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**COOPERATIVE ARID LANDS AGRICULTURE
RESEARCH PROGRAM
(CALAR)**

**A FINAL REPORT
FOR THE PERIOD
1982 - 1990**

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Prepared in Cooperation by
Scientists From
The Arab Republic of Egypt
The State of Israel
And
The United States of America

For The
Bureau for Near East
Agency for International Development

Submitted by
San Diego State University Foundation

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"We believed that if any field could pioneer Regional Cooperation, it was science . . . scientists, because they have standards and methods that have nothing to do with politics . . . can cross national boundaries and talk to each other as professionals . . ."

The Honorable Henry A. Waxman
U.S. House of Representatives
May 4, 1986

"If adversary nations can be encouraged to work together on projects of mutual benefit, this can help heal their differences. . ."

Fred J. Hansen

THE FRED J. HANSEN INSTITUTE FOR WORLD PEACE

One of the organizations that played a major role in initiating the Cooperative Arid Lands Agriculture Research (CALAR) Program was the Fred J. Hansen Institute for World Peace which was established at San Diego State University in 1981 to encourage peaceful relations among nations. Income from Mr. Hansen's estate provides funding for the Institute which is administered by the San Diego State University Foundation.

Since its inception, the Institute has engaged in a number of activities intended to further world peace. Initial activities focused upon the Middle East where, in the wake of the Camp David accords, historic events were occurring. The Institute funded a number of scientific conferences involving the Arab Republic of Egypt, the State of Israel and the United States.

A conference on marine sciences held in San Diego and sponsored by the Hansen Institute, during the summer of 1980 marked the first occasion that scientists from Egypt and Israel met to discuss common interests. Representatives came from the Egyptian Academy of Science and Technology and from Cairo and Alexandria Universities. From Israel, representatives attended from the Oceanographic and Limnological Research Organization in Haifa and the Ministry of Agriculture. Several institutions from the United States participated, including Scripps Institution of Oceanography, Texas A & M University, and Florida State University. This Hansen Institute-sponsored conference led to a grant from the

United States Agency for International Development for a cooperative program in marine science between the three participating nations.

A second Hansen Institute-sponsored conference, held in San Diego in 1981, also involved scientists from Egypt, Israel and the United States. This conference was devoted to cooperation in arid lands agriculture and was the first official trilateral meeting involving scientists from the three countries. This second conference led to a grant to San Diego State University from the U.S. Agency for International Development to conduct a cooperative agriculture research program involving Egypt, Israel and the United States--the Cooperative Arid Lands Agriculture Research (CALAR) Program--which operated from 1982 until 1990.

The idea for this highly successful program was born during the Camp David accords initiated by Presidents Jimmy Carter and Anwar Sadat and Prime Minister Menachim Begin. The idea was further nurtured in a dialogue between President Sadat and Prime Minister Begin when the two met at Ben-Gurion Universities to discuss peaceful pursuits between the two countries.

In an effort to take advantage of the progress made through the Camp David agreements, Hansen trustee, Mr. Leo R.B. Henrikson, contacted the San Diego State University Foundation to formulate a program that would carry out the wishes of the late Mr. Hansen. With the assistance of community members and SDSU staff, the historic meetings were arranged. In addition to Mr. Henrikson, other people active in formulating the programs were Dr. Robert Ontell, Executive Director, the Fred J. Hansen Institute for World Peace, San Diego State University Foundation; Dr. Albert Johnson, Vice President for Academic Affairs, San Diego State University; Dr. George Goodman, President, Facilities Development Company; Mr. Harry R. Albers, General Manager, San Diego State University Foundation; and Mr. Ronald Cady, grandson of Mr. Hansen and Vice President

and General Manager of Mesa Distributing Company.

The Egyptian delegation was lead by His Excellency, Dr. Yousef Wally, now Deputy Prime Minister and Minister of Agriculture; the Israeli delegation was headed by Dr. Joel Schechter, who has remained involved as a member of the program's Steering Committee.

Through the initiative of the Fred J. Hansen Institute for World Peace and the San Diego State University and its Foundation, the CALAR Program has provided a basis for continuing cooperative scientific research between Egypt and Israel.

INTRODUCTION

The Cooperative Arid Lands Agriculture Research (CALAR) Program was the first trilateral cooperative program conducted among scientists from Egypt, Israel and the United States that was within the framework of the International Security and Assistance Act of 1979 through which Congress launched a number of U.S. Agency for International Development Regional Cooperation Programs in the Middle East.

The CALAR Program had its beginnings in a conference held in San Diego in 1981. Sponsored by San Diego State University's Fred J. Hansen Institute for World Peace, the conference involved scientists from Israel, Egypt, and the United States and was devoted to cooperation in arid lands agriculture. It was the first official trilateral conference involving scientists from the three countries. This conference led to a grant to San Diego State University from the U.S. Agency for International Development to conduct a cooperative agriculture research program involving Egypt and Israel, as well as representatives from the United States.

The multidisciplinary CALAR Program initiated and built a unique scientific partnership among its participants; at the same time, its research projects were designed to achieve the stated goals of the governments of Egypt and Israel, making significant contributions to the development of arid regions in both countries.

Throughout its eight-year span, CALAR Program management philosophy has placed an equal emphasis upon science and upon cooperation. Each facet has had a significant impact upon the success of the program.

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Funding for the trilateral CALAR Program was provided by the Bureau for Asia and Near East (formerly the Near East Bureau) of the U.S. Agency for International Development, Contract Number NEB-0170-A-00-2047-00).



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" . . . The future of the Middle East will be determined by the ability of its peoples to work together to confront common challenges. . . "

The Honorable Lee H. Hamilton
U.S. House of Representatives
June 21, 1988

EXECUTIVE SUMMARY

CALAR Research

The CALAR Program research work and the application of its results was conducted over a period of eight years, starting in 1982, and involved more than seventy scientists from both Egypt and Israel, as well as some 15 scientists from the United States.

Researchers in the program concentrated upon three important areas of arid lands agriculture:

- Utilization of saline water for irrigation
- Production of fodder and small ruminants¹
- Industrial crops for arid lands

Each of these areas is presented in detail in this document.

A majority of the CALAR Program research areas were of an applied nature, directed toward practical solutions for real field situations. In both Egypt and Israel, field research was carried out in the farmer's plots, grazing ranges or in regional experimental stations.

The research and its impact has directly influenced thousands of farmers and grazers in both Egypt and Israel.

¹Small ruminants in Egypt only

Through saline water irrigation projects, scientists of both countries worked with two important vegetable crops; tomatoes and melons. Salinity research included a wide range of topics such as physiology of salt tolerance, agromanagement studies, salt effects on fruit quality and on post-harvest behaviour of fruit, breeding, and selection for salt tolerance.

In the area of fodder production, substantive work has been done on the contribution of drought and salt tolerant shrubs to arid lands range productivity. Small animal work centered around genetic improvement of Barki goats by cross-breeding with the Damascus goat. In addition, a basic study was carried out in order to characterize the potential of new management systems for goat and sheep production in Egypt's north west coastal zone.

The work with industrial crops for arid zones concentrated upon jojoba (*simmondsia drimensis*) and gauyule (*parthenium argentatum*). Other crops such as figs, evening primrose and buffalo gourd were also investigated.

The scientific output of CALAR has been significant. More than 60 papers have been published in refereed scientific journals and a number of additional papers are in preparation for publication.

The CALAR Program has also contributed significantly to the development of the large arid land regions of both Egypt and Israel.

In Egypt, the salinity work resulted in an improved Edkawy tomato cultivar, the incorporation of uniform fruit shape, and resistance to root born diseases and nematodes. Drip irrigation was introduced to an area which traditionally utilized surface irrigation. Greenhouses have been introduced to the El-Bousselly area to optimize the local mild climate for out of season production of tomatoes, melons and other vegetables.

In Israel, CALAR salinity studies have led to the commercial production of processing tomatoes with saline water irrigation.

Demonstration plots for the Bedouin are currently being investigated. In 1990, some 25,000 tons of processing tomatoes were produced with saline water irrigation and this number is expected to double in 1991. A new high quality salt tolerant melon cultivar was produced. Greenhouse tomatoes were found to be of higher quality when irrigated with saline water. Commercial production of high quality saline water irrigated tomatoes was started.

Fodder shrubs and trees were planted over an area of about 1,500 acres. A total of 100,000 seedlings were planted and are continuing to provide planting materials to Bedouin in the Western Desert, particularly *Medicago arborea* which was found to be the most promising of the introduced species.

Small animal improvement projects brought about the introduction of Damascus goats which has resulted in a significant improvement in the local goats. On the average, breeds having 1/4 Damascus "blood" (backcrosses to F1 into Barki) were 1.3 percent heavier in weight and yielded 1.44 percent more milk than pure Barki. Originally 67 Damascus bucks were introduced through the CALAR Program. It is estimated that by 1990 almost all of the true Barki goats of the northwest desert of Egypt will have been crossed with Damascus bucks.

In both countries the industrial crops programs did not lead to field application, nor was it not meant to do so. However, much basic knowledge has been accumulated on the productivity potential of jojoba and guayule in arid conditions.

CALAR: A Foundation for Cooperation

The Cooperative Arid Lands Agriculture Research (CALAR) Program has been especially significant in that it has provided an effective framework for the continuity and expansion of joint research efforts among participants from Egypt, Israel and the United States.

In providing a foundation for ongoing scientific cooperation, the CALAR Program has demonstrated the effective manner in which Egyptian and Israeli scientists can work together with their American colleagues to achieve major goals of the highest priority of the Governments of the two Middle Eastern nations.

Also successful has been the program's management philosophy, which has continually placed an equal emphasis upon science and upon cooperation. CALAR Program management has, throughout the eight years of the program, sought to involve many organizations within each country in the scientific and technical aspects of the program; and has established, maintained, enhanced and institutionalized viable relationships between a team of Egyptian, Israeli and U.S. participants in the program. The science itself has been the context of cooperation, and through this cooperative effort, CALAR's tangible results are now benefiting the people of Egypt and Israel. Cooperation, on the other hand, has been the mode for conducting science in the CALAR Program.

A trilateral Steering Committee, composed of representatives from Egypt, Israel and the United States, provided oversight and guidance for the CALAR Program and has been lauded by reviewers as a major contributor to the success of the program. Also important has been the strong commitment to excellence by the San Diego State University and its Foundation,

as the program's prime contractor. Important also, has been the support and commitment from Egypt's Ministry of Agriculture and Land Reclamation and from Israel's Ben-Gurion University of the Negev and the Ministry of Agriculture. This successful program can be used as an example for future cooperative programs in the Middle East, as well as in other regions where peaceful scientific cooperation can contribute to mutual development and understanding between neighboring nations.

Participants from the three CALAR Program countries wish to express their appreciation to the United States Agency for International Development whose financial and moral support were significant factors for visible success.

THE RESEARCH PROGRAM

NOTE: SCIENTIFIC OUTLINES IN THIS SEGMENT OF OUR
REPORT WERE PREPARED BY CALAR PROGRAM SCIENTISTS

THE RESEARCH PROGRAM

UTILIZATION OF SALINE WATER FOR IRRIGATION

Research Work in Egypt: An Introduction

Egypt faces two interrelated and fundamental problems which are receiving attention: a continuing escalation of population pressures, and a shortage of cultivable land. Egypt's population has reached more than 50 million and is growing at a rate of 2.9 percent per year, while the actual area of its cultivated land has remained fairly static. Although crop yields are increasing, this is offset by withdrawal of land for non-agricultural purposes and the deterioration of other agricultural lands to the extent that they are now classified as having medium or poor soils. One phenomenon associated with this deterioration is the increasing salinity of soils in the Nile Valley which is the result of poor drainage and the excessive use of water. Since the completion of the Aswan Dam, a high water table in some areas has caused the soluble salts in the soils to rise to the surface and form a thin white crust on non-irrigated or deteriorated land. Many such areas have been thus rendered non-productive.

Some of the semi-arid and arid areas which have been proposed for the expansion of cultivated agriculture lands have underground aquifers with brackish water and cannot be used for irrigation without employing a strategy of introducing salt tolerant plants and water and soil management suitable to the local ecological systems.

The CALAR trilateral project focused on improvement of the agriculture productivity in the semi-arid lands extending along Egypt's north-western coastal zone. CALAR scientists adopted a multidisciplinary approach to this problem by integrating elements of

plant breeding, physiology, post-harvest, and soil water management, in order to maximize yields of selected vegetable crops (i.e., tomatoes and melons).

The El-Bouseilly area was selected as a CALAR research and development site as it represents a unique example of sand dune agriculture. It is of interest to mention that production of tomatoes and melons is a major activity for local inhabitants of this area. They use either drainage water or rain water collected in reservoirs as the main source of irrigation water. Drainage water is often known to contain a pronounced concentration of salts. Thus, the research activity focused on improving both the conventional soils and water management practices adopted in this region by:

- A. Studying the traditional agromanagement practices in the area to increase water retention;
- B. Studying the influence of fertilization and irrigation methods on tomato production;
- C. Studying the effect of leaching requirements applied by furrow or drip irrigation methods on tomato production;
- D. Investigating the effect of antitranspirants and long chain alcohols on growth, water use efficiency and salt accumulation in the plant;
- E. Research on the possible role of cobalt in salt tolerances of tomatoes.

The introduction and adoption of the tested modern soil and water management technologies will be of the utmost benefit to the region.

The response of tomato and melon to salinity should be understood for immediate selection and screening goals in order to determine the best genotypes showing salt tolerance. This work could be achieved through breeding programs for salt tolerance. The breeding program consisted mainly of three aspects:

- A. Evaluation and screening for various commercial cultivars;

- B. Selection of cultivars showing salt tolerance, and;
- C. Hybridization between wild and cultivated genotypes.

Another aspect of research interest was the study on fruit growth and development. High yield of top quality tomato crops depends upon proper fruit set and development.

Problems at any point during the course of growth, i.e., salinity, can cause reduced yield in terms of fruit quantity and quality. A detailed study on the effect of variable salt levels on the fruit growth and development of tomato will aid in the process of producing marketable fruits. The changes in chemical composition due to the accumulation of carbohydrates and alteration in the plant growth regulators pattern will have positive effects on fruit behavior after post-harvest.

AGROMANAGEMENT

Monitoring Soil and Water Salinity in El-Bouseilly Area, Egypt **(A. El-Araby, A. Sheta, & A. Ibrahim)**

There are two different farming systems in the El-Bouseilly area, namely irrigated farms and Baaly farms. Several farms in each system were selected based upon the age of the farm and the agromanagement practices used. Representative soil and water samples were selected in each farm from a specific site down to the water table, then water table depth (cm) was monitored and salinity profiles were measured in the soil extracts with time. Cations and anions as well as pH values were measured in each sample. Samples were collected, prepared and analyzed during the period (1982-1984).

A brief description of the two systems follows:

Aboie Gahl farm (Baaly system). Monitoring of the salinity profile in this farm indicates that most of the salts accumulated near the surface in most cases and decreased with depth in the profile. Moreover, salinity may be accumulated with a peak at (30-60 cm) layer which is the effect of rainfall. This pattern of salt distribution reflects the effect of climatological changes prevailing in the area. There was no irrigation or drainage water seepage to this area.

Irrigated farms. The CALAR team selected six farms to represent the different ages (6 months to 6 years). The farms were different in water table depth, depth of soil profile, the intensity of the management and the duration of added sands into the top of the soil. A salinity profile in the system indicates that there is an accumulation of salt in the 40-70 cm layer in many cases which peaks in the bottom of the profile. It is anticipated under this system that the major elements contributing to changes in salinity throughout the soil profile are evapotranspiration, irrigation frequency (quantity and quality of irrigation water), rainfall and movement of salts with capillary action from the salty water table.

El-Bouseilly governmental station farm. Monitoring of the soil salinity profile in this farm was accomplished to conduct experiments and to develop the ideas for solving the problems identified in the entire area. Salinity at this particular farm was very low, the water table very deep and irrigation water quite good. The farm is located near the main drainage canal of the area. Based on the above study and an understanding of the system, we conducted several trials and experiments on the following:

- Rooting pattern in the soil profile.
- Establishing a mixing station (saline and fresh water) to mix water from the irrigation and drainage canals.

- Developing agromanagement practices by suggesting drainage to the farmers as well as the addition of fertilizers and improve the irrigation.
- Introducing drip or controlled irrigation methods as well as fertilization techniques with continuous monitoring of the changes.
- Introducing the protected agriculture (plastic houses) and developing management systems for higher yield and production.

**Solid Profile Modification and Water Management Influence on Roots
and Salt Distribution in Sandy Soil**

(A. Ibrahim, A. Sheta, A. El-Gindy, & A. El-Araby)

The main objective of this work is to investigate the agromanagement practices used by the local farmers in the sandy soils of El-Bouseilly, which is located along the Mediterranean coast of Egypt. The soil profile was modified by adding a thin layer of organic manure (chicken manure) at a depth of about 40 cm beneath the plant rows. Root patterns of tomato plants and salt and water distributions in the soil profile was considered.

Certain root patterns following the organic manure modification were observed in both drip and surface irrigation systems. Intensive root proliferation was observed in the organic manure layer. The root zone was generally shallow, but it was shallower in the drip system than that of the surface one. Soil moisture distribution in the modified soil profiles of both drip and surface irrigation treatments were improved compared with non-modified ones. This improvement was more pronounced in the drip irrigation system. Soil salinity increased in all treatments through the growing system. The highest water use efficiency of tomato plants was obtained from the modified soil profile treatments under the drip irrigation system.

Irrigation and Fertilization Management for Tomato Production
Under Arid Land Conditions
(A. El-Indy, A. Ibrahim, & A. El-Araby)

The main objective of this project was to study the effects of different leaching fractions, fertilization methods and the frequency of applications on growth of tomato plants produced on sandy soils and irrigated by a drip or furrow irrigation system. Data indicate that the crop yield of tomatoes gradually increase with increasing leaching fraction from 0.1 to 0.25 or 0.50. This increase was about 32% and 64% for 0.25 and 0.50 leaching fraction, respectively. The application of fertilizers through irrigation water was more pronounced in increasing the crop yield compared with the traditional method of fertilizers application (band application). Moreover, crop yield markedly increased under high frequency of fertilizer application (2 day intervals) comparing with low frequency (15 day intervals). The highest value of water use efficiency was obtained for plants fertilized through a drip irrigation system in high frequency of application under 0.25 leaching fraction. Concerning soil salinity levels, E_{Ce} decreased mainly due to increasing leaching fraction. On the other hand, fertilization techniques markedly reduced the cost of tomato production by about 23% and 35% for furrow and drip irrigation method, respectively.

The Effect of Sodium Acetate Buffer Pretreatment on the Clay
Minerals of Some Arid Land Soils and Reference Clays
(Naghshineh-Pour, B., A.S. Sheta, & D.M. Hendricks)

The pretreatment of soils with pH5 sodium acetate (NaOAc) buffer is widely used to remove carbonates from soils prior to dispersion and separation of clays for mineralogical analysis. The effect of this pretreatment on other minerals such as palygorskite and zeolite

(analcime) was evaluated. Soil samples from Arizona and Egypt as well as reference samples of palygorskite and analcime spiked with CaCO_3 were used. The pretreatment of the soils and reference samples resulted in no observable change in the mineralogy as indicated by x-ray diffraction and SEM analysis. The study further suggests that the somewhat tedious and time consuming step can be avoided for many purposes in arid land soils.

**Particle Size Analysis of Gypsiferous Soils Using Laser Light
Scattering Techniques**
(D.F. Post, A.S. Sheta, & B.A. Buchanon)

Particle size analysis are basic to laboratory and field studies of soils, and traditionally these analyses have been made using sieving and sedimentation methods. This research evaluated the use of Laser Light Scattering Techniques (LLST) to measure the particle size distribution of gypsiferous soils. Soil samples can be prepared in different ways, but basically an optimum ratio of soil to water (or other aqueous solutions) is prepared, and then the dispersed samples are passed through the instrument sensing system. To complete the analysis, a 1.0 to 3.0 gram sample of soil is kept continuously in suspension by mechanical stirring and/or ultrasonic agitation, then the intensity and angle of light scattering are measured after the light-particle interactions. LLST instruments are used in this study have from 13 to 32 particle size fraction channels, ranging from 2000 to 0.5 micrometers. Particle size distribution curves from many gypsiferous soils have been completed, and these data were used to estimate the probable texture of the soils. The data was also compared through correlation and regression analyses to selected soil properties like

15 bat water and other parameters closely related to particle size. LLST appears to have good potential for the particle size characterization on non-dispensable gypsiferous soils.

Sample Volume Effect on Determination of Soil Salinity
(A.M. El-Araby, A.W. Warrick & T.C. Tucker)

Five soil profiles from a 200 hectare area were sampled to study the affects of the soil sample volume on determination of salinity. Four sample sizes, 5, 50, 500, and 5000 g, were used, with five to ten replicates each, for the top 25 cm of the profiles. These samples were prepared and analyzed for soil salinity, soluble cations and anions in 1:2 (soil:water) extracts. Data revealed that the variations due to the different sizes were highly significant. Highest values of EC, cations and anions were obtained when using 5-g samples. The confidence intervals tended to be lowest from the 5000-g samples in most of the EC, cation and anion determinations. The 500-g sample size was awkward and apparently the 5-g sample size was too small.

PHYSIOLOGICAL STUDIES

Effect of Salt Stress on the Vegetative Growth and Development of Tomato Plants
(M.A. Atta-Aly, M.E. Saltveit, & A. El-Beltagy)

Tomato plants (*Lycopersicon esculentum* Mill, cvs. "Rutgers," an Egyptian salt tolerant cultivar "Edkawy" and a ripening mutant rin) were grown in sand cultures irrigated with half-strength Hoagland solution. The nutrient solutions were supplemented one week after transplanting with 0.0, 2.5, 5.0 and 67.5 g/l NaCl: CaCl₂ (3:1, Wt:Wt). Leaf water potentials (LWP) decreased significantly as salinity increased, with more pronounced

decreases in young plants of Rutgers and rin than in Edkawy. Edkawy plants maintained normal growth with minimal lowering of LWP during the first nine days of saline treatment. Five weeks after saline treatment, Rutgers and rin had increased their LWP to that of Edkawy, while the growth rate of Edkawy had decreased to that of Rutgers.

Leaf Na content was significantly higher in the 2.5 g/l treatment than in the control, but exhibited no further increase at higher saline levels. Na⁺ content in rin was significantly lower than in the other two cultivars. At 6.5 g/l, the Na⁺ content in Rutgers dropped to the same level as in rin, while it remained stable in Edkawy; it became significantly higher than in the other two cultivars. Leaf C1- content increased with salinity. LWP appeared to be more closely correlated with leaf C1-levels than with Na⁺ levels. Edkawy leaves had the highest CA⁺⁺ levels and percentage of leaf dry weight. Our data suggest that the salt tolerant cultivar Edkawy was able to absorb sufficient water to maintain growth with a minimum lowering of water potential during the early stages of growth, and by accumulating more CA⁺⁺ and Na⁺ than the less salt tolerant cultivars during the grand period of growth.

