet-Adlan	16
Kafr El-Sheikh	Mansheit Abbas	37
Beheira	Minit El-Said	33
Beheira	Kafr El-Rahmania	29

The purpose of the preliminary analysis has been to compare estimating techniques, as well as to give insight into the techniques to be used in the analysis of the total sample. No attempt has been made at this stage to interpret the implications of findings from the alternative estimating techniques.

The analysis of the data begins with the specifications of an aggregate production function:

$$Y = f(X_1, X_2, X_3, X_4)$$

where

Y = gross revenues from crop production in Egyptian pounds,
X_1 = acreage under cultivation in feddans,
X_2 = labor use in man-days,
X_3 = machine use in hours, and
X_4 = nitrogen fertilizer in kilograms.

Land is specified as the sum of feddans of all crops actually planted in the 1981–82 crop year. No adjustment for differences in fertility is made. Labor use is specified as the actual number of days worked by family members, shared labors (non-paid) from neighbors, and hired labors. One child labor is converted into one-half man labor; one woman labor is equivalent to two-thirds man labor. Machine use is specified as the total number of hours of machine operated in crop production. Again, there is no adjustment for differences in the types of operation, i.e., plowing, irrigation, harvesting, and so forth. Nitrogen fertilizer is specified as the quantity of pure nitrogen applied. Lastly, output is specified as the gross revenues from the production of all crops.

Technical Efficiency Estimates

The average technical efficiency index (TEI) resulting from the application of the four alternative estimating techniques were: Farrell Approach, 0.719; Deterministic Parametric Frontier, 0.614; Deterministic Statistical Frontier, 0.517; and Stochastic Frontier, 0.715. The technical efficiency derived for each technique depends upon assumptions specific to the technique. For example, Farrell's approach could be reasonably expected to produce a higher average TEI than that from a deterministic approach, because it imposes no restriction on the functional form.

parison of the techniques leading to their application to the larger data sets for rice and for vegetable farms. Future activity might also usefully seek to explain the reasons for differences in efficiency among farms of different sizes, types, and geographic location.

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INTERCONNECTIONS OF EGYPTIAN FOOD AND AGRICULTURE POLICY

Egyptian food and agricultural policy in the aggregate is a complex set of interconnected, overlapping and sometimes contradictory partial policies. Analysts frequently approach these partial policies, e.g., commodity policy, food subsidies, etc., using in-depth partial equilibrium analysis which allows the analyst to explore fully the direct impacts of a particular policy or subset of related policies on a particular commodity or closely related subset of commodities, e.g., food grain policy. Analytically such an approach may make the policy analysis tractable but in a real sense, the policy process is ultimately general equilibrium, at least in the *ex post* sense. Clearly, somehow the interests of producers, market agents, consumers, politicians and bureaucrats are traded off in the policy process to produce the totality of policies which influence the food and agriculture complex.

The magnitude of the food and agricultural sector in Egypt in terms of employment, GNP generation, foreign exchange balances, fiscal costs, and the sector's importance in economic and political stability, is such that food and agriculture are national policy issues which come together at the highest levels of government. National policies with respect to prices, food subsidies, investment, foreign exchange allocation, encouragement or discouragement of the private sector and budgetary expenditure continue to influence the food and agricultural complex in many and varied ways.

Ultimately effective long-term policy analysis must be able to capture this complex set of interrelationships between economic actors and policy makers. Thus, the general purpose of this research project has been to try to understand the Egyptian policy context. This study has attempted to identify the general framework of agricultural policies and to describe their elements, components, the interrelationships in order to build up composite models showing these relationships with the aim of putting them into quantitative forms so as to relate them to different policies.

The study focussed on eight main issues: land and water resources, agricultural production inputs, agricultural production, agricultural production services, food prices and subsidies, food consumption and distribution, foreign trade, and national investments. In each policy area the context of decision making was explored, and the roles of each ministry or organization in making decisions were investigated. Goals and objectives, stages of preparation of policies, methods of achieving adopted goals, the roles of executive departments, and the partial effect of each ministry organization on policy formation and implementation were outlined for each policy area.

The specific objectives of this study could be outlined as follows:

1. To identify the principal policy variables which influence directly or indirectly the food and agriculture sector while simultaneously identifying the principal actors such as Ministries, public sector firms, etc;
2. To present graphically and possibly in verbal equations the simple analysis of the Egyptian agriculture policy;
3. To integrate the findings and implications of ADS with studies conducted by other agencies thereby providing a conceptual framework for looking at short and long-term aggregate policy issues;
4. To integrate the supply and demand principles in the context of national macro policies given international constraints;
5. Ultimately to develop a preliminary model for the Egyptian policy process. The objective here is to identify the major actors who manage the policy model development in objective 4.

Objectives 1, 2, and 3 outline the major stages achieved thus far and interested readers can follow the main findings in the project working papers.

ACCOMPLISHMENTS

The comprehensive nature of the study made it necessary to form four study subgroups of researchers from the following institutions: universities, the Ministry of Planning, the Institute of Planning, the Ministry of Agriculture, the Ministry of Supply, banks, Agricultural Reform Cooperatives, and the private sector.

The research areas undertaken by the four study subgroups were: natural resources, inputs, agricultural production, and agricultural services; consumption and food distribution; foreign trade; and investment. Though each sub-group prepared detailed studies in its field, collaboration and discussions continued among the total group throughout the project.

In each policy area the context of decision making was explored and described. The rules of each ministry or organization in making decisions were investigated. Goals and objectives, stages of preparation of policies, methods of achieving adopted goals, the role of executive departments, and the partial effect of each ministry's organization on policy formation and implementation were outlined for each policy area.

An additional research component undertaken by the project was an attempt to conceptualize one aspect of the macro-sectoral linkages between the general economy and the Egyptian agricultural sector. This is necessary because

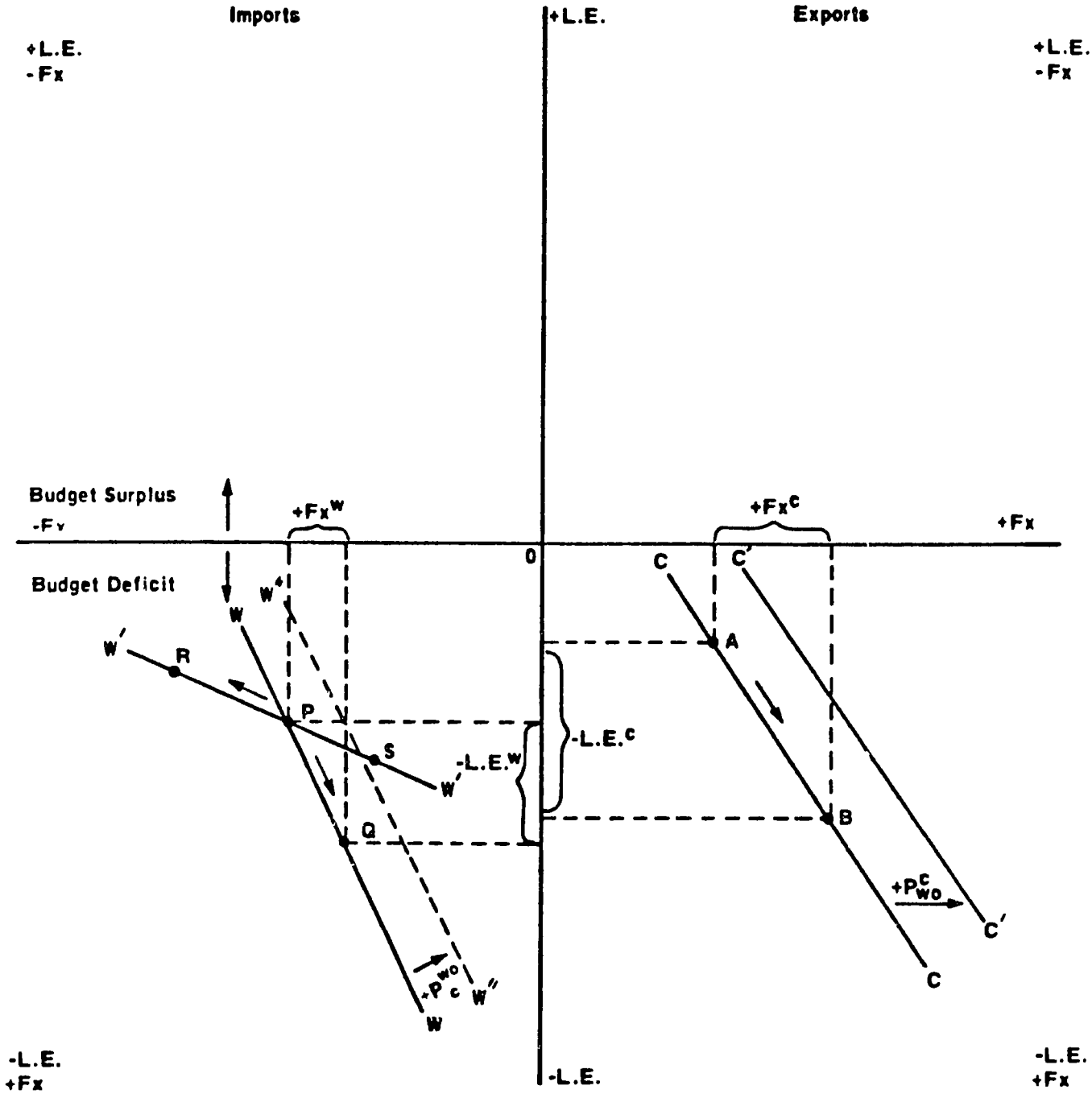

Figure 1. **Nature of domestic currency (LE) and foreign exchange (Fx) trade-offs.**

the essence of national policy making necessarily revolves around the two basic questions—what is the appropriate role of the food and agriculture sector in Egypt's economy and what are the implications that food and agricultural policies have for more general economic policy objectives and programs. For example, national policy makers in the Ministry of Finance, the Ministry of the Economy, the higher level economic coordinating bodies, may well be very interested in the trade-off involved between L.E. and foreign exchange which results from potential changes in food and agriculture policy. This requires a detailed understanding of programs in terms of fiscal and foreign exchange implications. It turns out that we can build on static-partial equilibrium commodity analysis and that we can simultaneously look at traditional measures of producer and consumer benefits and cost. A conceptual outline of the trade-off functions is shown in Figure 1.

Income-expenditure accounts can be influenced in four ways, by changes in commodity programs—namely increasing or decreasing income or increasing or decreasing expenditure. We represent this spectrum on the vertical axis. Net pound (L.E.) costs increase as we move down from the origin and conversely, net revenue increases as we move upwards. On the horizontal axis we represent changes in net foreign exchange balances (foreign exchange)—increasing surplus to the right of the origin,

increasing deficits to the left of the origin. Thus, programs falling in the northeast quadrant would be ones where both foreign exchange and fiscal revenue are positive. The southeast is where foreign exchange is positive but domestic currency costs are negative and so on. Programs to the right of the origin involve net exports, to the left net imports. Programs above the horizontal axis are net revenue generators on domestic fiscal accounts, below are net L.E. cost activities on domestic fiscal accounts.

We are interested in knowing, for example, how would the trade-offs between foreign exchange and L.E. change with alterations in a program parameter, say, support or requisition price paid to producers. For a program such as cotton, one would expect that as the requisition price (and quantity) is raised, production would increase, increasing export availability ($+Fx^c$) but also increasing domestic acquisition costs in terms of L.E. ($-L.E.^c$). Thus, we would expect a function (C – C) with a negative trade-off between increased Fx earnings and increased L.E. costs. A movement from A to B would result from the hypothesized increase in requisition quantity and requisition price. The exact shape of the function would depend on the actual program and we will derive it in the next section. Clearly, the relative changes in foreign exchange earnings ($+Fx$) and increased fiscal costs ($-L.E.$) depend on the shape of the function.

Similarly, in the wheat program an increase in the price paid for domestic production should increase production, increasing domestic acquisition costs but, with given consumer prices, should decrease foreign exchange costs. Therefore, the wheat trade-off function would fall at least in part in the southwest quadrant (W–W). The change (increase) in producer price should move us from P to Q resulting in increased fiscal cost ($-L.E.^w$) but less foreign exchange cost ($+Fx^w$). Again, magnitudes depend on the shape of the function.

Each of these functions is constructed on *ceteris paribus* assumptions, but, in fact, they are clearly related by production substitution. Suppose, given a fixed land base, that when cotton production rises (because of a program change), wheat (via a series of substitutions) becomes less profitable and the supply shifts to the left. Without changing the wheat support price (at say, P) the trade-off function rotates through P as in W′–W′. Shifts in wheat supply to the left (i.e., reduced supplies) move us from P towards R because production decreases (lessening L.E. acquisition cost but increasing Fx costs). Conversely, a shift in supply to the right (from, say, a decrease in vegetable prices) would move us along W′–W′ towards S. Obviously, a change in the wheat program could impact on the cotton function if the elasticities of substitution are different from zero. (We have not shown it to minimize diagram clutter.) Thus, the net effect of a change in the cotton program (A – B) would result in a gain in Fx in cotton but an increase in Fx cost in wheat and an increase in fiscal costs for cotton ($-L.E.^c$) but a decrease in domestic costs for wheat ($+L.E.^w$).

We also would be interested in knowing what happens if world prices change. An increase in the world cotton price would shift C–C to the right to C′–C′. A decrease would shift it in the opposite direction. Also, if, say, the domestic price of bread to consumers was increased quantity demanded would contract reducing the cost of domestic subsidies and reducing imports, thereby reducing Fx costs. Thus W–W would shift to the right to W″–W″. Obviously, we could explore other changes as well, such as reduced PL480 in shipments (on wheat) or a change in the allocation and or price of cotton going to domestic mills, but this is sufficient to introduce the general approach—a set of trade-off functions, movement along which represents the *direct* effect of a program change and shifts and rotations which represent the *cross*-effects of other programs. Functions from actual programs for three cases—cotton, wheat, and meat—are developed and presented in a working paper.

This approach has a number of useful outcomes.

First, it focusses explicitly on what must be an important trade-off for macro policy makers, particularly if the balance situation in one budget differs from the other, say, a large domestic budget deficit and significant foreign exchange surpluses. Adjustment of domestic program parameters could assist in simultaneously improving both situations. But more importantly, it should help agricultural policy analysts to make these implications explicit in their analysis. In a review of all ADS working papers very few embodied these trade-offs in their analysis but yet most could have, with minor effort.

Second, the analysis allows us to look at both direct and cross-effects of program changes and forces us to understand the implications of the cross elasticities for individual commodity analysis. While the approach is not fully one of general equilibrium, it is considerably more than a single commodity partial approach. It ought to be obvious that a succession of cross-effects could have one of three impacts on the net outcome—to wit (a) accentuate the direction of change; (b) offset change so as to negate the outcome; or (c) more than offset the direct effect and move us in the "wrong" direction. Yet all too often we do partial policy analysis as if there were no second round effects. This approach forces us to take them into account and at least identifies the expected sign of some of the changes.

Third, and related, it points to the crucial importance of understanding, and where possible, measuring cross elasticities of both supply and demand.

Fourth, even in the simple cases we considered it is clear that qualitative policy analysis has limited use in predicting actual outcomes. It may, however, be of critical importance in sorting through the conceptual maze which must precede empirical analysis. The bottom line, of course, is that empirical estimates are essential in reaching policy conclusions.

Fifth, the weighting given each of the targets (e.g., farmers, consumers, balanced budget) by policy makers could radically alter outcomes. All of the welfare analysis done within and outside of ADS implicitly implies *equal* weightings. But if urban consumers get a weighting of two while farmers get a weighting of one, results would clearly vary.

Sixth, the approach is useful in exploring the path of changes that result from incremental changes in one or more policy variables. While it builds on partial analysis of individual programs, it has more policy applicability simply because it is not limited to exploring the direct effects of one change. Most frequently the single commodity approach looks at the welfare effects of changing from the current "distortion" to a market with world prices prevailing. Such analysis, while having intrinsic, if not spiritual, interest to neoclassical economists, is of limited practical value in and of itself.

Finally, if nothing else, the approach forces us to try to deal simultaneously with at least some of the myriad of variables that enter into real policy decisions. Further, it should be an intermediate step to building better empirical models which would allow definitive policy conclusions.

The conclusions and policy recommendations of this project are too voluminous to reproduce briefly, since the project dealt with virtually the whole area of policy formation in Egyptian agriculture and the whole range of policy research carried out under ADS. This project represented a kind of policy analysis clearinghouse for all ADS policy research. However, several general policy recommendations do stand out. First, there is a great need for increased coordination among decision making bodies in order to reduce conflicting policy thrusts within the government. Currently, responsibilities for various closely related policies are divided among many decision making bodies. Second, policy implementation could be improved by increased decentralization of implementation responsibilities. Third, agricultural sector development policies need to take greater cognizance of the role of markets and private sector incentives in achieving national policy goals.

These general policy recommendations are supplemented by scores of particular policy recommendations on specific issues regarding subsidies, fertilizer policy, export policies, land and water resource development, investment policy, and so forth. The findings of this project represent in large part a synthesis of all the ADS economics policy research.

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ECONOMIC ANALYSIS OF THE EGYPTIAN CITRUS INDUSTRY

Fruit production, a major component of Egyptian agriculture, occupied about 350,000 feddans of prime agricultural land in 1980, more than half of which was planted to citrus crops. Most of the citrus crop is consumed domestically, but it is also an important export item with potential for expansion.

Increased fruit production, especially citrus, is a goal of Egyptian policy and reflects increased domestic demand and favorable export prospect. Achievement of this goal would be aided by improved information about the structure and performance of domestic markets, supply and demand relationships, and the economic effects of various government intervention strategies—for example, the use of price ceilings, quality grading, and export control.

The overall objective of this project has been to provide analyses of underlying economic relationships in the citrus industry and to suggest programs to improve its effectiveness in meeting policy goals. The work was conceptualized as a two phase operation: 1) The development of a set of supply and demand relationships of a dynamic economic model of the citrus industry, and its use to evaluate economic effects of alternative government policies and changes in factors such as population, production and marketing costs; and 2) a description of the economic structure of the citrus industry using a systems taxonomy, estimation of representative costs for production and marketing activities, and evaluation of how social and institutional constraints and marketing methods affect marketing efficiency.

ACCOMPLISHMENTS

DYNAMIC MODEL ANALYSIS

Major components of the economic model are functions which define consumer (retail) demand, behavior of retailers and wholesalers, export market demand, behavior of the government export company, new planting and removals and the various identities needed to tie the system together. Efforts to estimate the parameters of the industry model by conventional econometric time series were unsuccessful because of inadequate data, particularly concerning prices. The problem with price data stems from the system of price ceilings which leads to reported prices generally the same as the ceiling prices, although market observations indicate that actual prices commonly exceed ceiling prices by large amounts. Hence, the available reported prices often do not reflect actual market transaction prices. Further, in cases where ceiling prices are effective, the price-quantity points fall below the demand curve, thus precluding meaningful demand estimation.

As an alternative to the econometric estimation, a quasi-quantitative model was formulated which provides illustrations of potential effects of changes in exogenous variables and government policies for a range of plausible supply and demand parameters. This type of quantification greatly facilitates the evaluation of time patterns of adjustment which are particularly important for oranges due to the long lags in production response.

Values for the model parameters were drawn from demand elasticity estimates in other studies and restrictions imposed on the planting and removal functions based on biological considerations. The equations were formulated so that for any given set of parameters the model predictions would be consistent with observed prices and quantities. The set of equations so determined provided a basis for simulating the dynamic behavior of the system under alternative assumptions and specifications.

Because of the possible distortions that government intervention practices might impose on the results generated by the simple simulation model, the impacts of government imposed price ceilings were considered first. When the ceiling price is set below the equilibrium price, excess demand is created and the demand price exceeds the supply price for fixed quantities of oranges. However, violations of the orange ceiling price appear to be so common that the demand price and supply price may equilibrate approximately through black market sales. Hence, the orange economy may function much as an unrestricted economy except that actual transaction prices are not recorded and marketing margins may be wider to compensate for the risks of black market dealings. The effects of changes in the exogenous variables of the system were first evaluated under this equilibrium assumption; then, scenarios were formulated for an alternative specification involving more rigorous enforcement of policy ceilings. Demand and supply parameters were varied to test the sensitivity of the results to levels of demand and supply response elasticities. The specific numbers generated by this process are not of significance in themselves, but the general response patterns revealed suggest some important conclusions.

1. ***Price Ceilings***

The analysis found no economic basis for continuing the system of price ceilings for oranges. If fully enforced, price ceilings may lead to market distortions and, quite likely, prices that eventually are above, rather than below, competitive equilibrium values. Under what appears to be the more realistic scenario of lax enforcement and price equilibrium through black-market dealings, there is a loss of efficiency due to costs of added market risks

so that consumers may actually pay more and farmers receive less than they would with unrestricted markets.

2. ***Changes in Production Costs***

Many government policies affect costs of producing oranges. An analysis which assumes that price equilibrium is achieved through black-market dealings suggested the following:

(a) Total output response to a cost change is likely to be inelastic;

(b) Farm returns are affected immediately by cost changes but prices may be affected very little for a period of at least six years;

(c) Even after production from trees planted (or not planted) in response to a cost change begins to affect the market, another 15 to 20 years may be required before the full effects of the cost change are realized.

Under an alternative scenario of rigorous enforcement of ceiling prices, it was shown that it is possible to achieve a kind of long-run partial equilibrium in which the ceiling price is equal to the grower unit cost (so growers break even) but where demand may exceed supply at this price. This creates problems of nonprice rationing and maintains pressures for black-market sales.

The analysis suggests that policies which affect the production environment may have very long-term implications and that many conditions currently existing may have their roots in policies or programs no longer in effect and long forgotten. Hence, it is important for policy makers to evaluate both short- and long-run implications of their actions.

3. ***Export Policy***

An analysis which assumed a significant portion of domestic sales in black markets at prices in excess of ceilings led to the following observations concerning export market policy:

(a) Variations in exports of oranges may have relatively little long-run impact on grower prices, but may have substantial short-run impacts. The latter may persist for a number of years because of the lag in production adjustment;

(b) Although the precise goals of the orange export company are not known, efforts to expand exports may conflict with other goals of maintaining low consumer prices;

(c) With domestic demand shifting upward due to expanding population, it will be increasingly difficult to maintain high export levels;

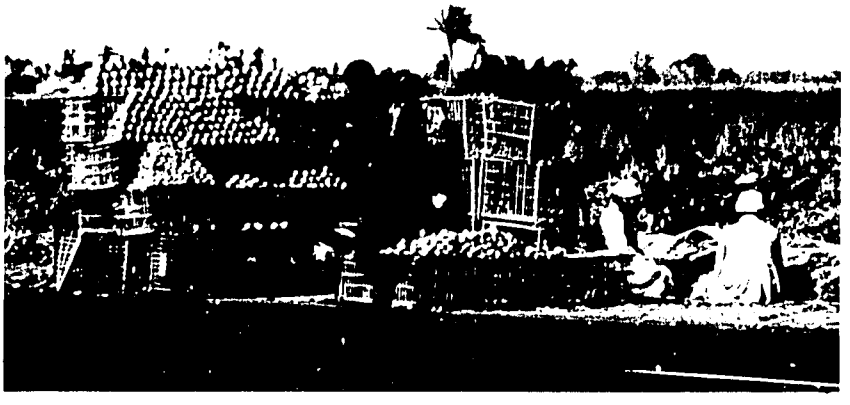
(d) Because of the expanding domestic demand, reduced export sales may have relatively small effects on farmer returns.

4. ***Population Changes***

The rapid growth in Egypt's population and the lag in production response suggest a continued upward pressure on orange prices. Real (black market) prices may remain stable (in deflated value) yet still remain higher than long-run equilibrium levels over extended periods. Efforts to set and enforce ceiling prices at break-even levels seem likely to be ineffective since that would retard the needed expansion. In the end, consumers may pay more with ceiling prices than they might have in an unrestricted market. Policies aimed at improving outlook information, providing assistance in improving productivity, and responding more quickly to upward shifting demand appear more promising. Such policies would, of course, need to be coordinated with conditions and policies affecting alternative commodities.

SYSTEMS ANALYSIS

The purpose of this phase of the project was to describe the economic structure and organization of the Egyptian citrus industry, to obtain estimates of costs of production and marketing activities, and to evaluate the effects of marketing methods, institutions, and social change on marketing efficiency.



Expansion of the citrus production is one of the goals of Egyptian agricultural policy and depends on government strategies sending the correct economic signals to growers and markets. The Citrus Marketing project has examined the structure and functioning of export and local markets to assess their potential role and needs in an expanded citrus economy.

Photo: Eric Gustafson

The work has so far focussed on developing extensive economic surveys of producers and marketing firms in the Egyptian citrus economy. Three main surveys were undertaken: the grower survey, the wholesaler survey, and the orchard merchants' survey. Orchard merchants are entrepreneurs who buy a farmer's crop on the tree and then handle the harvesting and marketing.

The Grower Survey

A grower questionnaire covering both production and marketing was designed to include growers in:

a. The most important four governorates in terms of area planted and production of oranges (Behera, Kalubyia, Sharkia, and Menoufia);
b. Three districts in each governorate according to the relative importance in terms of area and production in the district;
c. Two villages in each district according to the relative importance in terms of area and production in the district.

Individual elements in the sample were drawn, using the records of the Horticulture Department, and ten growers were randomly selected from each village. Four additional special cases were purposely selected in each village to include: a grower with a newly established orchard only; a grower dealing with export; a big grower (with 10 feddans or more of citrus orchard); and a grower dealing with processors.

Using 12 enumerators trained by the project, 305 completed forms were received and distributed among categories as follows: 240 growers (24 villages × 10 growers); 24 big growers of 10 feddans or more (24 villages × 1 grower); 24 growers of newly established orchards; and 17 growers dealing with export. The completed questionnaires were edited for consistency and completeness and sent to the University of California at Davis for computer processing. Similarly, a village questionnaire was designed and completed for each of the villages in the sample. Data from Ministry of Agriculture sources were compiled on the following: developments in orange production during the period 1951–1981; developments in the production of various orange varieties during 1962–1981; changes in total area in orange planting during the period 1951–1981; changes in bearing location of oranges during 1951–1981; changes in bearing location of various orange varieties 1962–1981; changes in orange yield during 1951–1981; changes in yields of various orange varieties 1962–1981; share of each governorate in total production of oranges 1955–1981; and share of each governorate in total orange area 1955–1981. A large volume of data has been collected from different governmental sources (namely, Land Reform Authority, Tahreer Governorate, and the El Gabal El Asfar) to prepare a paper on production and marketing of oranges and their problems in the state production by government agencies. This information is being tabulated at present.

