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9. ABSTRACT
This document reviews the efforts of Oregon State University in assisting Jordan with the necessary research and extension activities to double wheat production by 1980. Reports are included on the wheat project research, irrigation, soil fertility, chemical herbicide application, economic evaluation of dryland wheat technologies, availability of goods and services, and constraints on the adoption of improved wheat production practices. Practices such as chemical weed control and the use of improved varieties are being well received by Jordanian farmers. Practices such as improved tillage and use of chemical fertilizers need continuing adaptive research to accelerate the rate of acceptance. Alternate wheat fallow rotations and use of the grain drill are still questioned by most farmers. The wheat project should continue to strengthen its adaptive research program in the field of soil fertility, tillage methods, irrigation techniques, and seedbed preparation. Various alternative crop rotations at different levels of average annual rainfall should also be investigated. All of these adaptive research programs need to be designed so that more definitive economic information can be obtained from them. More technical training for the district extension agents, local managers of the cooperative societies, and employees of the agribusiness firms is needed. The demonstrational program has been very successful and has shown that most of the new technologies are adapted to Jordanian conditions.

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JORDAN WHEAT RESEARCH AND PRODUCTION

Final Report
of
Contract AID/sa-C-1024
between
Agency for International Development
and
Oregon State University

NORMAN GOETZE

Campus Coordinator

March 31, 1976

Jordan Wheat Research and Production
Contract No. AID/sa-C-1024
Final Report
March 31, 1976

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CONTRACT PERIOD

Services performed under this contract began on August 27, 1973 and were completed by March 31, 1976, the final termination date of the contract as amended.

METHODS

The contractor, Oregon State University, assisted the Jordanian Ministry of Agriculture in further developing an improved system of wheat technology and in its dissemination throughout the agricultural sector of Jordan. This assistance was provided through the services of Eugene P. Winters, Senior Advisor, whose counterpart in the Jordanian Ministry of Agriculture was Amin Abushaer, Director of the Wheat Project and Acting Director of Research and Extension within the Jordanian Ministry of Agriculture. The main thrust of the Senior Advisor's activities was to encourage institutional leadership within the Ministry of Agriculture in terms of defining its objectives and in developing programs of action for both Research and Extension disciplines.

Counterparts working on the Jordan Wheat Project were professionally strong and were very well motivated. There was, however, a great need for better program coordination and cooperation among the various research and extension projects that were concerned with wheat. The Senior Advisor successfully stimulated a more closely coordinated wheat project activity involving the various departments of the Jordanian Ministry of Agriculture.

This improved coordination resulted primarily from the excellent working relationships developed between the Senior Advisor and the Jordanian Wheat Project leader coupled with the sincere dedication of other wheat

project members to the objectives of improving Jordan's wheat industry. This dedication and high level of performance by individual members of the Jordanian Wheat Project is partly related to their earlier exposure to improved wheat technologies of the Pacific Northwest areas of the United States and to their personal convictions that many of these technologies could be transferred, with modification, to Jordanian conditions. The Senior Advisor periodically assisted the Jordanian project supervisor in systematic reviews of project activities and assisted in the development of both research and extension activities.

Short term specialists were periodically called in to add their expertise to particular program thrusts as deemed necessary jointly by both the Jordanian Wheat Project supervisor and the Senior Advisor.

Mr. Leonard Halsorson served as a short term specialist for two periods under this contract. His personal experience has been in the commercial spray services and agricultural supply business in the dryland wheat areas of Eastern Oregon. His objective under this contract was to assist in the strengthening of private industry's ability to provide materials and services for both weed control and fertilizer supplies. He also provided assistance to custom farm operators and representatives of the agricultural machinery industry in Jordan. Specialist Haldorson also made constructive suggestions to the Ministry of Agriculture officials relative to improving of their efficiency in working with the private sector and in determining most critical needs for additional herbicide research. He was able to make suggestions to the members of the Ministry of Agriculture relative to strengthening the activities of the Jordan cooperative societies which are providing agricultural goods and services for wheat production.

Elbert Neil Hoffman, irrigation specialist, analyzed the current procedures being used for surface irrigation of wheat in the Jordan Valley and in other irrigated crop producing areas. He stressed the need for extension of what is currently known about irrigated wheat production in Jordan and outlined an adaptive research program for the Ministry of Agriculutre personnel to obtain up-to-date information on improving irrigation efficiency. Very little research information on management of irrigated wheat is available in Jordan. Mr. Hoffman felt, however, that the Ministry of Agriculture had well trained personnel who could investigate such aspects as varieties, fertilization, irrigation frequency and timing, and chemical weed control and that these potential improvements in irrigated wheat could be implemented.

Dr. David P. Moore, soil fertility specialist, made two visits to Jordan under the services of this contract. He worked most closely with members of the Ministry of Agriculture staff who have responsibilities in the soil fertility area making suggestions on how to obtain much needed research information on the fertilizer requirements for various soil groups on which wheat is grown in Jordan. He also suggested methods of improving the efficiency of the soils laboratory.

Dr. W. E. Schmisseur, agricultural economics specialist, conducted a brief economic review of the demonstration projects for both the annually cropped areas and the alternate fallow wheat production areas in terms of returns from the value of inputs required for the increased production. Individual components of the package of practices could not be economically evaluated. Recommendations were made to the Ministry of Agriculture staff relative to further development of researhc trials which could produce more meaningful economic results and for the strengthening of the extension program in the farm management area.

Dr. David P. Moore, soil fertility specialist, and Dr. Norman Goetze, Campus coordinator, made a short review trip to Jordan to summarize the current status of the wheat project and to make suggestions for additional program activities. They consulted Jordan Wheat Project personnel, Jordan University Faculty of Agriculture members, AID personnel and representatives of other international developmental agencies. They concluded that the technologies of producing wheat in the Pacific Northwest had been successfully demonstrated to be transferable to Jordanian conditions. They also observed that some of these technologies were being adopted by the Jordanian farmers but that there were constraints to the adoption of other technologies. They recommended a course of action to be considered by the Jordanian Ministry of Agriculture for further developmental work on this project and suggested possible methods of support by agencies such as AID.