Effect of Antitranspirants on Salt Accumulation in Plant Root

Zone Under Saline Condition
(Acta Horticulture, 190:291-298
T. El-Kobbia, & A. Ibrahim)

A pot experiment was carried out in a greenhouse using a special design for the experimental pot to largely avoid removal or leaching of salt accumulated around the root zone and allow for measuring electrical conductivity in plant root zone using soil salinity sensors placed in the soil to a depth of 20 cm. Data reveal that the application of

antitranspirants significantly decreased salt accumulation in the root zone and increased total fruit yield of tomato plants under saline conditions. For example, total fruit yield of plants treated by 2.5% epoxy linseed oil increased by about 51% for SAR 4, EC_e 5 mmhos/cm - 25 degrees C. Salt accumulation in the root zone of salinized tomato plants markedly decreased upon using antitranspirants. It could be concluded that the application of antitranspirants, particularly epoxy linseed oil, was effective in reducing salt stress for salinized tomato plants.

**Effect of Antitranspirants and Long Chain Alcohols on
Water Use Efficiency and Growth of Tomato Plants**
(T. El-Kobbia, & A. Ibrahim)

Three pot experiments were carried out in a greenhouse using sand culture technique to study the effects of foliar application of long chain alcohols on water use efficiency and growth of tomato plant. Both antitranspirants and long chain alcohols increased water use efficiency, but the effect of antitranspirants was more pronounced. It was found that epoxy linseed oil and vapor-guard each at a concentration of 2.5% alone or in combination with 0.002% hexadecanol could be used effectively for increasing water use efficiency without any adverse effect on growth of tomato plant. Antitranspirants applications had no significant effects on N, P, K, Ca, Mg or micronutrient uptake by plants.

A Possible Role of Cobalt in Salt Tolerance of Tomato Plants
(A. Ibrahi, S. El-Abd, & A. E-Araby)

Three pot experiments were carried out to study the possibility of reducing transpiration and evaluate the importance of this reduction on growth of tomato plants under

saline conditions by adding Cobalt to growth medium. The results indicate that Cobalt applications as concentration up to 0.5 ppm positively affected dry matter production of shoots and roots and total root length. The application of Cobalt in growth medium at concentrations up to 0.5 ppm significantly decreased stomatal aperture, leaf angle, leaf water content, leaf water potential, transpiration and water use efficiency. Positive interaction between Cobalt and NaCl salinity on dry matter production of tomato shoots and roots were observed. It is evident that, Na and Cl contents in shoots and roots of salinized plants decreased with increasing Cobalt concentrations. It could be concluded that, the most beneficial effect of Cobalt on tomato plants grown in sand culture and irrigated with saline solution was obtained at a concentration of 0.5 ppm Cobalt.

POST HARVEST STUDIES

Effect of Silver Ions on Ethylene Biosynthesis by Tomato Fruit Tissue (M.A. Atta-Aly, M.E. Saltveit, & G.E. Hobson)

Mature green tomatoes (*Lycopersicon esculentum* Mill.) were treated asymmetrically with 2 millimolar silver thiosulfate (STS) through a cut portion of the peduncle while still attached to the plant. One-half of the fruit received silver and remained green while the other half ripened normally and was silver-free (less than 0.01 parts per billion). Harvested mature green fruit were also treated with STS through the cut pedicel. Green tissue from silver-treated fruit had levels of 1-aminocyclo-propane-1-carboxylic acid (ACC, the immediate ethylene precursor) slightly less or similar to that of turning or red-ripe tissue from the same fruit, and similar to that of mature green tissue from control fruit. Ethylene production was higher in green tissue from silver-treated fruit than from either red tissue

from the same fruit, or mature-green tissue from control fruit. By inhibiting ACC synthesis with aminoethoxyvinyl glycine, and by applying ACC + silver to excised disks of pericarp tissue from control or silver-treated tomatoes we showed that short-term silver treatment did not affect the biological conversion of ACC to ethylene, while long-term treatment stimulated both the conversion of ACC to ethylene and the synthesis of ACC.

**Effect of Salt Stress During Growth and Development on the
Post-Harvest Characteristics of Tomato Fruit**
(M.A. Atta-Aly, M.E. Saltveit, & A. El-Beltagy)

Tomato fruit (*Lycopersicon esculentum* Mill.), cvs. "Rutgers", its nearly isogenic mutant derivative rin and an Egyptian salt tolerant cultivar, "Edkawy" were produced with in sand culture techniques. Plants were irrigated with half-strength Hoagland nutrient solution until flowering, and then with full strength solution. The nutrient solutions were supplemented one week after transplanting with 0.0, 2.5, 5.0, and 7.5 g/l NaCl:CaCl₂ (3:1, Wt:Wt). Fruits were harvested at the breaker stage, or at equal age for rin fruit and stored at 15°C.

Fruit of the mutant rin did not show any ripening changes, e.g., characteristic changes in color, firmness, or C₂H₄ production, but their respiration did increase with increasing saline levels. In normally ripening cultivars, however, saline treatments enhanced color development, and increased respiration and C₂H₄ production over control fruit. In all cultivars, fruit from saline treated plants were significantly higher in total soluble solids (TSS), electrical conductivity (EC), and titratable acidity (TA), and lower in pH than control fruits.

The dry weight content of K^+ , Ca^{++} , and Mg^{++} in the fruit decreased significantly with increasing levels of salinity, while there was no effect on iron content. In contrast, fruit Cl^- -content increased significantly with increasing saline levels. While fruit Na^+ content increased significantly at the lowest saline level, it did not show any further increases at higher saline levels in the normally ripening cultivars. Plants of rin, however, were able to prevent Na^+ - accumulation in their fruit at saline levels below 7.5 g/l. An examination of the changes in Na^+ , Cl^- , Ca^{++} , K^+ , Mg^{++} , and iron with saline treatments revealed that increases in TSS and EC resulted more from the accumulation of soluble assimilates than of inorganic ions. Tomato fruit from saline regions may possess some advantages for processing because of their higher levels of EC, TSS, TA and reduced pH.

The presence of high levels of Ca^{++} in the saline solutions and the ability of rin plants to accumulate significantly less Na^+ in their fruit than normal ripening cultivars, could play a crucial role in preventing salt induced ripening in rin fruit.

**Endogenous PGR's and Protein Pattern Distribution Under
Normal and Saline Conditions in Tomato Fruit**
(Z.A. El-S. Lacheene, R. Horgan, & A.S. El-Beltagy)

Tomato fruits harvested during ontogeny under normal and saline conditions were examined for endogenous C_2H_4 , IAA, ABA, cytokinins and the distribution of protein bands.

Growth patterns expressed either as fresh and/or dry weight exhibit the characteristic sigmoid pattern with a slight decrease over the control for all varieties except for the Edkawy.

An increase in C₂H₄ emanation from the salt treated fruits were observed in all tested variety during the course of development. Endogenous IAA and ABA levels in the pericarya and seeds of salt treated and control Edkawy fruits was higher in concentration in comparison with other varieties and minimal changes in pattern was observed. The occurrence of endogenous Z, ZR and ZMP in tomato fruits were tested.

The polypeptide bands produced at different stages from control and salt treated fruits at different stage of development on sodium-dodecyl sulfate-polyacrylamide gel electrophoresis vary in intensity. The presence of a 14 and 26 kilo daltons polypeptide bands in fruits of Edkawy salt treated fruits in the tested five stages was observed.

BREEDING AND SELECTION FOR SALT TOLERANCE

Tomato Variety Evaluation and Selection for Salt Tolerance **(M.M. Hashim, R.M. Helal, & M.M. Maksoud)**

Seeds of six tomato cultivars, i.e., "Edkawy" (from El-Bouseilly area, Egypt), "Ace", Strain B, E 6203 (from FAO), UC 82 and VF 145-B 79 (from V.R.D.) were sown in Jiffy pots (#7) in the second week of September and irrigated with tap water until full emergence. Thereafter, they were irrigated with saline water (0, 2500, 5000, 7500, and 1000 ppm NaCl/CaCl₂, 3:1 in ratio), using stepwise increases in salt concentration technique.

Four seedlings, each one month old, were transplanted into plastic pots, and each was filled with 15 kg of sandy soil (from El-Bouseilly area, Egypt), mixed with 2.8 g N₂, 2 g P₂O₅ and 1g K₂O and were daily irrigated with the different salinity concentrations up to the field capacity, the drainage water was used again for further irrigation.

After 30 and 60 days from transplanting each pot received 1 g of a compound fertilizer (1:1:1. N₂-P₂O₅-K₂O) and at 45 and 90 days each pot received 50 ml of Hoagland solution containing all the micronutrients.

The following parameters were recorded:

1. Plant height (in cm) at 15, 30, 45 and 60 days from transplanting.
2. Number of clusters/plants: calculated at the end of the season.
3. Number of fruits/plant: determined throughout the harvesting system.
4. Total yield/plant: the average yield was calculated from all harvested fruits from each experimental plot.
5. Fruit TSS, determined from three harvests at the red stage using a Carlzeith refractometer.
6. Dry weight/plant: at the end of the growing season, one plant was dried at 70°C for two days.

Results can be summarized as follows:

1. An increase in fruit TSS of all tested cultivars with the increasing of salinity level was noticed.
2. The response of various genotypes to the increase in salt concentration varied to a great extent.
3. Edkawy, as compared with the other cultivars, gave the lowest decrement of clusters/plant. Meanwhile, E 6203 gave the highest decrement with the increase in salt concentration.

**Development Responsiveness of Salt Tolerant and
Salt Sensitive Genotypes of *Lycopersicon*
(R.A. Jones, M.M. Hashim, & A. El-Beltagy)**

Twenty-two accessions of *L. esculentum* were field grown under standard cultural practices.

Seeds were surface sterilized with a 10% solution of commercial bleach for 10 minutes then rinsed with sterile distilled water. Twenty-five seeds of each accession were aseptically plated on petri dishes containing 0.8% agar. The present work evaluated tolerance to a synthetic sea salt mix with a $\text{Na}^+/\text{CA}^{++}$ ration equal to 8. For comparative purposes an equivalent number of seeds from each accession were sown on agar (0.8%) containing 100mM NaCl.

Germination tests were conducted at $20\pm 0.5^\circ\text{C}$ in a Precision Model 815 incubator. Petri dishes were arranged in six complete, randomized blocks. Germination responses were scored as radicle protrusion every 6 hours for 15 full days.

Seedling growth was conducted on Plexiglass slant boards supporting an Agar (0.8T) slab containing 0 mM or 100 mM NaCl and maintained at 20°C . Twenty seeds of selected accessions were surface sterilized as in the germination test and sown directly on the agar slant. Germinated seedlings were maintained in the darkness and hypocotyl growth over time was measured at 12 hour intervals.

Results can be summarized as follows:

1. Germination response times increased and early seedling growth rates decreased in all accessions at 100 mM NaCl.
2. Wild ecotypes exhibiting rapid salt germinability were identified among *L. glandulosum*, *L. pennellii*, *L. pimpinellifolium*, *L. peruvianum* and landraces of *L. esculentum*.

3. Analysis indicated the LA716 and P1174263 had superior stability in germinability under salt stress.
4. A wide range in growth rates was observed among the accessions.
5. Stability of seedling growth rates was highest in two accession of *L. esculentum* (cv. Edkawy and P1174263), followed by wild ecotypes of *L. peruvianum*, *L. glandulosum* and *L. parviflorum*.
6. No correlation was found between germination performance and growth performance. This observation suggests that the genetic features conferring tolerance are different at each developmental stage.

Comparative Responses to High Salinity Between
Salt-tolerant Genotypes of Tomato
(M.M. Hashim, R.A. Jones, & A. El-Beltagy)

The accessions examined were a salt-tolerant ecotype of *Lycopersicon cheesmanii* (LA1401), and *L. esculentum* (cvs. "Edkawy" and a control, "Ace"). Seeds of the cultivars was surface sterilized for 10 minutes in 0.5% (v/v) sodium hypochlorite; LA1401 seed was treated for 60 minutes in 2.5% (v/v) sodium hypochlorite. Seed was rinsed copiously with sterile distilled water and plated in petri dishes containing 0.8% (v/v) agar, amended with a synthetic sea salt mixture. Salt treatments were 0, 50, 100, 150, 200 mM Na⁺. Each accession (25 seeds) was replicated in 6 plates and randomized within each salt treatment. Plates were maintained in the dark at 24 ± 0.3°C in a precision incubator. Germination scored was a radicle protrusion at six hour intervals under a green safelight. The experiment was repeated as a second block in time.

Plant Growth and Ion Accumulation

Plants were grown in the greenhouse during late spring with day/night temperatures of approximately 24/18° C. Seeds of each accession were surface sterilized as described above and sown in sterile sand/vermiculite. Young seedlings were transferred to aerated containers of half concentration modified Hoagland solution. Plants were grown in 5 liter pots and solution was cycled through the pots for 15 minutes every two hours from 340 liter reservoirs.

Growth rate comparisons were made by recording plant height above the cotyledon attachment, individual canopy development (leaf area), and fresh weight comparisons. Ten plants of each accession were grown in replicate at each salt level. Individual plants were separated into nearly fully expanded leaves, stem plus petioles, and roots six days after achieving treatment levels; samples of each tissue part were composites. Fresh material was weighted immediately after excision and again after oven drying at 70° C for 48 hours; succulence was calculated as the ration fresh weight:dry weight. Roots were rinsed in distilled, demineralized H₂O and briefly blotted before weighing. Dry tissue samples were ground in a Wiley mill and 0.5 g samples were taken. Na, K and Ca were determined in samples of this solution by flame photometry; C1 was determined by electrometric titration.

Results can be summarized as follows:

1. In response to increasing salt stress, the onset of germination was progressively delayed, germination rates were decreased and the final level reduced.
2. All genotypes showed qualitatively similar responses to increased salt levels, however *L. cheesmanii* (LA1401) showed greater sensitivity to salinity.
3. Under control conditions, the elaboration of leaf area was higher in the two cultivars than the wild ecotype.

4. Under saline conditions, leaf area as reduced to greater extent in Ace, while LA1401 and Edkawy tended to have greater succulence in the major tissues, particularly under saline conditions.
5. *L. cheesmanii* and the cv. Edkawy showed high accumulation of Na^+ , Ca^{++} , and Cl^- in leaves and a greater decrease in K^+ content under saline conditions in comparison with the cv. Ace.

Inheritance of Salt Tolerance in Tomato
(M.M. Hashim, R.A. Jones, & A. El-Beltagy)

Seeds of *L. esculentum* Mill, cv, E6203, all a highly inbred line (a relatively salt-sensitive), were obtained from Ferry-Morse Company and the *L. esculentum* cv. Edkawy (a salt tolerant cultivar) and grown commercially by local farmers in the saline afflicted area of El-Bouseilly along the north coast of Egypt, who were used in this study.

Crosses were made between the two parents to obtain F1 hybrid seeds. To determine the effects of NaCl on vegetative growth, plants of both parents and their Fq hybrid were exposed to a wide range of salt stress levels i.e., 0 to 250 mM NaCl, and growth measurements were taken. Ten plants of each genotype were grown in replicate at each salt level. At the completion of the experiments, individual plants were harvested and separated into leaves, stems plus petioles and roots. Leaf areas and fresh weight were measured immediately after excision. Plant parts were weighed again after oven drying for 48 hours. Dry tissue samples were ground in a Wiley mill and 0.5 g samples were ashed.

Ion contents (Na^+ , K^+ Mg^+ and Ca^{++}) were determined by atomic absorption spectrophotometry; Cl^- was determined by electrometric titration.

Based upon apparent wide differences in salt-responsiveness, Edwkay (P1) and E6203 (P2) were selected as parents for a study of the inheritance of salt tolerance. Reciprocal crosses were made in the greenhouse to obtain seeds of the following generations: F1, BCP1,

BCP2, and F2. Seeds of each generation were sown on sterile cheesecloth supported by Plexiglass grids and placed over 120 L polyethylene tanks filled with aerated 0.5 concentration modified Hoagland solution. Distilled water was added as required to raise the nutrient solution level sufficiently high to keep the cheesecloth moistened. At the 2-leaf stage, saline media was prepared by adding NaCl to the nutrient solution. Salinization was in 50 mM increment every other day and the Na⁺ to CA⁺⁺ ratio was maintained at 5:1, respectively. For the genetic experiments, salinization of the nutrient solution was completed when the equivalent of 150 mM NaCl was achieved.

Results can be summarized as follows:

1. Progeny analysis suggested the a small number of genes with mostly additive effects control the differences in shoot dry matter accumulation in leaf area development under salt stress.
2. Dominant gene action from Edkawy controlled Na⁺ accumulation in the young, actively expanding leaves.

Breeding Programs for Salt Tolerance in Melon
(R.M. Helal, H. El-Doweny, & M.M. Masoud)

Three local melon cultivars, i.e., Kahera 6, Ananas El-Dokki and Shahd El-Dokki, in addition to five introduced cultivars i.e., Imperial 45, Sierra gold, Farr north, Schools hard shell and Persian were subject to four salinity concentrations i.e., 0, 4000, 8000, and 12000 ppm. Data were recorded on survival plants as well as fruit characteristics. Results showed that Persian can be considered as a tolerant cultivar since it showed a high number of survival plants. Moreover, both Kahera 6 and Ananas El-Dokki exhibited a high degree of salinity tolerance at 12000 ppm.

Generally, salinity led to an increase in TSS percent of the tested cultivars, however, did cause a reduction in average fruit weight except Ananas El-Dokki.

A field experiment was conducted in the El-Bouseilly area to study the effect of gate and drip irrigation systems on the expression of yield and fruit quality. Four melon cultivars, i.e., Kahera 6, PI 1944, Ananas El-Kokki and Persian were used. Results showed that the gate irrigation system was more effective than drip irrigation on increasing melon productivity. However, PI 1944 produced the highest fruit yield either by using gate or drip irrigation. In this connection, fruit characteristics of the tested cultivars are genetically controlled and the irrigation systems played a small role in the expression of these characters.

F1 crosses were made last summer (1989) between some introduced and local melon cultivars. The F1 seeds were obtained and will be tested in El-Bouseilly area as well as at the Salinity Lab in Riverside, California, U.S.A., in collaboration with Dr. Michael Shannon.

Research Work in Israel: An Introduction

Israel is a relatively small country with a total area of 20,325 square kilometers and a population of 4.0 million. The climate is typically eastern Mediterranean, with rain occurring within the five winter months. Summers are hot and dry, and daily evaporation ranges between 8-20 mm according to region and elevation. These facts, together with the country's high rate of economic development, have led to intensive utilization of water for irrigated agriculture.

Today, practically all of Israel's known fresh water supplies are being fully utilized. The only large untapped waters that remain are the saline water resources which are mostly concentrated in deep aquifers in the Negev desert. There is still, today, very little experience worldwide on how to utilize saline water for irrigation of agricultural work. The study of this problem could be carried out only in the framework of an integrated scientific research team, such as the team which was created by the CALAR Program.

The research and development work on salinity in Israel was concentrated upon the utilization of the saline ground waters of the Negev desert for the irrigation of processing (canning) tomatoes and melons. At the second phase of the project, after realizing the potential and ability of salinity to improve fruit quality, an additional request was added; that of saline water irrigation of market tomatoes.

From the outset the project was an interdisciplinary one, involving all aspects relevant to crop production under salinity. These included: crop; soil and water management; plant nutrition; plant physiology; and, selection and breeding.

Crop, Soil and Water Management

The CALAR Program research carried out under this heading included the following topics:

- Irrigation water requirements of processing tomatoes and melons under a range of irrigation water salinity;
- Determination of irrigation frequency and drip lateral density as a function of irrigation water salinity;
- Identification of salt sensitive stages during the life cycle of tomatoes and melons and the design of treatments to avoid salt stress during sensitive stages;
- Management of saline water irrigation for processing tomatoes grown on sand dunes;
- Effect of intra-row planting density on tomato yield under saline water irrigation;
- Effect of planting date on yield of processing tomatoes in the Ramat Negev region.

Plant Nutrition

All the plant nutrition studies were carried out under well-controlled conditions of salinity and plant nutrient levels in an experimental arrangement built in a glasshouse. The objective of this work was to study the interactions between salinity ions (sodium and chloride) and the plant nutrition ion (nitrate, potassium, ammonium and phosphorus).

It was agreed upon that plant nutrition studies under field conditions could be carried out only after the basic interactions would have been clarified.

Plant Physiology

Plant physiology studies were conducted in conjunction to complement the management studies, the genetical studies and the studies of the effects of salinity on fruit development and fruit quality. The first two groups of physiological studies are reported

within the section of management and breeding whereas the studies of the effects of salinity on fruit development and quality are reported in a separate section. These studies included:

Effects of salinity and nutrition in fruit development and fruit quality under controlled conditions. These were carried out in conjunction with the plant nutrition studies. Interactions between salinity, season and cultivars on various aspects of fruit quality.

Selection and Breeding

Melons

The trials on breeding and selection of melons include the following steps:

- Selection for salt tolerance among 24 melon cultivars;
- Studies on the genetics and heritability of salt tolerance in melons;
- Breeding, selection and evaluation of salt tolerant hybrids tomatoes.

The work on tomatoes included the following studies:

- Selection for salt tolerance among some 60 tomato cultivars;
- The physiology of salt tolerance in the cultivated tomato and in tomato relatives;
- A breeding program based on selection salt tolerant genotypes among progenies of a back-cross of the *Solanum esculentum* x *S. pinellii* on *s. esculentum* and hybridization of selected progenies with male sterile commercial cultivars.

In addition to the scientific studies, the CALAR Program also included an application component. This involved the incorporation of Israel's extension officer for processing tomatoes, the director of the Ministry of Agriculture "Field Service" Unit for the Negev region, and the regional agricultural coordinators of the Negev farming communities into the CALAR family.

AGROMANAGEMENT

Irrigation Management of Processing Tomatoes with Saline Water (D. Pasternak, & Y. DeMalach)

This report summarizes the experience obtained in two field and one greenhouse trials. It appears that water salinity at levels up to 75 dS/m, has no effect on the water status of tomato plants, except in the first growth stages. It is possible that in field-grown tomatoes the salinity damage is due to sodium, since the concentration of this ion in the leaves increases sharply with saline water irrigation, more so than that of other ions.

Young tomato plants, during the first three weeks after germination, are much more sensitive to salinity than older plants. By alternating fresh with saline water irrigation (fresh through the 4th leaf stage and saline afterwards), or by planting large seedlings, one can bypass this sensitive stage and obtain commercial yields of tomatoes with water of relatively high salinity.

Plants which are stressed at the sowing stage by salinity produce a small load of fruit and therefore are not affected by salinity during the period of fast fruit growth. However, fruit-loaded tomato plants suffer from salinity, most likely because of the cessation of root growth and the transport of carbohydrates and nutrients from all plant parts to the developing fruit, all this coupled with an increase in sodium concentration in the leaves.

The conclusion with respect to fruit load must still be verified by field trials, but if they stand then one can predict that salt leaching would prevent salt damage in the rapid fruit filling phase.

The finding that, in processing tomatoes grown on loamy soils and irrigated with saline water, a density of 500 meters of drip line per hectare (one line per two rows of

tomatoes) is sufficient, and is of great economic importance. With water of high salinity it is extremely important to irrigate every second day. When irrigation intervals are shorter or longer than fruit yield is markedly reduced.

Irrigation Management of Processing Tomatoes on Sand Dunes
(Y. DeMalach, & D. Pasternak)

The central Negev desert is covered with an area of about 40,000 hectares of sand dunes. This relatively large stretch of land is presently not used for agricultural production. The only potential source of irrigation water is the saline water of the deep aquifers which lie at a depth of 500-1000 meters below the sand dunes.

The CALAR Program work on sand dune irrigation started in 1986. Previous to this work, there was virtually no knowledge whatsoever on the interaction between irrigation water salinity and sand dunes and production of processing tomatoes.