The Wholesaler Survey

Data on wholesale markets in Cairo, Zagazig and Alexandria were compiled from a survey which consisted of a description of the wholesale market and questionnaires for individual merchants.

The design of the wholesaler questionnaire and its adjustment took five months, starting in December 1981. A team of interviewers was selected and trained to meet with individual wholesalers and to complete the survey questionnaire. The data collection phase presented a difficult situation because many wholesalers were skeptical and thought that the information was being sought by executive agencies for administrative purposes. As field work proceeded, some interviewers found they were unable to cope with this problem and were replaced with newly recruited and trained interviewers. Data collection continued to the end of September 1982. The field surveys included six wholesale markets plus four markets in the capitals of the governorates included in the growers' survey (Damanhour, Shebin El-Koam, Banha, and Zagazig). The field surveys also included the wholesale markets in Cairo and Alexandria. The names of wholesalers in these markets were obtained and all six markets were represented in proportion to the relative numbers of wholesalers in each. The numbers of wholesalers considered as the minimum to be interviewed were: Cairo, 50; Alexandria, 25; governorates, 60 (15 in each governorate); making a total of 135 in all.

One hundred seventy-four questionnaires were actually completed, the difference consisting of additional enumerations: five at Damanhour, Behera governorate; six at Alexandria wholesale market; and 28 at Cairo (the interviewing covered some subordinate wholesale markets—Matariah market and Athar Elnaby market). The responses to the questionnaire were entered onto data sheets, coded, and sent to Davis for computer processing. The field survey on the organization of the wholesale market has been completed for the wholesale markets covered by this study and the data are being analyzed at present.

The Orchard Merchant Survey

A complete survey, using specially prepared questionnaires, was conducted of the orchard merchants identified through the grower survey in each of the four governorates. Two hundred questionnaires were completed from the governorates of Behera (66), Sharkia (60), Kalubia (41), and Menoufia (33), and prepared for tabulation. Tremendous difficulties were encountered in interviewing the orchard merchants because most of them had additional employment in other types of trade. Sometimes it was necessary to meet with the merchant at his home, at the wholesale market, at the orchard, or while driving his car. Completion of some forms required two interviews, and in some cases interviewers were not treated well by the merchants. Data were entered on special data sheets, edited, and then coded and sent to Davis. Data analysis is still in progress.

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COMMODITY SYSTEMS ANALYSIS

The organizational structure of the Egyptian commodity systems, the decision-making process, the effect various institutions have on production and marketing, and the forces that bring changes to Egyptian agriculture are not currently available to researchers or policy makers. This study, focussing on wheat and potatoes, is a combination of functional, institutional, and market analyses, with a blend of decision and authority analysis. By developing a perspective for evaluating the dynamics of the production-marketing systems of selected commodities, this study has worked towards providing greater understanding of the forces within each system that stimulate coordination, adaptation, efficiency, and other changes in performance of those who produce, process, and market the commodity. Two commodities were chosen as the focus of this project, wheat and potatoes, with the studies on each comprising three components: The production system, the marketing system, and the processing system.

The first part of the potato study dealt with the spatial, time dimensions and coordinating forces in the production of potatoes, and included the international situation of potatoes and the production of potatoes in Egypt. Production parameters that were examined included area, geographical distribution, kinds of potatoes, seeds imports and distribution, crop rotation production problems, and governmental ordinances regulating the production. Concerning the marketing of potatoes, the functions and marketing services, organizations, prices and margins, consumption, exports, and the ministerial ordinances regulating marketing were studied. A questionnaire was conducted to study the various factors influencing the production, marketing and consumption decisions of the growers. The size of the sample was 36 farmers in three governorates. The questionnaire and the pre-test were preliminary stages to the study planned for phase II. The processing of potatoes was too limited to deserve attention in this study.

The study of wheat was similar to that of potatoes, except for processing which was an important additional part. Milling industry in Egypt was described covering its capacity, geographical distribution of mills, kinds of mills, private and public sectors ownership, storage of wheat flour, etc. The baking industry was also studied; the study covered the kinds of bakeries, ownership, geographical distribution and capacity, kinds of bread, baked goods and other wheat products. The coordinating forces in the area of production and marketing were fully described and the ministerial ordinances and laws regulating the cultivation, marketing and processing of wheat, and its products were handled in detail.

A similar questionnaire to study the various factors influencing the production, marketing, processing, and the consumption of wheat and wheat products was conducted, but on a bigger scale and covering a wider geographical distribution. This was the pre-test of the other questionnaire conducted in the second phase. The work on potatoes was limited to this phase, according to the technical committee's recommendations, and hence phase II includes wheat only.

The objective of phase II was to identify the demographic and economic factors that influence decision making that formulates the wheat system at the micro level. This part of the study was designed to show the extent to which relationships between these factors influence the efficiency of producing, marketing, processing or consuming wheat, wheat flour or balady bread under the prevailing conditions. An understanding of this could be helpful in formulating policies to improve the efficiency of the system of wheat production and wheat products in Egypt.

For this purpose questionnaires were developed covering the areas of: a) production and marketing of wheat; b) processing of wheat flour and bread; and c) bread consumption.

The objective of the first questionnaire was to identify the influence of demographic and economic factors on decisions of the wheat growers on the production, marketing, consumption of wheat and other cereals.

Farmers from eight governorates responded to the questionnaire which covered: personal and family information of the farmer (age, size of the family, educational level, ownership, occupation, etc.); production decisions (reason for cultivating wheat, increasing or decreasing its area, prices and income, variety preferred, source and quantities of seeds, fertilizers, insecticides, etc.); marketing issues and questions related to consumption patterns (wheat versus other cereals, the preference between wheat or other flour used, the reaction to raising the price of wheat or bread, produced or bought bread, cereals for feeding animals, etc.).

The computer analysis of the data was presented first in the form of frequency distribution tables according to various physical or personal aspects of the farm or the farm family. An additional computer analysis covered the production, marketing and consumption decisions. The production decisions included reason and continuity of wheat cultivation, decreasing the wheat area, wheat variety, seeds source, and fertilizer sufficiency and source. Marketing decisions dealt with storage, selling to the agricultural banks, source of buying consumed wheat and selling the excess products, buying wheat versus wheat flour. Consumption decisions discussed degree of self-sufficiency in wheat and straw and way of its balance, kinds of animals using wheat or wheat flour, kind of bread preferred, the effect of increasing wheat prices, the existence of an oven in the village or at home and its effect on bread demand and consumption. Further analysis of

this part and the rest of the questionnaire will take place afterwards.

The processing of wheat and wheat flour was the subject of two questionnaires, one for mills and the other for bakeries. A sample of 20 mills (17 public sector and 3 private sector) was chosen for this study in Greater Cairo. The data were tabulated and analyzed. The factors influencing production decisions, mostly governmental, were studied and suitable recommendations were offered to correct the defects noticed in the mills. The difference between the efficiency of public and private sectors was noted and several recommendations made, such as replacement of low capacity stone mills with modern cylindrical mills.

A random sample (52 bakeries from both public and private sectors) was chosen from 14 quarters of Greater Cairo and polled. The objective was to investigate the prevailing conditions of the bakeries, identify their difficulties and reveal the factors affecting their current behaviour, the possibility of increasing their efficiency, and to know to what extent the government has succeeded in achieving the goals designed in the production and distribution of baladi bread. Information requested in the questionnaire included: the age of the building, number of ovens, working hours, worker's age, obstacles facing increasing working hours, production capacity, flour quotas, administration, flour waste, storage within the bakeries, source of energy, costs and margins, weight of bread, defective bread, stale bread, bread distribution, the desire to shift to automatic or semi-automatic bakeries, the desire of the owners to continue in this industry. Data from the questionnaire was tabulated and frequency distribution tables derived. Suitable recommendations were given to solve the problems and correct defects discovered.

Consumption of bread in Greater Cairo and urban areas was the subject of the last questionnaire designed and administered by the project team. A stratified sample was chosen according to the occupation, age, income level, size of the family, allocation, etc. Analysis of this data was incomplete at the time of project termination.

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RURAL DEVELOPMENT AND PATTERNS OF CONSUMPTION

The conventional measure of the success of economic development in low income countries has relied heavily on the use of gross national product (GNP) indicators. Despite widespread use, the measure has, nonetheless, received its share of criticism for its limitations. For example, distinctions between "goods" and "bads" and income distribution issues tend to be glossed over. The weaknesses have resulted in alternative measurements being suggested which would more adequately reflect changes in the "quality of life." However, these alternative indices have not withstood the test of acceptability over time.

Among the more interesting alternative measures discussed recently is that of the availability of consumption goods to the lower income mass markets within low income countries, a category of goods which we have called "grass roots goods." GNP does not adequately distinguish between expenditures on luxury items by elites and expenditures by lower income individuals on consumption goods. By implication, the availability of grass roots goods might better indicate development progress than GNP measures—not only because of the direct evidence of increased disposable income in a broad sector of the population, but also as indicator of structural changes within the society and economy that are needed for development to proceed. However, the thesis requires empirical examination and for several reasons. Egypt provides an excellent location to initiate such study: it has progressed considerably beyond the structural and institutional changes implied in land reform; it has demonstrated a concern for peasant living standards; and it has a policy of greater self-reliance in manufactured goods. The study has the added benefit that information about the availability of these goods could provide useful information to economic planners.

Prior to the examination of grass roots goods availability, criteria must be established for distinguishing between such goods and luxury goods that are more likely to be consumed by the elite. The team was fortunate in having access to a rich set of village expenditure data provided by the National Research Center (NRC) of Egypt, covering a wide array of goods. Little work has been done in Egypt on expenditure elasticity analysis (particularly for nonfood items) and indeed is believed to be nonexistent for rural villages. Thus, the estimation of expenditure elasticities is viewed as an important contribution in its own right as well as being necessary for subsequent study of grass roots goods availability.

Expenditure elasticities for subcategories of "low" and "high" income consumers within the villages were examined, and goods classified on the basis of "necessary", "normal", and "luxury" for the overall sample and for the high and low income subcategories.

In addition to the expenditure elasticity estimations, the availability of grass roots goods at the rural village level was determined. The objective of this work was not only to draw conclusions about the ability of a low income country to provide such goods to the rural population, but also to assess the feasibility of collecting such information and to evaluate its possible usefulness for economic development policy decisions.

The approach used was the most direct possible: representative villages were selected and a complete inventory of all goods available in village stores was conducted. This was supplemented by visits to "shopping centers," the next highest level of goods availability in nearby larger cities. Emphasis was on the documentation of the array of goods available and whether they were produced domestically or imported. Through use of a formal survey, changes in the shop inventory from the previous month were noted as were those items which were "slow movers." However amounts of the different items and their prices were not emphasized. Shopkeepers problems and complaints were also recorded.

The validity of the approach demanded that the village selected for analysis be viewed by the government as representative. In this regard we benefited greatly from prior work completed by the NRC. In an exceptionally well-documented process of elimination, two villages were selected as representing a traditional village of the Nile delta and a village in the new lands area of Egypt. The explicit objective was to identify villages which could be studied over time to provide basic information for formulation of national economic policy.

Village inventory data was collected directly by the UC Davis principal investigator who was accompanied in the villages by Egyptian university faculty and graduate students. The approach was to legitimize the study with village leaders and then visit all shops in the company of the leaders. Complete coverage of all shops was greatly assisted by a list of shopowners and types of shops provided by the NRC based on their earlier survey work. Cooperation was excellent. With a few exceptions, shopkeepers allowed virtually complete freedom in "behind the counter" rummaging, provided access to private residences serving as "shops" (without house sales windows), and responded willingly to the survey questions.

EXPENDITURE ELASTICITY ESTIMATIONS

Using data provided by the NRC, expenditure elasticities were estimated for the villages of Omar Makram and Kafr El-Khadra.

Six different functional forms were estimated: 1) linear, 2) double logarithmic, 3) semi-logarithmic, 4) logarithmic inverse, 5) logarithmic-logarithmic inverse, and 6) inverse. Results varied considerably according to the functional form but for purposes of discussion and interpretation, the semi-logarithmic functional form was selected. Data were divided into roughly equal portions to define a "low" and "high" income group. Differences between the overall sample and the low and high income groups were examined. Estimates were derived for both income and income-plus-family-size specifications of the independent variables. Though the results should be interpreted cautiously given the statistical significance tests, they do indicate clear distinctions in consumption patterns among differing income groups—even at the village level (which may generally be viewed as fairly uniform compared to conditions of urban areas). Hence, what are luxury goods for some portion of the rural population are necessities for other portions of that same rural population.

VILLAGE SHOP INVENTORY OF GRASS ROOTS GOODS AVAILABILITY

Establishing expenditure data, such as that obtained through household budget survey instruments as outlined above, is time consuming, expensive, and requires considerable talent to elicit accurate responses. Furthermore, interpretation is made more difficult by the level of aggregation required—even for as detailed a set of information as that collected by the NRC. Moreover, the estimation procedure is demanding, the functional form selected depends on *a priori* researcher assumptions about the nature of householder consumption and characteristics, and the results are not always unambiguous.

The type of information which can be gathered through village store inventories is quite different. As an example, information for such data can be collected very quickly and inexpensively. A team of two or three could complete each of the two villages visited in approximately two days. Further, the information is highly reliable and self-verified by the data collector. Enumerator abilities play a lesser role in determining the final quality of the data.

Interpretation of results in the context of how well the data conform to the mass-consumption-goods-availability school of economic development, must ultimately depend on individual subjective judgment. In our opinion, an impressive array of goods is available to a rather small rural village (749 households) which is located a considerable distance from Cairo and is isolated by virtue of its distance from principal paved roads. Furthermore, we were impressed by the relative importance of domestically produced to imported goods. If this conclusion is accurate, it would appear to contradict the expectation that a country such as Egypt (which is not viewed as particularly exceptional in its degree of proletarianization) would be severely lacking in grass roots consumption goods.

A principal accomplishment of this project is the indication that the mass-consumption-goods-availability thesis is capable of empirical examination. Of course, representative villages are required for valid results.

We believe that the shop inventory accomplishments extend considerably beyond the suggestion that they provide a means to examine the consumer-goods-availability thesis. For example, the approach could serve to flag important areas of unavailable goods. For the example at hand, we would note a rather surprising lack of medicine and medical supplies and agricultural inputs. If important to policy-makers, this could suggest the need to probe further into availability in other areas and possible difficulties involved.

Inventory information could also be useful in preliminary deliberations about possibilities for altered industrial production. For example, we note that metal snaps for clothes are available only through import. We are not in a position to judge the comparative advantage situation for Egypt as a producer of such items, nor do we know the nature of supply in other villages. However, the potential for a rather large market would appear to exist, and further examination might prove that valuable information from store inventory approaches could improve upon more conventional "forward-backward linkages" approaches.

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INTEGRATED VILLAGE STUDIES AND POLICY EVALUATION

The planning of rural development projects in Egypt requires a better understanding of the expected beneficiaries than is currently available. The characteristics of the fundamental socio-economic units in the Egyptian agricultural sector—the family households—and how they interact with each other and with governmental and private institutions in land, credit and labor markets and in quasi-markets are only recently beginning to be explored. Very little is known about farmer attitudes, perceptions, motivations and goals.

There is, in addition, much dynamic change occurring in Egyptian agriculture. Incipient labor scarcity due to outmigration, rural electrification, and increased opportunities for female education are generating social and economic pressures which, together with mechanization, can lead to very fundamental changes in the rural society and economy. This potential for change needs to be monitored and understood if good government programs are to be formulated for improving the livelihood of rural poor while, at the same time, increasing food production and food deliveries to urban areas.

The Integrated Village Studies project has aimed at gaining an understanding of the village economy, society, and institutions and their linkages to the outside in order to develop models which will aid in government policy formulation and project design.

The project produced an extensive review of recent village studies work done in Egypt, prepared an annotated bibliography of research in this area, and contributed several papers dealing with the modeling of rural behavior and village decision-making.

The survey of the current state of knowledge about Egyptian villages emphasized the extreme diversity in village organization and structure throughout Egypt. Efforts were made to develop a classification of Egyptian villages according to their social origin, their present socioeconomic particularities and their place within Egyptian society.

The second objective of the project, to develop a village simulation model, was begun by the UC counterparts. The model being developed was an empirically based mathematical model constructed at the household level with key institutions (e.g., land tenure) directly incorporated and where possible, endogenous to the system.

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INDEPENDENT PROJECTS

Several research projects which did not fit into the major categories of Horticulture or Economics were implemented. Of particular promise were those concerned with food technology.

The White Soft Cheese Project sought to introduce new technology to improve quality and quantity of Domiati cheese. The team has succeeded in devising methods for expanding the production and lowering the cost of Domiati cheese using skim milk powder and locally produced vegetable oils as extenders. New mechanized procedures were developed to improve sanitary conditions, reduce manufacturing costs and speed up production. A method for recovery of edible protein from whey was established which offers a route for development of low cost, nutritious, cheese-like products. The basic process for preparing a new cultured dairy product (similar to buttermilk) has been developed and now awaits pilot-scale and consumer testing.

The Tomato Processing Project has provided equipment and trained MOA staff in concepts and methods for producing good quality tomato juice and paste. The new high yielding varieties of tomato have been evaluated and the groundwork laid for making choices of raw material on the basis of variety, growing location and season, and for providing a domestic product that can match the quality of imported tomato products.

The Improved Honeybee Project has laid the foundation for the sustained development of a modern beekeeping system. A bee genetics and breeding program has been established, complete with laboratory equipment and the instruments needed for artificial insemination. Personnel have been trained in modern beekeeping methods and in breeding theory and techniques. Most of the new hives with improved stock are in place and desirable future activities have been established involving not only research but also extension and the involvement of beekeepers.

The Sheep Reproduction Project has explored the feasibility of using easily measured temperature changes to detect estrus and pregnancy in sheep. The value of this lies in the economic advantages to farmers who can then supplement the rations of pregnant ewes to insure high lamb survival or to offer the ewe for mating again if conception did not occur earlier. Experiments are continuing under field conditions prior to demonstration and extension of results.

The Small Power Unit Project is aimed at developing a solar power unit suitable for low lift irrigation for small farmers. Since the intention was to produce such units locally, the design specified construction and maintenance using local facilities. A prototype Stirling cycle engine was constructed powered by solar energy collected by large metal parabolic reflectors. The efficiency of the engines, constructed in a simple manner, was too low to warrant continued work on them so the project has investigated alternatives.

BREEDING IMPROVED HONEYBEES

Beekeeping in Egypt is typically a small farm activity, with the honey and wax providing important supplements to household income. However the major value of bees lies not in the benefits that accrue to their owner in the form of honey and wax, but in their contribution to pollination of the crops in the surrounding areas. In Egypt where arable land is severely limited it is highly desirable to have every plant yielding its maximum, and where a fruit is the product, honeybees must be involved. Adequate pollination of most crops can probably be achieved if there are simply enough bees for the task. Provision of this is likely to hinge on the immediate profitability of hives to the owner derived from sale of honey and wax. At present the yield per colony is very low, chiefly because of inferior stock, but also as a result of antiquated beekeeping methods. There is a clear potential for improving both yield and quality of honey production. An improvement in yield leading to increased incomes from beekeeping is likely to result in proliferation of hives, ensuring thereby more complete pollination of crops and heavier fruiting.

This project has aimed at originating an improved breed of honeybees in Egypt, improved yields of honey, and at providing a cadre of scientists and technicians trained in bee breeding and modern beekeeping methods.

ACCOMPLISHMENTS

The project was started essentially from nothing. There were no available hives, no available bees, no shops or laboratories, no trained personnel, and no scientific knowledge of beekeeping in various parts of Egypt nor of beekeeping resources. It was necessary to weld personnel from Ain Shams University and the Ministry of Agriculture into a research team while the surveys were being made and the equipment was being procured.

To gain an understanding of the beekeeping situation as it existed in Egypt at the time of inception of the project and to outline a solid program to meet the real needs, Drs. H.H. Laidlaw, M.A. El-Banby, and M.M. Ibrahim made a preliminary survey in November 1979. One feature revealed by the survey concerned the selection program with Carniolan bees which has been pursued for approximately 10 years by Dr. Ibrahim of the Ministry of Agriculture. Two oases in the New Valley region had been used as isolated mating stations, and had proved to be very effective for mating control of the queens. However, because the basic population of bees consisted of only seven colonies, the loss of sex alleles had been severe and had resulted in degeneration of the quality of this stock which later became the foundation stock for queen rearers in Egypt. Dissatisfaction with this stock and dislike of the native Egyptian bee, *Apis mellifera lamarckii*, tempted Egyptian beekeepers to import European bees, especially Italian and Carniolan. Restrictions placed on bee import by the Ministry of Agriculture were ignored and the parasitic mite, *Acarapis woodi*, accompanying the imported bees from Europe was introduced into Egypt. It has subsequently spread through much of the Nile Valley and the Delta on queens and colonies sold by bee rearers. It is probable that this mite will never be eradicated. Making high quality disease-free stock available to the beekeepers would eliminate casual importations and thus the danger of introducing even more serious diseases.

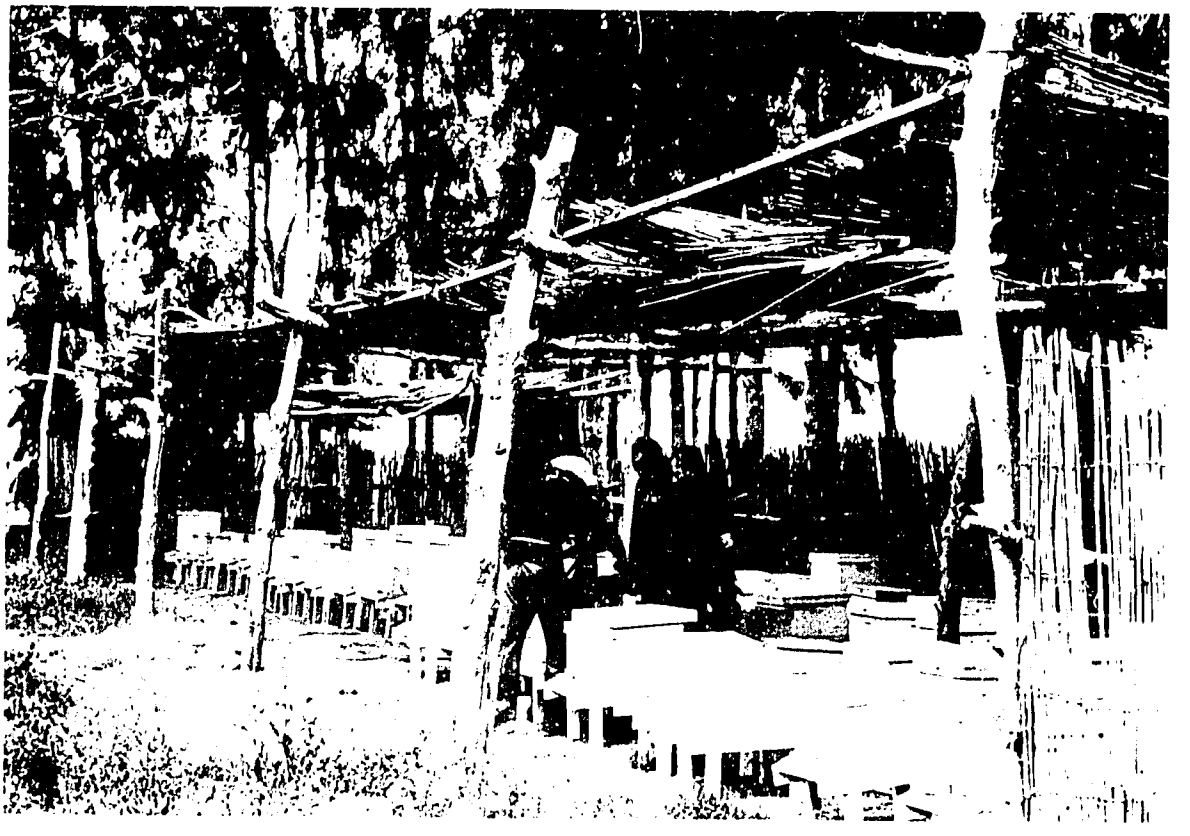
The work undertaken was, therefore, primarily a program to establish and breed a stock of high quality bees that are disease free and which would be available to Egyptian beekeepers. The establishment and breeding of such a stock involved identification of areas suitable for the work, procurement of equipment, supplies, and initial stock, selection and training of personnel in both theory and in practical skills, development of teaching resources, actual breeding operations, development and testing of beekeeping methods needed for efficient use of improved stock, publication of research results, and upgrading beekeepers' and instructors' knowledge and skill necessary for efficient utilization of improved stock and the realization of benefit from their use. The latter necessarily includes processing, packing, and marketing of honey and other hive products. The work we have undertaken in this project has addressed all these issues and has laid the basis for a modern beekeeping industry in Egypt.

Visits were made to the Delta, Nile Valley, oases, and the Suez area to obtain on-site knowledge of the suitability of various locations for the bee breeding program. Appraisals were made of current beekeeping operations and practices, the presence of bee diseases, pests, predators, and parasites, the extent of pesticide dangers, adequacy of melliferous flora, availability of satisfactory local labor, support of local officials and beekeepers, accessibility from Cairo, and whether and where other programs are operating.

The west side of the Suez Canal, in and around Fayed where citrus and clover are grown in quantities adequate for this project, was chosen as most suitable for the location for the project apiaries. This region had very few bees so that the project had freedom to locate apiaries as desired.

The key to establishing a source of improved honeybees lies in the project's program for artificial insemination, genetic selection, and queen rearing. Artificial insemination is essential because virgin queens mate only in free flight and selection of their mates by man is impossible when queens mate naturally. Imported, improved semen has been used to help in upgrading the colonies.