The contract provided training for six participants for Jordan, Amjad Sweidan, Sami El-Banna, Amin Abushaer, Mahmud Duwayri, Zuelkifl Ghosheh, and Samir Selti. The first five received training in the general technology of dryland wheat production with speical emphasis on public agency organization of adaptive reserach and extension programs for the wheat industry. Mr. Selti received a three-week indoctrination in soil fertility and soil physics laboratory techniques related to soils problems of wheat production.

Throughout the duration of this contract, the Senior Advisor, short term specialists and campus personnel worked directly with Jordanian counterparts and/or other contract members with the primary objective of enhancing the professional capability of the Jordanian counterpart. The Senior Advisor assisted the Jordanian Wheat Project supervisor in developing a master plan for adaptive research in wheat production and assisted the extension service members in designing and conducting the annual crop and summer fallow demonstrations throughout the Jordanian wheat producing areas and in the

organization of Farmer Field days associated with those demonstrations. Assistance was also given in the preparation of background information which was incorporated into technical bulletins and in audio mass releases. In every activity covered under this contract, the advisors and specialists worked directly with counterparts in an attempt to build their expertise and respect by the Jordanian wheat farmer.

ACCOMPLISHMENTS

The Ministry of Agriculture, through its wheat project, has successfully demonstrated that the technologies of wheat production used in the Pacific Northwest areas of the United States are transferable to Jordan. Hundreds of demonstrations have been conducted with one or more having been completed in each wheat growing community. Farmer field days, extension publications, and mass media news releases have exposed the Jordanian farmer to the benefits of improved wheat farming practices.

Thus far, approximately 25% of the area needing herbicide treatment for weed control is being sprayed. Improved seed sources of the newer varieties are being used and the amount of fertilizer used for wheat production has expanded. The adoption rate for improved tillage practices and use of the grain drill has been disappointing, however.

Further adaptive research on refinements of fertilizer recommendations improved herbicides, and tillage practices are being conducted by the Ministry of Agriculture. Variety development has been a continuing program by the Ministry. Conventional extension educational programs are being complemented by an expanded cooperative society movement.

Details of each of these accomplishments and other technological aspects of the project are covered in the individual reports following which are made a part of this final report.

WHEAT RESEARCH AND PRODUCTION
IN
JORDAN

A REVIEW REPORT

BY
Eugene P. Winters
Senior Advisor

USAID/OSU Contract
AID/sa-C-1024
PIO/T 278-139-3-20062 A-1

Amman, Jordan

January 31, 1974

CHAPTER I

INTRODUCTION

Oregon State University has entered into a contract with the United States of America Agency for International Development for Wheat Research and Production in Jordan taking effect August 27, 1973 with an estimated completion date of September 30, 1975.

The Senior Advisor arrived in Jordan in late November 1974 following a six week delay caused by the October war.

The Jordan Ministry of Agriculture has the responsibility for doubling wheat production by 1980. The Director of Extension and Research through the Wheat Project Manager has the primary tasks of implementing and conducting the necessary research and extension activities toward reaching that goal.

The Oregon State University Senior Advisor was assigned to the wheat project to assist those Jordanians involved in the administration, research and extension activities in coordinating a wheat program.

This review is undertaken as a part of the Operational Plan in Appendix A of the contract. Specifically, the objectives of this review as listed in the plan are to produce:

A. A master plan for research methodology in:

   1. Summer fallow wheat production practices
   2. Sprayer equipment use
   3. Soil classification and fertility analysis

B. The developments of training programs in:

   1. Field plot techniques
   2. Collection and analysis of research data from irrigated and dryland wheat trials
   3. Organization of farmer field days
   4. Preparation of technical bulletins and mass communication materials for radio and television programs.

SITUATION

The Jordan Wheat Project was organized in 1967 with the project goal of doubling wheat production by 1980. With assistance from the United States Government through the Agency for International Development, the Government of Jordan Ministry of Agriculture undertook a program to increase domestic wheat production. A Wheat Project Manager was assigned the task of overall supervision of the project and to be directly responsible to the Director of Extension and Research.

An experienced wheat specialist from Oregon State University identified possible program activities that USAID might help the GOJ Ministry of Agriculture implement. Since detailed wheat production and soil management research would take many years for development and since there would be need for constant motivation of the Jordanian counterparts, it was decided that some practical on-farm demonstrations might be most beneficial in the early stages of the program.

The results demonstrated, that from a practical standpoint, some production techniques used in Oregon could be satisfactorily modified to meet Jordanian conditions. An intensified program of adaptive research was initiated in 1968. Some 63 summer fallow and annual cropping demonstrations were established on farmers' fields for harvest in 1969. On these locations the use of improved seedbed preparation, fertilizer, a grain drill and chemical weed control were tried next to fields prepared and planted in the traditional manner. These demonstrations and those to the present have been shown to farmers through organized farmer meetings conducted by project personnel in cooperation with district extension directors.

Demonstrations have been established as well for the 1970, 1971, 1972, 1973 and 1974 crop years by wheat project and extension staff using project

materials and equipment. Through the 1972 crop year ninety field days have been held with a total farmer attendance of 6000. Twenty training sessions have been conducted to give in-service training to extension agents working with farmers to increase wheat production. Thirteen different extension type publications having to do with recommended practices for growing wheat have been prepared and 100,000 copies distributed. Additional training is under way at this time.

Wheat project staff with extension personnel have participated in over a dozen television shows to keep the public informed about the wheat project and its activities. A large number of newspaper and radio releases have been made starting from the first days of the project.

The Extension teaching and demonstration program has been expanded for 1974 to 109 sites having a total area of more than 3000 dunums. Approximately 24 demonstrations are in the summer fallow area of the country.

The wheat project activities have been kept before the farmers, businessmen and publics' eye. Current world wheat prices have attracted attention from persons high in government. A number of farmers with adequate capital have invested in modern wheat farming machinery after seeing project demonstrations on their own or their neighbors land the yield response to better wheat farming methods. One larger farmer in a primarily summer fallow area planted 11000 dunums for harvest in 1974 using recommended tillage, fertilizing and seeding practices with modern implements and machinery. He is prepared to follow up in a few weeks with a chemical weed control program with his own spray equipment.