The first trial was to study the effect of irrigation intervals on processing tomato yield. The treatments were irrigation with fresh (1:2 dS/m) and saline (6:2 dS/m) water and irrigation intervals of twice a day (1000 and 1500 ppm), once a day, every two days and every three days. Tomato yield was reduced by saline water irrigation by more than 50% (while the same water salinity reduced yields on less soil by only 25%). There was no yield difference in water quality treatments whether the plants were irrigated daily or twice a day. Irrigation every two or three days reduced yield in both fresh and saline water irrigation treatments. The second trial was designed to test irrigation water quantity on tomato yields. Tomatoes were irrigated according to 80%, 100%, and 120% evaporation from class A. ppm at daily intervals. This study would important since plants in all treatments suffered from

a severe phosphorus deficiency which clouded treatment effects. The third trial studied the effect of planting season (spring, early summer and mid-summer) and night versus day irrigation on tomato yield.

Spring planted saline water plants showed a 50% yield reduction, whereas mid-summer planted saline irrigated tomatoes showed a 70% yield reduction. In most cases, daytime irrigation gave better results than night irrigation.

In 1989, we studied the effect of radiation reduction (by means of shading), pulse irrigation, and salinization procedures (abrupt and gradual) on tomato yield. At the time of this report, it is obvious that pulse irrigation with saline water (5 times a day at 2-5 hour intervals) is giving striking results and that this method of irrigation gives the solution for saline water irrigation management on sand dunes.

**Production Function of Processing Tomatoes Irrigated
with Saline Water**

(A. Meiri, J. Shalhevet, J. Peretz, A. Viuten,
A. Feigin, & D.J. Lauter)

Increasing the quantity of non-saline water results in a linear increase in growth up to a maximum value. According to models developed for salinity, increasing the quantity of saline water results in a diminishing increase of growth rate towards the maximum value. The deviation from linearity has been attributed to the salinity and leaching effects. These models were developed for steady state salinity. However, for any area with a significant rainfall, like the saline irrigated area in Israel and many other places, conditions are of non-steady state salinity. In addition, the use of non-saline water during tomato establishment

and early stages is the recommended practice (see Pasternak, et al.). New models need to be developed for non-steady state conditions.

Field experiments were conducted (1983-1986) in the Ramat Hanegev Experimental Farm. In each year, yield and yield quality were determined for a wide range of water levels (severe deficit to over irrigation). The salinity of the irrigation water was either 1.0, 5.5-6.3 or 8.0-10.0 dS/m. The quantities were relative to reference treatments consisted in application rates that maintained the highest soil water content that does not result in drainage below 90 cm. Soil moisture was measured by neutron scattering. Planting in 1983 was in a wet profile. The reduction in soil water content for each irrigation interval was considered at ET and any water application above soil moisture deficit to field capacity was considered drainage. Drainage estimates were obtained also from drainage lysimeters. The low reliability of the estimates of ET under frequent drip irrigation, where changes in soil water content are small, and the significant water consumption from the wet profile storage brought a change in the experimental practice during following years. After 1983, planting was in a dry profile and soil wetting at depth below the root zone (90 cm) was considered drainage. Soil moisture was monitored weekly or twice a week.

The increase in yield at low watering levels was similar for all water qualities with a rapid deviation of the saline treatments from this line to a plateau (Y_{max}). The Y_{max} was lower for the higher salinities. This steep change into a plateau indicated only small effect of leaching on yield. Thus, increased water application at each irrigation for leaching is not expected to increase yield significantly in this non-steady state system. The data indicates also that optimal water application (minimum water for Y_{max}) decreased with the increase in water salinity. In all cases yield reduction was mainly the result of a reduced fruit size

and not fruit number. The decrease in fruit fresh weight was larger than the decrease in fruit dry weight. Both water and salt stresses improved quality by increasing fruit dry matter content and TSS and decreased quality by increasing Blossom End Rot.

**Reducing Row Spacing Increases Yield of
Processing Tomatoes Under Saline Irrigation**
(A. Meiri, A. Feigin, & N. Sharabani)

When starting on a wet non-saline profile, increasing of the saline water application for leaching did not increase yield marketability (see Meiri, et al.). The salinity suppressed plants have a reduced yield, reduced rate of LAI development and reduced final LAI. Planting at the recommended spaces in Israel (twin row spaced 40 m in the center of a 1.92 m bed = means for row 0.96m) resulted in significant bare areas under saline conditions. This reduced light intercept, photosynthesis and transpiration. Reduced interrow spaces can compensate for the lower rate of LAI development.

A field study in Ramat-Hanegev compared the response of tomato (var. Peto 81) to three rows spacing (0.48, 0.75, 0.96 m) when irrigated with water of three salt levels (1, 6.3 and 10 dS/m) at two water levels (base and base +20%). Base level is the optimal for each water quality (see Meiri et al.) with addition of 10 and 20 percent to the 0.75 and 0.48 m spacing, respectively.

In all treatments under irrigation over the period 10-50 DAP resulted in unintended water stress. On 28 DAP, the crop cover increased with the decrease in row spacing. At this age, there was not competition between plants, which were somewhat smaller at the higher salt treatments.

Yields were lower at a higher salinities. They were higher at smaller row spacings and a higher water levels. Yield quality as determined by TSS increased with the increase in salinity.

This experiment should be repeated to confirm the positive effects of reduced row spacing with plants that were not stressed at early stages.

**Growth of Non-Determinate and Determinate Types of
Fresh Market Tomatoes in Open Field and Protected Conditions**
(I. Rylski, A. Schaffer, N. Spiegelman, & Y. DeMalach)

The experiments were conducted in order to develop appropriate agrotechniques for the growth of high quality fresh market tomatoes under saline water conditions.

The experiments were carried out with a determinate type of tomato cv. BAR-54, and a non-determinate one, cv. 121, simultaneously in the open field and in the screenhouse.

Total seasonal yield reached about 176 kg/m² in cv. 121, most of it harvested during the period of September-October.

Irrigation with saline water (dS/m 5.5) caused a yield reduction of about 30% in both cultivars. However, a concomitant increase in the percent dry matter content nearly balanced the yield of dry matter per area until received. Smaller fruit size accounted for the yield reduction effected by saline water, whereas fruit number was unaffected. We conclude that the decrease in fruit size under saline irrigation is due primarily to a decrease in water contents of the fruit, without a decrease in dry matter production.

Yield in the screenhouse grown tomatoes was lower than in the open field, especially in cv. BAR-54. This cv. has a heavier foliage and perhaps, is more sensitive to reduction

in light intensity. Seed number per fruit was lower in the screenhouse than the open field and this difference was accentuated by the saline water treatment, whereas no effect of salinity was observed on seed number in the open field. Since there is generally a high positive correlation between seed number and fruit size, it seems possible that reduction in seed number accounts for the reduction in fruit size and fruit yield in plants grown in the screenhouse.

This experiment was carried out during the hot season, causing many physiological fruit disorders, such as blossom-end rot, blotchy ripening and fruit cracking. Blossom-end rot was more severe with saline water irrigation while the other disorders were less severe with saline water. Cherry tomatoes, tested in a preliminary trial showed very low sensitivity to blossom-end rot.

The effect of pruning techniques on yield and quality of the determinate cv. BAR-54 was also studied. It was found that training this cv. to two stems and increasing planting density led to higher yields per dunam than did the non-pruned plants when irrigated with non-saline water, and to similar yields as the non-pruned control when irrigated with saline water. These results support our hypothesis that some of the undesirable effects of saline irrigation can be overcome by appropriate modifications of existing agrotechniques.

**Shoot Growth and Fruit Development of Melon, cv. Galia,
as Influenced by Saline Soil-Moisture-Deficit and Leaching**
(D.J. Lauter, A. Meiri, & N. Sharabani)

Proper management of saline irrigations requires two considerations: maximization of production, and minimization of applied water. Reducing the rate of irrigation can improve water use efficiency and will decrease the rate of salt deposition.

Melon, cv. Galia, was cultivated at Ramat Hanegev field station during the summers of 1987 and 1988. Methods developed for this CALAR project (see Meiri, et al.) were used to determine the optimal amount of water use (i.e., ET) that would both maximize production and minimize deep drainage. Plants were also treated with quantities of saline water that maintained a soil moisture content near field capacity but resulted in deep drainage (i.e., leaching treatments).

Salinity (EC = b.b. cS/m) did not decrease shoot weight per cm ET and increased fruit number per cm ET. However, saline soil-moisture-deficit decreased the percentage of marketable fruit, and non-saline soil-moisture-deficit increased the percentage of marketable fruit. Leaching treatments did not affect cumulative fruit weight and decrease the percentage of marketable fruit.

In conclusion, soil moisture content must be maintained at a level near field capacity to prevent a decline in yield and yield quality, but leaching is unnecessary during the growing season. Optimal production is leached only once per season prior to planting.

PLANT NUTRITION

Effect of P Level in Saline-Nutrient Solutions on Dry Matter Yield and Chemical Composition of Melon Plants (A. Feigin, & I. Rylski)

The effect of P Level in Saline-Nutrient Solutions on the production of dry matter by melon plants (cv. Galia) grown for 68 days (December 28, 1986 to April 4, 1987) was studied in the greenhouse by means of an aeroponic system (described elsewhere, see Feigin, et al.,: Response of melon plants to chloride-nitrate ratio in nutrient solutions). Three levels of P, 0.1, 1.0 and 2.0 mmol H₂PO₄ per L were combined with a nonsaline and

saline (90 mmol Cl added as NaCl and CaCl₂ on a 4:1 molar basis) nutrient solutions. Yield of dry matter was greatly reduced by salinity but was not affected by P levels. The concentration of P in the nutrient solutions tended to reduce in time, but was periodically renewed, as the solutions were replaced every week. The higher the P level in the solutions, the higher was the P level in plant tissues.

**Effect of NH₄/NO₃ Ratio on Melon Plants Grown
in Nutrient Solutions**
(A. Feigin, & I. Rylski)

The effect of NH₄/NO₃ ratio in saline nutrient solutions on the production of dry matter and chemical composition of melon plants (cv. Galia) grown for 68 days (December 28, 1986 to April 6, 1987), after transplanting in the greenhouse, was studied by means of an aeroponic system (described elsewhere, Feigin et al.: Response of melon plants to chloride-nitrate ration in saline nutrient solutions). Four NH₄ treatments, 0, 15, 30 and 60% of NH₄ in a 5 mmol/L (NH₄ + NO₃)-N in the nutrient salt solutions were combined with a saline (90 mmol Cl per L added as NaCl and CaCl₂ in a 4:1 molar basis, and a non-saline nutrient solution.

The yield of dry matter (shoot and foot, no fruit) was greatly reduced by the addition of salt. Application of NH₄ increased yield only in the non-saline treated plants when its proportion did not exceed 15%, higher NH₄ levels reduced yield. Any ammonium addition was detrimental to the salt treated plants and was associated with Ca and Mg deficiency symptoms resulted from the combined presence of high levels of Na, and some NH₄ in the solution.

**Response of Melon Plants to Chloride-Nitrate Ratio
of Saline Nutrient Solutions**

(A. Feigin, I. Rylski, A. Meiri, & J. Shalhevet)

The purpose of this study was to obtain quantitative information on chloride-nitrate relationship in the root zone of melon plants as a means for optimizing fertilization management under saline conditions. Two greenhouse experiments were carried out. Melons (*Cucumis melon* L. c.v. Galia) were grown between January 26 and April 26, 1983 (91 days after transplanting) (Experiment I), and between January 13 and June 3, 1986 (141 days after transplanting) (Experiment II). The treatments were replicated three times in randomized blocks. The melon transplants were grown in a well controlled, well aerated aeroponic system consisting (each unit) of 130 L plastic containers covered by thick polystyrene plates on which two polystyrene boxes (50 x 39 x 20 cm deep) were mounted. Six plants were planted in each box, 12 per container (plot), using appropriate holes made in the coverings of the boxes. The plants were supported by their crowns while the roots extended through the air to the bottom of the boxes. The solutions were continuously circulated through the root system at a very high rate, using a small pump installed between the polystyrene boxes, and preformatted plastic tubing. The solutions were continuously sprayed on the roots flowing back into the main containers throughout a wide pipe inserted in the center of the box bottoms leaving a thin layer (2-4 mm) of solution on the bottom of the boxes.

In Experiment I, four levels of Cl (5, 30, 60 and mmol/L) given as Na and Co salts in a 4:1 molar basis, were combined with four levels of NO₃ (1, 5, 10 and 20 mmol/L). The other required nutrient elements (except for SO₄) were given in equal amounts. In

Experiment II, eight NO₃-C1 combinations (5-5, 9-1, 5-45, 25-25, 45-5, 5-85, 45-45, and 85-5 mmol/L) were tested.

Fresh melon yield and its quality, plant growth curve (dry matter production of root, shoot and fruit), transpiration and the chemical composition of the different plant parts were determined in each experiment.

The increase in C1 level (salinization) EC_x between 1.5 and 9 dS/m in Experiment I and between 1.5 and 11 dS/m in Experiment II) resulted in a dramatic reduction in yield. Since N was a major limiting growth factor at the low NO₃ concentrations (1 mmol/L), the depressing effect of salt addition on yield was pronounced only at the high salt levels. The decline in yield in both experiments resulted from the total salinity level (osmotic effect) rather than from C1 alone. Increasing NO₃ concentrations from 1 to 5 mmol/L (Experiment I) increased the production of dry matter only at the range of low and medium salinity levels but not at the high ones indicating that fertilization can be effective within a considerable range of salinity levels under field conditions. Yet, increasing the NO₃ concentration in the nutrient solution at the high salinity levels did not overcome the decline in yield.

While large differences in melon yield (Experiment II) were detected among the three groups of treatments (consisting of 10, 50 and 90 mmol total NO₃ + C1 per L), only small differences were determined within each of these groups despite the great differences in the C1/NO₃ proportion. However, yields were usually higher at the higher NO₃/C1 proportion at equipotential levels.

The chemical composition of the nutrient-salt solutions greatly affected the concentration of the major elements in the melon tissue. For instance, high C1 levels

reduced these of NO₃ and vice versa, and high Na and Ca levels resulted in lower K and Mg concentrations.

**Response of Processing Tomatoes to Chloride-Nitrate
Ratio in Saline Solutions**

(A. Feigin, I. Rylski, A. Meiri, & J. Shalhevet)

The purpose of the study was to obtain more information on salinity-nutrition relationships, especially on the possibility of using improved management to mitigate crop yield reduction and quality under saline conditions.

Tomatoes for processing (*Lycopersicon esculentum* L. cv. M 82-1-8) to different Cl and NO₃ concentrations was tested using an aeroponic system. The system was described elsewhere (A. Feigin et al.: Response to Melon Plants to Chloride-Nitrate Ratio in Saline Nutrient Solutions; see this abstract publication). Sixteen treatments were included in this greenhouse experiment: 4 levels of Cl (5, 40, 75 and 110 mmol/L) each combined with three levels of N₃ (1, 5 and 20 mmol/L) in a complete factorial design; the other four treatments were three Cl-NO₃ combinations to give the same total concentration of the ions, 115 mmol/L: 40-75-, 75-40 and 110-5, and 40-5 mmol/L Cl-NO₃ combination. The concentration of Na and Ca (being 4:1 on a molar basis) in the nutrient solution was increased in parallel with the Cl and NO₃ levels.

Tomato seedlings having four true leaves were planted in the boxes on February 5, 1984 and the final harvest of fruit (and the final determination of shoot and root dry matter) took place on May 27, 1984 (112 days after planting).

The salinity conditions created in the nutrient-salt solutions by the addition of the Cl salts, resulted in restricted plant growth and in reduced plant yields. The addition of

moderate amounts of NO_3 (in the range of 1-40 mmol/L) did not noticeably affect the relation of fruit yield to C1, although the concentration of organic-N and NO-N were larger in the plants supplied with high NO_3 .

Increasing NO_3 level in the nutrient salt solutions beyond 1 mmol/L increased the vegetative growth and fruit only when combined with low C1 levels. The beneficial effect of NO_3 decreased as C1 increased. It may, therefore, be concluded that the main effect of salinity at moderate concentrations of NO_3 was due to changes in the osmotic potential of the solutions. At high NO_3 concentrations a specific ion effect was detected as the plants exposed to a high $\text{NO}_3/\text{C1}$ ratio performed better than those grown in the presence of high C1/ NO_3 ratio. Yet, at this ion concentration, the yield was already reduced by 50-60%. Like the melon plants, tomato plants were less damaged by equipotential saline solutions having higher $\text{NO}_3/\text{C1}$ ratios.

The chemical composition of the tomato plants was greatly affected by that of the nutrient-salt solutions; lower C1 concentrations were detected in tissue of plants exposed to high NO_3 levels and vice versa. The addition of increasing levels of Na and Ca produced a reduction of K and Mg in plant tissue. High salinity levels were responsible for a decreased Ca content in fruit tissue even when plants were grown in rich Ca solutions.

The water production function for total dry matter yield vs. transpiration was linear, passed through the origin and was common to all treatments.

The fruit quality was improved by the increased ion concentration in the nutrient-salt solutions. The level of total soluble solids in the fruit was greater, at equipotential conditions, under higher $\text{NO}_3/\text{C1}$ ratios.

**Response of Determinate and Non-Determinate Fresh Market
Tomatoes to KNO₃ Addition to Saline-Nutrient Solutions**
(A. Feigin, & I. Rylski)

The effect of KNO₃ addition to nutrient-salt solutions containing NaCl and CaCl₂ at a 4:1 molar ratio, on the performance of fresh market tomatoes was studied by means of a greenhouse experiment using an aeroponic system (described elsewhere, see Feigin, et al.: "Response of Melon Plants to Chloride-Nitrate Ratio in Nutrient-Saline Solutions").

Tomatoes, *Lycopersicon esculentum* L. cv. 121 and BAR 54, non-determinate and determinate cultivars of fresh market tomatoes, respectively, were transplanted into the hydroponic boxes on December 14, 1987. The fruit harvest started on March 1, 1988 and the experiment (cv. 121) was terminated on May 5, 1988, 141 days after transplanting.

Four levels of salt, 5, 40, 80 and 120 mmol Cl per L (given as NaCl and CaCl₂, in a 4:1 molar ratio) were combined with optimal nutrition (including 5 mmol KNO₃/L) in both BAR 54 and the 121 cultivars. In the 121 cv. a suboptimal nutrition level (containing 1 mmol KNO₃/L) was also combined with the above-mentioned salt concentrations. Furthermore, four additional treatments of late salt application combinations of 5 mmol KNO₃ per L with each of two high Cl concentrations (added 45 and 95 days after transplanting) were also tested with the non-determinate cultivar. Total fruit yield was greatly and gradually reduced as the salinity level (being about 1.5, 4, 8, and 12 dS/m in the aforementioned and salt treatments, respectively) increased. The increase in the KNO₃ concentration above mmol/L was effective only at the low salinity level but not in combination with higher salt levels. Late salinization resulted in a higher fruit yield in comparison with similar salt level treatments applied 13 days after transplanting. Yield quality was

greatly increased as the total salinity level of the nutrient salt solution was increased; this was indicated by both higher TSS values and improvement of other quality properties (e.g., lower puffiness).

The chemical composition of the tomato shoot, root and fruit was greatly affected by that of the saline nutrient solutions.

EFFECTS OF SALINITY ON FRUIT QUALITY

Disorders in Fruit Development Due to Salinity **(I. Rylski, A. Schaffer, A. Feigin, & H. Spiegleman)**

Disorders in fruit development due to salinity under different climatical and agrotechnical conditions were investigated in this CALAR Program research segment.

During the summer when the incidence of disorders such as blotchy ripening and fruit cracking is high, we observed a general improvement in the incidence of the fruit disorders in response to salinity. On the other hand, the incidence of blossom-end-rot was increased due to salinity. During the summer of 1988, we compared irrigation regimes (every morning, every evening, twice a week) and found that changing irrigation regimes did not improve fruit quality, although irrigation twice a week did increase TSS levels, as compared to daily irrigation.

During the winter, the incidence of fruit disorders was low even in the non-saline treated fruit and salinity further reduced the incidence of blotchy ripening. The effect of salinity levels on fruit disorders was investigated in a hydroponic system. Low salinity (4 dS/m) greatly reduced the incidence of blotchy ripening and completely eliminated fruit puffiness. Under high salinity levels (8 and 12 dS/m) fruit blotchy ripening was eliminated).

Addition of salinity during the late developmental stages of the first clusters also greatly decreased the incidence of the ripening disorder blotchy ripening, but affected to a smaller extent the incidence of fruit puffiness, a disorder which is discernable at early stages of fruit development.

Fruit Growth and Sugar Accumulation in Tomato Fruit
Due to Salinity

(A. Schaffer, I. Rylski, A. Feigin, & M. Spiegelman)

Studies were carried out to obtain further information on the following subjects:

1. The cause and control of the decrease in fruit size due to salinity.
2. The physiological and biochemical basis of the increase in total soluble solids and sugar accumulation in tomato fruits due to salinity.

Previous experiments indicated that salinity caused a decrease in yield which was due to a decrease in fruit size rather than fruit number. In the experiments described here, different salinity levels were compared (1.5, 4, 8, 12 dS/m), to find that there was continual decrease in fruit size with increasing salinity level. This decrease continued throughout the harvest season. The decrease in fruit size due to salinity was already observable at the anthesis stage. Throughout the entire fruit development period the daily growth rate of the saline treated fruit was lower than that of the control fruit. The daily growth rate of the control fruit when the nutrient solution was changed from control level to saline.

Anatomical comparison of the pericarp tissue of control (1.5 dS/m) and high salinity (12.0 dS/m) showed a striking decrease in pericarp cell size due to salinity which accounted for the decrease in fruit size. The previous CALAR study as well as the more current work indicated that the decrease in fruit yield due to salinity was almost completely attributable

to lower water content in the fruit. This is presumably the cause of reduced cell expansion cell size.

We observed that under high salinity, fruit fresh weight water content and dry matter content was lower throughout development. In addition, however, we observed that under high salinity fruit growth and increase in fresh and dry matter content ceases during the latter stages of development, whereas the control fruit continues to increase in size, water and dry matter content until ripe. Again, the major cause of the size decrease throughout development is the lower water content in the saline treated fruit.

As previously observed TSS levels were higher in saline treated fruit. TSS does not change significantly throughout, whereas there is an increase in TSS during ripening in saline treated fruit. We investigated if salinity caused major changes in the sugar accumulation pattern of developing tomato fruit and observed that in both control and saline treated fruit the major sugars present were glucose and fructose with only trace amounts of sucrose. On a free weight basis both fructose and glucose levels were higher in the saline treated fruit, particularly during the latter stages of fruit development. Starch content was significantly higher in the saline treated fruit during the early stages of fruit development.

Paradoxically, the increase in fructose and glucose concentration on a fresh weight basis occurred during the period when there was no net increase in dry matter or total nonstructural carbohydrate content on a whole fruit basis. Therefore, we hypothesize that the increase in soluble sugars in the saline fruit comes at the expense of the breakdown of starch reserves rather than the import of carbohydrate translocate in the fruit.

Breeding Salt-Tolerant Tomatoes:
Physiological and Genetical Aspects
(Y. Saranga, J. Rudich, D. Zamir, & A. Marani)

The tomato is one of the most important vegetable crops in the world. It is characterized as being moderately sensitive to salinity, but higher tolerance was found in wild tomato relatives. The genetic potential for improving salt tolerance of the tomato plant encourages the breeding of varieties adapted to saline conditions. The increase of total soluble solids (TSS), in the fruit occurring when plants are exposed to saline conditions may be of a special advantage in processing tomatoes. This CALAR project was designed to develop salt-tolerant varieties of processing tomatoes, in order to be able to utilize the large brackish-water aquifer present in the Negev desert in Israel.