Closed populations were used for bee breeding rather than the inbred-hybrid system that has been popular for the past 40 years. Computer models showed that with



Project personnel examining improved breeding colonies of bees at the experimental apiary in Fayed. These ungraded colonies developed by the ADS Bee Project have an improved yield of honey and will provide the foundation for distribution of new stock to Egyptian beekeepers.

selection of 50 breeding queens each year from a closed population of 250 test colonies the vitality of the stock would not deteriorate in 40 generations (40 years), even with normal selection, provided that daughter queens from each selected breeding queen are mated to semen from a mixture of drones from every selected breeding queen. In this situation every queen has all the sex alleles of the closed population in her spermatheca, and the likelihood of losing sex alleles is minimal.

A further benefit of such a breeding system is that the most outstanding queens have genotypes that produce genomes which combine best with the greatest number of different kinds of other genomes. Drones from such queens carry the favorable genes undiluted by genes from the queens' mates and can be used for "top crosses." Emphasizing the hermaphroditic ability of a queen bee to be both mother of a colony and father of other colonies (by means of her drones mating with other queens) provides innovative ways to approach bee breeding.

The 150 colonies of bees, constituting a closed breeding population, have been established, and are now being upgraded using imported semen. Artificial insemination is regularly performed by Dr. Mazeed from the Ministry of Agriculture and Mr. El-Sherif from Ain Shams University. Tests on live nuclei have indicated that these small colonies are practical means of expanding the number of colonies in Egypt if they are abundantly supplied with pollen.

Studies were also pursued on flora, feeding, queen and drone rearing, as well as tests of hive nuclei. Dr. El-Banby's floral studies brought to light the threat to bees posed by feeding in treated cotton fields. A variety of cotton grown in Fayoum has six external nectaries on the outside of the calyx. Nectar secreted by these nectaries is vulnerable to contamination by insecticides and thus is poisonous to bees. Beekeepers are being made aware of this danger.

The project team has examined the desirability of assisting beekeepers who keep bees in mud hives to use better methods of harvesting and processing honey. Mud hives are very important to the poor people in the villages and they can be made for the cost of labor only. Swarms stock them naturally, and the honey produced is largely profit. In addition, the mud hives are scattered among the farmers and they constitute a little-recognized permanent pollination force for the crops of an area. In many areas imported bees for pollination purposes are not needed. Native Egyptian bees are suited to the mud hives and should be kept as a race; elimination of these hives or the replacement of the Egyptian bee with European bees would be a mistake at this time. However, better methods of harvesting honey from mud hives and of processing and

packing the honey should be taught with an emphasis on sanitation.

At the conclusion of the ADS project, the bee genetics program was well established. A large proportion of the hives needed for the breeding program are on location and additional ones were being established from hive nuclei. Shop equipment necessary for beekeeping and experimental items was available and in use. Laboratory equipment needed for artificial insemination was complete and was being used by trained Egyptian staff. Personnel have been trained both in modern beekeeping methods and in bee breeding theory and techniques. Desirable future activities have been established which involve not only research, but also extension and involvement of beekeepers. In short, the foundation is in place for the sustained development of a modern beekeeping system.

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THERMAL DETECTION OF OVULATION AND PREGNANCY IN SHEEP

Early detection of pregnancy and ovulation in domestic animals is an extremely important management tool in livestock husbandry, with potential for significant economic impact. By early detection, for example, a separation of the pregnant animal, (fed on special costly diet), from the rest of the flock will reduce consumption of highly expensive and scarce feeds. This would bring about savings in both feeds and management care, as well as ensuring higher survival rates in the newborn.

Experiments have indicated that the mammary gland responds to an increase in the level of circulating estrogen (at estrous and in pregnancy) with a rise in the temperature. Further, experiments comparing the ewe's udder temperature with that of other body regions indicate that the udder is not an organ of controlled heat loss in the sheep and so does not function as an agent of thermoregulation. The temperature of the ewe's udder thus appears to have real potential for use as a simple and very inexpensive way to detect changes in the level of circulating estrogen. Should such prove to be the case, temperature measurement could become a valuable tool in animal husbandry, providing a means of anticipating ovulation thus enhancing the correct timing for artificial insemination, as well as the early detection of pregnancy.

This project has embarked upon studies to confirm, under Egyptian conditions, relationship of udder skin temperature with the estrous cycle and pregnancy, and to provide the basis for a cheap and simple technique available to livestock producers.

ACCOMPLISHMENTS

THERMAL CHANGES DURING THE ESTROUS CYCLE IN BARKI EWES

Nine Barki ewes were used in this first experiment. The animals had been brought to the laboratory a year prior to the experiment from the northern desert of Egypt. At the time of the experiment the animals were located at the Desert Institute Experimental Station, near Cairo. Throughout the experimental period (February 1982–May 1982) the animals were kept in a controlled environment which was achieved by using an air conditioned room and fans to remove excess humidity. No effort was made to control the lighting hours. Animals were offered food and water *ad lib.*

Temperature measurements were taken daily at 0900 hours on the animals, and focussed on the temperatures of various organs, including: left and right ear skin, back skin, right and left lower leg skin, right and left udder skin, abdominal skin, and rectum.

A ram fitted with a marker was kept with the ewes, and behavioral estrous was determined by the willingness of the ewe to be served by the ram. Thirty-seven estrous cycles, ranging in length from 13 to 33 days, were recorded. Data are being compared with earlier work suggesting that an increase in udder temperature might be anticipated prior to estrous.

THERMAL CHANGES IN PREGNANT BARKI EWES

Twenty-one Barki ewes, obtained and housed as were the ewes in the first experiment, were used in experiment #2 to determine the most useful thermal indicator of pregnancy.

Rectal temperature, respiration rate, right and left udder skin temperatures, lower leg temperature, ear temperature, abdominal and back temperatures were measured weekly, at 0900 and 1400 hours on the day of measurement over an eight month period, June 1981–February 1982. The animals were not disturbed except at the times of measurement, feeding and watering. Food and water were provided daily at approximately 1000 hours.

Measurements were begun two weeks before the beginning of the breeding season. Rams were left with the ewes for the duration of the breeding season, which started July 1st and lasted for 51 days. Colored grease was applied to the ventral surface of the rams so that ewes would be marked when mounted. Ewes were checked daily for mating and dates of mating were recorded for each ewe. The first measurement day following conception and the first week of pregnancy were calculated after delivery to identify the specific mating which had resulted in conception. Weekly measurements were continued for four weeks after delivery. Summarizing the results briefly, both udder and rectal temperatures rose steadily during pregnancy, udder temperature rising somewhat more steeply than did rectal. Neither temperature however was significantly affected by changes in ambient temperature. The difference between rectal and udder temperature declined steadily during pregnancy, as expected from the slopes cited above.

Though ambient temperature did fluctuate moderately during the experiment, it was essentially unchanged between conception and parturition. It is therefore possible to compare the slopes of the temperature changes during pregnancy for the variables measured. Rectal temperature was least (1.2%), followed by back temperature (2.6%), abdominal temperature (2.9%), leg temperature (3.5%), and ear temperature (4.9%). Udder temperature (5.6%) showed the greatest slope of any measured temperature and thus provided the best thermal indicator of pregnancy.

In contrast to udder and rectal temperatures, both respiration rate and the other skin temperatures were clearly influenced by ambient temperature. These variables all showed both steady increases during pregnancy and responses to fluctuations in ambient temperature.

Following up on the results obtained in the study of thermal changes in pregnant Barki ewes in a controlled environment, a large-scale field study was conducted on a herd of Barki ewes. Focussing on similar thermal variables as in the earlier study, this experiment measured the skin temperatures of various organs before and during pregnancy. The data from this study are still being compiled in Cairo; they will subsequently be analyzed in the Human Physiology computer laboratory at UCD (Advanced Physiology Simulation Laboratory) and a manuscript prepared for publication. It is also anticipated that the data from both the controlled environment and field studies will provide a data base for a simulation study of thermoregulation in the pregnant Barki ewe.

THERMAL EFFECTS OF REPRODUCTIVE HORMONES ON BARKI EWES

The purpose of this series of four related experiments was to strengthen the case for using temperature measurement as a basis for detecting estrous and pregnancy. It is well known that blood estrogen levels rise at such times, and if artificially raising estrogen levels induced a similar temperature response, it could be inferred that temperature variations are indeed linked to estrous and pregnancy through mechanisms involving estrogen.

Eleven Barki ewes were used in Experiment A. The ewes were divided into two groups, an experimental group injected with 1.0 mg estrogen in 0.5 ml artichoke oil and a control group injected with 0.5 ml oil. All animals were kept in the controlled environment described for previous studies. Rectal temperature, respiration rate, udder skin temperatures, ear temperature, abdominal and back temperatures were measured prior to injection of estrogen, ½ hour after injection, and 4 and 8 hours after injection.

Four Barki ewes used in Experiment B, were injected with estrogen at four day intervals, the first day being the second day of estrous. Variables measured were as for Experiment A, measurements being made following injection, 4 and 8 hours after injection.

Twelve Barki ewes were used in Experiment C. As in Experiment A, the ewes were divided into experimental and control groups, the experimental group being injected with varying (0.5 mg, 1.0 mg, 2.0 mg and 3.0 mg) quantities of estrogen in oil and the control group with oil alone. Injections were at weekly intervals, and measurements were as for Experiment A.

The same six animals of the experimental group in Experiment C were used in Experiment D. These ewes were injected with 5.0 mg. progesterone, then one week later were injected with 10.0 mg progesterone followed by 1.0 mg estrogen. Measurements were made as for Experiment A.

Summarizing the results of these experiments very briefly, Experiment A showed that the injection of 1.0 mg estrogen caused increases in udder temperature, back and leg temperatures which were significantly above the circadian increase in these temperatures as indicated by the control group's measurements. Rectal temperature, respiration rate, abdominal and ear temperatures showed only circadian changes in both control and experimental groups.

Analysis of the data from Experiment B showed that the phase of the estrous cycle at which the injection was made did not affect the response to injected estrogen, indicating that the results of Experiment A may be considered typical of the Barki ewe's response to this injected hormone regardless of the phase of the estrous cycle. It was also noted that the 0900 measurement of udder temperature was lower on the second day of estrous than on the days of the cycle at which measurements were made.

The results of Experiment C, the dose-response experiment, showed that, although all four dosages led to the same maximum increase in udder temperature, the time to maximum increase did vary with the dosage. The maximum increase, 1.1–1.5°C, was obtained after 4 hours with 2.0 and 3.0 mg injections of estrogen; similar maxima were not recorded until 8 hours after the 0.5 and 1.0 mg injections. No clear dose-response relationship was found for back temperature, although increases were observed at both 4 and 8 hours. Significant increases in the other variables were not found, as anticipated from the results of Experiment A.

Experiment D showed that udder temperature was not affected by the injection of 5.0 mg progestrone. A 1.1°C increase in udder temperature was recorded at 4 hours, less at 8 hours, in response to the injection of 1.0 mg estrogen combined with 10.0 mg progesterone. Rectal temperature did show an increase in response to the progesterone injection (0.7°C at 8 hours, compared with 0.2°C for the control group). Rectal temperature increased by 0.5°C at 8 hours in response to the injection of estrogen plus progesterone. No significant differences were found in leg or ear temperatures or respiration rate at any time regardless of the injection (estrogen, progesterone, estrogen plus progesterone, or control).

The results of this experiment demonstrate that Barki ewes respond to injections of estrogen and progesterone in a manner similar to that reported for Merino cross Finnish Landrace ewes, and demonstrate further that the response to estrogen is independent of the phase of the estrous cycle and establish a dose-response relationship for the response. The data also show that back temperature appears to respond to injections of estrogen, albeit without the clear dose-response pattern found for udder temperature, a finding not previously reported.

DEVELOPMENT OF A SMALL POWER UNIT FOR IRRIGATION

A feature of the design for irrigation canals in Egypt is that they are lower than the fields they are intended to irrigate, thereby precluding water distribution by gravity feed. Low-lift water pumping in consequence is widespread, and commonly relies on the Persian water wheel (*Sakia*) powered by buffalo, cattle or donkey. Typically the amount of power required to pump water with a *Sakia* is in the order of a quarter horsepower since the height to which water must be lifted is only 1 to 3 meters. These low power requirements imply that the use of diesel powered pump sets of 7 horsepower or more, as is common, introduces large overcapacity when used in the existing irrigation systems.

The purpose of this project was to investigate the potential for a unit of approximately one horsepower which could substitute for animal power in driving the *Sakia*. A power unit of this size would be well matched to the application and there would be no need to change either the present irrigation system or its attendant social organization as is implied in the use of diesel pumps.

Soon after its inception the project conducted an energy survey to determine the most appropriate power sources for low-lift irrigation. It was evident that if an alternative source of power for water lifting could be substituted for animal or human power, significant animal and human energy could be released for more productive uses. The increasing use of electric and diesel pump sets was examined. In addition to being inefficient by virtue of being overpowered for the job, and demanding foreign exchange for purchase and running costs, their use was found to be based on a large government subsidy which covered their purchase but not maintenance. Aside from false economics, many sets were out of commission for lack of adequate maintenance and repairs. There seemed a *prima facie* case for designing a simpler power source that could be operated cheaply without incurring foreign exchange costs as well as being suitable for local manufacture. Two energy sources appeared to meet these requirements: solar and crop residues. Use of the latter, whether in direct combustion or after passage through a biogas converter, might present a problem of competition with its use as a household cooking fuel. Solar energy, on the other hand, is both abundant in Egypt, especially at times when irrigation is most needed, as well as being freely available. The project accordingly embarked on development of a solar powered engine of the well established Stirling type, which could drive the *Sakia*. The Stirling closed-cycle vapor engine envisioned by the project's team was a low horsepower unit which would be driven by heat energy supplied from simple parabolic solar reflectors.

The work was divided between the UC Davis team who developed the power unit, and a team from Alexandria University who were responsible for the design of the solar collector. Design criteria followed throughout the project were that both components should be capable of local manufacture, be inexpensive and easily maintained.

ACCOMPLISHMENTS

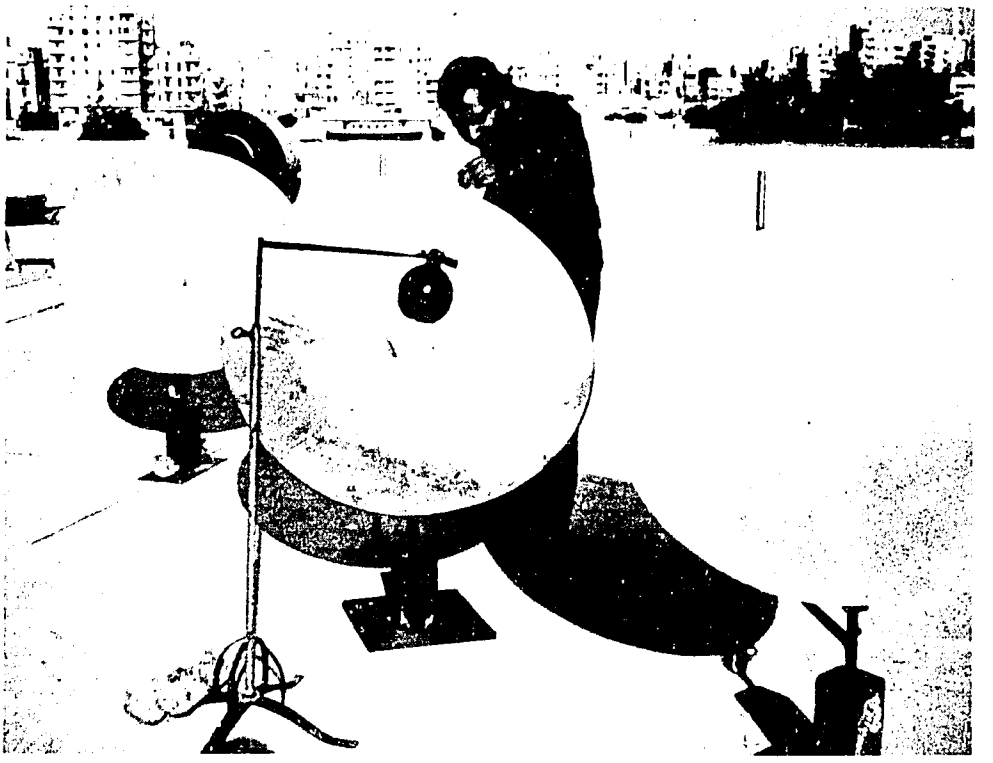
Design of the solar collector began in June 1981. A dish-type design was selected and investigations were begun to determine a collector size appropriate for a one horsepower output hot-air engine, and to choose possible materials for use in the manufacture of the concentrator.

The Egyptian team constructed their first prototype collector from aluminum sheets one meter in diameter. It was built by a local artisan to their specifications using the same method used to make cooking vessels, that is, using metallic and wooden hammers to beat the aluminum sheet into the desired parabolic shape. This hand method proved insufficiently precise, and resulted in a concentrator with a relatively large focal area. Without a well-defined focal area, it is impossible to obtain efficiencies which are high enough to provide useful heat output.

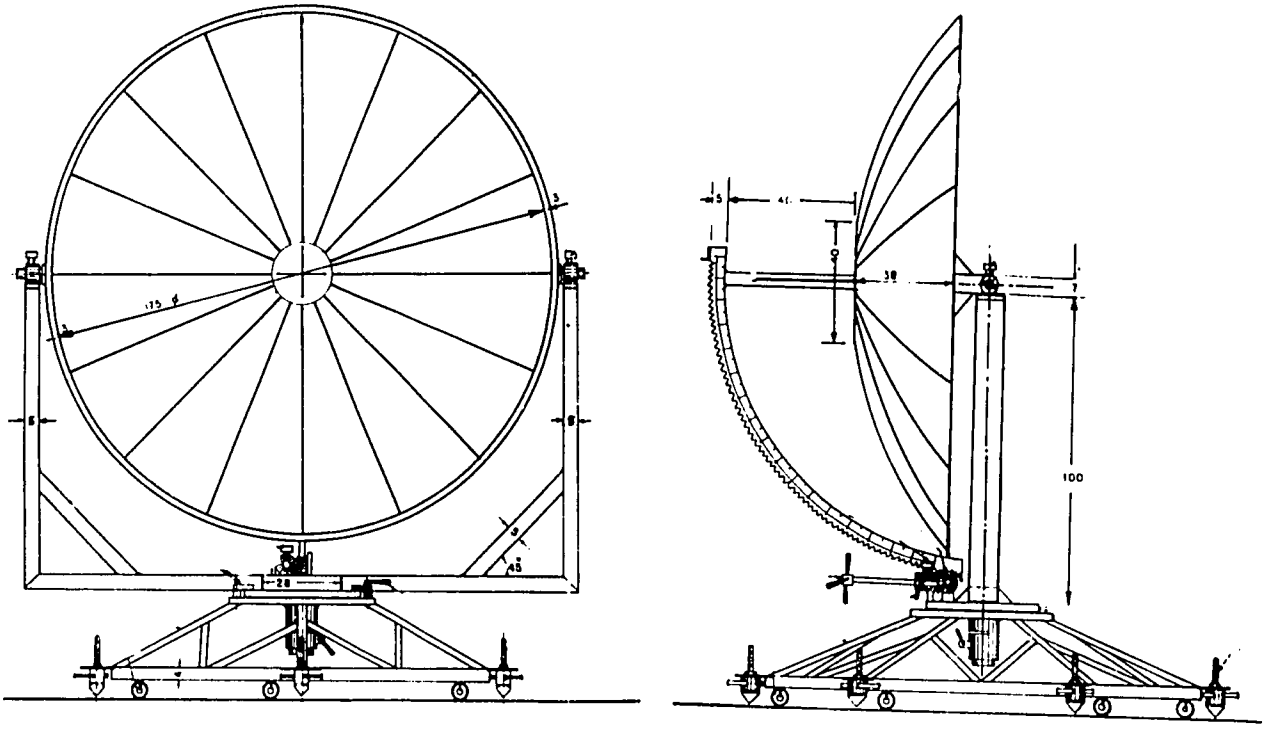
Greater precision in construction, using a different technique, was attained in the design of a second concentrator. Templates were used to inscribe patterns onto the aluminum sheets which were then cut out and the resulting segments were bent, folded, and riveted together into their final parabolic form. A third design of concentrator used the same construction technique but with the addition of a strengthening steel strip around the perimeter of the aperture to give it more rigidity.

A systematic series of experiments was carried out in order to assess and improve the efficiency of the overall collector and receiver system. The efficiency of the first concentrator was only about 12.5%. In comparison, the efficiency of the third concentrator design was always higher than that of the first and, with a non-painted glass heat receiver on the Stirling engine, its efficiency was about 19%. The design of the receiver was then changed to use copper instead of glass. With a coat of black paint and with better insulation between the receiver and the carrying frame, performance improved significantly. With a 21.3 cm copper receiver the efficiency increased to about 45%.

The main problem that confronted us at this stage was how to improve the concentrator-receiver unit to obtain the high temperatures needed for operation of the hot-air engine while using the modest and less accurate local manufacturing techniques. High precision is needed not



Concentrators I, II, and III illustrate progressive improvements in design and construction primarily in greater manufacturing precision and greater structural rigidity.



Concentrator IV schematic and relevant dimensions.

only to obtain high tempertures, but also because the thermal efficiency decreases as precision decreases and thus concentrator sizes have to be increased in order to develop the required power. As concentrator size increases the cost of manufacture rises and wind forces begin to play a major role in the design. A compromise was struck in the development of a larger concentrator (1.75 m in diameter) designed with greater structural rigidity and hence higher accuracy than the previous concentrators. It was constructed from two 1.5 mm thick aluminum sheets, compared to 1 mm thick sheets for the smaller concentrators. In order to obtain higher precision, greater care was taken to reduce manufacturing errors and the template used to lay out collector patterns on the aluminum sheets was constructed according to a more exact mathematical equation. Greater rigidity was obtained by riveting iron strips to the back of the concentrator and around the circular perimeter of its aperture.

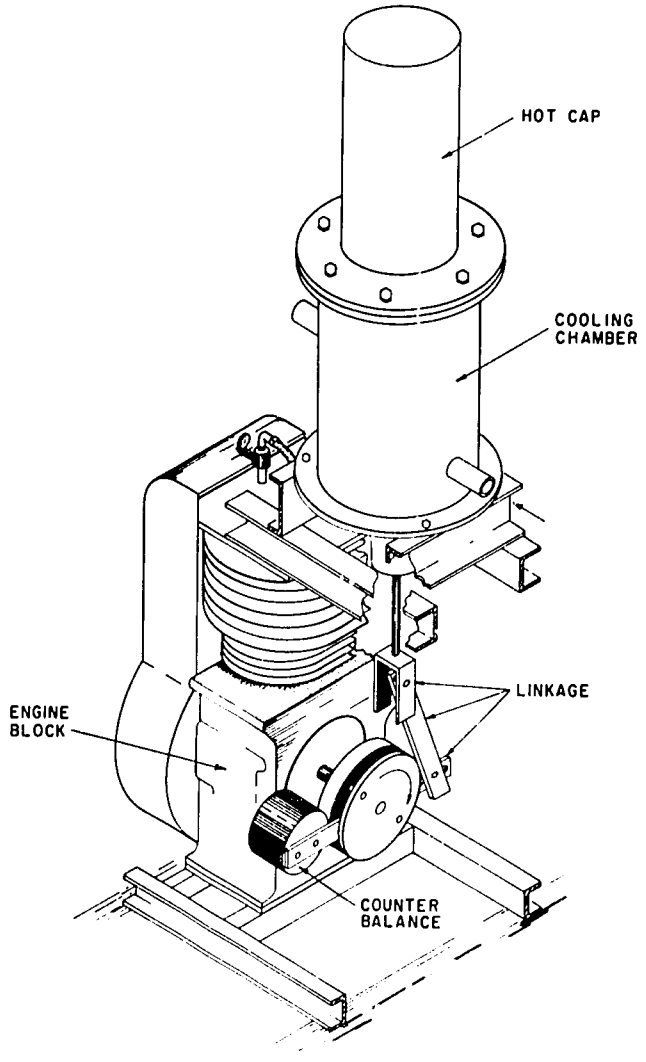
The support structure and tracking mechanism were improved by making the whole concentrator support structure a fixed one and by designing a complete new tracking system which incorporated high strength, ease of operation, and high precision. The new tracking system consisted of a steel hexagonal base supported by six precision leveling screws and six caster wheels for mobility. With this system, precise control of both the latitude (elevation) and azimuth angle was possible.

The tracking accuracy of the concentrator was evaluated by carrying out a number of experiments where the elevation and azimuth angle, as measured on the tracking system, were compared to the theoretical values for the city of Alexandria. The difference between the measured and calculated values did not exceed 0.5% for the azimuth and about 1% for the elevation angle. It is worth noting that the local time of solar noon is known exactly and is published every day of the year in most Moslem countries since it is directly coupled to the observance of the noon prayer. Thus the solar time can be obtained directly by subtraction from the local noon time for the city of Alexandria instead of going through the long calculation which relates local time to the solar time.

Although the Egyptian team started to built a 4 m diameter concentrator, they found that the cost would be very high because of the heavy supporting structure required. The team has proposed that a series of 1.75 m solar concentrators working in parallel would be more practical, easier to maintain, and tracking adjustments would be easier to make.

A second solar concentrator of 1.75 m diameter is therefore being built to enable testing of both 1.75 m collectors working in parallel. Plans are also underway to investigate further the optical performance of these two concentrators by examination of the temperature distribution in the focal plane, to calculate the intercept factor for each receiver size, and to carry out heat balance experiments. Such experiments would result in an estimate of the accuracy of the local manufacturing of the receiver.

The concept of using standard materials which are locally available in Egypt for building the solar concentrators was also emphasized in the development of the prototype Stirling engine built by the UCD team. A cardinal rule was that sophisticated and high precision machining of components was to be avoided.



The closed-cycle, hot-air engine. Assembly drawing of prototype II showing displacer cylinder and hot-cap above and working cylinder below. The lower portion of the engine utilizes a recycled engine block and the upper portion is fabricated from pipe stock and flat standard steel stock.