There are many small farmers anxious to adopt new methods and techniques who do not have adequate capital or credit. Three cooperative societies in the Irbid governorate have pooled the resources of 242 small farmers

together so that for the 1974 crop year they can use the same wheat production practices in 14000 dunums shown to give higher yields in the project demonstrations. The Jordan Cooperative Organization with multilateral assistance is now actively organizing and strengthening cooperative societies. The Director General of the Jordan Cooperative Organization has indicated that he sees the cooperatives as having an important role in helping reach the 1980 goal of doubling wheat production.

The capability of the Directorate of Extension (and Research) to conduct day by day extension type wheat project activities has increased substantially since 1968. Many of the early difficulties in those activities have parallel to the present Research program.

The Wheat Project Supervisor, who was appointed in September 1973, has been active in wheat project activities since 1967 as an Extension Agronomist and as Agriculture Director for the Amman governorate.

His task will primarily be one of recruiting and organizing a wheat research team from the Agronomy Section, Soils Section and Plant Protection Section and coordinating their efforts within the present extension oriented project organization.

Once individual team members have been assigned an assessment will need to be made as to their training, equipment or commodity needs. A research plan should follow.

There are few Ministry employees directly assigned to the Wheat Project. Demonstration work is conducted through the various Extension office staff of specialists, agents and laborers. There appears to be little research underway to solve farmers problems. Research work in wheat will need to be planned with the various section chiefs of the Research Directorate. Primarily involved would be the Chief of Soils, Chief of Agronomic Crops, and

Chief of Plant Protection. A technical advisory committee composed of Section Chiefs, the Director of Research and the Project Supervisor could coordinate research projects in meetings. At this particular time there is a shortage of qualified technicians to undertake needed wheat research. A wheat technical advisory committee could keep the Director advised as to the needs for staffing, equipment and facilities.

There is an indication that some research workers need more field experience. Most of their training, apparently, was received in class rooms, laboratories or greenhouses in the various countries of the world. An effort needs to be made to broaden their exposure to field conditions and become oriented more towards helping farmers and extension workers with agriculture production problems.

There is need for a coordinating committee other than the technical advisory committee of the Research Directorate mentioned above. There are organizations, agencies and institutions other that the directorate involved in research with wheat. The University of Jordan is establishing a facutly of Agriculture. At this time the University has a cereal breeder and a weed research worker who are planning wheat research. The American University at Beirut (AUB) has an agreement with the Ministry of Agriculture to provide training and specialist help. The Dryland Project of FAO/UNDP near Karak has established a date and rate of seeding trials with wheat. The DL project agronomist is planning to initiate tillage and herbicide trials. Another FAO/UNDP project for the development of groundwater resources was staffed by an agronomist who has done variety, irrigation and fertility testing with wheat. A committee of technical wheat workers could observe each others' trials, review results and consequently add to the total knowledge of wheat in the country. For the broadest dissemination of new in-

formation extension personnel should be kept informed of such research underway and that training sessions be conducted for them at suitable locations by the particular research worker under sponsorship of the Wheat Project in cooperation with the other agencies and institutions.

CHAPTER II

As noted in Chapter I, this review is undertaken as a part of the Operation Plan in Appendix A of the contract to produce

A. A Master Plan for Research Methodology and

B. The Development of Training Programs.

A. A Master Plan for Research Methodology

1. Summer Fallow Wheat Production Practices

Site selection is extremely important when locating summer fallow wheat trial areas. While some work could be done at the Rabba Experiment Station previous treatments could affect results so that it would seem better to locate on farmer fields now being used for wheat production and wherever possible the area be protected by fencing or be away from human and animal traffic. Approximately 15 dunums are needed for summer fallow research when using project implements. Soils of the site should be typical of the summer fallow wheat producing area and have uniform depth of 0.7 meter or deeper. Soil texture and appearance should be uniform. At least three protected locations should be established, however, six would be better because of high potential for loss. Suggested areas would be east of Irbid, east of the Amman-Madaba road and in the vicinity of Rabba.

After tentative sites have been selected the services of a soil scientist should be secured to classify the soils and give a physical description. The FAO Dryland Project has technicians trained in soil survey.

Soil samples should be collected to a depth of 2 meters or bedrock when shallower from at least 4 sites in the plot area. Chemical and physical analysis should be made by soil horizon or in increments of 15 cm for the first 30 cm and at 30 cm thereafter. The Research Soils Laboratory is equipped to make these analyses.

Analysis needed are organic matter content for the surface 30 cm at 15 cm increments; and at 15 cm increments PH; total salts; proportion of sand, silt and clay; P; K; bulk density, wilting point coefficient; and moisture content.

A rain gauge should be located near each site and records kept of precipitation.

With the trial site located, basic soils information known, and precipitation information arranged for, trials for tillage, fertility, rate and date of seeding and method or type of seeding should be planned. Such planning should be made within the recognized procedures for experimentation.

The summer fallow locations could also include variety trials, herbicide trials, etc.

Tillage trials should include methods of initial tillage, fallow operation and seedbed preparation and seeding.

Tillage operations could include:

1. Disk plow in spring, spring tooth harrow and rod weeder
2. Sweep plow in spring, spring tooth harrow and rod weeder
3. Disk plow in spring, spring tooth harrow and field cultivator
4. Sweep plow in spring, spring tooth harrow and field cultivator
5. Disk plow in spring, one-way covering disks

Soil moisture measurements should be made at different times during the fallow season in each tillage treatment. One schedule could include:

1. Soil moisture, June 1 + at 15 cm, then by 30 cm increments to 1.5 meter depth of profile or to bed rock
2. Soil moisture October 15 at the same depths
3. Soil moisture at exact depth of seed placement at planting
4. Soil moisture in profile (to 1.5 m or bed rock) after harvest

2. Sprayer Equipment Use

At the time of this review there is an Oregon State University contract short-term Herbicide Sprayer Specialist in Jordan evaluating current status of herbicide research and demonstration programs, and assisting the Ministry of Agriculture in a program of helping commercial firms become established in the weed spraying business and advising existing firms in how to become more efficient.

He is participating in five weed control meetings planned by the Wheat Project Supervisor in cooperation with the District Extension Agents and the Plant Protection staff.

The Specialist will cover most of the area under this heading in his report.

Experience in the U.S. has shown the need to keep an on-going chemical weed research program in wheat (and other crops). As those weeds species susceptible to the herbicide 2,4-D are controlled many of the 2,4-D resistant species will become a serious problem.