Under Negev conditions, high yields of high quality tomatoes for processing can be obtained. In the first stage of the program, trials were conducted in order to select the most salt tolerant among the existing commercial varieties. A 10-20% yield reduction occurred when the crop was irrigated with saline water having electrical conductivity (ECI) of GdS/m. However, increase in TSS content compensated for most of the yield reduction, resulting in a decrease of only 5-10% in the yield of soluble solids. Some other fruit quality traits such as titratable acidity and color were also improved by salinity. The varieties Peto-81 and VF-785 were found to be the most suitable for growing under irrigation with saline water. Subsequently, these varieties were cultivated by farmers with considerable saline growing conditions.

The breeding project concentrated on examining the response to salinity under field conditions, at the whole plant level and over a complete growing cycle. The objectives of the research were:

1. To screen genetic resources for salt tolerance in the cultivated tomato in wild relatives of the tomato.
2. To study physiological mechanisms involved in salt tolerance.
3. To examine the genetic base of salt resistance.
4. To develop rapid screening techniques.

Fifty-nine tomato varieties were grown under four salinity levels, $EC_i = 1.5$ dS/m (control) and $EC_i = 5, 10, 15$ dS/m, to study interspecific variation in response to salinity. Most varieties tolerated the 5 dS/m treatment, but at 10 dS/m the relative dry matter and relative yield were lower than 0.8 of the control. Some varieties exhibited a lower tolerance while others, were not affected by 109 dS/m. All examined varieties had substantially lower dry matter and relative yield (<0.6) at 15 dS/m. This was associated with a low plant survival rate (55%).

The variability between the cultivated tomato and the wild *Lycopersicon* species which are known to be salt tolerant was examined in three experiments under three salinity levels, $EC_i = 1.5, 10$ and 20 dS/m. The genotypes studied were: *L. esculentum* var. M82-1-8 (M82), *L. pennellii* (Lpen), *L. cheesmanii* (Lc) and *L. peruvianum* (Lper), and an F1 interspecific hybrid (M82 x Lpen). The wild species had higher salt tolerance than M82, with Lpen and Lper being the most tolerant. The salt tolerance of F1 in two experiments, even under 20 dS/m treatment, while the relative dry matter of M82 and Lpen in this treatment was 0.56 and 0.77 respectively. A higher response to salinity stress was found in

a third experiment, in which the F1 was also the most tolerant genotype. No substantial plant mortality was found in the wild genotypes, nor in the F1 under the examined salinity levels. The results suggest the existence of a genetic potential for high salt tolerance in the wild germplasm.

Concentrations of the ions Na, K, Cl, Ca and Mg in the leaves and stems were determined. The main differences between the salt tolerant genotypes and the sensitive ones were: (1) Salinity-induced changes in K/Na ratio of the tolerant genotypes, cultivated varieties as well as Lpen, Lper, and F1, were moderate compared to the sensitive genotypes. The maintenance of a stable ionic ratio in plant, that possibly results in more favorable internal environment, which may be advantageous under saline conditions; (2) Absolute concentrations of Na measured in the tolerant genotypes were similar to those in the sensitive ones. This may indicate that the tolerant genotypes had better ability to tolerate Na concentrations in the plant tissues; (3) Cl concentrations in all the cultivated varieties, tolerant and sensitive, were higher in leaves than in stems, while in the wild *Lycopersicon* and in the F1, no such difference was observed. The ability to prevent translocation of Cl to leaves, which was unique to the wild genotypes and to the F1 may be an additional factor contributing to their salt tolerance.

Interspecific segregating populations were used to study the genetic basis of the salt tolerance. M82 plants were pollinated by F1 pollen to produce a BC1 (back cross) generation. Progenies of self fertilized BC1's, F2BC1, were grown ($EC_i = 1.5, 10$ and 20 dS/m) to estimate the heritability of salt tolerance and of related traits. Heritability estimates were calculated by two methods: (1) correlation between parents (BC1) and offsprings (F_xBC1), and (2) intraclass correlation (according to F2BC1). Dry matter and yield traits

had the highest heritability estimates (0.3 - 0.45). Lower estimates were found for the ion concentrations, some of them not significantly different from zero. Heritability estimates of some traits increased with increasing salinity levels.

Linkages between isozyme markers and loci affecting the response to salinity were studied on BC1 and F2 (progenies of self-fertilized F1) populations under 1.5, 10, and 20 dS/m. Ten markers were examined in the BC1 plants and 16 in the F2; markers were located on 9 of the 12 chromosomes of the tomato. Linkage was found between isozyme markers and loci affecting total dry matter, Na, K and C1 concentrations and K/Na ratio. These traits were found to be affected by 4-8 loci indicating that they are controlled by several genes. Markers which were found to be associated with growth under saline conditions, were also associated with ion concentrations in the plants. The allelic combinations associated with high total dry matter were also associated with moderate changes in the K/Na ratio and low C1 concentration in leaves. These results support the conclusions of the physiological part of this work. The response to selection by using isozyme markers were similar to the response to selection by using physiological traits.

Advanced breeding lines were selected for yield, fruit quality and horticultural characteristics from the progenies of the F6BC1 population. In 1988, the F6BC1 generation was grown under $EC_i = 15$ dS/m and 83 single plants were selected. These selected plants had higher yields than their cultivated parental line M82, and the control varieties Peto-81 and VF-785. The fruit quality of the selected plants were similar to that of the control varieties. Progenies of the selected plants were propagated in a greenhouse in the winter of 1988-89 and crossed with male sterile-lines to produce hybrids. In 1989 the F6BC1 lines and the hybrids were examined under irrigation with fresh water and with saline water.

RFLP markers were being used to identify genes originating from wild germplasm and contributing salt tolerance to our breeding lines.

**Physiological Basis for Salt Tolerance in *Lycopersicon*
Esculentum and Three Wild Relatives
(A. Danon, Y. Rudich, & D. Pasternak)**

A series of greenhouse trials were conducted to study the response of *L. esculentum*, *L. Peruvianum*, *L. Cheesmanii* and *L. Pennellii* to salinity. These studies were carried out for selection of the most suitable tomato for a long term breeding program leading to the production of salt tolerant tomato cultivars. *Lycopersicon peruvianum* was the most salt tolerant of all species tested at all levels of salinity tried. *L. pennellii* and its cross with *L. esculentum* was most tolerant to salinity at solution salt concentrations of up to -7,000 ppm. At higher concentrations, it was not tolerant. *L. pennellii* had a much higher concentration of sodium and potassium in its leaves relatively to other species.

Due to the salt tolerance of *L. Pennellii* and its compatibility with *L. esculentum*, this species was selected to serve as a basis of a breeding program for salt tolerance in tomatoes.

**Breeding for Salt Tolerance in Melons (*Cucumis melo* L.)
(S. Mendlinger)**

Objectives

Underlying much of the Negev Desert is an extremely large aquifer that contains very brackish water, usually between 2,500 - 5,000 ppm. salinity. One of the major crops in the Negev is melons, *Cucumis melo*, a species that has been found to be moderately tolerant to salinity. Our primary objective was to develop a melon cultivar that could be grown in the

Negev using the local saline water and yet be economical; i.e., a cultivar that would have the necessary yield and traits needed for market. In reality, unless we were fortunate and found a cultivar that had the necessary traits, progress would entail a breeding program and strategies for salt tolerance, a trait that is not only quantitative but one that we had no genetic information nor a good screening test for. This necessitated the secondary objectives of developing breeding strategies and an understanding of the genetics of salt tolerance.

Strategies

It was decided early that the only reliable selection criteria, was measurable yield from plants grown in the field. We concluded so because of three factors: (i) plants grown under greenhouse conditions may produce data that are different from that produced in the field; (ii) selection at early life stages may have no correlation with yield; and (iii) we had no other reliable and consistent physiological, biochemical, ionic or other selection criteria to use.

The first step was an examination of a wide spectrum of the melon germplasm to determine the extent and to characterize the genetic variation for salt tolerance. We field tested 20 cultivars, breeding lines of feral types, including important Israeli and American cultivars. While several lines showed salt tolerance to some degree, no one cultivar was suitable for Israeli cultivation. Therefore two breeding programs were begun. The first, using a primitive that was found to be salt tolerant land race, was a backcross program crossing the feral line to two important breeding lines that would be the recurrent parents. The second, with an unacceptable cultivar that expressed a moderate level of salinity, used a hybrid breeding strategy.

The parameters that we examined included: number of fruit, mean fruit weight, yield, fruit appearance and marketability, date to harvest, fruit biochemistry, fruit taste and storage. In addition, in an attempt to find an easily usable screening parameter, water and osmotic potential, growth rates, biomass production, ion levels in various tissues and organic solutes were examined.

Results

Initial screening program. The first year's screening program consisted of field testing 20 melon lines at three salinity levels; control, EC=12; moderate salinity, EC=7.5; and high salinity, EC=14. The melon lines included important Israeli and American cultivars, breeding lines and feral landraces and their genetics included open pollinated lines, hybrid cultivars and homozygote lines. The field was designed in a Latin Square with seven plants, spaced 1 meter apart on 2 meter wide beds, for each cultivar (the first and seventh plants were border plants). All irrigation, fertilization and other aspects of agromanagement followed normal practices for the area. All plants were germinated in fresh water and began their salinity treatments at the first male flower (about 5 weeks). This experimental protocol was conducted in all future experiments unless otherwise stated.

The selection experiment found genetic variation for salt tolerance in melon. As no differences were found in the number of fruit produced due to salinity, yield differences were due solely to mean fruit weight. One line was found to be tolerant at all salinity levels tested, one to moderate salinity and the other were found to be sensitive, but with two different responses. Six showed sensitivity at the moderate salinity level but thereafter did not have any yield reduction. Twelve showed a constant yield reduction in respect to the salinity level.

Breeding Program-Backcross. The line that had salt tolerance at the high salinity level, EVAN KEY, is a primitive landrace that has very low yield combined with a cracked, low quality fruit, poor tasting fruit (low sugar). We decided that the best way of using this line is in a backcross breeding program with it as the donor parent. Two sensitive lines, an Ogen line and a cantaloupe line, were used as recurrent parents. The parent F1, F2, BC1 and BC2 generations were examined in yield trails with the same protocol as the selection experiment.

For Ogen generations, the F1 and F2 had better salt tolerance than the Ogen parent. However, the BC1 and BC2 generations were both very saline sensitive. The GBC2 generations were very similar to the recurrent parent in fruit appearance and growth habit.

The cantaloupe lines were more tolerant. The BC1 and BC2 lines were both saline tolerant even though the BC2 had the fruit appearance of the sensitive parent. However, its fruits were cracked and had poor quality.

We believe that continuing in this direction may have proved successful but would have taken a lot of time. We therefore looked at an alternative strategy that, if successful, would allow us to breed a new cultivar in a much shorter time period.

Hybrid breeding. We investigated the potential of a hybrid breeding program for salt tolerance. We did this for two reasons: (i) several different responses to salinity were found. This led us to the hypothesis that either several different mechanisms for salt tolerance existed and/or that quantitative trait is involved that may have many genes controlling it. Therefore, it may be possible to breed for a line that would have better salt tolerance than either parent (ii) we would be able to choose parent that would give us the set of fruit quality characters that are desirable for the grower and the market.

Two experiments to determine if combining abilities could be used for salinity breeding were conducted. If significant general combining ability, (i.e. additive genes), was found, then we may be able to cross two weakly or moderately tolerant lines to produce a more tolerant hybrid. If significant specific combining ability, (i.e., dominant genes), was found, then we may not be able to improve salt tolerance.

The first experiment crossed two cantaloupe lines to three Ogen lines (the cantaloupes were the pollen donor). With the control water irrigation, general combining ability for fruit size was not significant, which is consistent with genetic information on the control of fruit size. However, with saline water irrigation, general combining ability was found to be significant. It therefore appears that at least two different genetic mechanisms are controlling fruit size of which one, controlled by dominant genes is not important under saline conditions.

The second experiment conducted a year later tested four cantaloupes (as the pollen donor) crossed to three Ogen lines and a Honey Dew line. One cantaloupe line, cantaloupe - 1, was salt tolerant in this experiment. Unfortunately, it had too many negative qualities for it to be commercially viable. However, 3 out of 4 of its hybrids were tolerant, as was some of the other hybrids. It is very similar to the previous year's results with specific combining ability being important in determining fruit size in fresh water and general combining ability under both saline levels. We therefore concluded that a hybrid program would give us the best chance for success.

Field trials of new cultivars-yield data. A series of field trials were conducted over 4 years on the hybrids produced in our program. After a general screening using the same protocol as the selection experiment, several hybrids were found to be promising in respect

to their salt tolerance, potential yield, appearance, size and quality of the fruit and the time to harvest. A series of field trials using commercial densities were conducted. The results of the three most interesting trials are presented here:

1. In the first experiment, we tested one of our experimental hybrids, BG, against Galia, Israel's most important cultivar, at four salinity levels: EC 1.2, 4, 8 and 12. The protocol was the same as in the other experiments except that 6 blocks were used in the beds seeded at a density of 30,000 plants per hectare. Each treatment per cultivar was planted in a 2 x 10 meter bed with the seeds planted in a row parallel to and next to the drip line. The BGT line was found to out yield and be more salt tolerant than Galia.
2. The second experiment tested two improved BG hybrids, BG-84-3 and BG-84-5 against Galia. Two water qualities were used; (i) water from the National Water Carrier, EC 1.2, and (ii) water from a local well, EC 6.5. Three treatments were used: 1) control water throughout the experiment (F/F); 2) saline water throughout (S/S); 3) control water for germination and establishment and then saline water (F/S). Planting densities were 30,000 plant per hectare. Both BG hybrids out yielded Galia in every treatment. In addition, there was significant interaction between the 3 cultivars between yield and salinity treatment with the two BG cultivars having a lesser yield decrease than Galia (i.e. more salt tolerant). Salinity did not negatively effect any of the fruit quality parameters.
3. The third experiment compared our most promising cultivar, BG-84-3, against both of its parents and Galia at five salinity levels: EC 1.2, 3.9, 7.7, 11.6, and 15.5. The protocol is the same as in the selection experiment except that planting densities were 30,000 per hectare and each cultivar was sown in a 2 x 10 meter bed by itself. A Latin Square design was employed and salinity treatments began at first male flower. GB-84-3 not only out yielded both of its parents and Galia, but was also salt tolerant at all treatments. This further supports our hypothesis of additive genes controlling fruit size in melons. In addition, as BG-84-3 had the highest yield in all treatments, its tolerance is not a function of low yield or productivity.

Reproductive parameters. Both the pattern of flower development--sex and time flowering--and the number of fruit produced were examined for the influences of salinity in several experiments. In all parameters examined, salinity did not have any effect, and while differences between cultivars were found, none was for salinity. Salinity did not affect the number of fruit.

Fruitquality. Fruit biochemistry parameters were not uniformly effected by salinity. As can be seen, salinity greatly effected the EC of the fruit as would be expected. It also marginally increases the TSS. No other parameter was affected by salinity. In respect to taste we found that most people were not able to detect the difference between melons grown under different water qualities.

Significance

There are several significant theoretical and applied results from this work. The most important is a new approach presented here in respect to breeding for salt tolerance, (and other quantitative traits). That is, we have shown that it is not necessary to exclusively look for very salt tolerant lines in breeding for this trait. Instead, if additive genes are controlling the salt tolerance, these moderately tolerant lines may be useful.

Second, we demonstrated the importance of field trials and yield for selection for salt tolerance as yield, was the only consistent parameter we found for salt tolerance. All other physiological, biochemical, ions, etc. parameters proved worthless as selection criteria. We hypothesized that melons, which, under commercial growing conditions produced an over abundance of vegetable parameters should not be able to detect salinity tolerance. Most likely a partitioning effect is involved. Third, we have shown that it is possible to grow and reproduce an economical yield using a water quality of 5,000 ppm. Fourth, fruit quality and appearance was found not to be negatively affected by salinity.

FODDER AND SMALL ANIMAL PRODUCTION

FODDER PRODUCTION

Egypt: An Introduction

Project Achievements

The North Western Coastal Zone is the main rainfed area in Egypt. It lies between Alexandria and the Libyan border on a strip of about 550 km in length and 25-30 km in width and covers an area of 1.2 to 1.5 million hectares. Rainfall varies between 160-180 mm from Ras El-Hekma to Sidi Barani and 150-160 mm at Sallum. In this area, some lands are favorable to crop production and shrub production and shrub development. These lands are essentially depressions with deep, silty soils receiving some extra water from runoff, sandy soils, and deep, silty soils with little or no runoff. These lands are estimated to cover some 100,000 to 200,000 hectares, part of which is already planted with fig and olive trees with some minor other species of fruit trees; large portions are also cultivated with barley. The present population of ruminants in the area is estimated to be some 1 million sheep and 300,000 goat.

The rangeland vegetation of the western coastal zone can be described as an open shrub vegetation, characterized by few stands of semi-shrubs with a cover of ephemeral of varying density. Especially on inland dunes and on sites with sand accumulation, the lower part of the vegetation may contain small perennial (*Plantago albicans*) in addition to annuals, in certain range types of the semi-shrubs have a relatively high density as in areas with a relatively high soil salinity, in non-overgrazed areas with *Artemisia kerbaalba* as the

dominant semi-shrub, and in parts of the inland sand dunes. Generally, the density of semi-shrub decreases rapidly from about 15-20 km from the coast southwards.

The estimated range carrying capacity in the NWCZ for one small animal is about 25 feddans without supplemental feed and about 10 feddans with such a supplement; the uprooting of shrubs for fuel also contributes to the reduction of natural feedstock for small animals. Soils are generally calcareous.

The species are observed in these areas are: *Tamarix strobilacea*, *Hordeum murinum*, *Bromus catharticus*, *Heliotropism* spp., *Mathiola livida*, *Atriplex* spp., *Kochia indica*, *Halocnemon strobilacea*, *Solicornia frutescens* and most species of the legume family (leguminous) were palatable to livestock. Some of these species grow in the north coastal region as natural vegetation.

Objectives

The objectives of the CALAR fodder program were as follows:

1. To produce seeds from new improved species.
2. To improve native species by collecting seeds and selected good species of forage and rangelands.
3. To establish a nursery for producing seedlings of local and imported species.
4. Research work on selected forage and range species for high productivity in quality and quantity under salinity and/or water stress by individual or interdisciplinary under the umbrella of the CALAR Programs.
5. Seed production: because of the high cost of imported seeds, the local production of new introduced species is needed to decrease the establishment cost and increase the intensive production of nurseries in several spots at different locations in the coastal zone. For this reason, an area of 4/5 acres has been established in a state farm to produce seeds of different shrub species to be used for seedlings production. These seedlings will be distributed to Bedouin farms. At the beginning of the project, the Bedouin were producing their own seeds, but

now the CALAR Program has distributed high quality seedlings for these desert farmers.

6. Nursery establishment: seeds were treated to increase the germination rate. Seeds were shown in an artificially prepared media which contained sand and peat moss in appropriate ratios. Macro- and micro- elements were added to this media. Seedlings were placed at an age of 3-4 months to plastic bags and then moved to a shaded area for another three months. Then, seedlings were distributed to farmers for plantation during the winter season.

7. Main species have been used in the CALAR facility are:

A. *Atriplex* species

A. *nummularia*

A. *canescens*

A. *undulata*

A. *polycarpa*

A. *halimus*

A. *vesicaria*

A. *lentiformis*

A. *aminicola*

A. *barclaiana*

B. Forage trees

Acacia saligna

Acacia dormondii

Prosopis joliflora

C. Legume shrubs

Medicago arborla

In the last three years of the CALAR fodder project, work was continued with only *Atriplex nummularia*, *Acacia saligna*, *Prosopis joliflora* and *Medicago arborea*, all of which showed success and were requested by the Bedouin. These species are now showing a promising potential to increase a tolerance for environmental stress.

Transplanting seedlings in the permanent fields: At the beginning, the Bedouin did not accept the idea of growing fodder shrubs in deep soil which can be otherwise cultivated

by barley, fig and olive trees. Thus, the only available land for growing shrubs in Bedouin fields were the waste land, i.e., stony soil; soil with hard pans, and salt marshes near the sea coast. These kinds of soils need a supplementary irrigation during three months for establishing shrub seedlings in the permanent fields. Therefore, to encourage the Bedouin to participate, a bonus in Egyptian Pounds was paid for each surviving seedling after a year of transplanting.

Establishment of shrubs in permanent fields: When seedlings were about three (3) months old in the shaded nursery, the seedlings were transferred to Bedouin farms.

- a. Soil preparation in relation to topographical situation. In Marsa Matrouh area, soil leveling is different from site to site and is according to natural contour lines. Planting seedlings are sowed perpendicular on contour lines in order to catch more rainfall during the winter seasons. Soil preparations were made by the following methods:
 1. Construct hills 3-50 cm in depth and 50 cm in diameter.
 2. Contour ditches (furrow) with 50 cm depth and made perpendicular on contour lines to catch more rainfall.
- b. Seedling transplanting. According to CALAR results, shrub seedlings should be planted during winter rainfall seasons which begins in October to the end of March. Seedlings were transferred from the plastic bags and planted in hills or in furrows of 30-40% moisture. Distance between seedlings in the field are 3-4 meters and 2 meters between furrows. Distance was different according to each shrub species. The distance between both *Atriplex nummularia* and *M. arborea* seedlings were 2.4 meters and 4 x 4 meters for *Acacia saligna*, and 4 meters for hills and furrows of *Prosopus joliflora*.
- c. Hill counting and microcatchments. Each species required a different number of hills per feddan. the number of hills were: 600 for *Atriplex nummularia*, 250 for *Acacia saligna*, and 260 hills for *Prosopus joliflora*. Micro catchments for all species of shrubs are found to be 30-40% of moisture content in the soil. The moisture content in the soil is very important at the beginning of planting and the source of moisture is the rainfall during October to March. These moisture percentages help the seedling achieve for growth after transplanting from the nursery.

- d. Cultivable flat areas or small basins. Settlement of the Bedouin depends upon the water which is stored in basins during the rainfall seasons. Establishing the basins requires the lowest areas in the selected site. Basins are also used for drinking for humans and animals. This storage water can also be used temporarily for plant irrigation for a short period after transplantation. Bedouin always use the non-level area for planting shrubs. These areas are largely rocky soils which are not suitable for growing such crops as barley, figs and olives.
- e. Demand to fertilization. Leguminous sp. such as *Medicago arborea*, *Acacia seligna*, *Prosopis juliflora* and *Atriplex nummularia* need phosphate fertilizer during their growth and development.
- f. Need for fencing. In demonstration farms, *Prosopis juliflora* has been used as fences by planting one row surrounding the field of shrubs. These plants can protect the shrub from grazing during their growth because *Prosopis* plants have strong spines.

Project Achievements:

1. Introducing new fodder shrubs to the Egyptian flora which led to increasing settlements for the Bedouin.
2. Determination of the value of fodder shrubs as a protein, vitamin supplement to sheep when grazing dry pastures.
3. Improvements of natural ranges by transplanting the new fodder shrubs in the wasteland and further development of a management system to utilize such fodder shrubs.
4. Establishment of a nursery of seedlings for all new fodder shrubs.
5. Investigation of the long-term effects of drought and/or salinity stress on the production of fodder shrubs under different systems of management strategies.
6. Economical use of the wasteland and salt marshes for growing different fodder shrubs to reduce costs and losses caused by drought.