Two prototype engines were designed and built. The first had some serious design flaws which were eliminated in the second prototype. The result was a significantly improved engine which operated successfully but the net power output was very low. Problems included lack of efficient sealing, poor heat transfer, and an inability to pressurize the system to more efficient levels without the use of more exotic seals and expensive materials. The US team felt that it was not feasible to continue development of the Stirling engine utilizing only the simplest possible technology. Improved thermal efficiency could only be obtained at the sacrifice of simple design and inexpensive materials. This would be contrary to the original objective of the project. During the past year, two major automotive

manufacturers have abandoned their research programs on high-technology types of Stirling engines, lending some credence to our opinion that the benefits of the Stirling engine do not overcome its drawbacks. One consequence of these findings was that the scope of the research was broadened and alternatives to the Stirling hot-air engine were examined. In particular the team has investigated the use of the fluidyne or oscillating liquid drive pump and a similar vapor cycle pump. Both of these devices can utilize energy from either solar sources or from combustion of agricultural residues.

Investigations were begun on the design and fabrication of liquid piston oscillating drive pumps, the use of which would eliminate moving parts and would make the whole solar water lifting power unit much cheaper and easier to maintain. The first prototype was built and tested near the end of 1982 both in the laboratory and with the solar concentrator. Its discharge rate was very low (1 liter/min) but the total head was very large. Research is proceeding to improve its efficiency and to increase its discharge rate while lowering its total lift.

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AGRICULTURAL LAW STUDY

An important aspect of agricultural policy making is to incorporate features that encourage farmers to behave in ways supporting policy objectives. Economic incentives are frequently employed and a major concern of the Economics Sub-Project has been to develop an understanding, in terms of economic rationality, of why farmers behave as they do.

But economic rationality is only one dimension of understanding the grower's decision-making process. The law, and how it is applied and administered, is another vital component that molds a farmer's behavior. This is especially so in Egypt where cropping quotas and administered prices are policy instruments upheld by agricultural laws.

ADS commissioned a study on Egyptian Agricultural Law by Dr. John Spanogle from State University of New York-Buffalo in order to provide the project with both context and insight on the role of agricultural laws in determining production and marketing decisions.

Dr. Spanogle's work has been prepared for publication and is currently available at the International Programs Office, UC Davis.

INDEPENDENT WORKSHOPS AND CONFERENCES

Workshops have been used by most ADS projects as a forum for discussion of research problems and dissemination of project findings among Ministry, university and ADS personnel. In this report such workshops have not generally been singled out for special mention, since they were integral components of projects or sub-projects.

ADS did, however, sponsor two workshops which were independent of other ADS projects, namely the Biosalinity Conference and the Food Sanitation Workshop.

THE BIOSALINITY CONFERENCE

A conference involving Egyptian, Israeli, and US scientists was held at the University of California, Davis, California, September 1–4, 1981. The conference was sponsored jointly by ADS and the Fred J. Hansen Institute for World Peace, San Diego.

The focus of the conference was soil salinity in agriculture, a problem which occurs in many areas in the countries of the participants. Three areas discussed by the researchers were:

1) Physical-chemical characteristics of saline soils and the management of these soils;
2) Crop responses to application of saline and brackish waters;
3) Breeding of crop plants to enhance salt tolerance.

Recent research in these areas was summarized and the application of these results in management of saline lands was discussed. The individual papers have been abstracted and are available.

THE DAIRY AND FOOD SANITATION WORKSHOP

As part of the growing Egyptian interest in food technology projects, ADS sponsored a workshop held in Cairo September 5–9, 1981, on the topic of Dairy and Food Processing Plant Sanitation. Drs. Bruhn, York, Dunkley and Shehata provided a comprehensive technical update on the underlying principles in establishing effective sanitation in food manufacturing facilities. Using a workbook specially prepared for the occasion and visual aid materials, information was presented to participants in ways that should facilitate its extension to others.

TOMATO PROCESSING

The tomato occupies a major place in the Egyptian diet. Though the fresh tomato, eaten either raw or cooked, accounts for the overwhelming use of the fruit, an increasing amount of tomato paste is now consumed. In 1980 this amounted to about 18,000 tons, of which some 12,000 tons were imported.

Two major domestic food processing companies, Kaha and Edfina, are involved in producing tomato paste, and have a combined production capacity of around 22,000 tons per year. These companies operate their tomato processing units at only 25% of capacity; the principal reason is shortage of raw material. Clearly, utilizing this potential capacity would not only capitalize on investments already made in plants, but would also conserve the foreign exchange used in importing paste to make up the deficit from domestic production.

Introduction of new high yielding varieties of tomato by the ADS Tomato Production Project has offered the promise of much increased yields per feddan. In fact, by the time of termination of the ADS Project, commercial growers using new cultivars and cultural practices were already obtaining yields some three times greater than was normal with former production technology. The potential surge in production of both table and processing tomatoes provides opportunity for Egypt's tomato paste industry to obtain the raw material that has been constraining production, and operate closer to full capacity to supply the needs of the domestic market.

To make this possible, the objectives of the Tomato Processing Project were:

- to evaluate the suitability for processing of the new high yielding tomato varieties grown under Egyptian conditions;
- to evaluate tomato products processed from the new varieties emphasizing wholesomeness of product, color, texture, flavor, mold count and insect fragments;
- to cooperate with tomato processors in testing suitable varieties on a pilot and commercial scale and to reduce the cost of production;
- to establish a quality control system for tomato selection, handling, grading and product testing.

ACCOMPLISHMENTS

Evaluation of fresh tomatoes and their processed products was conducted on a number of new cultivars introduced by the project. Varieties tested for fruit qualities and suitability for processing are shown in Table 1.

Tomatoes are harvested in Egypt at two peaks, winter and summer. Since the characteristics of fruit vary with season, the project investigated the properties from each harvest, with emphasis however on the heavier yielding summer crop. The growing location also introduces variation in tomato quality and therefore we evaluated fruit from farms at two locations, Kanatir and Nobaria, in the vicinities of Alexandria and Cairo respectively.

Table 1. **New Tomato Cultivars Evaluated for Processing in Egypt**

Variety	*Growing Area*			*Variety/Type*
	Kanatir Season		*Nobaria Season*	
	S	*W*	*W*	
UC 82	*	*	*	Processing
E 6203	*	*	*	Processing
PETO 86	*	*	*	Processing
Cast long	*			Processing
UC 97-3	*		*	Fresh Market
UC 211-58	*			Processing
VF-145 B 7879	*			Fresh Market
XP-502		*	*	
VF-134		*	*	
E 1205	*			Processing
Rossol VFN	*			Processing
E 9208	*	*	*	
E 9209	*			Processing
FM 61012	*	*	*	Processing
PETO 95	*			Processing
PETO 96		*	*	
PETO 98	*			Processing
UC 204-9	*			Processing
Castlex 48960	*	*	*	Fresh Market

EVALUATION OF FRESH TOMATOES

Harvesting: The fruit of varieties grown either at Kanatir or Nobaria showed different degrees of maturity at the time of picking. It is important that fruit for processing should have uniform ripeness. More than one picking is therefore recommended for obtaining sound and ripe tomatoes by hand harvesting. However, when a contracting system is developed, and large scale cultivation of tomatoes is introduced, then mechanical harvesting may be preferred. In this case the need for spraying with ethephone to initiate uniform ripening and the effects of such a treatment on the quality of tomatoes should be studied.

Size and Weight: There was some variation in weight of individual fruits within variety: the maximum weights within variety ranged from 46 ('UC 97-3') to 143 gms ('Castlex 489G'). The average weight per fruit ranged between 37 ('Peto 86') and 88 gms ('Castlex 489G').

The count of fruits per kg ranged between 27 ('Peto 86') and 20 ('UC 97-3'). The size, weight, and counts/kg of fruits varied widely between varieties and also with the growing area and season. Such properties are important in relation to harvesting techniques but have little affect on the subsequent processing stages.

Vitamin C Content: The vitamin C contained in tomatoes can make a significant contribution to a consumer's daily requirements. Selection of tomato varieties high in ascorbic acid is therefore an important nutritional consideration. Values in the order of 15–20 mg of vitamin C per 100 gms of fresh tomatoes is considered satisfactory. Recorded values for varieties grown under Egyptian conditions varied from 6.8 mg/100 gms for 'Rossol VFN' (Kanatir, summer crop) to 21.2 mg/100 gms for 'E 9208' (Nobaria, summer crop).

Solid Content: Solid content is considered an important parameter in production of tomato pastes because it affects the case yield and the cost of evaporation. Values ranged between 3.5% ('VF 145B–7879') and 5.46% ('UC 82' and 'E 6203'). The growing area and season also had an effect on total solid content. The following varieties are considered suitable for production of tomato pastes from the standpoint of their total solids content: 'UC 82B', 'E 6203', 'Peto 86', 'VF 134', and 'E 9208'. 'UC 82B' and 'E 6203' contained high total solids when grown in the Nobaria area. The 'Peto 86' variety was best when grown in Nobaria as a winter crop.

In general, the total solids of the recommended varieties were higher when grown in areas with soil and climate conditions similar to those prevailing in Nobaria.

The varieties suitable for both juice and paste production are 'UC 82', 'Peto 86', 'VF 134' and 'E 9208' which contained no less than 5.0% total soluble solids. The difference between total solids and total soluble solids represents the insoluble solids, largely fibers and pectins. The 'E 6203' variety was high in insoluble solids. Varieties with high total solids and total soluble solids are preferred for processing into pastes.

Alcohol Insoluble Solids (AIS): The AIS content of tomatoes is important as a measure of ability to yield viscous products as canned juices or pastes. AIS values showed minor variation among the varieties investigated, ranging between 0.641 and 0.817% on a fresh weight basis.

Total Acidity and pH Value: The pH during processing is of crucial significance to product safety: a final pH above 4.7–4.8 does not protect against botulism.

Generally, the industry prefers a tomato with pH at 4.3 or lower to be safe for processing. The measured pH value of some of the varieties was higher than 4.5. Therefore, if any such variety is chosen for processing because of other outstanding characteristics, it will be important to adjust the pH of the juice to 4.3 through acidification with citric acid.

Lycopene Content: The minimum lycopene concentration required to produce good product color is 6 mg/100 gms of fruit. Lycopene content of varieties grown under Egyptian conditions was several times higher than the minimum indicating that suitable color is not likely to be a problem. Some varieties grown in Kanatir for the winter season were low in lycopene however.

Reducing Sugars and Amino Nitrogen: Sugar and amino nitrogen content provide indices of quality that affect the flavor of the canned product. Measurements on both these parameters indicated satisfactory levels were present in most varieties.

The Total Pectin: The level of pectin in the tomato fruit contributes to consistency of tomato juice and pastes. Tomato pulp with high pectin content produces highly viscous pastes and may present a problem during evaporation on account of the low heat transfer coefficient of the tomato concentrates.

Total pectic substances of the tomatoes were found to vary widely among varieties. The pectin content of seventeen varieties grown in Kanatir during the summer season ranged between 125 and 325 mg/100 gms. The varieties grown in Nobaria ranged between 182.5 and 465 mg/100 gms.

Sensory Evaluation of Tomato Fruits: A panel of 12 judges focussed on color, texture and flavor. Statistically analyzed results indicated that the color and texture scores of the samples were very promising for the varieties tested; flavor however was considered poor in some varieties.

The summer crops showed better sensory quality than winter crops for the varieties grown in both Nobaria and Kanatir areas. The most acceptable varieties were found to be 'UC 82', 'E 6203', 'Peto 86' and 'FM 61012' which are suitable both as summer and winter crops.

Microbiological Examinations: Total counts (TC), and counts of thermoacidurans bacteria (TAB), flat sour bacteria (FBS), yeasts and mold were carried out on tomato surfaces, as well as on the juice after heat pretreatment. Analyses also included TC, TPC (total plate counts), TAB and FBS on canned juices after canning and after storage for 3 months. Canned juices processed from the winter crop contained much less TPC than those made from summer crop. The average TPC varied with the date of harvesting and location where the tomatoes were grown. Juices canned from the winter crop were found to be contaminated with very few live microbial cells or TPC, while the total count was in millions. The remaining live cells were only about 0.01% of the TC demonstrating the effectiveness of heat treatment.

It was observed that about 6% of the TC of the juices canned from the summer crops were still alive. Therefore, the efficiency of the heat treatment was evaluated after storage of the canned juice for 3 months. The data show that the microbial load was greatly reduced after storage of the canned juice.

Drosophila Eggs, Larvae and Insect Fragments: Eggs, larvae and insect fragments frequently contaminate tomato products and may threaten their acceptability on international markets. The surfaces of tomato fruits from the first winter picking were examined before washing to obtain information about the degree of infestation by Drosophila and contamination when received at the factory. Examination of the fruits from the second picking of winter crop after washing provided an assessment of efficacy of washing procedures. All samples were found to be free from contamination with the exception of 'Castlex 479KG' variety which contained 12 larvae per 100 gm indicating that larvae infestation was beneath the skin and could not be easily removed by washing.

The Howard Mold Count: This process indicates the soundness of fruits and depends on the efficiency of washing, sorting, and trimming operations. The results showed much improvement in the summer crop runs which were picked under stricter supervision.

Crude Fiber Content: The amount of crude fiber was determined on the fresh fruits, canned juice, canned paste, and the stored products. The fiber content of fresh fruits differed greatly between varieties, locality, and season.

The winter crop of 'UC 82' tomatoes from Kanatir contained 8.16% crude fibers on the dry basis, but it was noticed that for a given variety the effect of locality was much more pronounced than the growing season.

After pulping and juice extraction, the fiber content was markedly reduced. Canned juices contained 0.32 to 8.78% crude fibers on the dry weight basis which might be considered a wide variation. Juices processed from fruits obtained from the Nobaria area contained higher fiber content than those obtained from the Kanatir area. These are areas different in soil type, climate, and irrigation practices. Generally, after storage of the canned juice for 3 months, a breakdown of crude fiber was noticed.

Relative Viscosity: Juices differed with variety, fruit maturity, picking season, the extraction process and the extent of heat treatment. The time lag between maceration and heat inactivation of the pectic enzymes in tomatoes also contributed to the viscosity changes in the juice.

The tomatoes grown in Nobaria yield juices different in viscosity than those from Kanatir. The summer crop showed lower values than the winter crop, which may be explained by the difference in ripeness level of the tomatoes at harvest time. Generally, the relative viscosity of fresh juice depends on the ripeness. However, the proper time for picking the fruits at the optimum stage of maturity could not be determined due to lack of information on heat units received for each variety, and lack of uniformity in ripeness levels.

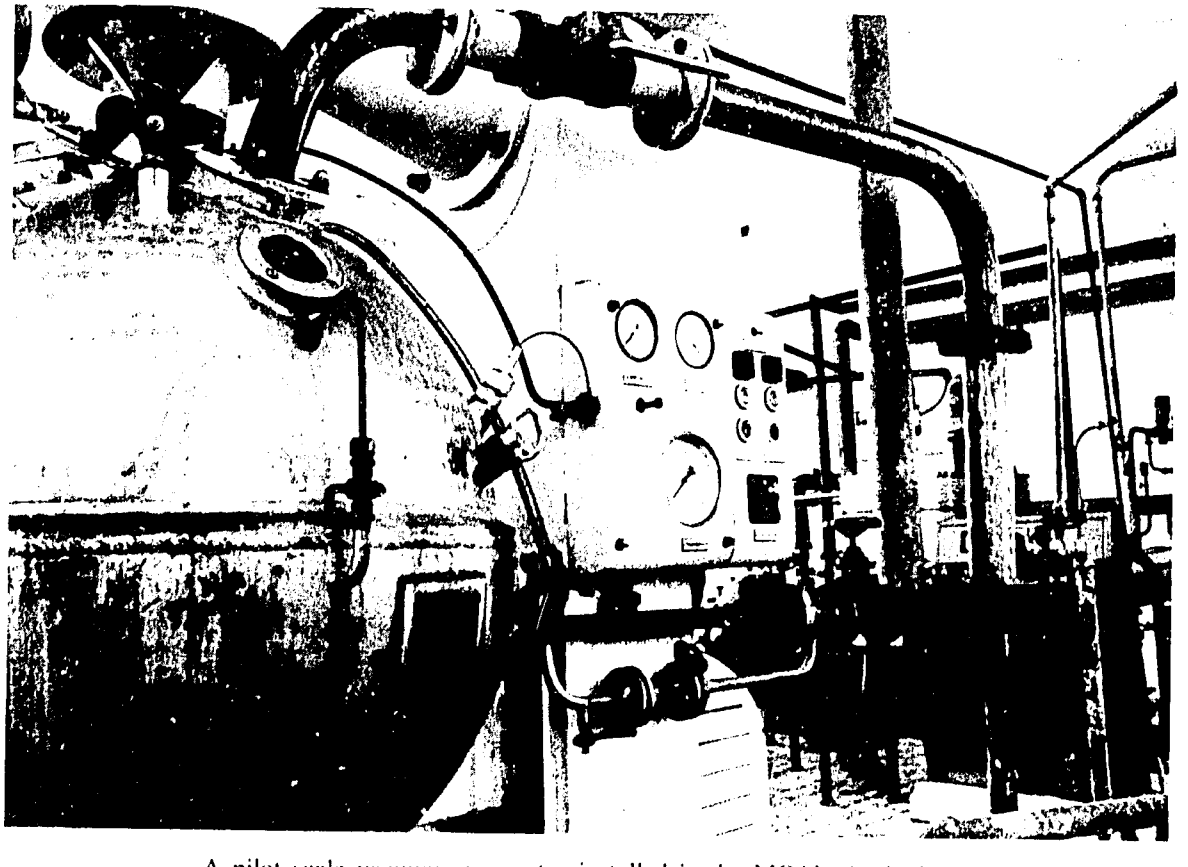
The changes in relative viscosity of juices due to heat processing differed widely with the tomato variety. Subsequently, after canning, the relative viscosity of tomato juice increased in some varieties, but decreased in others.

EVALUATION OF PROCESSED PRODUCTS

After sampling the fresh fruits, batches of tomatoes from Kanatir or Nobaria were processed into canned juices or to both juices and pastes at the Ministry of Agriculture (MOA) pilot plant. The following measurements were made to determine product quality.

Total solids, soluble solids and water/alcohol insoluble solids fractions were found to vary according to variety, growing location, and season.

The ascorbic acid content of the canned juice was lower than that of the freshly expressed juice, with a maximum value of 13.9 mg/100 gm in the samples grown in Kanatir. The values for Nobaria samples ranged between



A pilot scale vacuum evaporator installed in the MOA's Agricultural Research Center was used by the Tomato Processing Project for concentrating tomato juice in pastes as part of the evaluation of new cultivars.
Photo: Nadir Hashem

7.8 and 14.1 mg/100 gms. Generally, storage of canned juice resulted in some reduction in ascorbic acid content. Within each variety, some variation of vitamin content was found. The canned paste contained 13.1 to 45.8 mg ascorbic acid/100 gms.

The total acidity of the canned juices ranged between 0.28 and 0.76% for Kanatir samples and from 0.36 to 0.68% for Nobaria samples. The total acidity of the canned paste ranged from 1.60 to 2.69%.

The pH values of canned juices were measured, and for four varieties ('E 1205', 'Rossol VFN', 'Peto 95' and 'Castlex 489G') was found to be higher than 4.3. This value is higher than is safe and these varieties must be regarded as undesirable unless the juice is acidified by addition of malic or citric acid.

The amino nitrogen content differed greatly between varieties, season, and locality. For canned tomato juices, it ranged between 19.5 and 66.3 mg/100 gms for those grown in Kanatir and from 29.3 and 88.6 mg/100 gms for those grown in Nobaria. Amino nitrogen content of the canned pastes was between 144.9 and 415.7 mg/100 gms.

The calcium content of canned juice ranged between 7.50 and 19.00 mg/100 gms for the Kanatir crop, while that from Nobaria area ranged between 11.08 and 55.26 mg/100 gms.

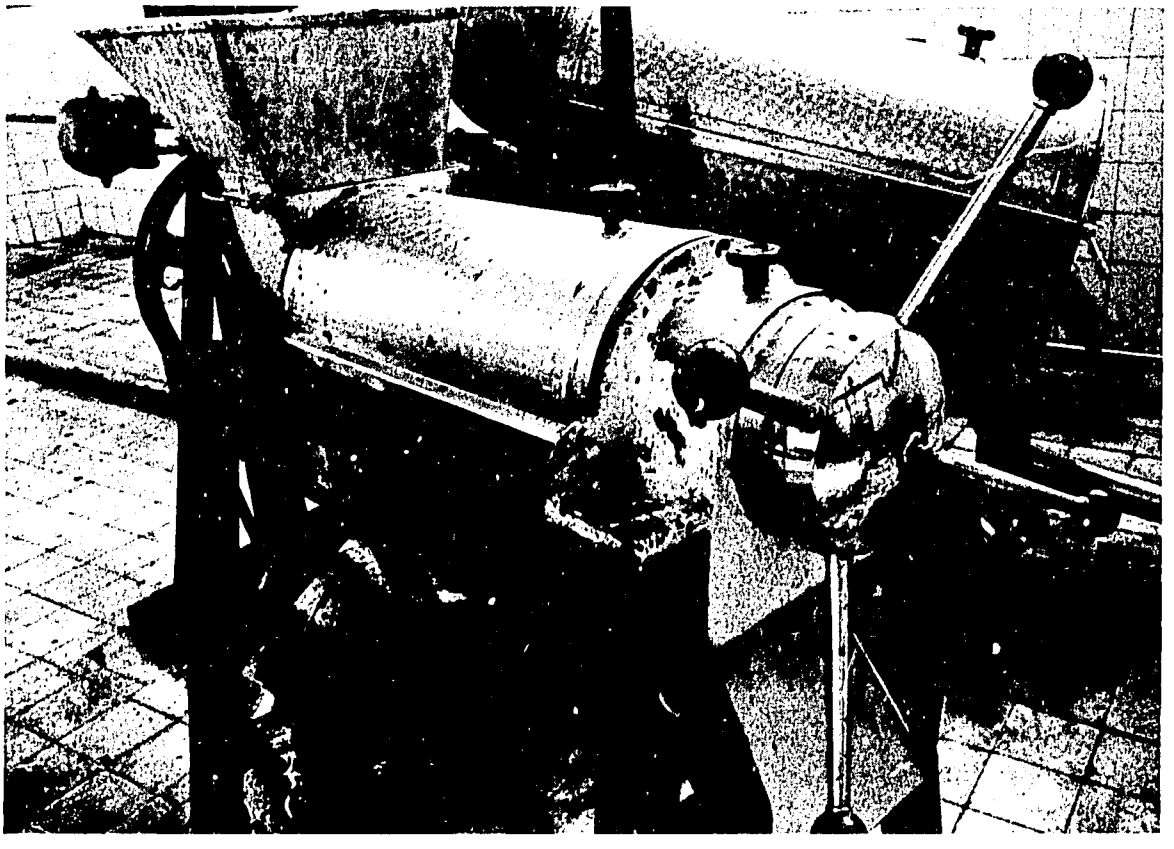
The potassium content ranged between 201 and 425 mg/100 gms in the canned tomato juices from Kanatir crops, and between 157.94 and 367.00 mg/100 gms in those from the Nobaria area. The canned paste contained 1244.6 to 2202.2 mg potassium/100 gm of sample on the fresh weight basis.

Phosphorus content of the canned juices ranged between 1.63 and 9.12 mg/100 gms in the winter crops from Kanatir. That of the summer crop from the same locality ranged from 2.10 to 88.53 mg/100 gms. Similar results were noticed between the crops grown during the two seasons in Nobaria. Phosphorus content of the canned pastes grown in the winter season ranged between 32.8 and 35.7 mg P/100 gms, while the paste from the summer crop contained 109.29 to 276.12 mg P/100 gms.

The ferrous iron content of the canned tomato juices from Kanatir area ranged between 0.220 and 0.972 mg/100 gms, and between 0.24 and 0.780 mg/100 gms for those from Nobaria. The tomato pastes contained 1.210 to 3.200 mg Fe/100 gms of sample.

The lead content of the canned tomato juices ranged between 0.144 and 1.90 mg/100 gms. Upon storage, the lead content increased, ranging from 0.200 to 1.790 mg/100 gms indicating further solubilization of lead from the internal solder surface of the can. These values are very much higher than those commonly observed in canned tomato juices. Future research should emphasize how to reduce the level of lead contamination in the products to internationally acceptable standards.

The tin content of the canned juices ranged between 0.131 and 9.70 mg/100 gms. After storage for three months, it ranged between 0.20 and 6.50 mg/100 gms.



The fruit pulper and finisher shown above is used to remove skin and seeds of tomatoes as they are processed into juice and paste.

Photo: Nadir Hashem

The paste contained between 1.94 and 7.27 mg tin/100 gms.

Sensory evaluations were conducted on the quality of tomato juices canned from different varieties grown in the two major areas during the two seasons. Color attributes were acceptable with most varieties. Some, but not all, varieties were acceptable with respect to flavor and consistency. Further studies are needed to determine optimum conditions of processing needed to yield a wholesome product. It was found that storage of canned juice results in some deterioration in color and flavor quality, depending on the storage temperature and vacuum in the can. Again, additional studies are required to ensure preservation of quality in the canned product.

Termination of the ADS Project after the Tomato Processing Project has been active for only 18 months, instead of the three years envisioned, has meant that the proposed research could not be completed.

Determination of varietal characteristics of tomatoes has been completed for only two growing seasons. This should be extended to cover several years if confidence in selection standards is to be established. In addition, research in processing variables (time and temperature at different process stages) is incomplete and requires pursuing in order to develop a high quality product. Despite the incompleteness of research, and that new products (canned peeled tomatoes and catsup) were not developed, the project's solid accomplishments in training and in varietal selection provide a basis for continuing work by MOA scientists.

PUBLICATIONS

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IMPROVED PRODUCTION OF CHEESE AND RELATED PRODUCTS

Domiati cheese is Egypt's most important dairy product, utilizing nearly two thirds of the nation's milk production. It is a widely used food, consumed by all levels of society. Traditional methods for making Domiati cheese developed logically and were appropriate for Egypt's conditions, taking advantage of the plentiful supply of salt used in preserving milk in a concentrated form without refrigeration. However, there are numerous opportunities for improving on traditional methods for making Domiati and similar types of cheese, and for augmenting the Egyptian supply of nutritious cheese-like foods. Possibilities include: increased and improved use of low-priced skim-milk powder and butter oil from Europe in recombined products; making products from combinations of milk and vegetable ingredients, such as soy milk, soy oil and soy protein; modifying the traditional method of making Domiati cheese from salted milk to make nutrients in whey available for human consumption. There are also opportunities for expanding milk consumption in the form of fermented beverages.