The current researhc program of surveying weed problems in wheat, tillage practices which influence weed infestations, and time and rate of application trials need to be continued and strengthened.

A research program should be initiated to screen new herbicides for possible future use under conditions existing in Jordan. To implement such a program additional well qualified weed researchers interested in doing field work are needed.

The wheat project demonstration sites provide excellent locations for applied weed research in wheat.

Methods for field testing of herbicides are well established.

3. Soil Classification and Fertility Analysis

Wheat is grown on a wide variety of soils under dryland and irrigated conditions. In irrigated areas and the higher rainfall areas wheat is grown in rotation with other crops.

Before undertaking an intensive fertility research program some basic soils information is needed. Ideally wheat producing soils of Jordan should be indentified and grouped by certain soil characteristics limiting production. From such a grouping, key soils having more importance could be selected for research sites.

Other than in the FAO Dryland Project area ther has been little, if any, soil classification of the desired intensity undertaken. In the absence of such information it will be necessary to choose experimental sites that appear to be typical for the wheat growing areas using color of soil, depth of soil, its position, parent material and rainfall as guides. The services of the Soil Scientists from the D.L. Project should be solicited to assist in cataloguing the soil or writing a physical description which would be helpful in tieing the results of trials to other similar locations.

A soil profile description would provide soil texture, structure, depth of rooting and limiting layers. Under summer fallow conditions, as indicated earlier, additional soil, physical characteristic information would be needed.

Once the experimental site is tentatively located and soil physical characteristics known, soil samples should be collected for chemical analysis. A sompling information sheet should be used showing sampling site, soil classification or grouping, soil texture, previous cropping history, method of tillage, field location to a landmark, approximate rainfall area and whether dryland or irrigated. Because the sampling sheet will also have the results of chemical analysis, space for other useful information should be included on the sheet.

Chemical analysis sould include organic matter content from 0 to 15 cm and from 15 to 30 cm depths. Other tests at 15 cm increments should be pH, total salt, textural class and phosphorous and potassium levels to a depth of 2 meters or to bed rock if the soil is shallower. Should there be much variability consideration should be given to selecting another title.

It is to be expected that the two main nutrients to increase the wheat yields in Jordan are nitrogen (N) and phosphorous (P). There is no evidence to indicate that P is needed at all locations. The relative efficiency of the local low analysis Psingle superphosphate and the imported treble superphosphate should be determined.

More information is needed about the rates of nitrogen to apply and the response of the different nitrogen fertilizer materials, which will be introduced to Jordan in the future, on the wheat growing soils of the country.

The status of sulfur (S) is not known. Sulfur has been applied with the ammonium sulfate formulation of N fertilizer. A continued evaluation of S will be needed as fertilizer materials not carrying S are introduced.

The use of fertilizer in improving wheat yields has been shown throughout Jordan. On wheat project demonstrations information is needed about the more economical rates and ocmbinations to recommend. An experiment using various combinations of nitrogen and the two phosphorous carrying materials mentioned earlier should be established in (1) the summer fallow areas, (2) where annual dryland cropping is practiced and in the (3) irrigated wheat producing areas. Such research should be planned to collect data for five or more years from key soils of the respective areas.

There are a number of ways the experiments can be set up. One way would be to establish a series of factorial experiments with 5 rates of N and 3 rates of P (single superphosphate) and 3 rates of P (treble superphosphate).

Summer fallow rates could be 0,2.5, 3.5, 4.5 and 5.5 kg N/dunum and 4.5,

6.5 and 8.5 kg P_2O_5/dunum. Anual cropping areas should receive higher rates. The irrigated trials should include higher total N rates in excess of 20 kg N/dunum.

A time of N experiment with irrigated wheat is needed. This could have 4 standard treatments: (1) all N applied at planting; (2) ½ at planting, ½ at jointing; (3) 1/3 at planting, 1/3 during tillering, 1/3 at jointing; (4) 1/3 at planting, 1/3 during tillering and 1/3 at late boot stage.

As information is collected the experimental program in soil fertility will need to be changed. The rates used in the N.P. factorial experiments may need to be adjusted to fit the response curve and the varietal interaction.

Other fertility work is needed to determine the importance of sulphur for wheat production in Jordan, response from different nitrogen sources and banding of N-P fertilizer with the seed.

Procedures for soil fertility experimentation with wheat have been established in other wheat growing regions and could be used as a guide in Jordan.

4. Other

Although the project requirements or operational plan do not specifically call for the review to produce a plan for wheat variety testing and research methodology in irrigated wheat production practices a few comments are in order.

The project supervisor has a number of excellent locations under his control where wheat variety nurseries could be established. Variety trials should be established for further examining of wheat cultivators which preliminary research by the plant breeder has shown to have promise of being of significant value for the area.

Wheat variety nurseries on project demonstration fields should be an important step in the wheat breeding, testing, seed increase and the release to farmer system.

There is need for research in irrigated wheat production. The services of a short-term irrigation wheat management specialist to help initiate this work is provided in the contract. The current price of wheat has made returns from irrigated wheat more attractive for farmer to include this crop in the rotation. Much can be done on an extension demonstration basis showing the results of smoothing and shaping fields before planting compared to traditional dryland seed bed preparation methods being used on irrigated fields. However, under an irrigation regime studies are needed to determine the amounts and times of application of water as well as optimum levels of fertilizer in association with varietal response.

B. The Development of Training Programs

The Food and Agriculture Organization of teh United Nations (FAO) as the Executing Agency has entered into a 5-year project with the Government of Jordan (GOJ) to establish and staff a higher Institute for Agricultural Training, Research and Extension. The main object of the project is "to strengthen the capacities of the Department of Research and Extension, to plan and conduct applied research, extension service activities and staff training and development activities."

The Institute has a building nearing completion on the Deir Alla Station which is to be equipped as a training center.

At this time an intensive training program is underway to orient and train 20 new extension agents recently graduated from 13 college or universities in Europe. Other training programs are in the planning stage. Any formal wheat project personnel training program would be done within the framework of the Institute.

1. Field Plot Techniques

Successful in-service type training programs in field plot techniques or statistical methods have been conducted in Oregon and California in as short a period as three days or as long as 6 weeks or more. The actual training period depends upon the background of the agricultural technician, his previous training and the sophistication of the research to be undertaken. A training program in field plot techniques for Jordanian wheat worker should have the goal of giving him a working knowledge of the statistical tools available and how they are used in the design, execution and analysis of experiments and why the use of these techniques is necessary.