Number of Seedlings of Different Shrubs Produced and Distributed by Fodder Program

CALAR Program

<u>Year</u>	<u>Number (000)</u>	<u>Planted Area (acre)</u>
1983	Nursery Estb.	
1984-85	40,000	100
1985-86	120,000	300
1986-87	130,000	350
1987-88	200,000	500
1988-89	<u>110,000</u>	<u>250</u>
Total	600,000	1,460

For the 1989-90 season, the nursery was planted with *Atriplex nummularia*, *Acacia seligna*, *Medicago arborea* and *Prosopus joliflora*. The production of seedlings is expected to be 400,000 to cover an area of 750 acres.

Contribution of CALAR Program to Improve Rangeland Conditions at the North Western Coast of Egypt

The CALAR Program has concentrated to overcome some constraints in rangelands.

These constraints were summarized as follows:

- a. Overgrazing due to high stock rates of flocks and poor rain during drought years.
- b. Low palatability of native shrubs such as *A. halimus*.
- c. Lack of rangelands management and no protection for grazing.

The CALAR Programs supported the fodder research in the north western coast of Egypt through the following activities:

- a. Introduction of a new shrub species such as *Atriplex nummularia* and *Medicago arborea*. These shrubs species had a high productivity of dry matter and can survive under limited water availability and/or high concentrations of sodium ions in their environment.
- b. Collecting seeds from the native ranges especially common vetch (*Vicia sativa*), *Acacia saligna* and *Prosopis juliflora*.

The vetch plants are commonly observed in barley fields which always were protected from grazing. The vetch is still observed extensively in barley fields, but out of the barley fields, the vetches are disappearing.

Success in Bedouin Use of Fodder Shrubs for Grazing of Small Animals

Atriplex

Extensive trials with *Atriplex nummularia* have been conducted. Results can be summarized as follows:

Nurseries for the increased production of *Atriplex* have been established and seedling have been successfully grown for transplantation on a considerable scale.

Planting of *Atriplex* were established from nursery grown stock utilizing Bedouin herders to make the plantation on their own land.

Grazing trials show that sheep and goats graze *Striplex* well and make good weight gains on such fodder.

Medicago Arborea

Medicago arborea, a woody relative of cultivated alfalfa, apparently enjoys less growth than *Atriplex* under desert conditions. However, its forage is much more palatable and of higher nutritional value to animals than *Atriplex*.

Bedouin herders consider *M. arborea* to be the most promising of the shrub species under test. Bedouin participants are anxious that rapid multiplication and distribution of this species be carried out.

Evaluation of Drought and Salinity Resistance of Some Atriplex Species in the North Western Coast of Egypt

Five *Atriplex* species, (*Atriplex nummularia*, *Atriplex halimus*, *Atriplex vesicaria*, *Atriplex lentiform* and *Atriplex canescens*) were grown in February, 1985 under greenhouse conditions. They were then transferred on May 27, 1985 to the trial field near El-Kasr, Matrouh. The soil salinity and electrical conductivity were 7,930 ppm and 17.05 m mho/cm. The transferred seedlings were irrigated immediately after transplanting, then left without irrigation.

Diffusive resistance, transpiration, temperature differential (ambient temp. - leaf temp.), sodium and potassium percentage were measured at four (4) monthly intervals starting from May, 1986. Green and dry weight per plant and leaf stem ration were measured by a simple correlation analysis to correlate diffusive resistance, transpiration, sodium and potassium to each other.

Atriplex nummularia was superior to the other *Atriplex* species in dry weight per plant and leaf dry weight. *Atriplex canescens* were lowest of all species in average percentage of potassium, while *Atriplex halimus* was the highest species in diffusive resistance (14.4 cm s^{-1}). Whereas *Atriplex nummularia* was the lowest in transpiration ($1.41 \text{ mg cm}^{-2} \text{ s}^{-1}$). A highly significant negative correlation coefficient between DR and TR (-

0.620) is estimated. The obtained results of this trial revealed that *Atriplex nummularia* is more suitable for the Egyptian north coast environment.

Preliminary Study for Evaluating Drought Resistance of Some *Atriplex* Species

Various plant, soil, and atmospheric measurements have been proposed to determine crop water needs and tolerance to drought. Also, it is very useful to screen for drought resistance in a rapid way and accurately. Information is scarce on this subject.

The objective of this study was to evaluate the drought resistance of *Atriplex* by measuring transpiration rates, diffusive resistance of stomata, leaf and ambient air temperature using available steady state prometer LI-1600.

Some Chemical Analysis on *Atriplex* Species Grown at Nubaria in a Calcareous Soil

This study was carried out in order to determine the following: variation in the chemical constituents within *Atriplex nummularia* which were grown in calcareous soils under the environmental conditions of Nubaria, and variation in the chemical constituent among seven *Atriplex* species which were grown under previous (pre-CALAR) conditions.

These species were grown in calcareous soil (salt affected soil) at Nubaria experimental station. Planting date was in April 1984. Vegetative growth in *Atriplex nummularia* were randomly collected in December 1984. The other seven *Atriplex* species were sampled after one year from the planting date.

Dry matter was taken to determine crude protein, crude fiber, other extract, saponin and ash percentages. Macronutrients content were determined such as phosphorus, sodium,

potassium, and calcium. In addition, micronutrients were measured such as magnesium, zinc and copper.

There were negative correlations (highly significant between potassium and each of Na⁺ and Mg⁺), whereas, positive correlations (highly significant) between potassium and calcium were found in *Atriplex nummularia*. Comparisons were made between various chemical constituents among the seven *Atriplex* species. *Atriplex nummularia* had the highest value of crude protein content by 17.2%, whereas, *Atriplex semibaccata* had the lowest by 11.3%. Crude fiber was ranged between 17.8% for *Atriplex amnicola* to 27.9% for *Atriplex undulata*. Ash percentages were considerably varied, where *Atriplex vesicaria* had the highest value with 13.4%.

All species showed higher values of sodium content ranged from 7.1% to 5.3% except *Atriplex canescens* had the lowest content of sodium 2/4%. On the other hand, *Atriplex semibaccata*, *Atriplex amnicola* and *Atriplex undulata* had the lowest K⁺ concentration within the tissue. It may be due to competition between ions uptake Na⁺ and K⁺.

Studies of Growth, Development and Chemical Analysis of Salt Shrubs (*Atriplex* Species) in Salt Affected Soil in Egypt

These experiments investigated the growth, development and chemical contents of *Atriplex nummularia* and *Atriplex undulata* grown in salt affected soil at Manzala Lake area in the north coast of Egypt. CALAR researchers found there was no significant differences between the two species in respect to green yield, green leaf, young branches, woody branches, and main stem per plant (Kg). *Atriplex nummularia* was slightly higher in

leaf/stem ratio than *Atriplex undulata*, whereas *Atriplex undulata* had a higher dry weight than *Atriplex nummularia*.

The two species were found not to be different in chemical content. However, *Atriplex undulata* had a higher crude fiber and lower ash percentage than *Atriplex nummularia*. On the other hand, ADF and ADF were higher in *Atriplex undulata* than *Atriplex nummularia*.

Saponin content in *Atriplex* plant leaves growing at El-Serw Agricultural Experimental Station (Domiata governorate) were estimated. Bioassay methods using *Trichoderma viride* as a test fungus was employed for saponin determination.

A. nummularia contains high amounts of saponin that *A. undulata*, however, variations within *Atriplex* plant populations in saponin levels were detected. It was found that young leaves contained a relatively high saponin content compared to middle and/or old leaves.

Behavior of Vetch Mixture with Oats and/or Barley Under Rainfed Area

The objective of this CALAR Program study was to test for mixtures of drought tolerant legume and gramine under rainfed conditions. The effect of grass-vetch mixtures was studied during 1988/89 in two experimental stations at Matrouh and Borg-El Arab which depends only upon rainfall as a source of water for irrigation. Nine treatments included the three crops, i.e. common hairy vetch, oats and barley in pure stands and in mixtures with different combinations. Mixture of vetch with 20 kg seeds/fedan + barley with 25 kg seeds/fedan gave the highest green yield and quality.

Saponin and Fungi Associated with Atriplex Nummularia Seeds

Atriplex nummularia seeds were collected from Nubaria and Giza regions during the 1980-87 growing seasons. These seeds have a very low percentage of germination. In order to determine, partially, the cause of such phenomena, an attempt was made to study the fungi associated with these seeds and the level of saponin content in the seed samples.

Biochemical Analysis of Atriplex Species Grown in Arid Conditions

Seven shrubs of Atriplex species have been grown in dryland in north western Egypt. These shrubs were: A. nummularia, A. amnicola, A. barclayana, A. canescens, A. vesicaria, A. halimas, and A. cinerea. The plant samples were dried and some chemical analysis on these samples were carried out.

Little differences in protein and ash contents were shown in Atriplex nummularia in the three locations while total carbohydrate was varied in these places. In general, there was no great difference between protein content in all species in the three locations except Atriplex amnicola which had low value of protein content. The ash percentage was varied from one species to another and from location to location. Also, the trend in carbohydrate level was different in all species and in the three locations.

Photosynthetic Activities of Atriplex Nummularia Grown in the North Western Coast of Egypt

Two year old plants of Atriplex nummularia were grown in two different extension range fields in El-Mathani (about 40 km west of Matrouh) for studying photosynthetic

activities. Environmental measurements of photosynthetic active radiation (PAR), relative humidity (RH), chamber air temperature (CT) and leaf-temperature (LT) in addition to apparent photosynthesis (PH), stomatal resistance (RS) and transpiration (TR) were recorded monthly on October, November, and December, 1988 and March and April, 1989.

PAR, RH, CT and LT decreased from October to November, then gradually increased through the rest of measurements. These parameters have no significant differences in respect to the research locations. Stomal resistance and apparent photosynthesis were increased significantly until December, then tended to decrease during March and April. These results were shown at the two locations but only differed in their magnitude according to soil properties of electrical conductivity (EC), Na, K and Ca content. There was a positive highly significant correlation between time and each of CT, TR and between each of RH, LT, CT, TR. A negative highly significant correlation was found between stomatal resistance and each of time, PAR, CT and TR; PH was negatively correlated significantly with RH and LT.

Effect of Salt and Temperature on Germination of Cheatgrass and Small Burnet

This CALAR Program experiment studied the effects of temperature on germination of cheatgrass (*Bromus tectorum*) and small burnet (*Sanguisorba minor*) or Delar accessions of 1986, 1987, and 1988.

In this study we determined the germination temperature requirements. Twenty-five seeds of four replication for each species were germinated at various temperatures 5, 10, 15, 20 and 25°C, for 20 days and checked every 24 hours. The role and percentage of

germination increased with increasing temperature. From 7-14 days of germination, there were no significant differences in all degrees of temperature except 5°C. At 20 days of germination there were no significant differences between varieties i.e., cheatgrass and variety (Delar) especially in lower temperature.

Study effects of sodium chloride and temperature on germination of cheatgrass and small burnet accessions of 1986, 1987 and 1988.

Twenty-five seeds of four replications for both species were germinated at three different temperatures (10, 15 and 25°C) and salinity regimes (0, 0.5%, 1%, 1.5%, and 2% NaCl) for 20 days. The objectives of these experiments were to determine the seeds germinability under these conditions. At lower temperatures, cheatgrass was faster in germination than small burnet in all salt concentrations. Differences were found with Delar accessions. Delar 1986 was faster and higher rate of germination percentage than Delar accessions of 1987 and 1988.

At 10 and 15°C of temperature and 2% of NaCl cheatgrass had a higher germination than Delar accessions. At 25°C Delar accessions were faster rate of germination in all salt (NaCl) concentrations. Delar accession is more suitable to grow under salt and dry condition than cheatgrass during winter and spring in Egypt.

Metabolic Heat Rates of Kochia prosta L. in Response to Salinity

Inhibition of plant growth by increased level of NaCl has been studied extensively, the biochemical mechanism and the energy relationships involved in this inhibition have not yet been clearly defined. The effect of salinity stress on metabolic heat output of Kochia

root types (*Kochia prosta* L.) measured by isothermal microcalorimetry. These root tips were treated with concentrations of salt (NaCl) at the following: 0, 100, 200, 250, 300 and 0mM. Ten accessions of *Kochia* forage were exposed to NaCl at different levels to measure the metabolic heat rates as a function of salt stress. Data indicated that there were a wide variation in metabolic heat rate related to salt stress. The accessions U4, U6, U9 and U10 showed a better osmotically adjustment and fast recovery than other accessions.

In general, increasing salt showed decreasing the metabolic heat rate measurement. This technique can offer another method for selection for salt stress. Further research is needed to study the relationships between long-term growth rates and metabolic heat rates measurements.

Interdisciplinary Research Work

A: Activity with Salinity Group. Effect of different levels of salinity on the growth and chemical compositions of some forbs and shrubs.

In fired clay glazed pots (15 cm diameter and 35 cm height) containing a sandy soil, four (4) species of *Atriplex*, two (2) species of *Sporobolus*, *Distichlis spicata* and one species of perennial wood alfalfa (*Medicago arborea*) were irrigated with different rates of salinity from 0 to 16000 ppm. The results indicated that the fresh and dry weight of *Atriplex nummularia* and *Lentiformis* were not significantly affected by increasing salinity up to 12,000 ppm, while the fresh weight of *Atriplex canescens* as increased significantly by increasing salinity. However, its yield was the least among the other species. The chemical analysis of the top parts of plants showed that the percentage of CP, C and fat were not affected by increasing salinity in *Atriplex nummularia* and fluctuated in *Atriplex canescens*.

Also, the study revealed that the frequency (7 and 14 day intervals) did not affect the fresh and dry weight of the different species.

The data illustrated that the fresh and dry weight for the *Sporobolus nannus* and *Sporobolus capensis* were not affected by increasing salinity, while the fresh and dry weight of *Distichlis spicata* were decreased significantly at the rate of 12,000 ppm. Also, the yield of *Sporobolus nannus* was the highest as compared with the other species. The results showed the CP and ash were significantly increased by increasing the level of salinity for *Sporobolus nannus*. It was also clear that the CP, CF and fat were similar for all species, meanwhile, the ash percentage was very poor in *Distichlis spicata*.

The data gathered by CALAR researchers indicated that the fresh and dry weight of the first cut (winter season) of *Medicago arborea*, decreased with increasing salinity to 16,000 ppm. With respect to the yield of the second cut (summer season), it followed the same trend of the first cut with respect to salinity. It may be noticed that yield of the second cut (summer season) was obviously less than of the first cut (one fourth of the first). The results also clarify that with respect to saline irrigation intervals, the yield obtained with 5 days intervals was optimum. It was also noticed that the effect of salinity was more severe with the 10 day intervals.

Conclusion

With respect to salinity, the yield of *Atriplex* and *Sporobolus* were more tolerant than *Medicago arborea*, but with respect to CP, the contrary is true.

- B. ²Activity with animal specialist group. Feeding *Atriplex nummularia* to sheep and goats; grazing behavior and feed utilization; and, the nutritive value of range plants in the NWCZ.
- C. ³Activity with nitrogen fixation group. Application of N-fixers in curing physiogenic disease of barley in arid zones on the NWCZ; and introducing new barley cultivars adaptable to salinity in semi-arid land at the NWCZ.

Potential of Growing Fodder Shrubs in the North West Coastal Zone (NWCZ) of Egypt

The potential and area for growing productive fodder shrubs in the north western coastal zone of Egypt is probably in the vicinity of 100,000 hectares, and perhaps more.

Assuming a mean annual production of 1 kg CM of fodder per shrub/year (1,000 kg CM/ha/yr), and 0.15 kg of crude protein (150 kg/ha/yr). We thus have a theoretical production potential of 100 thousand tons of DM and 15000 tons of Cp per annum in the whole area. That is the energy requirement equivalent of some 180,000 adult sheep/annum and the protein needs of 940,000 sheep annum. The present population of small flocks in the area is estimated to be one million sheep and 200,000 goats.

The shrub potential would thus meet the protein requirements of the small ruminants when range and crop residue resources are added. This would, in principle, free the area from buying nitrogen-rich concentrate.

Fodder shrubs should not be planted on the stony plateaus where production would be too low for economic viability, but restricted to deep soils in depressions in the zone located between the seashore and the Alexandria-Sallum road, above the 120 mm rainfall.

²Abstracts are presented in animal group reports.

³Abstracts are presented in nitrogen fixation group report.

These soils are usually cropped to barley; therefore, shrubs should be established in widely spaced rows (10 to 15 m apart) so as not to disturb mechanical tillage and harvesting of the cereal. Shrub density would be of the order of 500 individual per hectare -2/0 per acre.

In such conditions, production may be expected to reach an average of 1 kg DM of fodder per shrub (3 kg fresh leaves) i.e., 500 kg DM/h/yr.

To this should be added 500 kg of barley straw (and stubble) and 300 kg of barley grain. The total production per hectare would thus be 1,300 kg of DM and $(500 \times 0.15) + (300 \times 0.10) = 105$ kg crude protein. The carrying capacity is thus 2.7 sheep/ha/yr in terms of energy and 6.5 sheep/ha/yr in terms of protein (45 g CP/sheep/day).

If 5 hectares of rangelands are added to each hectare of barley + shrubs the carrying capacity of each hectare of barley + shrubs would be in the vicinity of 5 sheep/hectare, i.e., a potential flock of 500,000 sheep.

If we assume that some 70% of the diet requirement of the present one million sheep of the area is based on concentrate feed, we would have a saving of 255 kg of 500,000 = 128,000 tons of concentrate feed per annum, bought in hard currency on the international market.

Fodder Shrub Selection

The most productive species under the conditions of the study are:

On silty deep soils: *Atriplex nummularia*

On deep sand soils: *Acacia saligna* (*A. cyanophylla*), and *Opuntia ficus - indica* var. *inermis*

On shallow soils: *Atriplex halimus* (local)

Colutea istria (*C. aleppica*)

(from Quansour, Sinai, Jordan)

On saline soils: *Atriplex halimus*, *A. glauca*, *A. mollis*
On sand dunes: *Calligonum comosum* (Tunisia)
Calligonum azel (Tunisia)
Calligonum arich (Tunisia)
Haloxylon persiucum (Saudi Arabia, Iran, Jordan, Israel)
Hedysarum argentatum (Morocco)
At. canescens var. *linearis* (U.S.A.)

Recommendations

A pilot demonstration scheme of a few hundred hectares is recommended to be established in the project area, in order to demonstrate to farmers what modern technology can do to help them. An adjacent area of a few thousand hectares of rangelands should be added to the barley/shrubs farm in order to demonstrate the integration of farming cereals/shrubs/fruit trees and rangelands.

This pilot "farm/ranch" should be established as soon as possible as a five-year-period will be needed to reach any firm conclusion, in terms of socio-economic feasibility.

Medics--Range reseeding with medics is not advisable in Egypt; the rainfall is too low and erratic to avail significant success. In the southern and southwestern area of Australia, medics are not sown below a mean long-term rainfall of 250 mm. Attempts in other countries (Libya, Tunisia) with lower rainfall failed. Light dressing with superphosphate in rainy years would produce significant improvement of the fallow since, contrary to Australia medics are native and present in the fallow (*Medicago littoralis*, *M. truncatula*, *M. lacinata*). A light superphosphate dressing (10 kg P/ha = 23 kg P₂O₅) would increase their frequency and biomass, thus improving the grazing value of these fallow.

**H.N. 1e Houerou, Report on a Mission Carried Out
For CALAR in December 1988**

Further research needed.

1. Study of the regrowth potential of fodder shrubs as *Atriplex* spp., *Kochia* spp., and *Artimizia* spp. as affected by various environmental stress.
2. To investigate the long-term effects of grazing in sheep production system on the primary production of forage shrubs under different grazing management strategies.
3. Study the value of different shrub spp. for fodder and fuel at the NWC of Egypt.
4. Study in inter-cropping system of *Atriplex* spp. with parsley.
5. Increase the amount of seedlings production of different shrubs in order to improve areas of rangelands.

Israel: An Introduction to CALAR Fodder Research

Objectives of the CALAR Fodder Project in Israel:

- To determine the value of fodder shrubs for small ruminants in semi-arid regions,

To achieve this objective the following sub-objectives were formulated:

1. To establish a technology for the propagation and establishment of fodder shrubs.
2. To find a method for measuring fodder shrub biomass production.
3. To determine the shrub planting density per hectare that is optimal for the production of edible fodder.
4. To establish the recovery, regrowth production and nutritive value of fodder shrubs after complete defoliation by grazing in either the winter (two months), or the summer (6 months).
5. To measure the performance of animals grazing at high stocking rates (5 and 7.5 heads per hectare) in a sheep production system, that included pastures, wheat, and fodder shrubs (on 1/4 of the area).
6. To establish grazing management strategies that can provide a sustainable optimum edible fodder production from shrubs.
7. To apply the CALAR Program research findings by establishing a shrub plantation in a typical Bedouin commercial sheep production operation in a region with difficult terrain and rainfall conditions.
8. To integrate the findings of the project into a generalized quantitative model for application in countries of the Mediterranean region.
9. To establish areas of cooperation between Israeli and Egyptian scientists.

Results

Propagation and establishment. A technology was developed for the production of seedlings as "speedlings", which reduced the cost from US \$0.5 for a conventional bagged seedling to US \$0.1+ for a "speedling". An establishment method was developed that

enabled the fodder shrubs to be grazed 1½ to 2 years after planting at a total production cost of US \$500 per hectare.

Measurement of biomass production. A method was developed measuring the total standing biomass of fodder shrubs and of their constituent components. This method may also be used for calculating the intake of grazing animals. The average intake from the shrubs was found to be approximately 0.5 kg fodder per day per sheep.

Planting density. Shrub biomass production was maximized 3 to 4 years after planting at 12 tons DM per hectare at a planting density of 10,000 shrubs per hectare. Optimum edible production per hectare (balance between fodder and herbaceous species) was 6 tons per hectare at a planting density of 2,500 shrubs per hectare.

Recovery, Regrowth and Nutritive Value During Six Years of Grazing

It was established that shrubs could recover after complete defoliation by grazing and, after 6 to 10 months produce up to 2 tons of edible fodder. This is in addition to the 4 tons produced by the herbaceous species growing among the shrubs when the latter were planted at a density of 2,000 shrubs per ha.

Recovery and regrowth after winter grazing were superior to that after summer grazing.

Due to high ash contents of up to 25% of the DM, the nutritive value of the shrubs was found to be merely equivalent to that of a poor quality hay. However, this disadvantage was offset during the winter by the nonavailability of other feeds, and during the summer by the fact that shrubs constituted the only green feed available.

Sheep Performance

Little to no difference was found between the fertility and live weight changes of mature sheep grazing fodder shrubs and those of sheep of equivalent age grazing areas without fodder shrubs at both stocking rates examined. However, lamb mortality was up to 5% less in flocks grazing fodder shrubs.

In one year out of four young maiden sheep mated while grazing fodder shrubs had an up to 60% better lambing rate than maiden sheep grazing an equivalent area without shrubs. In the other three years no differences were found.

Grazing Management

It was established that shrub areas exhibiting degradation symptoms because of falling annual regrowth production could be quickly rejuvenated by grazing "out of season" during the spring months and by suppressing the herbaceous ground cover by selective grazing during the winter. These rejuvenated areas could then be regrazed the following year in the winter or summer as required.