The research focussed on introducing new and improved technologies for making soft white cheese and related products, improving quality and uniformity, and augmenting Egypt's supply of cheese and related foods by incorporating non-dairy extenders.

ACCOMPLISHMENTS

IMPROVED TECHNOLOGY FOR MAKING CHEESE AND UTILIZING WHEY

The research on improved cheese-making technology emphasized three aspects—use of ultrafiltration in cheese making, making Domiati from unsalted milk, and mechanizing the traditional process.

Ultrafiltration Studies

Ultrafiltration (UF) is now used commercially in France, Denmark and some other countries for making soft cheese such as Camembert and Feta. The project has extended previous studies on fractionating and concentrating recombined skim-milk by ultrafiltration, blending it with cream, and coagulating the mixture without separation of whey.

All experiments for making Domiati cheese from ultrafiltered milk used the following basic procedure. Skim milk powder was reconstituted (10% total solids), and ultrafiltered at 45°C using a DDS Lab 20 ultrafiltration unit. The milk was ultrafiltered to a concentration factor of 4. The retentate was heated to 65°C, anhydrous milk fat was added to give a 10% fat (w/w) in the concentrated recombined milk and then homogenized at 200 kg/m^2. To the concentrated recombined milk, sodium chloride was added at the rate of 5% (w/w), followed by starter (0.5%) of *Lactobacillus bulgaricus—Streptococcus thermophilus*, and rennet. The mixture was poured into 450 ml cans, left to coagulate at 41°C and then hermetically sealed.

The optimum coagulation conditions for making Domiati cheese from ultrafiltered milk were investigated using varying amounts of rennet, different coagulation temperatures and heat treatment of the concentrated recombined milk. Several combinations of the factors were tested, and their effects on the chemical composition and organoleptic properties of cheese were followed. The best results were obtained with the use of 2 g rennet/100 kg concentrated milk, a coagulation temperature of 41°C and no heat treatment of concentrated milk after homogenization.

The amount of rennet used in the coagulation of concentrated recombined milk represents 10% of that used to make an equivalent quantity of cheese by the conventional method, which resulted in reduction of the cost of the coagulant.

The effect of aging reconstituted milk before ultrafiltration was also investigated but was found to have little effect on the quality of the cheese.

A method was developed to improve the quality of UF Domiati cheese by using lipolysed recombined cream. Recombined cream (35% fat) was treated with different levels of lipase powder (Liberase 1100, Dairyland Food Inc., U.S.A.) and incubated at 40°C with continuous stirring overnight. The lipolysed cream was heated, added to retentate (5:12) and made into Domiati cheese as reported above. The quality of cheese was greatly improved after 4 months of storage particularly by the use of 2 g lipase/kg. The method developed has at least two advantages: it is possible to develop uniform flavor of pickled cheese in the new product, even when fresh; the flavor intensity can be standardized to suit the consumer preference.

In order to increase the economy of cheese-making from ultrafiltered milk, partial and complete replacement of milk fat with vegetable oils were tested. Maize, palm and cotton seed oils were used to replace 25, 50 and 100% of milk fat used in making pickled soft cheese from ultrafiltered recombined milk. Cheese with acceptable quality was obtained at several different levels of replacement with vegetable oils, maize oil being particularly suitable for incorporation.

Use of Unsalted Milk

Research on making Domiati cheese from unsalted milk has focussed on using buffalo, cow and mixtures of both

milks. Buffalo milk was initially heated to 85°C, cooled, and coagulated using different levels of rennet (10 and 20 ml/45 kg milk) at temperatures of 29.5 and 32.2°C. The best quality fresh cheese was obtained with 20 ml rennet/45 kg milk and coagulation temperature of 29.5°C. Salting was carried out using whey containing 10, 15 and 20% salt for 48 and 72 hours at 7 ± 2°C. The cheese was chemically analyzed and its organoleptic properties were assessed. The highest scores were given to cheese salted in whey containing 15% salt for 48 hours. Best results with cow's milk were obtained by heating initially to only 73.9°C, and adding 0.04% $CaCl_2$. The results on coagulation and salting of cow's milk were similar to those for buffalo's milk.

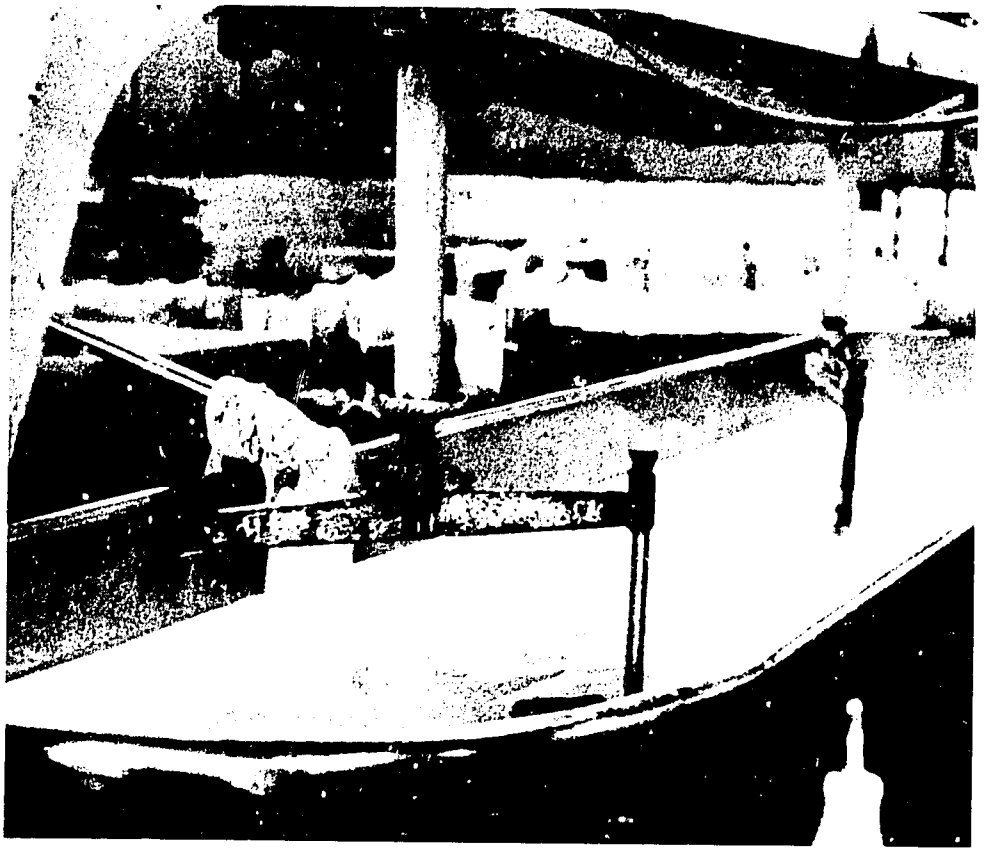
The addition of H_2O_2 to buffalo, cow and mixed milks as an alternative to heat treatment was examined for its effect on cheese quality. The use of 0.05% H_2O_2 gave satisfactory results.

The cheese, particularly the pickled variety from unsalted milk, was of poorer quality than that from salted milk. Different additives were investigated in order to improve the quality. Emulsifying salts (disodium phosphate and sodium citrate) were added at the rate of 0.025% to heated milk or milk with 0.05% H_2O_2 added. In general, heat treated samples were superior to the H_2O_2 treated ones and cheese from unsalted milk ripened more slowly than that from salted milk. The addition of the emulsifying salts had negligible effect on the quality.

The research is at the stage where pilot-scale trials are needed. Additional research into the acceleration of cheese ripening using starters and proteolytic and lipolytic enzymes, is also desirable.

Mechanizing Manufacture of Domiati Cheese

Research to speed up the manufacturing process by mechanization involved adapting the manufacturing process of Domiati to the use of equipment such as that manufactured by the ALPMA company or alternative equipment that could be manufactured in Egypt. Laboratory-scale experiments were used to guide selection of conditions that could be adapted to mechanization for coagulating the milk, cutting and agitating the curd to promote shrinkage, and salting the curd. The salted curd was fed into perforated columns for continuous draining, pressing and forming. Results of the laboratory studies have established conditions to be used on a pilot-scale with prototype equipment.



Recombined milk made from skim milk powder and butter oil is pumped into this large vat in which it is coagulated to make Domiati cheese at the Misr Milk and Food Company, Cairo. As part of the Soft Cheese Project, improvements in sanitary conditions in these facilities will permit salt free coagulation and increased efficiency in protein recovery from whey.

Photo: Walter Dunkley

Whey Utilization

The whey from cheese making still contains substantial amounts of protein and minerals which could be used for human nutrition if economical recovery methods were available. The problem of whey utilization was approached by trying to develop a cheese-like base from the whey by either condensing it or removing protein by precipitation or ultrafiltration.

Conditions suitable for preparing acid precipitated and heat denatured whey protein concentrates was studied. The affects of different pH values (4.0-5.5), addition of acids (acetic, citric, lactic and hydrochloric) and heating at 95 and 100°C for different periods were followed. The recovery of whey proteins was determined and organoleptic properties of the precipitated proteins evaluated. The highest protein recovery was found by boiling whey at pH 4.5 for 20 min. irrespective of the acid used. However, panel taste evaluations showed that whey proteins precipitated with citric acid ranked highest.

Ultrafiltration was carried out for the preparation of whey protein concentrates by a batch process using a DDS Lab-20 unit to a concentration factor of 14. About 12% of the whey proteins were recovered in the concentrate giving rise to whey protein concentrate containing 7.6-9.1% protein.

In the work on whey concentration, sweet whey was condensed in the preliminary experiments to 46% total solids and fortified with whey protein concentrate (obtained by ultrafiltration) and skim milk powder (8%). In further experiments whey was condensed to 50-55% total solids and fortified with 8-10% skim milk powder. A cheese-like spread was formulated from butter, Cheddar and Roquefort cheese, condensed whey, whey protein concentrate, skim milk powder, and gelatin. However, the product was characterized by sandiness due to lactose crystallization. This problem was further studied by the addition of emulsifiers and stabilizers and stirring while cooling the mixture. A commercial emulsifier (Acidan N 12) was added at the rate of 1% on a fat basis and collidan at the rate of 0.2%. The mixture was stirred for 1-2 hours at different temperatures (5-12°C). Of the different conditions investigated, the best preparation of whey cheese spread was produced by blending condensed whey (50-55% TS) and 8% skim milk powder and stirring the mixture for 1 hour at 5°C.

The next step in this phase of the work should be to explore interest of manufacturers in preparing products for market tests. Interest in commercial production would be increased if the cheese industry adapts to the manufacture of Domiati cheese from unsalted milk, which would augment the supply of whey suitable for use in food.

Incorporation of Vegetable Oil and Protein

Egypt's cheese production needs to be expanded to meet growing consumer demand. Using traditional cheesemaking technology this would ultimately mean an increased demand for milk and consequent expansion of livestock herds. A less costly alternative is to expand cheese production by incorporation of locally grown soy products.

To test the feasibility of this approach the project has developed a method for making soft cheese from skim milk powder and soy oil. Skim milk powder was reconstituted in warm water at the rate of 1:3 and then heated to 65°C for 30 min. Soy oil was added to the reconstituted milk to give an oil content of 9.1 in the filled milk and 0.63:1 casein:oil ratio. A commercial emulsifier was added at the rate of 0.05%. The cheese making was carried out in a similar way to that used for Domiati cheese, with some modifications to suit the use of filled milk. The cheese had an acceptable quality after pickling for one month. This method offers a less costly product due to the use of soy oil to replace milk fat, and of concentrated milk that needs less space, equipment and labor than milk of normal composition. However, a pilot study is needed to determine the economic feasibility of manufacturing and marketing the filled cheese.

Three methods for preparing soy milk were compared. These are: the traditional oriental process; the use of sodium bicarbonate in both blanching and extraction; and preparing soy milk from dehulled full fat soybeans. The yield and residues were determined and it was found that the third method for preparing soy milk gave higher milk yield and lower residues than the other two methods. A comparison of the chemical composition and properties of soy milk prepared using the different extraction methods again showed the superiority of soy milk prepared by the third method.

In order to improve the properties of curd made from soy milk, the addition of skim milk powder was tested. Skim milk powder was dissolved directly in soy milk to increase the total solids content of the blend to 18, 28, 38 and 48% respectively. The blended soy milk-skim milk powder was left for 2 hours then heated to 68°C for 15 seconds, salt was added at the rate of 5%, followed by rennet (1g/kg) and coagulation took place at 40°C. The best results were obtained with blended soy milk with total solids content of 38%.

The use of several cultures of lactic starter (*Lactobacillus bulgaricus*, *Streptococcus lactis*, *Streptococcus diacetilactis*, *Lactobacillus acidophilus* and *Streptococcus thermophilus*) was examined. *Streptococcus thermophilus* (5%) performed best and coagulated soy milk in 4 hours at 40°C.

The use of acid and rennet coagulation in making cheese analogues from soy milk-skim milk powder blends was investigated. *Streptococcus thermophilus* was added at the rate of 5% to soy milk-skim milk powder blends of different solids content (15-40%); rennet was added at a rate of 1 ml of 6% solution/kg of the mixture. The use of rennet and acid coagulation was found to improve the quality of the resultant cheese. The coagulation time was reduced by increasing the skim milk powder added. Ongoing research deals with the shelf life, palatability, as well as chemical and physical properties of cheese during ripening.

CULTURED BUTTERMILK

The objective of this investigation was to develop a process for preparing a cultured milk product, and to test

its consumer acceptability. Cultured buttermilk was the product selected due to its low level of acidity as compared with yogurt, its ability to withstand climatic conditions prevailing in Egypt without refrigerated transport, its expected low price, and its manufacture from skim or low fat milk. Other anticipated advantages were its high nutritive value, its acceptance as a refreshing fermented dairy product, and its availability to all socio-economic classes. The great similarity of this product to the local fermented milk 'Laban Rayeb,' available in most rural areas, may be important in the development of consumer taste for cultured buttermilk.

Research has been based on a product containing 1% fat in milk and using *S. diacetylactis* as a starter unless mentioned otherwise. To select the most appropriate technique to manufacture this product without altering its organoleptic properties and to investigate its acceptability and keeping quality, the following points were investigated:

- ***The effect of the type of milk:*** fresh, recombined (RM) and mixed milks (fresh:RM 1:1) were made into cultured buttermilk (CBM). The product made from RM had the best properties in regard to its curd tension, diacetyl content and organoleptic properties.
- ***The effect of milk heat treatment:*** recombined milk was heated to 80 and 85°C for 30 min. and to 90°C for 2 and 10 minutes. The product made from RM heated to 90°C for 2 minutes had higher diacetyl content and better organoleptic properties.
- ***The effect of varying the solids-not-fat (SNF) content:*** cultured buttermilk was manufactured from RM having 10 to 16% SNF in 2% increments. Samples containing 14 and 16% were found unsatisfactory and work was repeated to cover the range from 9 to 13% in 1% increments. The product made from RM having 10% SNF was preferred and its diacetyl content was higher. It was followed closely by samples having 9 and 11% SNF.
- ***The keeping quality of CBM:*** potassium sorbate and primaricin (Delvocid) were added to CBM during manufacture to control fungal growth. Samples and controls were kept in the refrigerator or at 30°C and analyzed periodically until they spoiled. Addition of Delvocid was most effective in improving the keeping quality of CBM. It extended its shelf life to 6 days at 30°C and 30 days in the refrigerator with acceptable appearance, flavor, body, texture and final diacetyl content. Coliforms were absent and sporeformers were present in small numbers in all samples. The molds and yeasts were absent only in the Delvocid samples.
- ***The effect of the type and ratio of started culture:*** in addition to *S. diacetylactis* which has been used as a starter culture throughout the previous work, CBM can be manufactured from mixed cultures having one of the lactic streptococci as an acid producer and *Leuconostoc cremoris* as an aroma producer. Ratios of 90:10%, 80:20%, 70:30% of *S. Lactis* or *S. cremoris* to *Leuconostoc cremoris* were tested and compared with *S. diacetylactis* on its own.

  CBM made with *S. diacetylactic* alone and that made with *S. cremoris* and *Leuconostoc cremoris* at the rate of 70:30% had better properties and higher diacetyl content. All samples made with *S. cremoris* were preferred to corresponding samples made with *S. lactis*.

  Further experiments included using cultures at the rate of 90:10, 80:20, 70:30 and 60:40 of *S. cremoris* and *Leuc. cremoris* or *S. diacetylactis*, and with a control using *S. diacetylactis* alone. The diacetyl content and the acceptability of the product made with both types of mixed cultures increased as the relative proportions of the aroma to the acid producing organisms increased reaching a maximum with a ratio of 30:70%. The products made with mixed cultures containing *Leuc. cremori* were preferred to those made with *S. diacetylactis* as an aroma producer in mixed cultures.
- ***The effect of lowering the SNF or the fat content:*** cultured buttermilk was made from samples having 8, 9, and 10% SNF and also from RM having 0 and 1% fat using mixed cultures of *S. cremoris* to *Leuc. cremoris* or *S. diacetylactis* combined in proportions of 70 to 30% respectively. Samples containing 9 and 10% SNF had equally high scores and diacetyl content, while those made with RM with no fat had slightly lower scores than those having 1% fat content.

Our research has demonstrated that CBM can be successfully manufactured in Egypt from recombined milk having 10 or 9% SNF and 1% fat content, heat treated to 90°C for 2 minutes and the use of either *S. diacetylactis* single starter or a mixed culture of *S. cremoris* and *Leuc. cremoris* at the rate of 70:30%. The keeping quality of CBM can be greatly improved by the addition of Delvocid as a preservative. At the time of the project termination we were working with MISR Milk and Food Company on the manufacture of cultured buttermilk combined with different fruit juices or preserves. A market study was being prepared to investigate the acceptability of the product by consumers. The prospect of manufacturing the product in Egypt is very promising as it is a very refreshing, highly nutritious and low priced beverage that could be available to a wide spectrum of consumers.

PUBLICATIONS

Abd El-Salam, M.H. and Safinaz El-Shibiny. (1983) Domiati Cheese Made with Ultrafiltered Reconstituted Milk and Lipolysed Recombined Cream. *Journal of Dairy Research*. (in press)

Abd El-Salam, M.H., S. El-Shibiny, L. El-Koussey and H. Haggag. (1982) Manufacture of Domiati Cheese from Milk Concentrated by Membrane Ultrafiltration. II. Effect of Aging of Milk. *Egyptian Journal of Dairy Science*, 10:237.

El-Shibiny, S., L.A. El-Koussy, E.S. Gergis and N. Mehanna. (1982) The Use of Vegetable Oils in Making Soft cheese from Ultrafiltered Recombined Milk. *Egyptian Journal of Dairy Science*.

Girgis, Elein S., S.N. Amer, M.R. Naghmoush, S.M.K. Anis and A.M. Mehriz. (1983) Studies on the Production of Cultured Buttermilk in Egypt. I. Effect of the Type of Milk, Milk Heat Treatment and Solids, not Fat Content. *Annals of Agriculture* (Moshtohor), 19:311.

Girgis, Elein S., S.N. Amer, M.R. Naghmoush, S.M.K. Anis and A.M. Mehriz. (1983) The Keeping Quality of Cultured Buttermilk as Affected by the Addition of Potassium Sorbate and Delvocid. *Annals of Agriculture*, (Moshtohor), 19:321.

FEASIBILITY AND PLANNING STUDIES

Though the main thrust of the ADS project was directed towards training and research, several feasibility studies were supported. The purpose of these was to provide the basis for development of separately implemented and independently funded projects on themes that were either complementary to those of ADS research or beyond its scope. Two major studies, on Agricultural Statistics and on a National Agricultural Library, are outlined below.

AGRICULTURAL STATISTICS FEASIBILITY

Quality statistics on agricultural production, the use of land and human resources, and the productivity of crop and livestock enterprises are essential for the national planning and policy process and the public management of food supplies and the export sector.

Research on production functions, supply response to prices, and optimum cropping patterns often result in inconclusive findings because of weakness and gaps in such basic statistics. Improving the data could provide a stimulus to research in the MOA, research institutions and the universities, and could be an important influence in the policy decision process.

The study and proposals for improvements, carried out by Drs. Henderson and Koffsky, have been developed into a project and are now being jointly implemented by the Egyptian Ministry of Agriculture and the USDA, and funded by USAID.

NATIONAL AGRICULTURAL RESEARCH LIBRARY PROPOSAL

An efficient library service is essential for sustained and successful research efforts. A survey of Egyptian agricultural library services conducted by Dr. Richard Blanchard, carried out as part of this project, has shown that the inadequacy of such facilities hampers research and the training of agricultural students. Libraries are severely fragmented, administratively and physically, and the Ministry's own libraries do not contain journals more recent than 1974. Use of libraries by agricultural research scientists is dwindling as the collections become increasingly out of date and material becomes inaccessible. The ADS study by Blanchard has proposed a new Ministry of Agriculture Central Library which merges several existing units, involves new housing, improvement and updating of collections, expands services offered, and improves administrative structure. On the basis of space provisionally allocated in the new Agricultural Research Center building in Cairo, outline floor planning was carried out by specialist library architects.

APPENDIX
PROJECT DATA AND PARTICIPANTS

JOINT PLANNING AND POLICY BOARD

The following persons served as members of the Joint Planning and Policy Board:

Egypt:

Dr. Gamal Abdel-Samie	Chairman, Vice-President, Academy of Scientific Research and Technology
Dr. El-Sayed Gaballah	Member, National Board for Production and Economic Affairs (Former Minister of Planning)
Dr. Zaki Shabanah	President, University of Menufia
Dr. Abdel-Fattah Moursi	Consultant and Member of the Board, Agricultural Research Center (Former Under-Secretary of Agriculture for Plant Protection)
Dr. Abbas El-Itriby	Consultant and Member of the Board, Agricultural Research Center (Former Under-Secretary of Agriculture for Animal Production)
Dr. Mohamed Taha Eid	Consultant and Member of the Board, Agricultural Research Center (Former Chairman, Agricultural Stabilization Fund)
Dr. Mahmoud Abu-Zeid	Director, Water Management and Distribution Research Institute, Ministry of Irrigation
Dr. Mohamed Kamel Hindy	Under-Secretary of Agriculture, and Supervisor, Agricultural Economics Research Institute
Dr. Hassan Abdallah	Under-Secretary of Agriculture for Foreign Agricultural Relations
Dr. M. Abdel Ghany	University of Menufia
Dr. Said Mostafa Dessouki	Head of the Agricultural Research Center
Dr. M. Taher Kera	Dean, Faculty of Agriculture, Cairo University
Dr. Mohamed Dessouki	Director General, Foreign Relations Bldg, Ministry of Agriculture
Dr. Y. Mohieldin	Under-Secretary of the Ministry of Agriculture, Co-Director, Agricultural Development Systems Project

UCD:

Dr. Elmer Learn	Vice Chairman, Executive Vice Chancellor
Dr. Charles Hess	Dean, College of Agricultural and Environmental Sciences
Dr. Allen G. Marr	Dean, Graduate Studies and Research
Dr. Maurice Peterson	Professor, Agronomy and Range Science
Dr. Fred W. Hill	Coordinator of International Programs and Associate Dean for Research
Dr. David W. Robinson	Associate Dean, International Programs
Dr. William Rains	Chairman, Agronomy and Range Science

DAVIS OFFICE

Dr. Frank C. Child	Coordinator	UCD
Dr. David W. Robinson	Assoc. Dean, International Prog.	UCD
Ms. Ruth E. Shea	Business Officer	UCD
Mr. Arthur Small	Financial Adviser	UCD
Dr. Abdolhassain Zahedani	Adviser	
Ms. Lindy S. Watts	Purchasing & Shipping	UCD
Ms. Elia E. Baiocchi	Travel Clerk	UCD
Ms. Judy Erwin	Secretary	UCD
Ms. Charlotte Mater	Purchasing Assist.	UCD
Ms. Lin-Sau Fung	Student Assistant	UCD
Dr. Ridwan Blond	Editor	UCD
Dr. Lawrence Rappaport	Horticulture Co-Director	UCD
Ms. Muriel Bailey	Secretary/Horticulture	UCD
Ms. Anita E. Gentry	Secretary/Horticulture	UCD
Dr. Harold O. Carter	Economics Co-Director	UCD
Ms. Judy Seppala	Secretary/Economics	UCD

CAIRO OFFICE

Dr. M.K. Hindy	Co-Director	MOA
Dr. Y. Mohieldin	Co-Director	MOA
Dr. Claron O. Hesse	Co-Director	UCD
Dr. Pierre Loiseaux	Co-Director	UCD
Dr. Frank C. Child	Acting Co-Director	UCD
Dr. Bruce Glassburner	Co-Director	UCD
Dr. Ahmed Goueli	Assoc. Director of Economics	MOA
Dr. John Rowntree	Assoc. Director of Economics	UCD
Dr. M.M. Azzouni	Assoc. Director of Horticulture	MOA
Dr. Ronald E. Voss	Assoc. Director of Horticulture	UCD
Dr. William L. Sims	Assoc. Director of Horticulture	UCD
Dr. Talaat Shehata	Program Director	UCD
Mr. James Scott	Business Officer	UCD
Mr. Donald Krueger	Business Officer	UCD
Mr. Ahmed Loutfy Abdelmoniem	Business Officer	
Mr. Al Meneni	Adviser	UCD
Mr. Bud Fleishman	Adviser	UCD
Ms. Ernestine P. Estiban	Administrative Assist.	
Mr. Adel Rahim M. Y. Amira	Senior Accountant	
Mr. Mohamed El-Melegiy	Administrative Assist.	
Mr. Adel Ibrahim El-Katton	Accountant	
Mr. Saad Senoussy	Accountant	
Ms. Mona Ezzat	Librarian	
Mr. Ahmed A. Abdelmoniem	Residence Manager	
Mr. Mahmoud M. Walyallah	Motor Pool Supervisor	
Dr. Mohamed Fahmy Issa	Program Specialist	
Mr. Abdel Fatah Salem	Expeditor	
Mr. Abdel Meguid A. Radwad	Administrative Assist.	