A five-day program could be devoted to (1) the need for statistical evaluation, (2) some basic concepts about sampling, (3) choice of site, (4) treatment, (5) experimental design, (6) evaluation, (7) processing of data, (8) reporting and summarization of data.

A field session would be needed to demonstrate the art of establishing trial plots. Some time should be devoted to learning about how to interpret research data collected or that published by other research workers.

2. Collection and Analysis of Research Data for Both Irrigated and Rain Fed Wheat Production

A training program in field plot techniques would include how to collect research data and analyze, evaluate and interpret the results.

3. Organization of Farmer Field Days

Wheat project personnel have shown an excellent capability for organizing and conducting farmer field days. This has been shown by them with the wheat machinery exhibit, wheat fairs, demonstration tours, and wheat production seminars. In-service training is currently meeting the needs for planning and conducting farmer meetings.

4. Preparation of Technical Bulletins and Other Mass Communication Materials for Radio and Television

Wheat project personnel in cooperation with Extension Information Specialists have done an outstanding job in preparing extension-type publications for distribution to farmers, and material for dissemination by newspaper, radio and television.

The information developed from project demonstrations and activities has been easily adapted for use in mass media.

Few of the results so far of the applied research done on field trials has been of a technical or sophisticated level suitable for publication in a technical bulletin. Technical bulletins are not normally for general farm distribution. Their value in the wheat project would be to report results of research to other technicians and extension agents for use as a reference for making farmer recommendations. With the adoption of statistical methods in planning and conducting research the data should be interpreted and published. Publications should be part of the consideration when preparing plans for experiments. Publications could be in a Technical Bulletin.

A policy requiring the publication of experimental results by the Research Directorate would facilitate making the information available for extension eductional program. There is some indication that there is more interest by research workers in reporting their results in bulletin from that in the previous six years. Farmers' bulletins for popular distribution could be prepared from Technical Bulletins by extension specialists.

SUMMARY AND CONCLUSION

The Jordan Wheat Project staff working through the District Extension Agents and Extension agronomists have done a very good job showing and telling farmers about the "new methods" of improving wheat yields. The project has strengthened the extension directorate by developing a closer association among personnel working towards a common goal as well as the individuals improving professionally in the process.

Farmers have been selective in adopting practices recommended by Extension Agents. Chemical weed control in wheat as a practice has been well received. Farmers at this writing are concerned about the shortages of fertilizer. Fertilizing wheat is another practice having wide acceptance. Farmers in general have been slow to improve the plowing techniques and seed bed preparation practices. A few large farmers have invested in full complement of modern wheat farming machinery such as used in the Pacific Northwest of the United States.

There is little local research to back up extension agent recommendations in the culture of wheat. Most of the recommendations are based upon results of summer fallow research conducted in Oregon and Washington and demonstrated on farmers' fields here. Investigations with herbicides need to be expanded and become more sensitive to the farmers' eneds. Much needs to be known about the wheat producing soils of Jordan, the response to fertilizer materials and economic rates to use.

Most of the wheat farmers either have tractors with disk plows or the services of these from a custom tractor operator is readily available to him. There has been little information gathered under local soil and weather conditions for the better ways to retain soil moisture in the summer fallow areas. A series of on going tillage trials such as initiated in 1969-1970 should be reestablished.

As cultural practices with wheat are developed or improved upon there will be a need for wheat varieties having a higher yield potential in the summer fallow area. There is a need for better improved varieties in the annual cropping and irrigated wheat growing areas. Wheat nurseries are needed to test the response of promising cultivars in the various wheat growing districts and to provide a basis for variety recommendations.

There is a considerable interest in growing wheat under irrigation in the Jordan Valley and in the desert areas to the east. Research is needed to determine the most economic amounts of water and fertilizer needed and the timing of application. Demonstrations are needed to show farmers better ways to prepare land for irrigated wheat.

At the time of this review there is little wheat research underway other than the variety screening trials and some minor herbicide work. This can be attributed to the shortage of sufficiently well trained agricultural technicians to conduct applied research.

The problem is not so much a lack of trained Jordanians but one of better paying opportunities in other countries in the region.

The wheat project supervisor has started discussions with the Chief of Sections to assign personnel to work on project problems. Once an adequately prepared research worker is assigned with major responsibility for leadership in some designated area of wheat research a proposed research plan can be discussed and, if necessary, the services of a University TDY backstopper be arranged for counterpart training.

At this time preparations are being made to send four participants, most of whom have Bachelor degrees, to Oregon to receive practical 10 weeks training on farms and experiment stations.

The Extension Directorate staff has made good progress in planning and coordinating extension wheat project activities over the past six years. Research Directorate staff need additional training in the planning, coordinating and conducting wheat project research. The Research group could benefit from the same kind of participant training received by their extension co-workers in the U.S. The Research Director, Wheat Project Supervisor, the Chiefs of the Agronomy Section, Soils Section and Plant Protection Section could meet with the Dean of College of Agriculture at Oregon State University and his directors and departments heads. They would benefit from seeing and learning how the results of research are evaluated, filed, published and disseminated to extension agents and the public so that the information can be put to some use in the shortest period of time.

ADDENDUM

The GOJ has initiated a program to identify what is needed to increase food, feed and fiber production to meet the needs of the country. Nine areas to receive emphasis have been identified. A wheat committee has been designated to prepare a report and submit a plan to the Ministry of Agriculture on what the government can provide to increase wheat production.

A committee of Wheat Project Leaders, the Heads of the Research Directorate Agronomy Section, Soils Section and Plant Protection Section are now estimating funds necessary to provide sufficient implements and machinery, fertilizer, herbicides and seed wheat for the wheat farmers.

The Cooperative Organization is apparently an important part of the planning. Approximately 60 cooperative societies are to be organized in the wheat growing areas to helo small farmers get the necessary "in-puts" to increase production as well as technical assistance.

Planning has not been completed at this writing.