The optimum grazing pressure for sustained intakes of fodder from shrubs of up to 0.5 kg per sheep per day was found to be 5 sheep or 10 young maiden ewes per hectare (these are high pressure for semi-arid regions).

Application

A 20 hectare plantation was established in a rocky hillcountry area with an annual rainfall of 220 mm for utilization by a Bedouin commercial flock. Two years after planting (initiation of grazing), the shrub survival rate was 75% when planted at 2000 shrub per hectare. The Bedouin expressed satisfaction at having winter feed when no other grazing feed was available.

Production Analysis Model

A model was developed incorporating all results from the project. In cooperation with Egyptian colleagues this model was adapted for application in Egypt for use in evaluating agropastoral systems.

Areas of Future Cooperation

During the project a dialogue was established with Egyptian colleagues for future cooperation and mutual benefit in the following research areas:

1. Propagation of fodder shrubs.
2. Methods of measurement.
3. Application and relevance of research results to Egypt and Israel.
4. Development of a production analysis model, incorporating results from both countries.
5. Further cooperative projects.

Conclusions

The eight years allotted to the project enabled the development of close personal relationships between the cooperating scientists from Egypt and Israel and eventually resulted in "on-site" cooperation with mutual benefits to both countries. Both parties share the desire to cooperate further in the future and to submit joint collaborative projects.

The results garnered in this, the first known long-term (8 years), in-depth study of fodder shrubs integrated with sheep agro-pastoral systems, constitute an important contribution to our understanding of the place of fodder shrubs in realistic animal production systems.

According to the two world authorities selected as consultants by CALAR, this research project produced the most comprehensive "state of the art" information on shrub propagation and utilization available today. In addition to its scientific value, the results can provide a rational basis for planning regional fodder shrub development projects.

**Azospirillum Effects on Susceptibility to Rhizobium
Nodulation and on Nitrogen Fixation of Several
Forage Legumes**
(Eli Yahalom, & Amos Dovrat)

Azospirillum effects on susceptibility to Rhizobium nodulation and on nitrogen fixation of several forage legumes. Can. J. Microbiol. 33:510-514.

Azospirillum brasilense Cd cell concentration of 10^7 - 10^8 colony forming units (cfu/mL applied 24 hours before Rhizobium (10^6 cfu/mL), increased nodule formation in the non root hair zone, more than two fold, in pouch-grown Medicago polymorph and Macroptilium atropurpureum seedlings, compared with Rhizobium alone. The increase in nodule formation in pouch-grown Trifolium alexandrinum following preinoculation with Azospirillum was 20%. The percentage of modulated seedlings rose from 0 to 25% when Medicago polymorph was preinoculated with Azospirillum followed by the application of 10^6 cfu/mL Rhizobium meliloti, a level which by itself was not sufficient to initiate nodule formation. Acetylene reduction activity in Medicago polymorph and Macroptilium atropurpureum seedlings after inoculation with Azospirillum-Rhizobium was markedly increased. A possible reason for the increased susceptibility to Rhizobium infection may be that Azospirillum stimulates the formation of a larger number of epidermal cells that differentiate into infectable root hairs.

**Possible Mode of Action of Azospirillum brasilense Strain Cd
On the Root Morphology and Nodule Formation in Burr Medic
(Medicago polymorph L.)**
(Eli Yahalom, Yaacov Okon, & Amos Dovrat)

Possible mode of action of Azospirillum brasilense strain Cd on the root morphology and nodule formation in burr medic (Medicago polymorph). Can. J. Microbiol. 36:10-14.

The mechanism(s) involved in the effect of Azospirillum brasilense strain Cd on root susceptibility to nodulation was studied in medic seedlings grown in pouches. The number of nodules above the position of the root-tip mark at the time of inoculation and the position of the uppermost nodule were used as parameters for determining the rate of nodule initiation. Cell-free extracts and culture supernatant prepared from Azospirillum and the cytokinin benzyladenine (10^{-9} M) significantly increased the number of nodules formed above the root-tip mark when applied together with Rhizobium compared with those formed with Rhizobium alone. The application of indoleacetic acid did not cause an increase in the number of nodules. In the absence of Rhizobium, exposure to Azospirillum at a concentration of 10^9 cfu/mL or to compounds excreted by the bacteria into the growth medium caused a 40% increase in endogenous ethylene production by the roots. A less concentrated inoculum did not increase ethylene production. Inoculation with Azospirillum significantly increased the specific activity of the enzymes glucose - 6 phosphate dehydrogenase, L-phenylalanine ammonia-lyase, and shikimate dehydrogenase compared with roots inoculated with Rhizobium alone.

**Early Nodulation in Legumes Inoculated with
Azospirillum and Rhizobium**
(Eli Yahalom, Yaacov Okon, & Amos Dovrat)

Abstract

The effect of *Azospirillum brasilense* combined with *Rhizobium* on nodule formation, was studied under the CALAR Program during the establishment phase of various forage legumes. The uppermost nodules on the primary roots of pouchgrown burr medic (*Medicago polymorph*), siratro (*Macroptilium atropurpureum*) and Egyptian clover (*Trifolium alexandrinum*), appeared significantly earlier following combined inoculation with *Rhizobium* and *Azospirillum*, compared with *Rhizobium* alone. Root tip positions were marked on pouches at the time of inoculation and the marks then used as reference points in following the course of nodule formation. *Azospirillum* increased the total number of nodules by 3.6, 1.8 and 1.3 fold at days 5, 7 and 10 from inoculation, respectively, in pouch-grown medic. The number of nodules located above the root tip mark (RTM) increased by 4, 3 and 2 fold at the same days, respectively, as compared with inoculation with *Rhizobium* alone. Also in pot-grown medic, the number of nodules on the upper part of the main roots increased after inoculation with *Azospirillum*. Significantly higher root dry weight and root surface area were obtained at day 20 and also higher shoot dry weight and N content, 32 days from emergence. The possible mechanism of early nodulation by the combined *Azospirillum/Rhizobium* inoculation is discussed.

**Effect of Inoculation with Azospirillum Brasilense Strain
CD and Rhizobium on Root Morphology of Burr Medic
(Medicago Polymorph L.)**

(Eli Yahalom, Amos Dovrat, Yaacov Okon, & Hanoch Czosnek)

The inoculation of burr medic seedling grown in pouches with *Azospirillum brasilense* Cd at a concentration of 10^6 cfu/mL significantly increased the number of lateral roots and main root diameter but not the length of roots in the presence or absence of *Rhizobium*. At *Azospirillum* concentrations exceeding 10^8 M cfu/mL root elongation was inhibited, although less when combined with *Rhizobium*. Exogenous indole acetic acid (IAA), or benzyl adenine (BA), concentrations of 10^{-8} M stimulated root elongation.

Concentrations exceeding 10^6 M inhibited root elongation and shortened the length of the root elongation zone. Root hair density was not affected following inoculation with *Azospirillum* although the number of root hairs per unit of root length increased as a result of the increase in the root circumference. In cross sections taken near the root tip shortly after inoculation with *Azospirillum* (10^9 cfu/mL), larger cortical cells were observed; however their number (in cross section) did not increase compared with the controls. The DNA concentration of root segments formed 24 hours after inoculation with 10^9 cfu/mL *Azospirillum* was significantly lower than in roots inoculated with a concentration of 10^9 cfu/mL or the controls. From this finding it was concluded that the reduction in root growth may have resulted from decreased cell division in the apical meristem of the root. The purpose of this research was to study the morphology and anatomy of medic roots following inoculation with *Azospirillum* in the presence or absence of *Rhizobium* and the possibility of mimicking some of these effects by applying auxin and cytokinin.

FODDER AND SMALL ANIMAL PRODUCTION IN ARID LANDS

Small Animal Production in Egypt

Introduction

The CALAR project area extends over 550 km from Alexandria in the east to the Libyan border in the west, and reaches inland from the coast to a depth of 50 to 80 km. The landscape is distributed into a northern coastal plain and a southern tableland. The climate is qualified as "Arid Mediterranean with mild winter." Average annual rainfall is 140 mm (ranging from 50 mm to 250 mm). Rainfall is higher in the coastal areas from, 5-15 km deep, then decreases sharply. Rainy season is October-May, peaking out in December and January.

The total rangeland area is estimated at 1.2-2.8 million acres. Generally, the pasture is communal with traditional grazing rights without consideration for number of animals or time spent in the pasture. Early in the 1960's, the range was described as open shrub vegetation characterized by sparse stands of semi-shrub with a cover of ephemerals of varying density depending upon rainfall. By the beginning of the eighties, the range was described as short-life ephemerals that appear during December-April, according to the rainfall, where the area is almost barren in the dry season.

The main agricultural activity in the area is sheep and goat raising; some limited cultivation of barley and fruit trees (figs and olives) also occurs.

Stocking rate estimates vary from 14-22 acres/head to 2-4 acres/head. Sheep and goat population increased rapidly in the last decade from 650,000 in 1967 to 1.33 million in 1982.

The main constraints in the animal production system are:

- Continuous depletion of natural ranges;
- Overstocking and misuse of the ranges;
- Low productivity of the animals, and;
- Marketing problems due to transhuman way of life.

The objects of the animal program were:

1. Pilot field studies for characterizing the management system potentiality and constraints for sheep and goat production in the area.
2. Improving productivity of desert Barki goats by crossing with Damascus goats.
3. Evaluation of the nutritive value and utilization of pasture species selected by the fodder group.
4. Investigating summer feeding problems in the area and ways to overcome them.
5. Preliminary studies on system analysis of sheep and goats in the project area.

Productivity and Management System of Desert Barki Sheep and Goats in the Coastal Zone of Western Desert of Egypt (NWCZ)
(A.M. Aboul-Naga, M.B. Aboul-Ela, H. Mansoure, E.S.E. Galal, A. Heider, E. Shehata, & Ferial Hassan)

Surveys were carried out covering 250 breeders at different sites in the project area through administering questionnaires to the breeders. The study aimed at characterizing the prevailing production systems of small ruminants.

Most of the flocks are a mixture of sheep and goats, with a sheep to goat ratio of 4:1. Flock size ranged from 50 to more than 1000 head with an average of 255 heads.

Natural pasture covers feed requirements for only 3 to 5 months, depending upon rainfall. About 1/3 of the flocks move about seeking better pasture for periods up to four months every year.

During summer and in dry years, flocks are fed mainly on grains. Annual total grain consumption in the area was estimated as 1.4 million tons.

Annual offtake from both sheep and goat flocks is higher than that expected under an extensive system, being .79 lamb and 1.2 kid, respectively.

Conception rate averaged 88% in both sheep and goat flocks. Twinning rate was 10% and 48% in sheep and goat flocks, respectively. Mortality of lambs and kids up to weaning (at 3.5 months of age), averaged 6.7% and 8.2%, respectively.

Marketing weight of lambs and kids averaged 26 and 16 kg, respectively. Large proportions of lambs and kids are subjected to fattening periods of about 3.5 months to attain marketing weight of 40-45 and 25-30 kg, respectively.

Goat milk production averaged 50 kg for a lactation period of 75 days on average. Wool is sheared in April-May with an average yield of 1.8 kg/head. Other management and productivity aspects are discussed.

Lamb and kidding occur throughout the year with peaks in November and April. Average ram:ewe and buck:doe ratio were 1:44 and 1:39, respectively. Sires are mostly selected from within the flocks based mainly upon their body size and dam performance.

Rate of increase in flock size was high which potentially may double the flock size in 4-5 years.

The system looks fragile and depends on higher exotic inputs and cannot presently be characterized as an extensive system.

Pilot Field Studies of Sheep and Goat Productivity
In the North West Coastal Zone of Egypt
**(E.I. Shehata, A. Heider, A.M. Aboul-Naga,
E.S.E. Galal, & H.M. El-Mahdy)**

Pilot field studies were planned to assess the productive potentiality of native Barki sheep and goats raised in the NWCZ.

This work utilized data collected through monthly visits over two years from six flocks located in western and eastern parts of NWCZ (3 each). A format was administered to generate data on reproductive and productive traits, managerial practices and flock dynamics.

Flock size ranged from 45 to 300 sheep and from 25 to 160 of goats. Numbers of sheep tended to change according to availability of pasture while goat numbers kept somewhat constant. This pattern of change indicates that sheep act as the main cash crop for the Bedouin in the region, while goats are kept mainly for domestic use.

Lambing and kidding took place all year round, with market lambing peaks in October-November (41.2%) and April-May (22%). Intensity of kidding extended over a longer period (October-March), where 77% of the produced kids are born. The overall lambing and kidding rates were estimated to be 1.1/ewe/year and 1.2/doe/year.

Negligible monthly changes in mature body weight of the animals were noticed in both sheep and goats. Breeders seem to maintain their animals in a good condition even during the period of pasture insufficiency by supplementing with concentrates. There were significant differences found among flocks in average body weight.

Mortality rates in mature sheep and goats were 2.4% and 3.5%, respectively. While post-natal mortality up to weaning were 4.2% and 21.5% in lambs and kids, respectively. Incidence of abortion was higher in winter in both sheep and goats.

Total number of lambs marked per ewe per year was estimated as 0.81 compared to .64 for doe. The higher incidence of abortion and post-natal mortality in goats, beside domestic consumption may explain this difference. Culling rate was estimated as 8.3% and 6.9% for sheep and goats, respectively.

**Improving Desert Barki Goats Through the Introduction
of Damascus Blood at the Producer Level**

**(E.S.E. Galal, A.M. Aboul-Naga, A. Heider,
E. Shehata, & H. Almahdy)**

In 1982 and 1983, 67 Damascus bucks were distributed to goat breeders in the NWCZ of Egypt. Periodical visits were made to these breeders to gain information on the performance of the introduced bucks and their progeny, acceptability to the growers, and the sustainability of the crossbreeding system at the producer level. A series of questionnaires were made. Four interview segments were conducted at different stages of the program.

The first questionnaire was distributed shortly after dispatching the bucks, the second when they started to have progeny, the third when the progeny started to produce and the fourth when progeny had completed a full production cycle.

Goat raisers reported that F1 bucks were either equal or better than the Barki in both sexual activity and fertility. Ninety-five percent of the respondents said that the F1 bucks can breed all year round. The Damascus F1 buck fertility reported was higher in number of does kidding per does joined being 0.81 to 0.91 in the three mating seasons. Mean age

of F1 bucks at first mating observed as approximately 17 months older than that of the Barki bucks, which usually are about one year of age when they are first used for breeding.

The average respondent reported that the crossbred doe produced 1.44 times as much milk as the Barki. This result should be evaluated in light of the fact that the average age of the crossbred does is less than that of the Barki and that the majority of the former had not reached maturity. The increase in milk yield was realized mainly through the higher daily milk yield rather than increase in the lactation period. Only 5% of the respondents said that F1 gave more twins than the Barki's while 95% said that both breed groups were similar.

As compared to the Barki, the average respondent reported that F1 goats were 1.5 times as heavy while the backcross (1/4 d 3/5 B) was 1.34. Mortality rate was similar in both F1 and Barki goats which may lead to the conclusion that the backcross is not different from either major sub-type.

The statistics obtained indicated high degree of acceptability of the crossbred goats to the breeder. These breeders in fact, ceased to receive D or DB Bucks from the distributing agencies and depended upon themselves in changing the genetics of the flocks. Among respondents reviewed, the average number of bucks is 1.83 per flock, of which 29% are Barki and 71% are crossbreeds (home produced). The average grower participating in the project has changed the genotype of his flocks from 100% Barki does to 53% Barki and 47% having Damascus genes. The number of does assigned by the breeders to Damascus of F1 buck increased the first season to the third season, being 53%, 58%, and 84% of the total number of does in the flock, respectively.

From 67 goat raisers who originally received Damascus bucks, 300 mature does were estimated to be exposed to bucks with Damascus genes. At the end of the CALAR studies, 47% of these does were crossbreeds. In addition, there is a continuous output of crossbred bucks from these flocks to other flocks. Over the three seasons reviewed there were an average of 8.8 young crossbred bucks per flock sold to other flocks for breeding purposes. This amount to a total of 590 young crossbred bucks sold for breeding purposes. Also, there is an average of 32.2 crossbred bucks per flock now sold on the market, part of which could be used for breeding purposes. Demand for these crossbred kids is great, as reflected in their higher prices.

A relatively small number (67) of Damascus and F1 bucks were distributed, 67, but the 590 more sold to breeders for breeding, indicates that the systems of introducing Damascus goats can be self-sustained, through it may require monitoring to allow breeders whose production conditions allows for higher Damascus gene proportion (0.50-.75) are able to obtain it and to satisfy the high demand for the Damascus breed.

Comparative Physiological Studies on the Response
of the Desert Barki Goats and Crosses to Heat,
Water Deprivation and Exercise Stresses
(A.M. Aboul-Ela, T. Shalaby , Ferial Hassan, & A. Heider)

A preliminary trial was carried out at Borg El-Arab Research Station. Six mature barren does of each of Desert Barki (B), imported Damascus (D), Valley Zaraibi goats (Z) and DB and ZB crossbreeds were used in the study to investigate their physiological responses to exposure to solar radiation (SR). Half the animals from each breed group were exposed to direct SR for 3 hours (from 1100 to 1400 h) and kept in shade otherwise, while

the others were kept in shade all day. On the second day, the groups were switched. This procedure was repeated three times. Rectal temperature (RT) and respiration rate (RR) were measured on each day at 1100 (prior to exposure to SR) 1300, 1400, 1500 and 1600 h. Blood samples were taken at 1100, 1400 and 1600 h to determine plasma concentration of T3, T4 and cortisol.

Exposure to SR caused significant ($p < 0.01$) increased in RT and RR in all breed groups with D being the most affected, B was the least affected breed group. Plasma T3 and T4 concentrations were significantly ($p < 0.05$) reduced with exposure to SR and difference being most pronounced in D and DB. T3 and T4 levels were higher in D than in local breeds but the differences among breed groups were statistically insignificant. Cortisol level did not show any particular trend in response to the heat stress of SR.

The second trial was carried out under natural grazing conditions similar to that practiced by the breeders in the NWCZ desert.

A group of five lactating does from each of Desert Barki (B), imported Damascus (D), and their crosses ($\frac{1}{2}$ D and $\frac{1}{4}$ D), in addition to another group of 7 B and 6 $\frac{1}{4}$ D, were used to investigate responses to water deprivation and muscular activity under the desert conditions. Water was offered once daily to the first group and once every two days to the second group. The animals walked 7 km daily under direct solar radiation. The results obtained showed that:

1. Walking 7 km under direct SR resulted in significant increase in RT and RR in all groups. The magnitude of increase was larger in the D and $\frac{1}{2}$ D than in other breeds. Watering treatment did not induce great differences in RR and RT.
2. In G1 (drinking once daily), the total water intake over two days was almost similar for B and $\frac{1}{4}$ D. D goats consumed the largest amount of water (58%

more), while the $\frac{1}{4}$ D consumed the least amount (3% less). In G2 (drinking once/2 days), the total water intake was reduced by about 24% in B and $\frac{1}{4}$ D compared with the first group.

3. After one week of the experiment, all animals lost 7.7-15% of their initial weight. From the second week, the losses in body weight leveled off and the animals began to compensate the losses in their body weight. At the end of the experiment, BW was close to the initial values.
4. Watering treatment had no effect on BW.
5. Under the studied natural grazing conditions, a marked decrease in milk yield (50%) was recorded in B goats, while B and crossbred does were not affected.

It can be concluded that the Damascus goat can withstand natural grazing conditions in the Western Desert, only the milk production was affected. The $\frac{1}{4}$ D showed similar responses to all stress factors studied as the native desert Barki. Therefore, $\frac{1}{4}$ Damascus could be recommended as improved genotypes for milk production in the NW desert.

Saponin and Fungi Associated with Atriplex Nummularia Seeds
(E. Shehata, I. El-Sayed, A. Heider, A.M. El-Serafy,
& T. El-Gallad)

The effect of adding a balanced mineral mixture, an available energy source (barley grains) or both on intakes of dry matter and water and on nutrients digestibility and nitrogen balance by sheep being fed Atriplex nummularia, was studied. Fat-tailed Barki ram lambs 10 months old and about 26 kg live body weight, were used in this experiment. Four parallel intake metabolism trials of a 28-day period each, were conducted utilizing three rams per trial.

Four feeding treatments were tested; 1) Atriplex nummularia (AN) alone; 2) AN plus a mineral mixture; 3) AN plus 250 g barley grains; and, 4) AN plus a mineral mixture plus barley grains.

Highest values ($p < 0.05$) for DM, water intakes and nutrients digestibility were recorded in treatment 3 (sheep fed barley add to AN). Lowest values on the other hand, were recorded in treatment 4 (sheep fed AN plus minerals plus barley). In that treatment, water intake relative to DM intake was the highest value (3.282).

When sheep were fed Atriplex alone, N balance was negative while the positive N balance values were obtained in treatments 2 and 4 and almost a balance in nitrogen utilization was calculated from sheep fed Atriplex plus barley (treatment 3). Differences between N balance values were not significant.

The digestibility values were corrected within treatments, to equal DM intake and the only noticeable positive effect on nutrients digestibility was that of treatment 3 (when sheep were fed AN plus barley).

It was concluded that available energy is the first limiting factor which affects sheet utilizing Atriplex nummularia.

Feeding Atriplex nummularia to Sheep and Goats:
Grazing Behavior and Feed Utilization
(E.I. Shehata, A.I. Heider, T.H. Shalaby, M.B. Aboul-Ela,
A. Rammah, & A.M. El-Serafy)

Differences between sheep and goats in their utilization of Atriplex nummularia shrubs fed either solely or supplemented with barley were studied in two trials. In the first, whole bushes were cut and offered ad libitum, while in the second, the bushes were grazed until being defoliated. Goats performed better than sheep on feeding Atriplex alone. In sheep, feeding Atriplex solely was associated with wool shedding, diarrhea and wool biting.

Relative to metabolic body weight, ram lambs consumed the greatest amount of Atriplex (113 g DM.d-1.kg-1.W.75) compared to bucks (91 gDM) and rams (81 gDM). Barley supplementation enhanced Atriplex consumption in ram lambs (+22.3%) while no difference was noticed in goats (-0.3%).

Introducing barley to the system increased leaf consumption by goats (from 576 to 82% while no change was observed in sheep (from 69 to 69%). Feeding of Atriplex caused an increase in water intake. Further increase in water intake occurred with barley/grain supplementation.

When animals were allowed to graze Atriplex shrubs, sheep spent less time in eating Atriplex (-24.8%) and laying down (-88.9%) and more time in standing (+33.3%) compared to goats. Offering water once per day reduced the time spent for eating Atriplex in sheep (-22.2%) but not in goats (+8.2%).

The Nutritive Value of Range Plants in the NWCZ
**(E. Shehata, A.M. El-Serafy, A. Rammah, T. El-Galad,
H. Metawie, & M. Shoukry)**

Two trials were conducted to evaluate native range plants and the newly introduced Atriplex nummularia (AN), in the NWCZ. In trial one, samples of grazable plants were collected from five grazing locations during the grazing seasons of 1986 and 1987 (February through April). After identification and classification into annuals (ANL) and perennials (PRN), an evaluation was done on the basis of chemical composition, in vitro nutrients disappearance (IVDMD of IVOMD) and calculated TDN. In trial two, in vivo digestibility and nitrogen balance were done on AN, (alone or with added barley grains), utilizing bucks and rams.