HORTICULTURE SUB-PROJECT TECHNICAL ASSISTANCE

Dr. Doran L. Hughes	Technical Adviser	UCD
Mr. James T. Yeager	Technical Adviser	UCD
Mr. John Whisler	Technical Adviser	UCD
Dr. Oscar Lorenz	Adviser	UCD
Dr. Harold Olmo	Adviser	UCD
Dr. Clyde Elmore	Weed Specialist/Adviser	UCD
Dr. Terry Prichard	Irrigation Systems Specialist/Adviser	UCD

THE CENTRAL LABORATORY

December 1980 – August 1983

Expenditure $926,719 LE 169,697

Dr. M. Said Tewfik	Scientific Director	MOA
Dr. Jack Pangborn	Scientific Director	UCD
Dr. James Settlage	Adviser	W. Germany
Dr. Terryl Mast	Adviser	UCD
Mr. James Quick	Adviser	UCD

THE HORTICULTURE LIBRARY

December 1980–August 1983

Expenditure $113,207 LE 13,012

Dr. Adel Kader	Principal Investigator	UCD
Ms. Mona Ezzat	Librarian	
Ms. Pamela Moyer	Research Assistant	UCD

IMPROVED TOMATO PRODUCTION

July 1980 – August 1983

Expenditure $149,320 LE 207,367

Egypt

Dr. Sayed Nassar	Team Leader	MOA
Dr. Monir N. Stino	Senior Investigator	MOA
Dr. Hamid M. Mazad	Senior Investigator	MOA
Dr. Arafa Imam Arafa	Senior Investigator	MOA
Dr. Salah M. Ahmed	Junior Investigator	MOA
Dr. Adel F. Erian	Junior Investigator	MOA
Dr. Ebrahim A. Mahfouz	Junior Investigator	MOA
Dr. Salah El-Din Sayed	Junior Investigator	MOA
Mr. Ahmed Y. Bishr	Station Director	MOA
Dr. Safwat A. Dous	Senior Investigator	MOA
Dr. Adel Metwally	Senior Investigator	MOA
Mr. El-Sayed K. Hashim	Assistant	MOA
Dr. Mokhtar El-Shenawy	Junior Investigator	MOA
Mr. Hassan A. Ghazal	Assistant	MOA
Dr. Ahmed Z. El-Zamel	Junior Investigator	MOA
Dr. Hassan H. Salih	Junior Investigator	MOA
Mr. A. Moursy Hammada	Assistant	MOA
Dr. M. Hosny Khalifa		MOA
Mrs. Etma Adb El-Bar		MOA
Mr. M.H. Aboel-Atta		MOA
Mr. M. Abdel-Moneam Aly		MOA
Mr. Ibrahim M. Ibrahim		MOA
Mr. Salah Abdel-Razek		MOA
Mr. Saber Afify Mostafa		MOA
Dr. A. Abdel-Moneim Hassan	Principal Investigator	Cairo University
Dr. Adel El-Beltagy	Senior Investigator	Ain Shams University
Dr. Hassan Nassar M. Hosni	Station Director	Fayoum University
Dr. Saad Abdel-Gaid	Senior Investigator	El-Azhar University
Dr. Maher Amin Waly	Senior Investigator	El-Azhar University
Dr. M. Abdel-Rehim Abo-Baker	Station Director	El-Minia University
Mr. Samir M. Abdel-Aziz	Assistant	El-Minia University
Dr. Mostafa Kamel Iman	Senior Investigator	Assiut University
Dr. Abdl-Hamied M. Butt	Station Director	Assiut University
Dr. Kamal Ahmed El-Fadaly		Cairo University

UCD

Dr. William L. Sims	Team Leader	UCD
Dr. Richard Jones	Adviser	UCD

IMPROVING OLIVE CULTIVATION IN EGYPT

February 1981 – August 1983

Expenditure $191,759 LE 74,324

Egypt

Dr. Hassan Hosni A. Selim	Team Leader	Cairo University
Dr. Mohamed Mounir Foad	Principal Investigator	Cairo University
Dr. Mostafa Said Fadl	Junior Investigator	El-Azhar University
Dr. Mohamed Abo-Rawash Ali	Junior Investigator	Ain Shams University
Dr. Mohamed Anwar Zahran	Junior Investigator	Fayoum University
Dr. Omaima Ahmed Kilany	Junior Investigator	Cairo University
Dr. Mamdouh Mohamed Zaid	Junior Investigator	El-Azhar University
Dr. Ahmed Sweidan	Junior Investigator	El-Azhar University
Mr. Hamid Salem El-Sayed	Junior Investigator	Fayoum University
Dr. El-Said Sadek Higazy	Senior Investigator	Cairo University
Dr. Sanad El-Sayed Habib		Suez Canal University
Dr. Seifeldin A. Sarieldin	Senior Investigator	MOA
Dr. Nawal M. Gamaledin	Junior Investigator	MOA
Dr. Girgis S. Abdel-Malik	Junior Investigator	MOA
Mrs. Ekram Saadeldin	Assistant	MOA

IMPROVING OLIVE CULTIVATION IN EGYPT *(Cont'd)*

Mr. Abdel-Hamid Arafat	Assistant	MOA
Mr. Lotfy H. Osman	Assistant	MOA
Mr. Aly Yosry Hamza	Assistant	MOA
Mr. Adly Farhat El-Khatib	Assistant	MOA
Mr. Mohamed E. Mohamed	Assistant	MOA
Mr. Zaki A. El-Sayed	Assistant	MOA
Mr. Arafa A.H. El-Sherif	Assistant	MOA
Mr. Ibrahim E. Shaaban	Assistant	MOA

UCD

Dr. G. Steven Sibbett	Team Leader	Farm Adviser, Tulare County
Dr. Hudson Hartmann	Team Leader	UCD
Dr. Richard Rice	Adviser	UCD
Mr. John Whisler	Technical Adviser	UCD

INTRODUCTION AND IMPROVEMENT OF DECIDUOUS FRUIT

July 1980 – August 1983

Expenditure $116,217 LE 110,084

Egypt

Dr. George Ramzy Stino	Team Leader	Cairo University
Dr. Mohamed Ahmed Fayek	Principal Investigator	Cairo University
Dr. Ahmed Mahmoud Sweidan	Senior Investigator	Cairo University
Dr. Mokhtar Mohamed Hassan	Senior Investigator	Cairo University, Fayoum
Dr. Ehab Yasin Youssif	Senior Investigator	Zagazig University
Dr. El-Said Ibrahim Bakr	Senior Investigator	Cairo University
Dr. Ahmed Tewfik Salem	Junior Investigator	Cairo University
Dr. Faiza Amin Taha	Junior Investigator	Cairo University
Mr. Nabil Raafat El-Sherbini	Junior Investigator	Cairo University
Dr. Hussein Mehanna	Junior Investigator	Cairo University
Miss Amina Hamed Gomaa	Junior Investigator	Cairo University
Dr. Magda Mahmoud Khattab	Senior Investigator	Cairo University
Dr. Moustafa El-Sherif	Senior Investigator	Cairo University
Dr. Samir Ibrahim El-Sherif	Senior Investigator	Cairo University
Dr. Tayseer Ahmed Hassahnen	Assistant	National Research Center
Mr. Ibrahim Ibrahim Mosbah	Assistant	Cairo University
Mr. Ahmed Mohamed Simeda	Assistant	Cairo University
Dr. Assem Ibrahim Shaltout	Assistant	Ain Shams University
Dr. Magdi T. Matta	Senior Investigator	MOA
Mr. Sobhy F. Zaklama	Senior Investigator	MOA
Dr. Mohamed M. Zaki	Principal Investigator	MOA
Dr. Nadia M. Mansour	Junior Investigator	MOA
Dr. Fatma Amin Khalil	Junior Investigator	MOA
Dr. Enayat A. Kenawy	Junior Investigator	MOA
Mr. Mahmoud M. Gebeili	Assistant	MOA
Dr. Ahmed M. Hammouda	Junior Investigator	MOA
Mr. Ibrahim A. Said	Junior Investigator	MOA
Mr. Abdel-Rahman El-Sheikh	Assistant	MOA

UCD

Dr. P.B. Catlin	Team Leader	UCD
Dr. Claron O. Hesse	Adviser	UCD
Dr. R.E.Rice	Adviser	UCD
Dr. H.K. Kaya	Adviser	UCD
Mr. Greg Vogel	Research Assistant	UCD
Mr. E.A. Olsson	Technical Adviser	UCD

IMPROVEMENT OF CITRUS CROPS

July 1980 – August 1983

Expenditure $88,058 LE 159,627

Egypt

Dr. Mahmoud Hashim El-Barkouky	Team Leader	El-Azhar University
Dr. Issam Azzouz Hassaballa	Senior Investigator	Cairo University

IMPROVEMENT OF CITRUS CROPS *(Cont'd)*

Dr. Hosseiny Abdel-Hak Bosiela	Senior Investigator	
Dr. Mohamed Abdel-Wahab Khamis	Senior Investigator	Cairo University
Mr. Galal Abdel-Kader Baghdady	Junior Investigator	Cairo University
Mr. Mahmoud Abdel-Hamid	Junior Investigator	Cairo University
Dr. Mohamed Aly Galal	Senior Investigator	Cairo University
Dr. Abdel-Azim Mahmoud El-Gazzar	Principal Investigator	Alexandria University
Dr. Ahmed Abdo Issa	Senior Investigator	Alexandria University
Dr. Hassan Ahmed El-Shamy	Senior Investigator	
Dr. Ibrahim Darwish Mostafa	Assistant	Cairo University
Dr. Nabil Ahmed Mansour	Junior Investigator	Alexandria University
Dr. Abdel-Maguid H.A. Selim	Senior Investigator	
Mr. Nassif Nada	Junior Investigator	Ain Shams University
Mr. Amr A. Abdel-Gawad Nawar	Junior Investigator	Alexandria University
Dr. Gamaledin Mohamed Youssef	Senior Investigator	Cairo University
Dr. Hefny A. Hefny		Cairo University
Dr. Farouk Abdel Hamid		Cairo University
Dr. Mohamed H. Edris		Cairo University
Mr. Fathalla Kenawi		Cairo University
Dr. Ahmed Abdo Issa		Cairo University
Dr. Sami Saadeldin		Cairo University
Mr. Mahmoud Kobia		Cairo University
Dr. Bakir Abbas Oteifa	Adviser	Cairo University
Dr. Mohamed Ahmed El-Shourbagy	Principal Investigator	MOA
Mrs. Samiha Abdel-Khalek	Senior Investigator	MOA
Dr. Moustafa Afify El-Nakrashy	Senior Investigator	MOA
Dr. Magdy Nagib Abdel-Mesiah	Senior Investigator	MOA
Dr. Ahmed Ahmed Mostafa Khalil	Junior Investigator	
Dr. Said Abbas Eid	Junior Investigator	
Mr. Latif Fahmy Gindy	Assistant	MOA
Mrs. Salama Eid Salem	Assistant	MOA
Mr. Said Abdel-Khalik Mohanna	Assistant	MOA
Mr. Youssef Nasif Gobran	Assistant	MOA
Mr. Rashwan Mohamed Rashwan	Assistant	MOA
Mr. Abdel-Mohsen Afify Abou-Zeid	Assistant	MOA
Mr. Mahmoud Mohamed El-Hady Nasr	Senior Investigator	MOA
Mr. Hamed Mokhtar Mahmoud	Assistant	MOA
Mr. Mahmoud Taha Abdel-Hady Deiab	Assistant	MOA
Dr. Ahmed Bahaeldin Hassan	Senior Investigator	MOA
Mrs. Amira M. Ibrahim El-Khadery	Assistant	MOA
Mr. Hani Mostafa Sonpol	Assistant	MOA
Mrs. Sabah Mahmoud El-Said	Assistant	MOA
Mr. Mohamed Abdel-Aziz El-Safty	Assistant	
Mr. M. Mahmoud El-Said Shehata	Assistant	MOA
Mrs. Ablam Abdel-Moneim El-Said	Assistant	MOA
Mr. Mohamed Ahmed Abdalla	Assistant	MOA
Mr. Mahmoud Hassan Abdel-Kader	Assistant	MOA
Miss Ratiba Rabie	Assistant	MOA
Mr. Mohamed Sabbeh	Assistant	MOA
Mr. Mohamed El-Safty	Assistant	MOA
UCD		
Dr. Alfred Krezdorn	Team Leader	University of Florida, Gainesville
Dr. Robert K. Soost	Team Leader	UC Riverside

MANGO DISEASE CONTROL

July 1980 – August 1983

Expenditure $84,236 LE 121,063

Egypt

Dr. Sayed Azzouz Farghaly	Team Leader	MOA
Dr. Mokhtar Metwally Satour	Senior Investigator	MOA
Mr. Zakaria Ismail Ragab	Senior Investigator	MOA
Dr. Ahmed Sayed Khalifa	Junior Investigator	MOA

MANGO DISEASE CONTROL *(Cont'd)*

Dr. Ibrahim Mohamed Ibrahim	Junior Investigator	MOA
Dr. Maher Looka Wahba	Junior Investigator	MOA
Dr. Mohamed Zaki Dawood	Junior Investigator	MOA
Dr. Mohamed Abdel-Motaal Aly	Junior Investigator	MOA
Dr. Zainab Mohamed Hamdy	Junior Investigator	MOA
Dr. Ahmed Salah Eldin	Junior Investigator	MOA
Dr. Ahmed Aly Keshta	Junior Investigator	MOA
Dr. Kamaleldin Gaafar	Junior Investigator	MOA
Dr. Mamdouh Reyad Tadrous	Junior Investigator	MOA
Mr. Hamdy Mohamed El-Masry	Assistant	MOA
Mrs. Galila Ahmed Said	Assistant	MOA
Mr. Monir Youssef Adb-Allah	Assistant	MOA
Mr. Taymour Mohamed Nasr Eldin	Assistant	MOA
Mr. Michael Bottros Bastoros	Assistant	MOA
Mrs. Samiah Said Mostafa	Assistant	MOA
Mr. Mohamed Salim Bayoumy	Assistant	MOA
Mr. Abdel-Aal Abdel-Aziz	Assistant	MOA
Mr. Fathy Gad Ramadan	Assistant	MOA
Mr. Salah Abdel-Moneim	Assistant	MOA
Mrs. Samia Ibrahim Abo Basha	Assistant	MOA
Mrs. Samira Mohamed Abdel-Aziz	Assistant	MOA
Mr. Aly Saliem Salim	Assistant	MOA
Mr. Ibrahim Aly Mosa	Assistant	MOA
Mr. Metwally Hassan Shata	Assistant	MOA
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Dr. Emad El-Din Hussein Wasfy	Senior Investigator	Alexandria University
Dr. Mohamed Samir Abdel-Gawad	Senior Investigator	Ain Shams University
Dr. Hesham Afify M. Mostafa	Junior Investigator	National Research Center
Mr. Saied Awad Shehata	Junior Investigator	Ain Shams University

UCD

Dr. George Nyland	Team Leader	UCD
Dr. Carl Campbell	Team Leader	University of Florida
Mr. Edward M. Khalil	Research Assistant	UCD

FRUIT AND VEGETABLE POSTHARVEST LOSSES

July 1980 – August 1983

Expenditure $245,240 LE 209,703

Egypt

Dr. Mohamed Tallat Kabeel	Team Leader	Cairo University
Dr. Fouad Abdel-Latif Ibrahim	Principal Investigator	Cairo University
Dr. M. Abdel-Gawas Shahin	Senior Investigator	Cairo University
Dr. Mohamed Reda Said Barakat	Senior Investigator	Cairo University
Dr. M. Anwar Abdel-Sattar	Senior Investigator	Suez Canal University
Dr. Samira Mansour Mohamed	Junior Investigator	Cairo University
Miss Hemat M. Kamal Badawy	Assistant	Cairo University
Mr. Ahmed El-Said Kilany	Junior Investigator	Cairo University
Miss Wafaa Abdel-Haleem	Assistant	Cairo University
Dr. M. Abdel-Kader El-Gorany	Principal Investigator	Alexandria University
Dr. Hussein M. El-Kacheir	Senior Investigator	Alexandria University
Mr. Aly Hassan Abdel-Razek	Junior Investigator	Alexandria University
Miss Alia Abdel-Baky Shoeib	Assistant	Alexandria University
Mr. Mohamed Mohamed Attia	Assistant	Alexandria University
Dr. Awad Mohamed Hussein	Senior Investigator	Alexandria University
Dr. Mohamed Kamal El-Kazzaz	Junior Investigator	Tanta University
Dr. Atif Fathalla Ibrahim	Junior Investigator	Alexandria University
Mr. Mohamed Shawky Regheb	Senior Investigator	MOA
Mrs. Rawhia Ibrahim Khalil	Senior Investigator	MOA
Dr. Bahia Abdel-Azziz Fahmy	Senior Investigator	MOA
Dr. Kamla Mohamed Mansour	Principal Investigator	MOA
Dr. Yaldiz Mahmoud Ishak	Senior Investigator	MOA
Dr. Zeinab Mahmoud El-Toobshy	Senior Investigator	MOA
Dr. Samia Gamal Eldin El-Oraby	Junior Investigator	MOA

FRUIT AND VEGETABLE POSTHARVEST LOSSES *(Cont'd)*

Mr. Mohamed Taher El-Essawy	Assistant	MOA
Mr. Mohamed Mahmoud M. Yehia	Assistant	MOA
Mr. Ali Metwally Baraka	Assistant	MOA
Mr. Mahmoud M. El-Baghdady	Assistant	MOA
Mr. Nabil Mohamed Talaat	Assistant	MOA
Dr. Hoda Ahmed Ismail	Junior Investigator	MOA
Dr. Atwa Ahmed Atwa	Senior Investigator	MOA
Dr. Said Zakaria Abdel-Rahman	Senior Investigator	MOA
Dr. Ahmed Mokhtar Sharara	Junior Investigator	MOA
Dr. Sonia Mohamed Dossouki	Junior Investigator	MOA
Mr. Tawfik Mahmoud El-Shaikh	Assistant	MOA

UCD

Dr. Adel Kader	Team Leader	UCD
Dr. Irving L. Eaks	Adviser	UC Riverside
Dr. J. W. Eckert	Adviser	UC Riverside
Dr. Mohamed Ismail	Adviser	Florida Dept. of Citrus
Mr. Robert Kasmire	Adviser	UCD
Dr. Klayton Nelson	Adviser	UCD
Dr. Frank Gordon Mitchell	Adviser	UCD
Dr. Michael Reid	Adviser	UCD
Dr. Noel Sommers	Adviser	UCD

IMPROVEMENT OF GARLIC PRODUCTION

October 1980 – August 1983

Expenditure $46,061 LE 117,064

Egypt

Dr. Mohamed Abdel-Maksoud Mohamed	Team Leader	Ain Shams University
Dr. Hashim Mohamed M. Ibrahim	Junior Investigator	
Dr. M. Abdel-Hamid El-Beheidy	Station Director	Zagazig University
Mr. Mahmoud Abdel-Aziz Ibrahim	Junior Investigator	Zagazig University
Mr. Maged Abdel-Mohsen Zaki	Technical Assistant	
Mr. Mohamed Hashim Mohamed	Technical Assistant	
Mrs. Rashida Garieb Ali	Clerical	
Miss Annam Maher Boutrous	Clerical	
Dr. Hussein Mahmoud El-Hinnawy	Senior Investigator	Ain Shams University
Dr. Abdel-Moneim Amer Gad		Zagazig University
Dr. Ahmed Effat El-Sherbini	Senior Investigator	Zagazig University
Dr. Abdel-Rehim Sharaf	Junior Investigator	Ain Shams University
Dr. Ahmed Said Hamed Hussein	Junior Investigator	Zagazig University
Dr. Zaki Ahmed El-Sawy	Junior Investigator	Ain Shams University
Dr. Sherif Hafiz Tawfic	Junior Investigator	Ain Shams University
Dr. Mohamed Taher Bahgat	Junior Investigator	
Dr. Abdel-Samie Hazem Yossif	Senior Investigator	Ain Shams University
Dr. Mohamed Taher Fayed	Junior Investigator	Ain Shams University
Dr. Abdel-Moniem Sayed El-Tabagh	Junior Investigator	Ain Shams University
Dr. Ibrahim Ibrahim El-Oksh	Junior Investigator	Ain Shams University
Dr. Hossnia Mohamed Gomma	Junior Investigator	Ain Shams University
Dr. Sherif Ali Foda	Senior Investigator	MOA
Mr. Mohamed Serry Abdel-Aliem	Assistant	MOA
Mr. Abbas Zaki Osman	Assistant	MOA
Mr. Ali Mostafa Shahin	Assistant	MOA
Mr. Mohamed Refaat El-Shamy	Assistant	MOA
Mrs. Mahdia Farid Gabr	Assistant	MOA
Mr. Ibrahim Hossien Mostafa	Assistant	MOA
Dr. El-Sayed M. Taha		MOA

UCD

Dr. Warren Barham	Team Leader	Texas A&M University
Dr. Ronald E. Voss	Team Leader	UCD
Dr. Dennis Hall	Adviser	UCD

IMPROVEMENT OF CUCURBIT PRODUCTION

October 1980 – August 1983

Expenditure $141,939 LE 196,857

Egypt

Dr. Ahmed A. Radwan	Team Leader	Cairo University
Dr. El-Saied Ahmed Salama	Senior Investigator	Cairo University
Dr. Farouk Abdel-Aziz Omar	Senior Investigator	Suez Canal University
Dr. Ibrahim Abdel-Moneim	Technical Assistant	Cairo University
Dr. Refaat Mohamed Helal	Senior Investigator	Ain Shams University
Dr. Ahmed Hassan Kheraba	Junior Investigator	Cairo University
Dr. Raafat Sadek Bekhit	Junior Investigator	Cairo University
Mr. El-Said Mohamed Agwah	Technical Assistant	Cairo University
Mr. Sayed Fathy El-Sayed	Technical Assistant	Cairo University
Mr. Said Abdalla M. Shehata	Technical Assistant	Cairo University
Mr. Mohamed El-Said Hassan	Technical Assistant	Cairo University
Mr. Ahmed El-Maghawry	Technical Assistant	Suez Canal University
Dr. Sanaa Ahmed Awny	Junior Investigator	Suez Canal University
Dr. Salah Ahmed Bahaaeldin	Principal Investigator	MOA
Dr. Fahmy Abdel-Moneim Fadl	Senior Investigator	MOA
Mr. Abdel-Hakim Ahmed Ibrahim	Senior Investigator	
Dr. Abdel-Hamid Mawardy Amin	Senior Investigator	MOA
Dr. Wagih Ragheb Rezkalla	Junior Investigator	MOA
Dr. Ali Abdel-Razek Saied	Junior Investigator	MOA
Mr. Mihieldin M. Abdel-Wahab	Assistant	MOA
Dr. Mohamed Mahros Mostafa	Assistant	MOA
Mr. Hamdi Hassan El-Dawiny	Assistant	MOA
Mr. Abdel-Monsef Abdel-Raouf	Assistant	MOA
Mr. Sayed Sayed Mohamed	Assistant	MOA
Mr. Mohamed Samy Abdel-Moneim	Senior Investigator	MOA
Dr. M. Salaheldin Mohamed	Assistant	MOA
Mr. Hassan Hassan Shahin	Assistant	MOA
Mr. Welliam Moeshreky M. Rezk	Assistant	MOA
Mr. Hossein Abdel-Rahman	Assistant	MOA
Mr. Maher Abdel-Malek Beshara	Assistant	MOA
Mr. Adel Mohamed Elgohary	Assistant	MOA
Mr. Mahmoud Gheta Abdel-Gawad	Senior Investigator	MOA
Mr. Yousef Talaat Iman	Assistant	MOA
Mr. Hanna Morkos Yakoub	Assistant	MOA
Dr. M. Rashad Hassan Emara	Junior Investigator	MOA
Mr. Ahmed El-Meghawry	Assistant	MOA
Mr. Mahmoud M. Zaki Farrag	Senior Investigator	MOA
Mr. Hussein Abdel-Gaber	Junior Investigator	MOA
Mr. Mohamed Samir Shosha	Junior Investigator	MOA
Mr. Abdel Hakim A. El-Sheny	Junior Investigator	MOA

UCD

Dr. Henry Munger	Team Leader	Cornell University
Mr. Frank Zink	Principal Investigator	UCD
Mr. Douglas W. Gubler	Adviser	UCD
Dr. Albert O. Paulus	Adviser	UC Riverside
Dr. Rosario Provvidenti	Adviser	Cornell University

IMPROVED GRAPE PRODUCTION

March 1981 – August 1983

Expenditure $ 74,314 LE 87,158

Egypt

Dr. Ahmed Mohamed Kamel	Team Leader	MOA
Dr. Wafik Khalil Ahmed	Principal Investigator	MOA
Dr. Hoda Habib Honein	Junior Investigator	MOA
Dr. Abdel-Salam Aly Abdel-Kawy	Junior Investigator	MOA
Dr. Mohamed Fathy Abdel-Moneim	Junior Investigator	MOA

IMPROVED GRAPE PRODUCTION *(Cont'd)*

Mrs. Izis Abdel-Shehead Rizk	Assistant	MOA
Dr. Ghobrial F. Grobrial	Junior Investigator	MOA
Mr. Sayed Eid Abdel-Fattah	Assistant	MOA
Mr. Victor H. Grgis	Assistant	MOA
Mr. Mohafouz M. El-Mqougy	Assistant	MOA
Mr. Moustafa M. El-Behiry	Assistant	MOA
Mrs. Samira Salah	Assistant	MOA
Mr. Mohamed W.A. Hassan	Assistant	MOA
Mr. Medhat Y. Morad	Assistant	MOA
Dr. Mostafa Atef El-Hamadi	Senior Investigator	Tanta University
Dr. Ghazi Ibrahim El-Banna	Senior Investigator	Mansoura University
Dr. Abdel-Aal Higazi Hassan	Senior Investigator	Mansoura University
Dr. Mohamed Foad Ibrahim	Junior Investigator	El-Azhar University
Dr. Mohamed M. Al-Ansary	Technical Assistant	Tanta University
Mr. Attia Tawfic Mostafa	Junior Investigator	Gianiclis Co.
Mr. Raouf Abdallah Ata	Technical Assistant	Gianiclis Co.
Dr. Abbas Mohamed Kheir	Junior Investigator	Cairo University