WHEAT PROJECT RESEARCH

A PLAN FOR EXPANDED EXPERIMENTATION

WITH WHEAT BY THE MINISTRY OF AGRICULTURE

RESEARCH DIRECTORATE

By

Eugene P. Winters

Wheat Advisor

USAID/OSU Contract
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PREFACE

A plan for wheat Project Research in Jordan has been prepared to provide direction for expanded experimentation with wheat by the departments within the Research Directorate of the Ministry of Agriculture.

The plan presents broad objectives to the Departmentheads and involved research workers in those areas of investigations needed to solve many of the important problems liniting wheat production in Jordan. It is intended that the results of such research be used as a basis for making recommendations to wheat farmers through such agricultural extension eductional activities as farmer meetings, bulletins, mass media, etc.

The Wheat Project Supervisor Amin Abu Sha'er and the Wheat Advisor have used the wheat project demonstration experiences with farmers in selecting the important wheat production problems. We have relied upon reports prepared by Oregon State University staff members: Dr. Norman Goetze, Dr. Thomas Jackson, and Mr. Merrill Overson in identifying those research areas needing attention in Jordan. Also helpful in planning were the results from summer fallow tillage trials reported by the OSU team in Turkey.

The introduction provides a brief history of the wheat program, the status of research with wheat and broad obfectives for wheat research in Jordan. The remainder is arranged into five subject matter areas: Cereal nursery, wheat fertility, irrigated wheat, weed control and tillage. Each area is further divided into the specific problems requiring attention, the objectives to be reached by undertaking research and a suggested procedure to follow.

It has been left to the responsible research worker to prepare a specific detailed research plan.

The general plan will supplement to some extent the Review Report prepared earlier.

Eugene P. Winters
Wheat Project Advisor
USAID/OSU Contract

A PLAN FOR WHEAT PROJECT RESEARCH IN JORDAN

INTRODUCTION

Wheat is the national food staple of Jordan. It is harvested from about 2 million dunums each year. The modern average yield has been estimated to be approximately 60 kg per dunum. Average production provides less than half the requirement of the population.

While yield per unit of area has increased markedly in many other countries within the last 25 years, there has been little increase noted in Jordan. Improved soil and water management, fertilizer use, pest control, improved varieties, power machinery, and other technologic improvements have been major factors in these advances.

The Government of Jordan has recognized the importance of wheat and its increasing dependence upon importing larger quantities in the future to meet the needs of an increasing population. Consequently, the Government in 1967 with assistance from USAID undertook a program to increase wheat production.

One important part of the program was to activate the agricultural extension educational phase to demonstrate improved modern wheat production techniques to wheat farmers. During the past seven crop years 428 demonstrations having a total area of 12,000 dunums were conducted on farmer fields to show farmers and other persons the benefits from improved tillage, mechanical seeding, fertilizer use, use of improved seeds, and chemical weed control. These methods and techniques were, for the most part, adopted from those developed and used in the Pacific Northwest. Yields were increased on the average, to about 60 percent over the neighboring field being farmed in the traditional or normal manner. Because of distinct differences in

climate, soils and wheat grown it is believed that additional yield increase will depend upon information resulting from locally conducted research. Such new information could be used as a basis for making better recommendations to farmers to help increase production.

THE PROBLEM

Field research with wheat in Jordan has been somewhat limited. An active wheat breeding and testing program has been underway for a number of years, but few new superior varieties have been released for commercial porduction. Chemical weed control was introduced in 1967 and has been adopted as a practice by an increasing number of farmers each year. A number of herbicide trials have been conducted on a year to year basis, but there has been a general lack of continuity due to changes in personnel. A moisture conserving summer fallow research plan was initiated a few years ago, but for a number of reasons could not be continued. Some soil fertility work has been underway, but there are many questions needing answers about the uses of fertilizer in wheat production under conditions existing in Jordan. Irrigated wheat soil fertility research has been underway for the past two years.

A shift in emphasis in the Jordan wheat project has been made from extension educational activities with farmers to an applied research program. A review of the project indicated a need for additional personnel to conduct such work. The recruiting and training phase is nearing completion. Sufficient capable research workers have been assigned or will be available to undertake a coordinated wheat research program.

Research to date has been piece meal in nature with little coordination among the departments showing up in a lack of cooperative planning and

reporting of accomplishments by personnel doing research. Both long and short range plans are needed to develop wheat research. The primary planning goal being to provide information the farmer can use to increase wheat production.

This plan was designed to outline ways the Research Directorate and the Wheat Project can coordinate an applied research program. Broad objectives are presented as a guide for planning. More specific objectives are indicated for the first year by the area of activity.

The Wheat Project Supervisor has a major role in coordinating the planning and conduct of trials. He will need adequate support from the Director and Department heads involved in the way of personnel, materials and services.

It is suggested that a special wheat research committee be established by the Director to assist the wheat Project Supervisor as he and the researchers proceed during the phases of planning, establishing of trials, taking data and reporting of accomplishments.

The Objectives

The broad objectives for wheat research in Jordan are:

1. To determine the most practical combination of tillage procedures which will most efficiently conserve moisture for maximum wheat production under summer fallow conditions in each of the dry and medium rainfall areas.

2. To determine the response by wheat from applications of nitrogen, phosphorous and sulphur on different wheat producing soils of Jordan.

3. To develop a soil testing program for use in predicting phosphorous needs of wheat.

4. To ascertain those herbicides which will be effective in controlling weeds in wheat grown under the different growing conditions found in Jordan.

5. To ascertain which cultural practices or combination of practices can be used for effective weed control in the wheat producing areas of Jordan.

6. To ascertain the best combination of tillage, fertility, weed control practices and variety to use under summer fallow, annual cropping and irrigation for optimum yields of wheat.

7. To broaden the variety testing program to farmers fields to facilitate an early release to farmers of improved better yielding varieties adapted to the different growing conditions.

8. To ascertain the value and benefits from including wheat in the irrigated crop rotation.

It is proposed for the first year that relatively simple experiments be conducted. After one years' experience in planning, establishing trials and collecting data and with adequate support including protected locations, more sophisticated factorial experiments would be appropriate.

There are two approaches used to increase crop water use efficiency. One involves the method or practice to increase the total water supply available to the crop through more effective storage of rainfall. The other approach involves how to make more efficient use of stored water. Both approaches are used in the dryland wheat trials.