Massive grazing, however, is in the Sidi Barrani area west of Marsa Matruh on *Hordium vulgare* (IFN:2-00-511) for about a 60 day period (January-February).

The results of CP and CF analysis were 15-25% higher and 10-17% lower than the respective listed book values of both ANL and PRN. Between locations, no differences ($p < 0.05$) in chemical analysis were detected. Among the above ANL or PRN, positive and negative simple correlations, respectively, were calculated between IVDMD (or IVOMD) and CP and CF contents. Also in all samples, ADL as percent of ADF was negatively correlated with CP and IVDMD.

Non-protein-nitrogen NPN as percent of total N range between 37-43%, except in *A. halimus* where it was between 42-47%.

Bucks consumed more ($p < 0.05$) ATN-dry matter than rams (91.4 vs. 81.2 g/w/75/d) and almost maintained their body weight (-0.7 g/h/d) while rams lost weight (70g/h/d). When barley grains were introduced with ATN, both bucks and rams gained weight (90 v 18 g/h/d). Nutrients digestibility of ATN was generally higher ($p < 0.05$) by bucks than by rams, but when barley was added, no difference in digestibility was noticed between bucks and rams and their nitrogen balance was improved.

It was concluded that during the grazing season, native grazable plants had high and low contents of crude protein, in vitro digestibility and crude fiber and that ATN is a potential source of mechanical safety for sheep and goats in the dry season

Mineral Survey in Grazing Areas of NWCZ
**(T. El-Gallad, E. Shehata, H. Metawie, H. Gado,
& A.M. El-Serafy)**

Screening of the mineral levels in indigenous plants and in the blood plasma of sheep and goats in different grazing locations was initiated to study the mineral profile and possible mineral deficiencies or imbalance.

Samples of plants, blood-plasma, wool, wool of sheep and hair of goats were collected from five grazing locations around Marsa Matrouh, northwest of Egypt during spring, summer and autumn of 1986, 1987, and 1988. Totals of 236 plants, 468 of each of blood, hair and wool samples were analyzed using an atomic absorption apparatus for the following minerals: Ca, P, Mg, Mn, Cu, Zn, Mo and Se. Triplicate readings were done and the data were statistically analyzed.

The results indicated low levels of Zn, Mn in plant samples irrespective of year or season. Also, Ca and P levels although adequate in plant samples, yet the Ca:P ratio was between 6:1 to 9:1 which indicates an imbalance from the point of view of ruminant nutrition. Phosphorus, Mo and Se were high in plant samples in the three seasons studied.

Mineral levels of blood plasma, wool and hair were correlated with the mineral content of the plants. Plasma Mn, Cu, Zn, Mg and Ca were significantly ($p < 0.05$) correlated with their levels in plant.

It was concluded that mineral mixtures recommend for feeding sheep and goats as supplement should correct for deficiencies in Zn, Mn and Mo.

Fattening Potential of Barki Lambs in the NWCZ
(E. Shehata, A. Heider, & A.M. El-Serafy)

On farm experiments were conducted to investigate the fattening potential of Barki lambs from weaning, 16-18 kg, to market weight of 30-35 kg when fed different rations based on high concentrates. In experiment one (1987), 234 lambs at four Bedouin locations were used to evaluate three fattening rations: namely, 1) USFG consisting of 83% whole barley grains, 15% soybean and 2% minerals and vitamins mixture; 2) a natural Bedouin type consisting 85% whole wheat grain and 15% hay (from *Trifolium alexandrinum*); and, 3) AMTRS, consisting of 15% ammonia-treated rice straw and 85% of whole wheat grain. In experiment two (1988), 251 lambs used in five locations were fed the USFG ratio.

In experiment one, average daily gains (ADG) of lambs were 197 to 262 g: 143 to 177 and 141 to 150 g for the USFG, Bedouin and AMTRS rations, respectively. Corresponding figures for DM feed:gain rations, respectively were: 3.8, 8 and 7:1. Feed costs to produce one kg live weight gain were 2.21, 2.49 and 2.49, respectively.

The results of experiment two showed ADG values between 181-285 (average, 218 g). Feed - DM = gain ratio was 4.1 to 6.9 according to differences in management. Feed costs to produce 1 kg live body weight gain averaged L.E. (Egyptian Pounds) 3.04.

It was concluded that Barki lambs have a potential for growing more than 200 g/d if fattened on 100% concentrate-based ration and that the lamb fattening operating for export, is a profitable enterprise.

**Nutrients Requirement for Prevailing Level of Lamb-Production
Of NWCZ Sheep in Relation to Range Nutrients Availability
Synthesis of Data of Feed Resources and Animal Performance**
(A.M. El-Serafy, E. Shehata, E.S.E. Galal, & A.M.
& Aboul-Naga)

The data of the research trials conducted in NWCZ through the CALAR project were analyzed to integrate information available on prevailing levels of lamb production with that on nutrients requirements and their availability from natural range and ultimately describe the existing feeding system.

Metabolizable energy (ME) and digestible protein (DP) requirements for maintenance and production of grazing sheep were calculated from NRC tables while ME and DP contents of range were taken from previously determined values estimated at 2 kcal/g DM. An assumption was made that the maximum dry matter intake per ewe per year from natural range pasture will not exceed 303 kg DM/ewe/y (1.5 kg DM x 120d plus 0.5 kg DM/d x 245d), an amount of DM which will provide 606 Mcal and 25 kg DP/Y.

The results of estimated values of ME and DP requirements from different production levels against intakes were as follows:

Production Level Mcal/kg	Requirements/ewe/y		Intake as % of DP Requirement	
	MD	ME	ME	DP
Maintenance (M)	580	15.1	104	166
M + Production (P1)a.	845	24.0	71.7	104
M + Production (P2)b.	1030	31.2	58.8	80.1

- a. Prevailing lamb production level: 15 kg weaned lambs per ewe of 40 kg weight per year.
- b. Ewe producing 25 kg weaned lambs.

It was concluded that maximum intakes from grazing is not sufficient to meet the energy requirements of the prevailing production level and at least 30% of energy required for the prevailing lamb production level, is imported from outside the zone in the form of feed concentrates. This amount of energy deficit is equal to about 82.4 kg of barley (or its equivalent) per ewe per year. Extra inputs of high quality feed concentrates are required for the higher levels of lamb production.

Multiple Criterion Analysis of Lamb Production System
In the North Western Coastal Zone (NWCZ) of Egypt
(E.S.E. Galal, N.G. Seligman, H. Mansour, A. Aboul-Naga
A.M. El-Serafy, & H. Almahdy)

Since the 1970's the livestock production system in the NWCZ has been undergoing considerable changes. Numbers of sheep and goats have increased, producers are raising animals for export and the system has been moving towards intensification with more inputs of concentrated feed. The aim of this study was to assess the bioeconomical performance of the sheep production system in NWCZ under a side set of environmental and bioeconomical circumstances. Parameters that are the basics of the study, all as a function of animal production level were: feed resources for different animal classes, labor requirements, stock replacement, veterinary costs, buildings and equipment, water transport, taxes, and germplasm. Outputs of the system are meat from lambs and wool. The model utilized is target orientated in the sense that the output, i.e., independent variables are the annual total saleable lamb produced by the ewe ranges from 10 to 50 kg. This represents the degree of intensification. A second independent variable was the stocking rate, ranging from 0.25 to 2.25, ewe equivalent (EE)/ha.

The system was evaluated as composed of rangeland, with 70% of cultivated barley and a variable proportion of planted forage shrubs. An enterprise based on 4500 ha of land, according to the criteria analyzed were gross margin (GM) per farm, GM per man-day, GM per ewe, internal rate of return (IRR), added value in foreign currency AFC and cost of added value (CAV). The minimum acceptance/rejection thresholds that were chosen for each criteria to define the space were, LE (Egyptian Pounds) 10000 and LE 2000, LE 10 and LE 20, LE 20 and LE 50, respectively for the six criteria. Three scenarios were tested; Basic which is the standard system of production prevailing but at actual market non-subsidized prices, Bush where *Atriplex nummularia* is introduced and Export where lambs are exported. Under the given set of parameters the feasible production space in Basic was limited between low stocking rates of less than 1-3 EE/ha and an intermediate level of intensification, 20-30 kg/ewe/year forage about introductions decreased the feasible space according to most of the criteria but made the system more able to afford a somewhat higher stocking rate. The Export scenario performed very well according to all criteria and under the defined circumstances. Export scenario was very favorable to the grower as indicated by the high GM, and to the loaning organization (high), and to the national economy.

ARID LANDS SPECIES AS A SOURCE OF INDUSTRIAL MATERIALS

Introduction

Plants are a rich source of materials of economic value. Several species, in fact, have a status of cultivated crops. Other species, still wild, are primitively exploited. Additional species have a potential, which is being disclosed and is becoming relevant thanks to and in light of continuously evolving technologies, which made possible the identification of raw materials, their extraction, processing and utilization.

Many species of industrial potential have their origin in arid and semi-arid areas. Cultivation of these plants can contribute to the development of such areas and their adaptation to harsh climates may be of advantage. Wild species, however, need research and development to fit modern economies and this introduces a dimension of funding and time. Changing conditions change also priorities. The CALAR Program was originally designed during the era of a global energy crisis. It is therefore not surprising that the program included several species (*Euphorbia lathyris*, *Euphorbia tirucalli*, *Calotropis procera*, *Calotropis gigantea* and others) as potential hydrocarbon producing plants. *Acacia senegal*, *Acacia auriculiformis* and other *Acacia* spp. were proposed for cultivation as sources of gum Arabic, and *Astragalus adsedens* and other *Astragalus* spp. as sources of gum tragacanth. Several *Cassias*, widely used in medicine as sources of laxatives, but not cultivated with modern technologies, were included in the program, while a large collection of species of the genus *Oenothera* was intended to improve the production of gammalinolenic acid currently extracted from *Oenothera biennis*, the sole cultivated species of Evening primrose. Also included in the tentative program was the cultivation of underdeveloped legumes for

human consumption (Maraca and Teary bean) and of the Buffalo gourd (*Cucurbita Foetidissima*) as a source of an edible oil and of starch. Candelilla (*Euphorbia antisiphilitic*) was suggested for the extraction of a well known wax along with jojoba (*Simmondsia chinensis*), in its initial stages of agricultural development. Even when growth and development were satisfactory in the field, most of the species tested did not display yields high enough or exhibit qualitative advantages attractive enough to justify the continuation of the work beyond the preliminary trials, Evening primrose and Cassias excepted. Work was thus concentrated on guayule, the interest for, and the research on, which had persisted over the years in the search for an alternative source of natural rubber.

General Objectives

In a series of successive research phases the project concentrated upon:

1. Screening among a large number of candidates, plant species suitable to grow in the semi-arid areas of Egypt and Israel.
2. Evaluating the economic of these species as sources of raw materials, food or fodder.
3. Concentrating the research after the initial screening, on one or a few species of most promising traits in order to:
 - a. Develop suitable propagation methods
 - b. Investigate pertinent agrotechnical practices and study their effect on the level and quality of yields.
 - c. Develop techniques for the extraction and analysis of the raw material produced.
 - d. Select lines of superior traits as a basis for improved performances.
4. Promoting, if possible, the application of results in commercial operations or in pilot plants.

Egypt

General Objectives. The main object of the CALAR Program industrial plant activity was to select the suitable plants to be grown under the harsh conditions of desert environments and adapt them to tolerate stress conditions of heat and salinity. Egypt's industrial crops program consisted of a wide variety of species adaptable of arid lands agriculture with the objective of identifying one or more species for intensive research and development in the future. Arid and semi-arid plant species are particularly endowed with a diversified range of valuable substances such as oils, waxes, gums, rubber, pharmaceutical substances and fuel crops.

In Egypt, the many plant species that grow wild include: (Arabic gum); *Cacia senegal*; *calotropis procera*; *Cenna* (*Cassia acutifolia*); fig (*Ficus carica hortensis*).

Moreover, new plants such as jojoba and guayule were introduced through this program as they were considered the most suitable plants for arid and semi-arid agriculture.

Intensive work was carried out to spread these plants, cultivate them on different sites, to acknowledge the easiest and best methods for propagation, collect data on plant behavior and evaluate the economic value of selected plants.

Achievements. The major achievements could be summarized as follows:

1. Planting sites: several experiments were carried out at the following sites:
 - a. Fouka (near Marsa Matrouh, Western Desert) cancelled;
 - b. El-Bahria Oasis (350 kms from Cairo, Western Desert);
 - c. Southern Tahrir I and II (85 kms from Cairo);
 - d. Al-Hussein Assembly (46 kms from Cairo);

- e. Experimental farm of the Faculty of Agriculture, Al-Azhar University, Madinet Nasr, Cairo;
 - f. El-Kassassin (near Ismailia).
2. Plant materials: the Industrial Raw Material Program carried out trials on the following species:
- a. Jojoba (*Simmondsia chinensis*), oil crop;
 - b. Guayule (*Parthenium argentatum*), rubber crop;
 - c. Buffalo gourd (*Cucurbita coquimbana*), oil and starch production;
 - d. Senna (*Cassia acutifolia*), pharmaceutical crop;
 - e. Grindilia (*Grindilia camporum*), source of resins;
 - f. Candelilla (*Euphorbia antisyriaca*), wax production;
 - g. Fig (*Ficus carica*), varieties for drying;
 - h. Asparagus (*Asparagus officinalis* var. *altilis*), intercrop.

Jojoba. Plants of jojoba are grown successfully at El-Bahria Oasis, southern Tahrir

I. In addition to one feddan planted March, 1987 at Al-Husseini Assembly, 45 kms from Cairo, twelve feddans were planted July, 1987 at southern Tahrir and another five feddans were planted in El-Kassassin site in April, 1988, under drip irrigation methods. In both sites, plants were grown directly from seeds. El-Kassassin was planted to establish a wide genetic base for observation and selection of individuals of proper qualifications to be multiplied through vegetative propagation to ensure uniform, high yield and to control sex ratio, which are essential for the development of proper jojoba plantations of economical value. Also, an area of about one-fourth feddan was established in the experimental farm of the Faculty of Agriculture, Al-Azhar University, Cairo.

Guayule. Several strains and genotypes of guayule were collected and grown at the experimental farm of the Faculty of Agriculture, Al-Azhar University. Experiments on water requirements and other factors affecting their growth and chemical components were carried out.

Buffalo gourd. This crop was grown successfully at the experimental farm of the Faculty of Agriculture, Al-Azhar University and at southern Tahrir I under drip irrigation. At Fouka, plants showed a rather modest growth due to the lack of rain. In all cases, very few fruits were produced, roots were not systematically distributed and vines were susceptible to powdery mildew. Trials concerning this plant were frozen due to impurity of the seeds, and most of the trials need further investigation.

Senna. El-Synamiky is one of the most important medicinal plants of the family leguminosae. Leaves and bod coast of Senna plants contain the most reliable laxatives naturally occurring in plants. Experiments carried out on Senna were reported in the 1987 annual report, after which, experiments on Senna came to an end.

Grindilia (Grindilia comporum). This is a member of the family Compositeae, and is known as gum weed. This plant was brought by Dr. Mahmoud Barkouky from Arizona and experiments are still in progress.

Candelilla (Euphorbia antistylitics). Candelilla is a member of the family Euphorbiaceae. The plant produces wax used as a substitute for bee's wax and carnouba. These plants were introduced by Dr. M. Wally from University of Arizona to Egypt. The experiments on this plant are still in progress.

Fig. Fig trees have proven to be successful under desert conditions. The tree is unique among deciduous fruit species because most of its varieties produce two crops of

fruits annually. Fruits are consumed fresh after sun or artificial drying. Three varieties of common fig were selected. In February, 1987, seedlings of these varieties of figs were planted in the nursery of the Faculty of Agriculture, Al-Azhar University, as well as El-Baharia Oasis, El-Kasr "Marsa Mathrouh" and El-Hussein Assembly. Experimentation on water requirements, growth, yield, and quality of fresh and dried fruits will be carried out.

Work Team

The industrial plant activity started in 1987 with a team of five members:

Principal Investigator:	Dr. M.H. El-Barkouky
Junior Investigator:	Dr. Ebd El-Reheem Dr. Fouad Ibrahim Dr. Fathallah Kenawy (deceased)
Technical Assistance:	Mahmoud El-Serafy Nassef Salah El-Din

Effect of Different Soil Types on Jojoba Root Distribution and Shoot Growth

Three types of soils: pure sand; loamy; and clay soil, were selected to study the effect of each type of Jojoba root and shoot growth.

After twelve (12) months of growth, the following results were obtained:

Loam soil produced the longest roots and shoots and higher shoot weight;

Clay soils produced the highest number of heavier shoots; Sandy soil produced the shortest roots and shoots, the least number of shoots and the lightest roots and shoots.

Studies on Jojoba Propagation by Cuttings and the Effects of Sex on Rooting Percentage

Cuttings were taken from clones of Jojoba plants (four years old), with both male and female plants used. Terminal, medium and basal nodes long cuttings were prepared from each plant with 100 ppm 1BA was used for five seconds and the rooting media was perlite and vermiculite (1:1). The following results were obtained:

1. Male cuttings of Clone A produced more roots than the female cuttings, while opposite results occurred with Clone B cuttings.
2. Cuttings of Clone A (male type) produced more roots than the female, Clone B.
3. Terminal (tip cuttings) gave higher root percentages followed by sub-terminal (middle) cuttings; lower percentages were observed with basal cuttings.

Studies on the Effect of Cuttings Position on Jojoba Propagation by of Stem Cuttings

This work has been carried out to study the influence of cutting type on the propagation of Jojoba plants.

Results showed that rooting percentage decreased according to the cutting position which may be due to age and activity of the cutting and the ability to produce root primordia. In the fully rooted cuttings, root number and root fresh weight showed the same trend; terminal and sub-terminal cuttings had a larger root system and better root quality than did the basal cuttings. From the CALAR Program studies, it can be recommended to use terminal and subterminal cuttings with a green color.

Effect of Cold Storage Pretreatment of Jojoba Cuttings on Rooting Percentage

The pre and post-treatment with 100 p.p.m. IBA for five seconds has increased the average of root number. Pre-treatment for seven (7) days storage produced the highest results of root number. Concerning cold storage temperature, the degree of 34°F was more stimulating temperature than that of 42°F.

The fluctuation in the results obtained was quite clear, there seems to be no direct explanation to the different responses, especially those cuttings which show very little or even no growth sign, except that the observed phenomenon may be due to the unbalanced levels of hormones in the cutting tissue, since the increases of the inhibitors or the decreases of the stimulating auxins could cause inhibition or reduction to the root or shoot growth.

Studies on Physical and Chemical Characteristics of Some Guayule Cultivars Grown in Egypt

Seeds of N-5665, N-576 and 12229 Guayule cultivars were imported from Arizona and grown in Cairo, Egypt. The following results were obtained:

Rubber Content of Roots

One-year-old plants of N-565 cultivars had the highest percentage of rubber in their roots. Two-year-old plant roots of N-576 cultivars contained the highest rubber percentage while roots of 12229 cultivars contained the lowest.

Rubber Content of Stems

Obvious differences among the tested cultivars either for one or two years old stems were observed specimens of N-576 cultivars which contained the highest rubber percentage

and 1229 cultivar which contained the lowest either in the first or second year. It was obvious that accumulation of rubber in Guayule stems increased in the two-year-old plant.

Rubber Content of Leaves

Rubber percentage in leaves is always less than 2% at one or two-years-old. In one-year-old plants, leaves of cv 576 cultivar contained the highest percentage of rubber while leaves of N-565 contained the lowest, while in two-year-old plants, leaves of N-565 cultivar had the highest percentage and 12229 had the lowest percentage. The differences observed among cultivars were statistically significant.

Effect of Different Germinating Media on Seed Germination of Some Guayle Cultivars

Seeds of four cultivars of Guayule N-576, 593, 11591 and 11605 were sown in different media composed of peat sand, and silt in different percentages. Germination percentage and germination rate index were obtained. The following results were obtained:

Highest germination percentage took place when seeds were sown in peat moss followed by 1/2 peat moss and 1/2 sand, 1/2 peat moss and 1/2 silt and 1/3 peat moss and 1/3 sand and 1/3 silt, respectively.

Peat moss medium has enhanced germination significantly as all tested cultivars emerged earlier in peat moss than in any other medium.

Physical and Physiological Studies on Saltani Figs

Saltani fig variety is considered the most commercial variety cultivated in Egypt.

This investigation was carried out to provide further information on the physical and chemical characteristics of fruits during developmental stages.

Results showed that Saltani fig trees produce two crops. The first crop is born on wood of the previous seasons's growth from buds differentiated in the distal leaf axial during the later part of the growing season. The second, or main crop, is produced in the axils of the leaves of the current seasons shoots. Fruits of the second crop are somewhat smaller but considerably greater in number and contained relatively higher percentage of moisture, lower percentage of TSS, a higher percentage of acidity and higher percentages of reducing sugars compared with fruits of the first crop.

Effect of Planting Dates and Spacing on Growth and Seed Yield in Cassia Acutifolia Delil

Alexandrian senna (*Cassia acutifolia delil*) is one of the most important medicinal plants of the family leguminosae. The objective of this investigation was to study the effect of different sowing dates and spacings on growth, seed yield and effective material.

Results showed that the month of April was the most suitable time to produce the highest seedling emergence percentage, the highest anthraquinone formation in Rad Coats and the heaviest seed weight per plant. It was also found that, seed weight per plant increased by increasing spacings between plants.

Israel

Studies on Guayule in the Northern Negev of Israel

David Mills, Aliza Benzioni, & Meir Forti

Research under the CALAR Program on guayule (*Parthenium argentatum*), a potential source of natural rubber was conducted in Beer-Sheva, Israel from 1985 to 1989. When studying rubber distribution in the various parts of the plant, it was found that the highest rubber concentration was in the branches (0.8%). Roots had intermediate concentration of rubber (5%). Branches contained more than 80% of the plant total rubber.

In a study conducted to learn means to store rubber, it was found that rubber deteriorated under all conditions examined. Rubber degradation was minimal under cold temperature storage. It was preferable to store small fractions of branches than ground material.

Two-year-old guayule plants from 13 USDA lines were evaluated for various characteristics such as: height, spread, canopy weight, branch and leaf weight, rubber and resin concentration and rubber and resin yield per plant. Significant differences were found among the lines for all the characteristics tested. Lines 11600 and 11604 excelled in rubber and biomass production. These lines were taller than others and their leaf/branch ratio was smaller. The correlation between rubber yield per plant and rubber concentration was poor, rubber yield being related mainly to biomass production and to a lesser degree to the height and spread of the plants.

Guayule plants of three different USDA lines (11604, 11591, and 12229) were subjected to three irrigation regimes (300, 450, 650 mm/year), and were clipped at various stages over a period of several years. The survival, regrowth rates, biomass production, and

rubber and resin accumulation of the plants after cutting was then examined. It was found that there was a good survival rate (92-100%), if the plants were clipped in February (end of dormant period), or October (just before the dormant period). When plants were cut in mid-summer (July), regrowth was smaller and presumably dependent upon plant water status and age. No large differences were evident between the different lines. The best plant development, as determined by the rate of height increase, occurred in plants clipped in February. It was found that total biomass production and total rubber yield (before and after clipping), or clipped plants was lower than that of unclipped plants. This reduction in rubber yield was highest in plants irrigated with the medium and high water treatments.