UCD

Dr. Robert Weaver	Team Leader	UCD
Dr. Harold Olmo	Team Leader	UCD

IMPROVED TECHNIQUES FOR THE EGYPTIAN NURSERY INDUSTRY

January 1981 – August 1983

Expenditure $ 55,867 LE 24,949

Egypt

Dr. Hosni Ali Kamel	Principal Investigator	MOA
Dr. Mohamed Kamal Ahmed Nada	Junior Investigator	MOA
Mr. Ahmed Asad Ibrahim	Assistant	MOA
Mr. Fathy Mohamed Abdel-Karim	Assistant	MOA
Mrs. Laila Abdalla Abdel-Fattah	Assistant	MOA
Mrs. Azza Ahmed Taha Ibrahim	Assistant	MOA
Mr. Mohamed Abdalla Idris	Assistant	MOA
Dr. Samir Sallam	Senior Investigator	MOA
Dr. Alfred Misiha	Junior Investigator	MOA
Dr. Mahmoud Khtab M. Hussein	Senior Investigator	Alexandria University
Dr. Attef Zakaria Sarhan	Junior Investigator	Cairo University

UCD

Dr. Andrew T. Leiser	Team Leader	UCD

CUT FLOWERS FOR EXPORT

January 1981 – August 1983

Expenditure $34,942 LE 43,074

Egypt

Dr. Amin Mahmoud El-Gammassy	Team Leader	Ain Shams University
Dr. Mahmoud El-Sayed Hashim Aly	Junior Investigator	Ain Shams University
Mr. Awad Mohamed Abdalla	Technical Assistant	Ain Shams University
Dr. Mustafa El-Dessouki Badr	Senior Investigator	Alexandria University
Mrs. Naglaa El-Said Abou-Taleb	Technical Assistant	Ain Shams University
Mr. Hesham Abdel-Raoof El-Shawa	Technical Assistant	Ain Shams University
Mr. Ali Nabih Mahmoud Fahmy	Assistant	MOA
Mr. Ismail Ail Mousa	Assistant	MOA
Mr. Asem Abdel-Wahid Ail	Assistant	MOA
Mrs. Maray Nabih Nasr Rizk	Assistant	MOA

UCD

Dr. Tom Byrne	Team Leader	UCD
Dr. Andrew T. Leiser	Team Leader	UCD
Dr. Anton M. Kofranek	Team Leader	UCD

NEW ORNAMENTAL PLANTS

January 1981 – August 1983

Expenditure $ 54,445 LE 41,129

Egypt

Dr. Abo-Dahab Mohamed Abo-Dahab	Team Leader	Cairo University
Dr. Bayoumy Mohamed Mansour	Senior Investigator	Cairo University
Dr. Rafia Saadeldin El-Dabh	Senior Investigator	Cairo University
Mr. Mahmoud Ahmed Salem Gad	Technical Assistant	Cairo University
Mr. Abdallah El-Tantawi Abdalla	Technical Assistant	Cairo University
Mr. Salah Abdel-Aziz Gomma	Assistant	MOA
Dr. Mahmoud Mohamed El-Meligy	Junior Investigator	MOA
Mr. Mostafa Mohamed Mostafa	Assistant	MOA

UCD

Dr. Anton M. Kofranek	Team Leader	UCD

AROMATIC AND MEDICINAL PLANT PRODUCTION

January 1981 – August 1983

Expenditure $ 46,458 LE 70,770

Egypt

Dr. Mohamed El-Moataz M. Kamel	Team Leader	MOA
Dr. Farouk Oman	Principal Investigator	MOA
Dr. Sayed Abdel-Hamid El-Gamal	Senior Investigator	MOA
Mr. Sayed Mahmoud Ibrahim	Assistant	MOA
Mrs. Soheir Abdel-Azia El-Deeb	Assistant	MOA
Mr. M. Hamdi Ibrahim Abo-Zeid	Assistant	MOA
Mr. Said Mahmoud Mohamed	Assistant	MOA
Mr. Ahmed Attef Sadiek	Assistant	MOA
Mr. Abdel-Fattah M. Hassanein	Assistant	MOA
Mr. Mohamed Tharuat Mahmoud	Assistant	MOA
Mr. Ibrahim Mohamed A. Haredy	Assistant	MOA
Dr. Mahmoud M. Mahmoud	Senior Investigator	Ain Shams University
Dr. Gamal Taha Mousa	Senior Investigator	Assuit University
Mr. Ismail Hassan El-Salamy	Technical Assistant	Assuit University
Dr. Gamila M. Wassel	Senior Investigator	National Research Center
Mrs. Azza Abdel-Aziz Tawfic	Technical Assistant	Assuit University
Dr. Shafik I. Balbaa	Adviser	Cairo University

UCD

Dr. Michael Reid	Team Leader	UCD
Dr. Clinton Green	Adviser	Tropical Products Institute, London
Mr. Arthur Cameron	Research Assistant	UCD
Ms. Ann I. King	Research Assistant	UCD
Ms. Catherine Kiener	Research Assistant	UCD

CLONAL PROPAGATION OF PLANTS BY TISSUE CULTURE

September 1981 – August 1983

Expenditure $ 220,296 LE 30,119

Egypt

Dr. Alaa Zaki Bondock	Senior Investigator	Ain Shams University

UCD

Dr. Wesley P. Hackett	Team Leader	University of Minnesota
Dr. Lawrence Rappaport	Team Leader	UCD
Dr. Toshio Murashige	Adviser	UC Riverside
Dr. Brent Tisserat	Instructor	USDA

CLONAL PROPAGATION OF PLANTS BY TISSUE CULTURE *(Cont'd)*

Ms. Asma Sabour	Trainee	USDA
Ms. Mahdia Gabr	Trainee	USDA
Dr. David Burger	Instructor	Texas A & I
Mr. Mohamed Hamid Idriss	Trainee	Texas A & I
Dr. R.W. Michelmore	Instructor	UCD
Dr. Mohamed Khairat Dawood	Trainee	UCD
Dr. Carole Meredith	Instructor	UCD
Dr. Andrew Kuniyuki	Instructor	UCD
Ms. Faiza Taha	Trainee	UCD

VEGETABLE SEED PRODUCTION AND CERTIFICATION

November 1981 – August 1983

Expenditure $134,800 LE 47,509

Egypt

Dr. M.M. El-Shirbini	Team Leader	MOA
Mr. H.M. Shabana	Senior Investigator	MOA
Mr. M.Z. Farrag	Senior Investigator	MOA
Mr. A.M. Hammouda	Senior Investigator	MOA
Mr. E.K. Hashem	Junior Investigator	MOA
Mr. M.N. Hanafy	Junior Investigator	MOA
Mr. M.H. Osman	Junior Investigator	MOA
Mr. E.M. Metwaly	Technical Assistant	MOA
Mr. H.A. El-Shamaa	Technical Assistant	MOA
Mr. A.A. Omar	Technical Assistant	MOA
Mr. S.S. Farag	Technical Assistant	MOA
Mr. A. Nassif	Technical Assistant	MOA
Mr. S.M. Nassar	Technical Assistant	MOA
Dr. Mohamed A. Abdel-Rehim	Principal Investigator	Alexandria University
Dr. Hani Mohamed Badr	Junior Investigator	Alexandria University
Dr. M. Abdel-Aziz Abdel-Fattah	Principal Investigator	Cairo University
Dr. Eid Mohamed Abou Taleb	Junior Investigator	Alexandria University
Dr. A.G. Moussa	Junior Investigator	Alexandria University

UCD

Dr. Don Grabe	Team Leader	Oregon State University
Dr. James F. Harrington	Team Leader	UCD
Dr. Burt Ray	Adviser	UCD
Dr. Yaaco Ventura	Adviser	Israel
Dr. James E. DeVay	Adviser	UCD

IMPROVED DATE PALM PRODUCTION

December 1981 – August 1983

Expenditure $ 59,166 LE 55,066

Egypt

Dr. Fathi Hussein	Team Leader	Zagazig University
Dr. Abdel-Azim M. El-Hammady	Principal Investigator	Ain Shams University
Dr. Ahmed Sayed Montasser	Junior Investigator	Ain Shams University
Dr. Samy Ismail Hassan Gaffar	Junior Investigator	Zagazig University
Dr. Ibrahim M. Dessouky	Senior Investigator	Ain Shams University
Dr. Mohamed Sharaf Darwish	Junior Investigator	Moshtohor College Agric.
Dr. Said Abdel Aty El-Shazly	Assistant	Ain Shams University
Mr. Hassan M. Fadl El-Wakeel	Assistant	Ain Shams University
Mr. Abdel-Rahman Abdel-Hamid	Assistant	Ain Shams University
Dr. Kamaleldin Mohamed Abdalla	Senior Investigator	Zagazig University
Dr. Mahmoud Ibrahim El-Kady	Junior Investigator	Mansoura University
Dr. Abbas Ahmed Moustafa	Junior Investigator	Fayoum University
Dr. Mohamed R. Salah	Senior Investigator	Zagazig University
Mr. Saad M.M. El-Shakaa	Technical Assistant	Zagazig University

IMPROVED DATE PALM PRODUCTION *(Cont'd)*

Dr. Ahmed Khalifa	Principal Investigator	MOA
Dr. Ibrahim Mohamed	Principal Investigator	MOA
Dr. Gamal M. Nour	Junior Investigator	MOA
Dr. Ahmed M. Hussein	Junior Investigator	MOA
Mr. Ibrahim A. Moussa	Assistant	MOA
Mr. Mostafa S. El-Hakeem	Assistant	MOA
Mr. Fayez G. Nakhla	Assistant	MOA
Mrs. Nemaat Younis	Assistant	MOA
Mr. Fayik M. Badawy	Assistant	MOA
Mr. Mohamed Hussein	Assistant	MOA
Mr. Refaat T. Bernaba	Assistant	MOA
Mr. Adel Mougazy	Assistant	MOA
Mr. Taha M. Saleh	Assistant	MOA

UCD.

Dr. John Carpenter	Team Leader	USDA

IMPROVEMENT OF BANANA PRODUCTION

July 1982 – August 1983

Expenditure $ 8,702 LE 14,497

Egypt

Dr. Abdel-Mongy Bayoumy Abo-Aziz	Team Leader	National Research Center
Dr. Ibrahim Shawky El-Sayed	Principal Investigator	Ain Shams University
Dr. Hamdy Adbel-Aziz Mousry	Senior Investigator	National Research Center
Dr. Essam Abdel-Aziz Shabaan	Junior Investigator	National Research Center
Dr. Mahmoud Mohamed Naguib	Junior Investigator	National Research Center
Dr. Mohamed Mohamed El-Tanahy	Junior Investigator	National Research Center
Dr. Ahmed Ahmed Keshta	Senior Investigator	MOA
Dr. Mamdouh Riah Tadros	Senior Investigator	MOA
Mr. Mehamed Mohamed Saad	Assistant	MOA
Mr. Ahmed Mostafa Abdel-Kader	Assistant	MOA

UCD

Dr. Paige L. Taylor	Team Leader	Independent Consultant

THE IMPACT OF PRICING ON LAND AND WATER ALLOCATION

April 1980–December 1982

Expenditure $ 12,922 LE 2,603

Egypt

Dr. Ahmed Goueli	Team Leader	Zagazig University
Dr. Kamel El-Kheshen	Senior Investigator	Ain Shams University

UCD

Dr. Richard Howitt	Team Leader	UCD

RURAL LABOR SUPPLY

April 1981 – December 1982

Expenditure $ 142,405 LE 57,381

Egypt

Dr. Ahmed Goueli	Team Leader	Zagazig University
Dr. Rafeat Naggar	Team Leader	Zagazig University
Dr. Aly Abdella Hadhood	Senior Investigator	Zagazig University
Dr. Said El-Sanhooty	Senior Investigator	Zagazig University
Mr. El-Sayed H. Mahdy Amer	Junior Investigator	Zagazig University

RURAL LABOR SUPPLY *(Cont'd)*

Mr. Ahmed Gamal M. Mahmoud	Junior Investigator	MOA
Mr. Yehia Abdel Wahab	Junior Investigator	MOA
Mr. Mohamed Kamal Soliman	Junior Investigator	Menia University
Mr. Akram Mohamed El Said	Junior Investigator	Private Sector
Mr. Sayed Amin Nasr	Junior Investigator	MOA
Ms. Bilkeis Mohamed Omran	Junior Investigator	MOA
Mr. Nagi Ibrahim M. Zaki	Junior Investigator	MOA
Mr. Nabil Wahba Hanna	Junior Investigator	MOA
Mr. Khairat Ismail Mohamed	Junior Investigator	Ministry of Cultural Affairs
Dr. Ibrahim Ahmed Yousef	Junior Investigator	Zagazig University
Mr. Mohamed Khaled M. Ragheb	Research Assistant	MOA
Mr. Mohamed Al-Oasia	Research Assistant	MOA
Mr. Mazhar M. Abd El-Aal	Research Assistant	MOA
Mr. Gamal M. Labib	Research Assistant	MOA
Mr. Mohamed T. Saad	Research Assistant	MOA
Mr. Ahmed Shehata Ahmed	Research Assistant	MOA
Mr. Mokhtar A. Mohamed	Research Assistant	MOA
Mr. Mohsen Sadek Hassan	Research Assistant	MOA
Mr. Saleh Ahmed El-Hadary	Research Assistant	MOA
Mr. Abd El-Aaty El-Sherbiny	Research Assistant	MOA
UCD		
Dr. Alan Richards	Team Leader	UC Santa Cruz
Dr. Philip Martin	Team Leader	UCD
Mr. Scott E. Thomas	Research Assistant	UCD
Mr. Hector Gancedo	Research Assistant	UC Santa Cruz
Mr. Hasan Schaafsma	Research Assistant	UC Santa Cruz
Mr. Kyle Samuels	Research Assistant	UCD
Mr. Peter Simmons	Student Assistant	UCD

PRICE POLICY AND TRADE

July 1980 – December 1982

Expenditure $ 23,114 LE 8,673

Egypt		
Mr. Tarek Moursi	Research Assistant	MOA
UCD		
Dr. James C. Ingram	Team Leader	University of North Carolina

FOOD SECURITY AND AGRICULTURAL PRICE POLICY

October 1980 – September 1982

Expenditure $ 315,992 LE 71,409

Egypt		
Dr. Mohamed Ragaa El-Amir	Team Leader	Assuit University
Dr. Saad Zaki Nassar	Team Leader	Fayoum University
Dr. Gamal Mohamed Siam	Principal Investigator	Cairo University
Dr. Mahmoud El-Sayed Eisa	Principal Investigator	MOA
Dr. Shawky Iman	Principal Investigator	Zagazig University
Dr. Hamed Abdel Shafy Hadhod	Senior Investigator	Minia University
Dr. Ahmed Dia Al-Din Zaiton	Senior Investigator	Minia University
Dr. Ahmed Abd El-Hafez M.	Senior Investigator	Assuit University
Dr. Abd El-Azim Mohamed	Senior Investigator	Cairo University
Dr. Osman Ahmed Gad	Senior Investigator	Cairo University
Dr. Rabie Zaki Amer	Senior Investigator	Cairo University
Dr. Ghazal Abdel Aziz Amer	Senior Investigator	Cairo University
Dr. Fatheia Mostafa El-Sayed	Senior Investigator	MOA
Dr. Nabil Atia Ewis	Senior Investigator	Canal University
Dr. Osman Hegazy	Senior Investigator	Cairo University
Dr. Abd El-Wakeel Ibrahim	Senior Investigator	Assuit University

FOOD SECURITY AND AGRICULTURAL PRICE POLICY *(Cont'd)*

Dr. Mahmoud Mansour	Senior Investigator	MOA
Mr. Abdel Sattar Abdel Aziz	Research Assistant	Cairo University
Mr. Magdy Mohamed Khalifa	Research Assistant	Cairo University
Mr. Ali Asem Zaki Fouad	Research Assistant	Cairo University
Mrs. Shahinaz Eid Mahmoud	Research Assistant	El-Fayom University
Mr. Rashad Sayed Abd El-Salam	Research Assistant	MOA
Mr. Mohamed Tarek Ahmed	Research Assistant	MOA
Mrs. Sawsan Sayed Mohamed	Research Assistant	MOA
Mrs. Hoda Abd El-Razek	Research Assistant	MOA
Mr. Ahmed Mohamed El-Shater	Research Assistant	MOA
Mr. Ahmed Hosni Ghanima	Research Assistant	MOA
Mrs. Safia Omer Mohamed	Research Assistant	MOA
Mrs. Azza Ibrahim Emara	Research Assistant	MOA
Mr. Mahmoud Shebl El-Ramy	Research Assistant	MOA

UCD

Dr. Alain de Janvry	Team Leader	UC Berkeley
Dr. Alexander Sarris	Team Leader	UC Berkeley
Dr. Luis Crouch	Research Assistant	UC Berkeley
Mr. Jean-Jacques Dethier	Research Assistant	UC Berkeley
Mr. Hadi Esfahani	Research Assistant	UC Berkeley
Mr. K. Subbarao	Research Assistant	UC Berkeley

FOOD CONSUMPTION IN RURAL EGYPT

November 1980 – August 1983

Expenditure $ 156,230 LE 19,718

Egypt

Dr. Mohamed A. El-Shennawy	Team Leader	MOA
Dr. Afaf Abdel Aziz Mohammed	Principal Investigator	MOA
Dr. Amin Ismail Abdou	Senior Investigator	National Research Center
Dr. Marzouk Abdel Rehim Aref	Senior Investigator	Menia University
Dr. Mohamed Samir Moustafa	Senior Investigator	Institute of National Planning
Dr. Isis Azer Nawar	Senior Investigator	Alexandria University
Ms. Bahiah Ibrahim Fawzy	Senior Investigator	MOA
Ms. Nadia Mohamed Kandiel	Research Assistant	MOA
Mr. Mohamed Maher El-Ainy	Research Assistant	MOA
Mr. Ragy Anggli Goergy	Research Assistant	MOA
Mr. Mohamed Zaki Khatab	Research Assistant	MOA
Mr. Mahmoud M. Abdel Fattah	Research Assistant	MOA
Mr. Mofied Ayooub Saad	Research Assistant	MOA
Mr. Mohamed Ibrahim Gamea	Research Assistant	MOA
Mr. Zarief Hezkeial Looka	Research Assistant	MOA
Mr. Samier Salam Youssef	Research Assistant	MOA
Ms. Samah Kamel Mohamed	Research Assistant	MOA
Mr. Fawzy Mahmoud Barghash	Research Assistant	MOA
Mr. Shaikhon Ezz El-Din M.	Research Assistant	MOA
Mr. Mohamed Mahmoud Kasalah	Research Assistant	MOA
Ms. Fatma El-Nabaweia Osman	Research Assistant	MOA

UCD

Dr. Sylvia Lane	Team Leader	UC Berkeley
Dr Carlos Benito	Team Leader	UC Berkeley
Ms. Rosa Maria Berninsone	Research Assistant	UCD
Ms. Melissa Cadet	Research Assistant	UCD

EXPORT MARKETING POTENTIAL FOR VEGETABLES

October 1980 – September 1982

Expenditure $ 76,115 LE 52,591

Egypt

Dr. Waheed Megahid	Team Leader	Ain Shams University
Dr. Hamdi Salem	Principal Investigator	Ain Shams University

EXPORT MARKETING POTENTIAL FOR VEGETABLES *(Cont'd)*

Dr. Albert Beshara Resk	Senior Investigator	MOA
Dr. Mohamed Abdel Sadik	Senior Investigator	Ain Shams University
Dr. Mohamed S. Zaied	Senior Investigator	Ain Shams University
Dr. Nagla Mohamed Waly	Senior Investigator	Moshtohor University
Dr. Abdel Khalik El-Ashry	Senior Investigator	Ain Shams University
Dr. Mohamed El-Saadany	Senior Investigator	Ain Shams University
Dr. Mossad Ragab	Senior Investigator	Ain Shams University
Dr. M.A.S. El-Sentressy	Senior Investigator	Ain Shams University
Mrs. Fatma El-Dardderi	Research Assistant	MOA
Dr. Fatma Abbas Fahmy	Research Assistant	Ain Shams University
Mr. Bahaa El-Din M. Morsy	Research Assistant	Ain Shams University
Mr. Salah Mahmoud Maklad	Research Assistant	Ain Shams University
Mr. Sameer El-Said El-Shazly	Research Assistant	Ain Shams University
Dr. Shehata El-Sayed Shehata	Adviser	Ain Shams University
UCD		
Dr. Richard Simmons	Team Leader	North Carolina State University
Dr. Lynn Hinton	Adviser	University of Cambridge, Cambridge, U.K.

FARM MECHANIZATION AND PUBLIC POLICY

December 1980 – December 1982

Expenditure $ 77,687 LE 25,286

Egypt		
Dr. Shawky Iman	Team Leader	Zagazig University
Dr. Tawfik Kashif Hany	Senior Investigator	National Research Center
Dr. Abd El-Rahman Abd El-Aziz	Senior Investigator	Fayoum University
Dr. Morad Aly Nashat Khalil	Senior Investigator	MOA
Dr. Mahmoud Alaa Abd El-Asis	Research Assistant	National Research Center
Dr. Mohamed Nasr Farid	Research Assistant	Institute of National Planning
Mr. Taher Mohamed Hassanein	Research Assistant	Zagazig University
Mr. Mokhtar M. Ezz El-Din	Research Assistant	MOA
Mr. Said Nabawy El-Sayed	Research Assistant	MOA
Mr. Abd El-Razek Mohamed	Research Assistant	MOA
UCD		
Dr. Wayne Dyer	Team Leader	Stanford University
Dr. Carl Gotsch	Adviser	Stanford University
Mr. Pierre Lemoine	Research Assistant	Stanford University

PRICE POLICY AND FOOD SUBSIDIES

October 1980 – December 1982

Expenditure $ 80,599 LE 26,098

Egypt		
Dr. Dyaa Abdou	Team Leader	Zagazig University
Dr. Adel Mohamed Moustafa	Senior Investigator	Al Azhar University
Dr. Sonia Mohamed Ali	Senior Investigator	Zagazig University
Dr. Sobhy M. Ismail	Senior Investigator	Cairo University
Dr. Nagla Mohamed Waly	Senior Investigator	Moshtohor University
Mr. Iman Mohamed El-Gamasy	Research Assistant	MOA
Mr. Morad Mousa Soliman	Research Assistant	MOA
Dr. Rasmia Moustaf El-Sayed	Senior Investigator	MOA
UCD		
Dr. B. Delworth Gardner	Team Leader	UCD
Dr. Richard Green	Team Leader	UCD

THE ECONOMICS OF EGYPTIAN LIVESTOCK PRODUCTION

December 1980 – December 1982

Expenditure $ 94,529 LE 32,843

Egypt

Dr. Ibrahim Soliman	Team Leader	Zagazig University
Dr. El-Shabat M. Zaki	Senior Investigator	Zagazig University
Dr. Abd El-Moneim Ragab M.	Senior Investigator	Zagazig University
Dr. Mousa A. Ahmed Mousa	Senior Investigator	MOA
Dr. Nesreen A. Saied	Senior Investigator	MOA
Dr. Ali Ahmed Ibrahim	Senior Investigator	Zagazig University
Mr. Mohamed H.M. Sadik	Junior Investigator	Ain Shams University
Mrs. Tesby Mohamed Rashad	Junior Investigator	Zagazig University
Mr. Imam Ahmed Bashir	Research Assistant	Zagazig University
Mrs. Niven Ahmed Hamed	Research Assistant	Cairo University
Mr. Mohamed Amin Moselhy	Research Assistant	Zagazig University
Mr. Youhanna El-Kommus Dawood	Research Assistant	Ministry of Supply
Mr. Mohamed I. Abd El-Naby	Research Assistant	MOA
Mr. Ahmed M. El-Itriby	Research Assistant	MOA
Mr. Hassan M. Samour	Research Assistant	MOA
Ms. Nabila E. Sharaf	Research Assistant	MOA
Mrs. Ragaa Mahmoud Rizk	Research Assistant	Zagazig University
Mr. Ahmed El-Isnawy	Research Assistant	Cairo University
Mr. Ibrahim Ahmed	Research Assistant	MOA
Mr. Farouk Hibib	Adviser	Ministry of Supply
Dr. Osman Shehata Khedr	Adviser	Ain Shams University

UCD

Dr. James Fitch	Team Leader	Agrimanagement, Inc. Yakima, Washington
Dr. Carl Gotsch	Adviser	Stanford University
Mr. George Haynes	Adviser	AMEC, Bozeman, Montana

COTTON MARKETS AND GOVERNMENT POLICY

December 1980 – December 1982

Expenditure $ 135,321 LE 14,645

Egypt

Dr. Hassan Khedr	Team Leader	MOA
Dr. Hanaa Khier El-Din	Principal Investigator	Cairo University
Dr. Salwa Mohamed Khalil	Senior Investigator	MOA
Dr. Mohamed Ibrahim Toreyeh	Junior Investigator	Zagazig University
Mr. Mohamed Serif Omran	Research Assistant	MOA
Mr. Samy Zaki Mousa	Research Assistant	MOA
Mr. Alfons Wanis Karkour	Research Assistant	MOA
Mr. Ahmed Abou-Rawash	Research Assistant	MOA
Ms. Hodda Abbas Mohamed Mousa	Research Assistant	MOA
Mr. Adnan Roshdy Nassar	Research Assistant	MOA
Mr. Hania Shaaban Morsi	Research Assistant	MOA
Mr. Said El-Agagy	Research Assistant	MOA
Ms. Laila Hafez Alla	Research Assistant	MOA
Mr. Sabri Abd El-Aziz	Research Assistant	MOA

UCD

Dr. Eric Monke	Team Leader	University of Arizona
Dr. Todd E. Petzel	Team Leader	Stanford University
Dr. Carl Gotsch	Adviser	Stanford University
Dr. Lester Taylor	Adviser	University of Arizona
Dr. Donald Heckerman	Adviser	University of Arizona
Mr. Coty Pickney	Research Assistant	Stanford University
Ms. Antoinette Nahmias	Research Assistant	Stanford University
Ms. Barbara Hoffman	Research Assistant	University of Arizona