Objectives and suggested plans for research in the 1974-1975 wheat crop year follow under the headings Cereal Nursery, Wheat Fertility, Irrigated Wheat, Weed Control and Summer Fallow Tillage. The actual treatments selected will depend upon the availability of personnel, materials, services, machinery and space. The experimental design will need to take these factors into consideration.

The research worker doing the investigation will design the experiment in accordance with acceptable standards which have been established.

CEREAL NURSERY

THE PROBLEM

A wheat breeding and testing program has been underway for several years. Many new lines and varieties of durum and bread wheats have been evaluated each year. Few varieties have been released to replace recommended varieties.

The culture of wheat is changing. Farmers are now adopting new practices such as moisture conserving summer fallow, the use of fertilizer, the use of chemical weed control, the use of grain drills, etc. Improved varieties may respond to better soil moisture, fertilizer and the chemical control of weedy competition than the varieties now recommended.

Objectives

The objectives of expanding variety testing to farmers fields in cereal nurseries for 1974-1975 are:

1. to determine which varieties of durum and bread wheats are superior to recommended varieties.

2. to speed up the testing and release procedures so that better varieites will be available sooner to farmers.

Procedure

Select 15 to 20 durum and bread wheat varieties that have shown promise under the Agronomy Section screening trials in Jordan and other trials in the region.

Plant these in a properly designed randomized-replicated plots on three wheat project summer fallow demonstration locations in Irbid, Amman and Karak districts.

The trial area to receive the same tillage and fertilizer treatments as applied to the demonstration area.

Determine yield and adaptation. Record data on date of maturity, height, straw strength, shattering and other agronomic characteristics.

Report results in written form.

(10) Present information from trials to selected extension staff and research workers in seminar.

Plan for 1975-1976 cereal nurseries.

WHEAT FERTILITY

PROBLEM

The use of chemical fertilizers in Jordan wheat production is a relatively new practice. Demonstrations on farmers fields have shown wheat has responded to applications of nitrogen, phosphorous and sulphur carrying materials when moisture was not the limiting factor. The optimum amounts of nitrogen, the phosphorous requirement and the need for sulphur on the various dryland wheat producing soils are not known.

With improved soil moisture conserving techniques and chemical weed control; superior yielding varieties can make more efficient use of available moisture when fertilized.

Many changes are underway in the fertilizer industry which may have some impact upon the availability of some fertilizer materials and encourage the use of others.

The relationship between soil analysis values and response from fertilizer nutrients by wheat is not known in Jordan.

Objectives

The objectives for the wheat fertility testing program for the 1974-1975 crop year with three varieties of wheat (a recommended variety, a new variety and the high yielding potential variety Mexi-Pak) are:

1. To obtain information to serve as a basis for improving the fertilizer recommendation for the summer fallow wheat growing area.

2. To generate fertilizer response data for use in the calibration of diagnostic soil tests for P.

3. To gather information about the response of wheat to the different nitrogen and phosphorous carrying fertilizer materials.

4. To determine the role of sulphur in a wheat fertilization program.

Procedure

Select locations for wheat fertility trials on summer fallow demonstrations in Irbid, Amman and Karak districts.

Take soil samples for soils analysis.

Establish a properly designed randomized - replicated plots of different levels of nitrogen and phosphorous with three varieties of wheat in the sub-plots. Include the recommended variety for the area, a newly released variety and a recognized variety having high yielding potential.

Observe, measure and record characteristics of growth during the season.

Harvest for quantitative and qualitative data.

Resample soils for analysis.

Prepare results in report form for discussion with research and extension personnel.

Plan the next cropping seasons wheat fertility program preferably in the same field.

Make visual observations or measurements of response from residual fertilizer carry over in the following crop.

IRRIGATED WHEAT

PROBLEM

Wheat yields under irrigation in Jordan have been substantially lower than those reported in most other irrigated wheat growing areas.

There is some question about the normal crop rotation making the best use of growing season, land, soil and water. It has been shown in many regions that crops grown in systematic sequence can help farmer manage lands and conserve the soil, reduce diseases and insect problems and be beneficial in the control of weeds. The benefits of wheat in an irrigated crop rotation in Jordan have not been measured.

Objectives

The objectives for irrigated wheat research for the 1974-75 crop year are:

1. to find the necessary factors of fertilizer, irrigation water and varieties needed to bring wheat yields up to acceptable economic levels.

2. to determine the role of wheat in irrigated agriculture rotations to make better use of the land and water reserve during the winter season and to ascertain any soil and crop improvement benefits with its use.

Procedure

1. Establish a properly designed irrigated crop rotation study with wheat and other crops on the two experiment stations in the Valley.

Observe and measure differences among the various treatments.

Prepare a report in written form for discussion with research and extension workers.

Plan for the following crop seasons work in the rotation.

2. Locate experimental sites on farmers fields and experiment stations.

Sample soils for soils analysis.

Establish a properly designed trial including treatments of different levels of nitrogen and phosphorous with 2 high yielding wheat varieties.

Observe, measure and record characteristics of growth during the season.

Collect yield data and make quality determinations.

Prepare a written report for discussion with research and extension personnel.

Prepare a bulletin on the results of three years work with wheat variety and fertilizer interaction. Use as a basis for making recommendations.

Evaluate the research program and plan for the coming season. Investigate the possibilities to test date and rate of seeding, depth of seeding, improved irrigation practices, methods of seeding, etc. with better varieties as they become available.

WEED CONTROL

PROBLEM

Wheat farmers in Jordan have generally accepted the practice of controlling weeds in wheat with the herbicide 2,4-D. With changes taking place in the timing and method of tillage there may be a different set of weed problems in the making. The conservation of soil moisture and the use of chemical fertilizer materials may enhance weed growth which will require herbicides that can be applied safely at earlier stages of wheat growth. As 2,4-D resistant weeds infest sprayed fields, farmers need alternate materials to use for economic weed control. New pre-emergent and post-emergent herbicide materials have given good results in other wheat growing areas and may have adaption for use in Jordan. New improved superior wheat varieties may be susceptible to herbicide use.

Objectives

The objectives for a weed control program in wheat for the 1974-1975 crop year are:

1. determine the influence of herbicides on weeds and wheat varieites.

2. isolate chemical and agronomic methods that appear promising in exploratory research and determine effectiveness in control, selectively and safety, and time of application.