Irrigation regimes of 250, 450 and 650 mm/year were applied to guayule in a manner designed to alternate good water status and water stress. The duration and severity of stress were maximal in the treatment receiving the lowest water dose and minimal in the wet regime. Relative water content and transpiration rates decreased only when the available soil were depleted to about 40%. Very low values (<30%) were recorded for the relative water content. Water-stressed plants generally recovered as soon as irrigation resumes. Growth and biomass accumulation as well as yield of rubber and resins were found to be directly related to the irrigating rates. About 16-18 t/ha of branch DW and 1.5-1.7 t/ha rubber were produced by plants receiving the best irrigation treatment after four years. Low irrigation resulted in much lower yields. Coupled with the use of drip irrigation, the regimes described resulted in a relatively high water use efficiency of about 50 g rubber/m³. The incorporation of IC-acetate into rubber in detach thin stem sections was maximum (25%), in the winter (October through March), and minimum (3-4%) in summer for plants having

high RWC of 80-100%. Water stress caused an increased in 14C- incorporation into rubber from 3-4% to about 23% when plant RWC dropped to 40% or less.

Buffalo Gourd
Samuel Mendlinger

The object of the program in Israel was to determine if this plant would have the proper agricultural and economic criteria needed for successfully extracting starts from its roots. We grew plants under extremely dense planting (30 plants per square meter) with sowing in April and harvest in November. We found that we could get yields of up to 6,000 kilograms per hectare from semi-selected material, due to the 12,000 kilograms needed for its economic minimum yield. However, industry did not show a need for this crop and all further work ceased after two seasons.

Evening Primrose
(Samuel Mendlinger, & A.J. Arouson)

The primary objective of this program was to determine the feasibility of the Evening Primrose for growing in Israel. The oil from its seeds have an economic potential for the health food industry. Our aim was two-fold: agromanagement and selection.

In respect to selection, high yielding, nonshattering lines that were found to be three times that of anything reported to date. Agromanagement studies found ideal planting dates, densities, and water requirements.

COOPERATIVE ACHIEVEMENTS

The Cooperative Arid Lands Agriculture Research (CALAR) Program has been especially significant in that it provided for the continuity and expansion of joint research efforts among scientists from Egypt, Israel, and the United States. Working together from 1982 until 1990, scientists from the participating nations were involved in three major fields of applied research: irrigation with saline water; the production of fodder shrubs and the genetic improvement of small animals in arid lands; and the introduction of new arid land industrial crops. Funding for this eight-year trilateral program was provided by the Bureau for Asia and Near East (formerly the Near East Bureau), of the U.S. Agency for International Development (Contract Number NEB-0170-A-00-2047-00).

In providing a foundation for ongoing scientific cooperation, the CALAR Program has demonstrated the effective manner in which Egyptian and Israeli scientists can work together with their American colleagues to achieve major goals. And the program has made a number of important technical advances.

For example, both Egypt and Israel now show successes in saline water irrigation in growing melons, tomatoes, and vegetable crops; progress has been made in fodder production and in animal production, and the value of industrial crops is apparent in both nations.

Also successful has been the program's management philosophy, which continually placed equal emphasis upon science and upon cooperation. CALAR management sought to involve many organizations within each country in the scientific and technological aspects of the program; and established, maintained, enhanced and institutionalized viable

relationships among a team of Egyptian, Israeli and U.S. participants in the program. The science itself has been the context of cooperation, and through this cooperative effort, CALAR's tangible results are now benefitting the people of Egypt and Israel.

Cooperation was the mode for conducting science in the CALAR Program. Through such cooperation, in fact, scientific and technological advances and the effective application of CALAR research have been achieved.

A strong scientific accord in cooperative activities is exemplified by a number of CALAR achievements. Some specific examples in cooperation are:

- Since 1984, five large-scale joint scientific meetings were held. One of the largest of these meetings, held in August 1988 in San Diego, involved 47 Egyptian, Israeli and American scientists who presented results of extensive scientific experiments and the application of program results.
- Collaborative relationships now exist between Egyptian and Israeli scientists in several significant areas of agricultural research.
- Egyptian and Israeli participants exchanged working visits to one another's laboratories and research sites on a number of occasions.
- Cooperation among scientists from four independent Israeli institutions and eight Egyptian institutions has been fostered by CALAR relationships.
- An unprecedented level of cooperation now exists between Bedouin leaders and herders in the Western Desert and Egyptian Ministry of Agriculture scientists. This has occurred because, to carry out CALAR research with goat and fodder improvement, program scientists had the foresight to organize direct on-farm trials with the Bedouin as full participants.
- Coordination between a team of researchers in related but traditionally different fields, i.e., plant breeding and soil science, was achieved to a high degree. The results is that working relationships have been strengthened so as to form the basis for on-going association that will provide a solid foundation for the future.
- Administrative coordination among United States, Israeli and Egyptian officials has been conducted with high efficiency. Here, too, collaborative relationships have been built that will form the basis for new proposed cooperative programs.

Research for the CALAR Program was carried out in Egypt and Israel and significant cooperative scientific achievements are:

- Scientists in the soil salinity phase exchanged research results useful to both countries, even though salinity conditions have been found to be somewhat site-specific, as was expected by CALAR participants.
- In Egypt, the native Edkawy table tomato cultivar was found to be more salt tolerant than a range of introduced cultivars. The quality of the Edkawy cultivar was genetically improved and a tolerance to verticillium, fusarium and nematodes was introduced to produce a superb variety for the production of out-of-season tomatoes in the El-Bousseily region using saline drainage water and saline soils.
- In Israel, CALAR started a complete new industry, that of processing tomatoes grown in saline water irrigation. This industry in 1989 produced a total of 16,000 tons of saline water tomatoes on 2,000 dunams.
- New salt tolerant, revolutionary hybrid tomatoes were tested. These hybrids will more than double the salt tolerance of existing tomato varieties.
- The CALAR Program hybrid Damascus-crossed Barki goats have been distributed to a large number of Egypt's Western Desert breeders. These goats have a much higher capacity for meat and milk production than the original Barki goat.
- An exciting potential breakthrough in salt-tolerant forage shrubs, using Medicago arborea, was made by Egyptian scientists with plant material obtained from Syria. Egyptian program participants made seeds of this species available to Israeli participants who otherwise probably could not have obtained them and were apparently unaware of the value of the species.
- Field surveys (system analysis) of small ruminant herding in Egypt were greatly assisted by methodologies and techniques developed by Israeli CALAR participants.
- The program has demonstrated that salinity markedly improves the quality of tomato and melon fruits. This had led in both countries to successful trials of table tomato production inside walk-through plastic tunnels for maximum utilization of this unsuspected and unplanned added benefit.

From a technical point of view, the CALAR Program is considered to be one of the major agricultural R&D programs conducted at the national level, both in Egypt and in

Israel. Throughout its span, the program received high level support and commitment from the Egyptian and Israeli governments because it was in concert with the national goals and objectives of both nations. Due to this commitment and support, the CALAR Program prospered during times of high regional tension.

CALAR and Maryut Programs

Large scale meetings/workshops held in the eight year period include:

Steering Committee Meetings

STEERING COMMITTEE MEETING **March 17, 1982** **Cairo, Egypt**

Number of Participants:

American:	5
Egyptian:	14
Israeli:	9

Egyptian Institutions/Universities involved:

Ministry of Agriculture and Land Reclamation, Cairo
Al-Azhar University
Ain Shams University, Cairo
Agricultural Research Center, Giza
Desert Institute, Cairo
Animal Production Research Institute

Israeli Institutions/Universities involved:

Agriculture Research Organization, Volcani Center
Faculty of Agriculture, Hebrew University
Applied Research Institute
Ben-Gurion University

STEERING COMMITTEE MEETING **April 16-17, 1983** **San Diego, CA.**

Number of Participants:

American:	9
Egyptian:	4
Israeli:	3

Egyptian Institutions/Universities involved:

Foreign Agricultural Relations, Cairo
Ministry of Agriculture and Land Reclamation, Cairo
Ain Shams University

Israeli Institutions/Universities involved:

Applied Research Institute
Ministry of Agriculture
Ben-Gurion University

STEERING COMMITTEE MEETING

January 10-13, 1984
Alexandria, Egypt

Number of Participants:

American:	6
Egyptian:	7
Israeli:	13

Egyptian Institutions/Universities involved:

Ministry of Agriculture and Land Reclamation, Cairo
USAID
Ain Shams University

Israeli Institutions/Universities involved:

Ministry of Agriculture, Tel Aviv
Ben-Gurion University of the Negev

STEERING COMMITTEE MEETING

March 17-18, 1985
Beer-Sheva, Egypt

Number of Participants:

American:	3
Egyptian:	9
Israeli:	8

Egyptian Institutions/Universities involved:

Ministry of Agriculture and Land Reclamation, Cairo
USAID

Israeli Institutions/Universities involved:

U.S. Representatives of Israeli Embassy, Israel
Ben-Gurion University of the Negev

STEERING COMMITTEE MEETING

May 2-3, 1986
Washington, D.C.

Number of Participants:

American:	2
Egyptian:	2
Israeli:	2
Others:	3

Other Organizations Represented:

SDSU Foundation
Hansen Institute for World Peace
AID Washington

STEERING COMMITTEE MEETING

October 5-7, 1987
Malaga, Spain

Number of Participants:

American:	2
Egyptian:	2
Israeli:	2
Others:	3

Other Organizations Represented:

SDSU Foundation
Ministry of Agriculture
Ben-Gurion University

STEERING COMMITTEE MEETING

October 19-21, 1987
San Diego, CA.

Number of Participants:

American:	2
Egyptian:	2
Israeli:	2
Others:	7

Other Organizations Represented:

SDSU Foundation
Hansen Institute for World Peace
Ben-Gurion University of the Negev

STEERING COMMITTEE MEETING

June 3, 1988
Florence, Italy

Number of Participants:

American:	2
Egyptian:	2
Israeli:	2
Others:	6

Other Organizations Represented:

SDSU Foundation
Ministry of Agriculture, Egypt
Ben-Gurion University of the Negev

STEERING COMMITTEE MEETING

February 14-15, 1989
London, UK

Number of Participants:

American:	2
Egyptian:	2
Israeli:	2
Others:	5

Other Organizations Represented:

SDSU Foundation
Ben-Gurion University
Ministry of Agriculture

STEERING COMMITTEE MEETING

February 7-8, 1990
Washington, D.C.

Number of Participants:

American:	2
Egyptian:	2
Israeli:	2
Others:	20

Other Organizations Represented:

SDSU Foundation
Ben-Gurion University
Ministry of Agriculture
SDSU University
Embassy of Egypt, Washington, D.C.
Embassy of Israel, Washington, D.C.
AID Representatives
State Department, Egypt Office
State Department, Office of Cooperative Science and Technology Programs
State Department, Office of Israeli Affairs

CALAR SCIENTIFIC WORKSHOPS

CALAR SCIENTIFIC WORKSHOP I

June 3-6, 1984

Kona Kai Club, San Diego, CA.

Number of Participants:

American:	11
Egyptian:	10
Israeli:	13

Egyptian Institutions/Universities involved:

University of Mansoura - Faculty of Agriculture
Ministry of Agriculture - Cairo
Al-Azhar University - Shubra El-khima
Ain Shams University - Shubra El-khima
Nubaria Research Station - Alexandria, Egypt
Salinity Laboratory - Alexandria, Egypt

Israeli Institutions/Universities involved:

Volcani Institute - Israel
Applied Research Institute - Div. of Desert Agriculture
Ministry of Agriculture - Tel Aviv
Ben Gurion University - Negev Ins. for Arid Zone Research
The Hebrew University of Jerusalem - Israel

CALAR SCIENTIFIC WORKSHOP II

January 15-23, 1986

Alexandria, Egypt

Number of Participants:

American:	9
Egyptian:	52
Israeli:	24

Egyptian Institutions/Universities involved:

Ministry of Agriculture - Agriculture Research Center
Ain Shams University - Cairo
Al-Azhar University
Alexandria University
Assyout University
Mansoura University
Agriculture Research Center - Cairo

Israeli Institutions/Universities involved:

Ben Gurion University
Hebrew University
Agriculture Research Organization-Volcani Center
Ramat Hegev Regional Council
Ministry of Agriculture

CALAR METHODOLOGY WORKSHOP

June 27-29, 1987
Hurghada, Egypt

Number of Participants:

American:	6
Egyptian:	19
Israeli:	10

Egyptian Institutions/Universities involved:

Ministry of Agriculture -Cairo
Ain Shams University - Cairo
Al-Azhar University - Cairo
Field Crops Research Institute-Agriculture Research Ctr.
Vegetable Research Institute & Agriculture Research Ctr.

Israeli Institutions/Universities involved:

Ramat Negev Salinity Research
The Hebrew University of Jerusalem
Ben Gurion University of the Negev, Israel
Hebrew University, Faculty of Agriculture, Rehovot

CALAR SCIENTIFIC WORKSHOP III

August 22-27, 1988
San Diego, CA.

Number of Participants

American:	10
Egyptian:	15
Israeli:	15

Egyptian Institutions/Universities involved:

Ain Shams University, Cairo
Ministry of Agriculture, Cairo
Al Azhar University, Cairo
Field Crops Research Institute-Agricultural Research Ctr.
Vegetable Research Dept. of Horticulture Institute
Alexandria University

Israeli Institutions/Universities involved:

Ben Gurion University of the Negev, Israel
Hebrew University, Rehovot, Israel
Agriculture Research Org.-Volcani Center, Israel
Ramat Negev Agriculture Experiment Station, Israel

CALAR SCIENTIFIC WORKSHOP IV

August 7-13, 1989
San Diego, CA.

Number of Participants:

American:	9
Egyptian:	30
Israeli:	21

Egyptian Institutions/Universities involved:

Animal Production Research
national Research Center
Ain-Shams University
Field Crops Research Institute/ARC
Vegetable Research Department
University of Alexandria
Al-Azhar University
Agriculture Center for Research, Soil Salinity Lab, Alexandria
Nubaria Research Station, Agri. Research Section

Israeli Institutions/Universities involved:

Hebrew University of Jerusalem
Agricultural Research Organization, Bet Dagan
The Volcani Center
Ben-Gurion University of the Negev
Hebrew University, Rehovot
Ramat Haganev Agriculture Experimental Station
Ministry of Agriculture
Local Council Ramat Hanegan, Revivim

Mechanisms for Cooperation

A number of mechanisms for cooperation were established to help assure ongoing and cooperative exchanges between Egyptian, Israeli and U.S. participants at all levels. These were: national Steering Committee Meetings, one-to-one visitations between scientists, specialized meetings among program investigators, annual scientific workshops, exchanges of technicians and trainees -- and students involved in the program -- as well as the exchange of important new methods, techniques, products and crops and cooperation in joint publications highlighting program achievements.

Specific mechanisms for cooperation were:

- a. **Annual workshops.** The major mechanisms for cooperation, the Annual Workshops were established by the CALAR Program and served as the principal means for scientific interaction between Egyptian, Israeli, and U.S. participants. In these Annual Workshops, scientists from the three nations presented research results and formulated plans for on-going research, drawing upon their colleagues for input. The Annual Workshops were conducted in Egypt, Israel, and the United States. In each occasion, site visits were a part of the Annual Workshop. These Workshops served as a foundation for building strong interpersonal relationships between the participants. The Annual Workshops also served as a major tool for the participation of U.S. scientists who provided experience and expertise in the formulation of program research plans and presented state-of-the-art knowledge in their specific areas of interest.
- b. **One-to-one visitations between scientists.** This mechanism for cooperation provided valuable experience in the exchange of program plans, research and ideas, as well as for informal discussion of both problems and progress in specific research topics.
- c. **Technology exchange.** The program was designed to adapt and develop new technologies and varieties which will be tested at research sites in Egypt and Israel. Successful varieties and technologies were exchanged between the participants on a regular and on-going basis.
- d. **Steering Committee Meetings.** Cooperation at the management level was a vital aspect for the continuing success of the program. Steering Committee Meetings provided the mechanisms not only for crucial scientific and technical planning

and direction of the program, but also fostered and expanded important personal interchange between those responsible for its achievements.

- e. **The Newsletter and Other Publications.** These regular publications provided the means for expanding the audience for program research and results. In addition, they served as an informal record of the program for its participants and as an informational tool for those individuals who are interested in regional cooperation.

CALAR PROGRAM MANAGEMENT

Program funding for the Cooperative Arid Lands Agriculture Research (CALAR) Program was provided by the Bureau for Asia and Near East, U.S. Agency for the International Development (contract number NEB 0170-A-00-2047-00). A factor in the success of the CALAR Program has been the cooperation of USAID representatives who have been involved in its operation since 1982.

The United States

The prime contractor has been the San Diego State University Foundation which is located in San Diego, California. The SDSU Foundation has been responsible for developing, in cooperation with its Egyptian and Israeli partners, the detailed program; contracting with USAID for the overall management of the program; contracting with the appropriate parties for local management support for the program; and with Egyptian and Israeli entities for the drafting and execution of the research, development, demonstration and training segments of the program.

According to reviewers who have made regular detailed studies of the CALAR Program, the SDSU Foundation's dedication to service and to excellence are among the factors that are significant in the visible success of the CALAR Program.

Arab Republic of Egypt

In Egypt, the Ministry of Agriculture and Land Reclamation has been the main subcontractor. The Ministry has been responsible for establishing, coordinating and participating in, all the initial research, development and demonstration activities in Egypt; devising the technical program relating to the experimental and demonstration sites; data

collection; and drawing and executing the training and educational segments of the program. The strong support and commitment of Egypt's Ministry of Agriculture and Land Reclamation has played a critical role in the success of the CALAR Program.

State of Israel

In Israel, the Ben-Gurion University of the Negev was the main subcontractor. The University has been responsible for establishing, coordinating, and participating in research, development and demonstration activities in Israel; and devising the technical plan relating to the research and development segment of the program, as well as for the actual research, demonstration and application aspects of the CALAR Program. The Ministry of Agriculture of the State of Israel has also played an important role in assuring the success of the CALAR Program.

In both Egypt and Israel, a number of institutions and universities were involved in the CALAR Program. In the United States, scientists from a range of universities and institutions participated in planning aspects, conducting internal evaluations, contributing to the program's workshops, serving as consultants, as well as active participants in CALAR research.

In total, the CALAR Program involved more than 70 scientists from Egypt and Israel, as well as some 15 scientists from the United States.

Management and Coordination

The Steering Committee. The Cooperative Arid Lands Agriculture Research (CALAR) Program Steering Committee was made up of six members, two members from each of the participating countries: Egypt, Israel and the United States. In a management format that proved highly effective, the Steering Committee was entrusted with the overall

responsibility for the entire program, while the San Diego State University Foundation, as the prime contractor, was responsible for the overall management, administration and coordination of the CALAR Program.

The Steering Committee met at least once in each of the eight years of the CALAR Program to review and examine progress, provide policy direction and assure that all technical and cooperative aspects were at optimum levels. Program Coordinators who were not members of the Steering Committee attended the meetings as non-voting members. Because of the strong commitment to the success of the CALAR Program by the SDSU Foundation, key management staff members who were involved in the operation of the program were often invited to contribute to the Steering Committee meetings.

The voting members of the Steering Committee were:

Egypt

Mr. Mohamed Dessouki
First Undersecretary of State
Foreign Agricultural Relations
Ministry of Agriculture and Land Reclamation

Dr. Adel S. El-Beltagy
Undersecretary of State
Land Reclamation and Foreign Agricultural Relations
Ministry of Agriculture and Land Reclamation

Israel

Mr. Joel Schechter, Former Director
Negev Institute for Arid Zone Research
Ben-Gurion University of the Negev

Dr. Samuel Pohoryles, Director General
Rural Planning and Development Authority
Ministry of Agriculture

United States

Mr. Harry R. Albers, Executive Director
San Diego State University Foundation

Dr. Albert Johnson, Vice President for Academic Affairs
San Diego State University

Ex-Officio Members

Dr. Dov Pasternak
Israeli Program Coordinator and Principal Investigator

Dr. Mohamed El-Assal
U.S. Program Coordinator

(Dr. Adel El-Beltagy, a voting member of the Steering Committee, was the Egyptian Program Coordinator and Principal Investigator)

In addition to the formal organization of the program, CALAR also utilized a Technical Consultant Panel. The Technical Consultant Panel was selected jointly by the three Program Coordinators in consultation with the Steering Committee and provided expertise for technical assistance and advice when required. Evaluators were selected by the U.S. Program Coordinator in consultation with the Egyptian and Israeli Program Coordinators and with the advice of the Steering Committee. Evaluators provided informal reviews of the program's progress, visiting sites and investigators to evaluate the progress of the CALAR Program from a technical perspective.

Working as a team, representatives from Egypt, Israel and the United States provided the commitment for strong leadership for the CALAR Program. This cooperative effort has led to an on-going basis for continuing efforts among the three countries.

"Egyptian-Israeli cooperation is a mountain peak in a sea of sand. . ."

Samuel W. Lewis
The New York Times
March 21, 1986

CONCLUSION

The Cooperative Arid Lands Agriculture Research (CALAR) Program was based upon two equal factors--science and cooperation. The science itself was the basis and the context for cooperation; while cooperation was the mode for conducting science. The program has effectively demonstrated the effective manner in which Egyptian and Israeli scientists can work together with their American counterparts to achieve major goals and the results of these achievements are now benefitting farmers and herders in the arid regions of both Middle Eastern countries.

Through the eight-year CALAR Program, complementary research in Egypt and Israel addressed a number of issues of critical importance to the development of the vast regions of arid lands that are a large part of both nations. CALAR concentrated upon three important areas of arid lands agriculture:

- utilization of saline water for irrigation;
- production of fodder and small ruminants;
- industrial crops for arid lands.

A majority of the efforts were of an applied nature and were directed toward practical solutions for use by the farmers and herders in the region. And the program made a number of important technical advances. In both Egypt and Israel, melons, tomatoes and vegetable crops are now being grown with saline water irrigation; progress has been made in fodder

production and in animal production; and the importance of industrial crops has been explored.

From a cooperative aspect, Egyptian, Israeli and American participants worked as a team to coordinate the technical aspects of the CALAR Program. This coordination was accomplished by regular joint meetings, country-to-country travel, the exchange of ideas and plant materials and the sharing of results.

Oversight for the CALAR Program was provided through a Steering Committee composed of members from the three participating nations who assured the success of the technical program. Other mechanisms for cooperation initiated by the CALAR Program included Annual Workshops that provided large scale interaction between program participants; one-to-one visitations between scientists; technology exchanges between participants who shared results and plant varieties; and regularly published newsletters and other publications that outlines program research and results.

Other important factors in the success of the CALAR Program has been the commitment of the prime contractor, the San Diego State University Foundation, as well as the commitment and support of the Ministry of Agriculture and Land Reclamation of Egypt and Israel's Ben-Gurion University of the Negev. Both organizations were the main subcontractors for the program. Also important has been the support of the Ministry of Agriculture of the State of Israel. Due to these commitments and support the program has prospered in times of high regional tension.

From a technical point of view, the CALAR Program is considered to be one of the major agricultural research and development programs ever conducted at a national level in

both Egypt and Israel, because it was in concert with the national development goals of both nations.

From the cooperative aspect, the CALAR Program has brought together participants from nations with a history of adversity and has formed a strong technical bond among those participants that is today, the basis for continuing cooperation.

The United States Agency for International Development has been a true partner with the CALAR Program participants in expanding and furthering regional cooperation efforts among scientists from the Arab Republic of Egypt, the State of Israel and the United States of America. The results of the CALAR Program are a unique symbol of the merits of regional cooperation in a region where such results have a high visible impact.