THE EFFICIENCY OF THE EGYPTIAN FARM

January 1981 – December 1982

Expenditure $ 33,135 LE 21,676

Egypt

Dr. Ali Soliman Aitah	Team Leader	Zagazig University
Dr. Dessouky Abdel Salama	Principal Investigator	Zagazig University
Mr. Ahmed Mohamed El-Sayed	Research Assistant	MOA
Mr. Osman Mohamed Salama	Research Assistant	Moshtohor University
Mr. Adel Eid H. Mahfoze	Research Assistant	Zagazig University
Mr. Mohamed Gaber Mohamed	Research Assistant	Zagazig University

UCD

Dr. John Antle	Team Leader	UCD
Ms. Carol E. Levin	Research Assistant	UCD
Ms. Wendy J. Warren	Research Assistant	UCD

IMPROVEMENT IN AGRICULTURAL COOPERATIVES

February 1981 – June 1983

Expenditure $ 78,601 LE 44,781

Egypt

Dr. Taha Abou-Sheasha	Team Leader	Cairo University
Dr. Ibrahim Moharrum	Team Leader	Ain Shams University/AUC
Dr. Hussein Abdel Wahab	Senior Investigator	Ain Shams University
Dr. Abdel Hamid Sharshar	Senior Investigator	Azhar University
Dr. Mohamed Ramadan El Shohnah	Senior Investigator	Cairo University
Dr. Faris Said Shaker	Senior Investigator	Cairo University
Dr. Fawzy A. El-Shazly	Senior Investigator	MOA
Dr. Abdel Aziz El-Shabrawi	Senior Investigator	MOA
Mr. Mohamed Nassim A. Swilem	Junior Investigator	Azhar University
Mr. Ahmed Korashy Mohamed	Junior Investigator	Ain Shams University
Mr. Samir El-Sayed A. Shazly	Junior Investigator	Ain Shams University
Mr. Farid A. Amer	Research Assistant	MOA

UCD

Dr. Refugio Ismail Rochin	Team Leader	UCD
Ms. Judith Stoft	Research Assistant	UCD
Ms. Ana Castro	Student Assistant	UCD
Ms. Jodee Solomon	Research Assistant	UCD
Mr. Joseph C. Grossman	Research Assistant	UCD
Mr. Gary Thompson	Research Assistant	UCD
Ms. Patricia Soberanis	Student Assistant	UCD
Ms. Chisty Bengard	Computer Programming	UCD
Ms. Kathy Edgington	Computer Programming	UCD

ECONOMIC CONSTRAINTS TO POULTRY PRODUCTION

April 1981 – August 1983

Expenditure $ 37,711 LE 30,093

Egypt

Dr. Yehia Mobieldin	Team Leader	MOA
Dr. Ibrahim Siddik Ali	Principal Investigator	Menofia University
Dr. Wassima Moustafa Affify	Senior Investigator	Menofia University
Dr. Hosni Abd El-Hamid	Senior Investigator	MOA
Dr. Mohamed El-Sayed Raghib	Senior Investigator	Menofia University
Mr. Ahmed M. El-Shaarwy	Junior Investigator	Menofia University
Mr. Mansour Maghawry Hassan	Junior Investigator	National Research Center
Mr. Mahmoud M. Abdel Moneim	Research Assistant	Menofia University

ECONOMIC CONSTRAINTS TO POULTRY PRODUCTION *(Cont'd)*

Mr. Tarek Mohamed Ibrahim	Research Assistant	MOA
Mr. Mohamed Abd El-Hakam M.	Research Assistant	MOA
Ms. Awattef Mohamed Ramadan	Research Assistant	MOA
Mr. Usama Mansour El-Gindy	Research Assistant	MOA
Ms. Nadia Mohamed Ali	Research Assistant	MOA
Mr. Mostafa Hafez Ali	Research Assistant	MOA
Mr. Refaat A. Salam Hassan	Research Assistant	Menofia University

UCD

Dr. Tim Carpenter	Team Leader	UCD
Dr. James Cothern	Team Leader	UCD
Dr. Robert Schneider	Adviser	International Monetary Fund
Dr. Ralph Ernst	Adviser	UCD
Dr. Wade Brandt	Adviser	UCD
Mr. Ghazanfar Ullah Khan	Research Assistant	UCD
Ms. Susan McManigal	Student Assistant	UCD
Mr. Ezekiel U. Rikin	Student Assistant	UCD
Ms. Kirsten Smith	Student Assistant	UCD
Ms. Miha Wang	Student Assistant	UCD
Mr. Shakeel Masood	Student Assistant	UCD
Ms. Kendra Coon	Student Assistant	UCD

AN ECONOMIC EVALUATION OF NORTHERN LAKES DEVELOPMENT

April 1981 – August 1983

Expenditure $ 74,155 LE 62,762

Egypt

Dr. Osman El-Kholei	Team Leader	Menofia Univ./MOA
Dr. Saad El-Shayal	Team Leader	Cairo University
Dr. Mohamed Nabil Ganieh	Principal Investigator	Alexandria University
Dr. Mohamed Salah El-Kholei	Principal Investigator	Menofia University
Dr. Mohamed Mahdi Assar	Senior Investigator	High Institute of Agriculture Cooperatives
Dr. Moustafa Ibrahim Abou-Saad	Senior Investigator	Menofia University
Dr. Taher Youssef	Senior Investigator	MOA
Dr. Abbas Abdel Rahman Abou-Auf	Senior Investigator	Ain Shams University
Dr. Hassan Badr El-Din	Senior Investigator	MOA
Dr. Ahmed El-Henedi Radwan	Senior Investigator	MOA
Mr. El-Sawy Mohamed El-Sawy	Research Assistant	MOA
Mr. Mohamed Fawzy Said	Research Assistant	Alexandria University
Mr. Hussein El-Sayed Hussein	Research Assistant	Menofia University
Mr. Aly Abdel Fatah El-Sayed	Research Assistant	Menofia University

UCD

Dr. Eric Gustafson	Team Leader	UCD
Dr. Turid Reid	Team Leader	UCD
Dr. John Rowntree	Team Leader	UCD
Dr. Richard E. Howitt	Adviser	UCD
Mr. James M. Hunter	Student Assistant	UCD

ECONOMIC EVALUATION OF POSTHARVEST LOSSES

October 1981 – August 1983

Expenditure $ 48,544 LE 12,366

Egypt

Dr. Nabil Habashy	Team Leader	MOA
Dr. Abdel Latif Atcia El-Kak	Senior Investigator	Alexandria University
Mrs. Azza Attia Abd El Kader	Research Assistant	MOA
Mrs. Samah H. Swedan	Research Assistant	MOA
Mrs. Soheir K. Armanios	Research Assistant	MOA
Mrs. Ivon A. Rizk	Research Assistant	MOA

ECONOMIC EVALUATION OF POSTHARVEST LOSSES *(Cont'd)*

Mrs. Soaad H. Salama	Research Assistant	MOA
Mr. El-Sayed A. Abd El-Aal	Research Assistant	MOA
Mr. Abd El-Fattah A. Salama	Research Assistant	MOA
Mr. Abdo Mohamed A. Mostafa	Research Assistant	Ministry of Trade
Dr. Mohamed Galal El-Din Aboul Dahab	Adviser	Helwan University
UCD		
Dr. Jerry Foytik	Team Leader	UCD
Dr. Hoy Carmen	Team Leader	UCD

AN EVALUATION OF BIOGAS TECHNOLOGY

October 1981 – March 1983

Expenditure $ 32,566 LE 18,143

Egypt		
Dr. Nabil Alaa-El Din	Team Leader	MOA
Dr. Kamal Sulton	Senior Investigator	Cairo University
Dr. S. El-Shimi	Senior Investigator	MOA
Dr. Emad Mokhtar El-Shafie	Senior Investigator	Cairo University
Mr. Ezzat Ahmed El-Azzouni	Junior Investigator	Zagazig University
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Mr. F. Hashim	Research Assistant	MOA
Mr. S. Robert	Research Assistant	MOA
Mrs. N. Herzalah	Research Assistant	MOA
UCD		
Dr. James Wilen	Team Leader	UCD
Mr. Russell Davis	Research Assistant	UCD

ECONOMIC EFFICIENCY AND THE RESOURCE USE ON THE EGYPTIAN FARM

October 1981 – December 1982

Expenditure $ 45,079 LE 37,489

Egypt		
Dr. Abdel Tawab El-Yamani	Team Leader	Kafr El-Shiekh University
Dr. Mohamed Kamel El-Etr	Senior Investigator	Helwan University
Dr. M. El Shafie	Senior Investigator	Alexandria University
Dr. Kamel Sultan	Senior Investigator	Alexandria University
Dr. Nagi Abdel Karim Sayed	Senior Investigator	Kafr El-Shiekh University
Dr. M. H. El-Gazzar	Senior Investigator	Kafr El-Shiekh University
Dr. Abdel Karim El-Sayed	Senior Investigator	Kafr El-Shiekh University
Dr. Mokhtar Mohamed Abdalla	Senior Investigator	Kafr El-Shiekh University
Dr. Ibrahim Sobhi Ali	Senior Investigator	Kafr El-Shiekh University
Mr. Abdel Fattah M. Mehahed	Senior Investigator	Kafr El-Shiekh University
Mr. Hussein Youssif M. Amaish	Research Assistant	Helwan University
Mr. El-Sayed Hashem Mohamed	Research Assistant	Kafr El-Shiekh University
Mrs. Fatma Abdel Salam	Research Assistant	Kafr El-Shiekh University
Mr. Ahmed Mohamed Ahmed	Research Assistant	Helwan University
UCD		
Dr. Warren Johnston	Team Leader	UCD
Dr. Harold Carter	Team Leader	UCD
Mr. Yen Shong Chiao	Research Assistant	UCD
Mr. Mohamed Hasheesh	Research Assistant	UCD
Ms. Mary Hawkins	Research Assistant	UCD

INTERCONNECTIONS OF EGYPTIAN FOOD AND AGRICULTURE POLICY

November 1981 – December 1982

Expenditure $ 43,153 LE 33,591

Egypt		
Dr. Ahmed Goueli	Team Leader	Zagazig University
Dr. Essam Abdel Atie Abou-Wafa	Principal Investigator	Alexandria University

INTERCONNECTIONS OF EGYPTIAN FOOD AND AGRICULTURE POLICY *(Cont'd)*

Dr. Mohamed Sobhy El-Atriby	Principal Investigator	Ministry of Supply
Dr. Galal Abdel Fattah El-Mallah	Senior Investigator	Alexandria University
Dr. Barakat Ahmed El-Ferra	Senior Investigator	Institute of National Planning
Dr. Sohair Abdel Rahmen Gouefel	Senior Investigator	Ministry of Supply
Dr. Riad E. Emarrah	Senior Investigator	Cairo University
Mr. Magd Ibrahim Mohamed	Research Assistant	Suez Canal Bank
Mr. Mohamed Mousa El-Faragy	Research Assistant	Ministry of Planning
Mrs. Shadia Salah El-Din	Research Assistant	Private Sector
Mrs. Shokria El-Said Tawfic	Research Assistant	Ministry of Supply
Mrs. Fawzia Mohamed Arafa	Research Assistant	Alexandria University
Mr. Helmy A. Saad	Research Assistant	Ministry of Planning
Mrs. Mona Mohamed Fahmy	Research Assistant	Alexandria University
Mr. Nabil Bayoumi Sammour	Research Assistant	Ministry of Planning
Mr. Fathi Abdel Baky El-Shiekh	Research Assistant	Ministry of Planning
Mrs. Omyma Shafic	Research Assistant	MOA
Mrs. Fatten Arien	Research Assistant	MOA
Mr. Mohmed Abdel Naby	Research Assistant	MOA

UCD

Dr. Alex McCalla	Team Leader	UCD
Dr. Gordon King	Team Leader	UCD
Dr. Harold Carter	Adviser	UCD
Dr. Bruce Glassburner	Adviser	UCD
Mr. Charles C. Crissman	Research Assistant	UCD
Mr. Enrique Figuroa	Research Assistant	UCD

ECONOMIC ANALYSIS OF THE EGYPTIAN CITRUS INDUSTRY

November 1981 – April 1983

Expenditure $ 44,004 LE 12,081

Egypt

Dr. Mohamed Gomaa	Team Leader	Zagazig University
Dr. Mohamed Sharaf	Team Leader	MOA
Dr. Mohamed El-Sayed Radwan	Senior Investigator	Zagazig University
Mr. Mohamed Taher El-Masry	Research Assistant	MOA
Mr. Mohamed Y. Sultan	Research Assistant	MOA
Mr. Mahran S. Aita	Research Assistant	MOA

UCD

Dr. Ben French	Team Leader	UCD
Dr. Loy Sammet	Adviser	UC Berkeley

COMMODITY SYSTEMS ANALYSIS

December 1981 – December 1982

Expenditure $ 25,798 LE 34,376

Egypt

Dr. Hussein Abd El-Samie	Team Leader	Azhar University
Dr. Adel I. Hindy	Principal Investigator	Azhar University
Dr. Fawzy Halim Rizk	Principal Investigator	Ministry of Supply
Dr. Mahmoud Mansour	Principal Investigator	MOA
Dr. Mahmoud Abou Zeid Saleh	Senior Investigator	Azhar University
Dr. Alaa El-Din El-Menoufi	Senior Investigator	Azhar University
Dr. Amin A. Montasser	Senior Investigator	Azhar University
Dr. Nasr Mohamed El-Kazaz	Senior Investigator	Azhar University
Mr. Hossam El-Din Mahmoud	Research Assistant	Azhar University
Mr. Hussein El-Din Soliman Shalaby	Research Assistant	Azhar University
Mr. Mohamed Tewfik Abdel Latif	Research Assistant	Azhar University
Mr. Ahmed M. Abd-Allah Mostafa	Research Assistant	Azhar University
Mr. Roshdy El-Ansary	Research Assistant	MOA
Mr. Mohamed El-Sayed	Research Assistant	MOA

COMMODITY SYSTEMS ANALYSIS *(Cont'd)*

Mr. Abdel Fattah Abou Baker	Research Assistant	MOA
Mr. Mohamed Farag El-Desoki	Research Assistant	MOA
Dr. Shehata E. Shehata	Adviser	Ain Shams University
UCD		
Dr. Leon Garoyan	Team Leader	UCD
Dr. Kirby Moulton	Team Leader	UC Berkeley

RURAL DEVELOPMENT AND PATTERNS OF CONSUMPTION

April 1982 – August 1983

Expenditure $ 32,342 LE 7,510

Egypt		
Dr. M. Said Badawi	Team Leader	National Research Center
UCD		
Dr. David Hansen	Team Leader	UCD
Dr. Assma El-Bilassi	Collaborator	MOA/UCD
Mr. Gary D. Thompson	Research Assistant	UCD

INTEGRATED VILLAGE STUDIES AND POLICY EVALUATION

October 1980 – August 1983

Expenditure $ 99,216 LE 6,996

Egypt		
Dr. Said Badawi	Team Leader	National Research Center
Dr. T. Sharara	Senior Investigator	Cairo University
Dr. A. Seifelnasr	Senior Investigator	Cairo University
Ms. Soheir Mahanna	Adviser	AUC
UCD		
Dr. Irma Adelman	Team Leader	UC Berkeley
Dr. Nicholas Hopkins	Principal Investigator	American University
Dr. Michael Hihn	Research Assistant	UC Berkeley
Dr. Harry Lemel	Research Assistant	UC Berkeley

BREEDING IMPROVED HONEYBEES

June 1980 – August 1983

Expenditure $ 97,436 LE 52,099

Egypt		
Dr. Mohamed El-Banby	Team Leader	Ain Shams University
Dr. Mohamed El-Sherif	Principal Investigator	Ain Shams University
Dr. Shokry A. El-Refaie	Technical Assistant	Ain Shams University
Dr. Mohamed Ibrahim	Team Leader	MOA
Dr. Mohamed Mazeed	Principal Investigator	MOA
Mr. Helmy A. Selim	Technical Assistant	MOA
UCD		
Dr. Harry H. Laidlaw	Team Leader	UCD
Mr. Robert E. Page	Research Assistant	UCD

THERMAL DETECTION OF OVULATION AND PREGNANCY IN SHEEP

March 1980 – August 1983

Expenditure $ 51,262 LE 29,713

Egypt		
Dr. Aida M. Nassar	Team Leader	MOA
Dr. Ahmed A. Younis	Principal Investigator	MOA

THERMAL DETECTION OF OVULATION AND PREGNANCY IN SHEEP *(Cont'd)*

Mr. Magdi Abou El Ela	Technical Assistant	MOA
Ms. Madeha Helal	Technical Assistant	MOA
Ms. Sameha N. Mousa	Technical Assistant	MOA
Mr. El-Sayed El-Hassanein	Technical Assistant	MOA
Dr. Essam El-Tawil	Principal Investigator	Ain Shams University
UCD		
Dr. Robert E. Smith	Team Leader	UCD

DEVELOPMENT OF A SMALL POWER UNIT FOR IRRIGATION

July 1980 – August 1983

Expenditure $ 59,790 LE 23,510

Egypt		
Dr. Aly Y. Korayem	Team Leader	Alexandria University
Dr. Ahmed E. Ahmed	Principal Investigator	Alexandria University
Mr. Fakher M. Hamed	Technical Assistant	Alexandria University
UCD		
Dr. M. Stephen Kaminaka	Team Leader	UCD
Dr. Roger E. Garrett	Adviser	UCD
Mr. Bashira A. Majaja	Research Assistant	UCD
Mr. Myk Manon	Research Assistant	UCD

AGRICULTURAL LAW STUDY

July 1980 – July 1982

Expenditure $ 22,629 LE 7,507

Egypt		
Dr. Mohamed Nazeeh	Principal Investigator	Cairo University
UCD		
Dr. John A. Spanogle	Team Leader	State University of New York at Buffalo
Dr. Pierre Loiseaux	Team Leader	UCD

BIOSALINITY CONFERENCE

September 1981

Expenditure $ 8,247 LE 7,859

Dr. D. W. Rains	Organizer	UCD
Egyptian Participants		
Dr. Ibrahim Antar	Director	Soil Salinity Lab. Alexandria
Dr. Abdel El-Beltagy	Horticulture Dept.	Ain Shams University
Dr. R. A. El Einein	Wheat and Barley Section	EMCIP/ARC-GIZA
Dr. Michael Azia Farah		Soils and Water Research Institute
Dr.Abd El-Rahman Gabr		Ain Shams University
Dr. Mohamed Abd-El-Rahman Ghaly	Senior Investigator	Soils and Water Research Institute
Dr. A. A. Gomaa	Wheat and Barley Section	EMCIP/ARC-GIZA
Dr. Nabil M. El-Mowelhi	Agricultural Attache	Egyptian Embassy, Washington, D.C.
Dr. Ali Raagat	Botany Dept. Chairman	Ain Shams University
Dr. Mohamed El-Sawaby		Soils and Water Research Institute
Dr. Balegh Shindy Zikri	Director	Soils and Water Research Institute/MOA

BIOSALINITY CONFERENCE *(Cont'd)*

Israeli Participants

Dr. Beny Aloni		Volcani Center
Dr. A. Banin		Faculty of Agriculture
Dr. E. Bresler	Head of Div. of Soil Physics	Volcani Center
Dr. H. Frenkel	Dept of Soil Physical Chemistry	Volcani Center
Mr. I. Hausenber	Extension Service	Ministry of Agriculture
Dr. A. Meiri		Volcani Center
Dr. I. Shainberg	Head, Dept. of Soil Physical Chemistry	Volcani Center
Dr. J. Shalhevet		Volcani Center

U.S. Participants

Mr. Julio Berdeque	Agronomy and Range Science	UCD
Dr. Del Henderson	Land, Air and Water Resources	UCD
Dr. T. C. Hsiao	Land, Air and Water Resources	UCD
Dr. Andre Lauchli	Land, Air and Water Resources	UCD
Dr. Don Munns	Land, Air and Water Resources	UCD
Dr. Jack Norlyn	Land, Air and Water Resources	UCD
Dr. James O'Leary	Environmental Research Laboratory	Arizona
Dr. Bob Ontell		Fred Hansen Foundation
Dr. Cal O. Qualset	Chairman, Agronomy and Range Science	UCD
Dr. Bill Rains	Coordinator, Biosalinity Conference	UCD
Dr. Frank Robinson	Imperial Valley Research Station	El Centro, CA
Dr. Virgil Smail	Egypt-New Mexico Major Cereals Improvement Project	New Mexico State
Dr. Jan van Schilfgaarde	USDA Salinity Laboratory	Riverside, CA
Dr. Lynn Whittig	Land, Air and Water Resources	UCD
Dr. Mark Winslow	Agronomy and Range Science	UCD

TOMATO PROCESSING PROJECT

August 1981 – August 1983

Expenditure $ 62,335 LE 47,083

Egypt

Hassan A. Heckal	Team Leader	MOA
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Fouad A. El-Ashwah	Senior Investigator	MOA
Shaker S. Rizk	Senior Investigator	MOA
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Salah I. Kamel	Technical Assistant	MOA
Galal El-Shirbiny	Technical Assistant	MOA
Ahmed El-Sharkawy	Technical Assistant	MOA
Fathalla A. El-Wakeel	Team Leader	Cairo University
Esmat T. El-Ashwah	Senior Investigator	Cairo University
Mohamed K. Moursi	Senior Investigator	Cairo University
Ahmed M. Alian	Senior Investigator	Cairo University
Sobhy M. Mohsen	Technical Assistant	Cairo University
Saad A. Hallabo	Technical Assistant	Cairo University
Yehia I. Sallam	Technical Assistant	Cairo University
Adel Z. Abdel Badie	Technical Assistant	Cairo University
Dr. Mohamed Akher	Adviser	MOA
Dr. Ahmed Hussien	Adviser	MOA

UCD

Dr. Bor Luh	Team Leader	UCD

IMPROVED PRODUCTION OF CHEESE AND RELATED PRODUCTS

August 1981 – August 1983

Expenditure $ 72,882 LE 93,344

Egypt

Dr. Abdel Magid Hamdy	Team Leader	MOA
Dr. Leila A. El-Koussy	Senior Investigator	MOA

IMPROVED PRODUCTION OF CHEESE AND RELATED PRODUCT S *(Cont'd)*

Dr. Hayam El-Gazzar	Senior Investigator	MOA
Dr. Shaher El-Hefnawy	Senior Investigator	MOA
Dr. Safenaz El-Shebiny	Senior Investigator	National Research Center
Dr. Mohamed A. Khorshid	Senior Investigator	National Research Center
Mr. Abdel-Kader A. Hefny	Technical Assistant	MOA
Mr. El-Sayed Hafez	Technical Assistant	MOA
Mr. Sayed M. Aweis	Technical Assistant	MOA
Mr. Mohamed N. Nassr	Technical Assistant	MOA
Mr. Shaarawy Gamal	Technical Assistant	MOA
Dr. Mahmoud Kamal Ibrahim	Team Leader	Cairo University
Dr. Mounir R. Naghmoush	Senior Investigator	Cairo University
Dr. Salem Nassr Amer	Senior Investigator	Cairo University
Dr. Elein S. Girgis	Senior Investigator	Cairo University
Dr. Abdel-Gawad Abou Dawood	Senior Investigator	Cairo University
Dr. Mohamed M. Metwally	Senior Investigator	Cairo University
Dr. Ferial Ismail	Senior Investigator	Cairo University
Mr. Sherif M. Kamel	Technical Assistant	Cairo University
Mr. Abou-El Samh Mehrez	Technical Assistant	Cairo University
Mr. Ibrahim Abdel Salam	Technical Assistant	Cairo University
Mr. Abdel Nabi Abdel Atty	Technical Assistant	Cairo University
Ms. Fawzi R. Abd Rabou	Technical Assistant	Cairo University

UCD

Dr. Walter Dunkley	Team Leader	UCD
Dr. T. E. Shehata	Adviser	UCD

TECHNICAL COMMITTEES

Horticulture Sub-Project Technical Committee

UC	*Egypt*
Dr. N. Sommer	Dr. M. M. El- Azzouni
Dr. P. Catlin	Dr. S. Azzouz
Dr. J. Harrington	Dr. A. H. Radwan
Dr. A. Kader	Dr. S. Nassar
Dr. W. Moller	Dr. Y. Wally
Dr. L. Rappaport	Dr. M. A. Maksoud
Dr. R. Voss	Dr. H. El-Hamawy
Dr. R. Soost	Dr. R. K. Stino
Dr. D. Hall	
Dr. W. Sims	
Dr. F. Zink	
Dr. M. Reid	

Economic Sub-Project Technical Committee

UC	*Egypt*
Dr. H. Carter	Dr. A. Goueli
Dr. B. Glassburner	Dr. M. K. Hindy
Dr. B. French	Dr. O. El-Kholie
Dr. E. Gustafson	Dr. S. Shayal
Dr. R. Howitt	Dr. S. El-Shehata
Dr. W. Johnston	Dr. A. El-Yamani
Dr. J. Rowntree	Dr. T. Abou-Sheasha
Dr. C. O. McCorkle	Dr. H. Khedr
	Dr. Y. Mohieldin
	Dr. S. Gaballah
	Dr. Z. Shabanah
	Dr. El-Zalaky

Food Science Special Technical Advisory Committee

UC	*Egypt*
Dr. J. C. Bruhn	Dr. M. A. Akher
Dr. M. W. Miller	Dr. A. A. Hussein
Dr. B. S. Schweigert	Dr. A. M. Hamdy
Dr. T. Shehata	Dr. M. Sobhi
	Dr. A. A. A. Gawad
	Dr. M. A. Salam

TECHNICAL COMMITTEES *(Cont'd)*

The Policy Committee for the Central Laboratory

Dr. M. K. Hindy, Chairman	MOA
Dr. Said Tewfik	MOA
Dr. Abdel Fattah Moursi	MOA
Dr. Bruce Glassburner	UCD

The Central Laboratory Technical Committee

Dr. Said Tewfik, Chairman	MOA
Dr. George Stino	Cairo University
Dr. William Sims	UCD
Dr. Jack Pangborn	UCD
Dr. Alaa Bondok	Ain Shams University
Dr. Talaat Shehata	UCD