Procedure

1. Establish herbicide phytotoxicity screening trials in cooperation with the Agronomy Department using promising lines or varieties of wheat and herbicides registered for use with wheat.

2. Locate three sites on summer fallow demonstrations, if suitable, for herbicide screening trials on wheat.

Establish a properly designed experiment.

Observe, measure and record any visual differences.

Harvest plants for yields and quality.

Prepare a report in written form evaluating the results for discussion with extension and research people.

Plan for the next years testing program.

TILLAGE

PROBLEM

More than one-half the wheat producing area lies in a rainfall belt receiving an annual average of between 250-350 mm precipitation. Annual cropping is an extremely hazardous operation in most of this area because of the winter rainfall pattern as well as the erratic rainfall from month to month and year to year in the rainy season. The growing season is determined by the beginning and ending of significant rainfall. The decline of rainfall at the end of season occurs at a time when wheat is in the period of highest transpiration and plants are entering the reproduction stage of growth.

Fallowing of land to store moisture in the rootzone for the next years crop is a common practice. In other winter rainfall wheat growing regions, soil water storage during fallow is greatly affected by tillage methods. In Jordan the usual or common methods of fallow have not proved efficient compared to other methods used in winter rainfall semi-arid wheat growing regions. Clean summer fallow techniques adopted for the Pacific Northwest have been demonstrated on many farmers fields. Yields have been increased from the more efficient storage of moisture and in driery years the difference between a crop and a complete failure has been noted.

Distinct differences in climate, soils and wheat growth characteristics found in Jordan from those found in the Pacific Northwest require that a tillage system be found to reduce precipitation losses to run off, drainage, evaporation from the soil and transpiration by weedy plants under local conditions.

Objectives

The objectives of a summer fallow tillage trial are:

1. to determine the effect of fall tillage on the conservation of precipitation falling during the rainy season following harvest.

2. to determine the effect of spring tillage implements in the conservation of soil moisture.

3. to determine the effect of summer tillage implements in the conservation of soil moisture.

4. to find the amount of soil moisture that can be used by a wheat plant in the summer fallow area.

Procedure

Select three suitable sites on typical soils of the summer fallow wheat growing area of Irbid, Amman and Karak districts.

Gather basic soils information as to physical and chemical characteristics of trial area.

Arrange for the recording of precipitation as close to site as possible.

Design a trial including fall, spring and summer tillage methods within the recognized procedures for experimentation.

Establish trial.

Take soil moisture measurements during the summer fallow season from each plot.

Make frequent observations and record any visual discernable differences.

Report results and evaluation up to planting time in written form for use in discussion and for record purposes.

Plant to wheat.

Log wheat growth characteristics.

Take yield data.

Take soil moisture samples at harvest.

Analyze results and evaluate trial.

Prepare a written report including all moisture observations, plant responses and yield results.

Plan for the next summer fallow tillage trials.

IRRIGATION OF WHEAT IN JORDAN

by Elbert Neil Hoffman

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Contract No. AID/sa-C-1024

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INTRODUCTION

This report is prepared following a visit of three weeks in Jordan during which I visited both irrigated and dryland wheat growing regions. My observations and suggestions, however, will pertain to the irrigated areas only. My appreciation is expressed to personnel of GOJ and AID staff who planned and arranged for travel, handled transportation and assisted in language translation and for the many other courtesies shown.

My observations are based on visits to irrigated areas and with local personnel - many of whom have had years of experience in the area compared with my few days here. Some conditions are similar to those where I live and work. Many, particularly the soils, are quite different. And, of course, the irrigation practices are entirely different. My suggestions should be considered in light of this short visit and no personal experience here. Perhaps some of these suggestions have already been tried and found impractical. They should be tempered with the experience and knowledge of those who have been here longer.

This report will deal solely with surface irrigation, even though there is interest in sprinkler and drip irrigation. Some of my suggestions, especially land leveling, should not be considered for areas where sprinkler irrigation might become a reality.

No wheat improvement program can be considered complete until all essential management practices affecting production have been considered. During recent years most practices have been subjected to research and demonstration and have already been put into use in varying degrees by some farmers in the Jordan Valley. These include new varieties, chemical weed control and the use of fertilizer (nitrogen and phosphate). Any one and/or combination of these practices, and particularly the use of nitrogen, is likely to require greater quantities of moisture for maximum production. This may mean one additional irrigation per season and the application of water earlier in the season. The possibility of improving irrigation practices and management needs to be studied. This will be accomplished by the recent employment of Mr. Muhammad Shatanawi, Irrigation researcher. He will be conducting irrigation research in several locations and, hopefully, at the same time some demonstration work. In my opinion, demonstrations can provide some useful information for farmers in less time than will come from detailed research on the same subject. For example, land fitting or leveling for the more uniform application of water and the use of corrugations or furrows in place of the present practice of wild flooding and to some extent the zigzag method could be tested on demonstrations.

As I view the overall irrigation program for wheat and barley, I offer the following management suggestions which are not necessarily in any order of priority. Some are demonstration oriented and some need adaptive research.

1. Land fitting or leveling.

*2. Use of corrugations and/or furrows.

3. Seedbed Preparation.

4. When to begin Irrigating.

5. How many times to irrigate and/or how much water to use.

6. When to stop irrigating.

7. Date of planting and pre-plant irrigation.

8. Possible equipment needs.

*This is an appropriate time to clarify the difference between corrugations and furrows. Local irrigation personnel consider furrows to be in the range of 15 cm. in depth and spaced wider than one meter. Corrugations in my concept are similar except that they may vary in depth from around 6 cm. to 10 cm. and would rarely be spaced wider than one meter and most generally near 60 cm.

Discussion of above items.

1. Land fitting and/or leveling.

A limited amount of leveling has been done in the area. The practice is admittedly costly and requires machinery not now readily available. It can only be accomplished on a long-time basis as resources become available. Some old equipment is presently stored at El-Yabis but is in very poor condition. A few items could possibly be repaired and made usable. A landplane is reported to be in the area and would be most useful if in working condition.

In the beginning, fields requiring only minimal leveling should be selected for this practice. While I observed the area when grain was knee high - and this is not a good time to form opinions as to the amount of leveling necessary - there appears to be many fields where minimal leveling

would be required for the installation of better systems of water management.

Several farmer fields were observed where minimal land leveling would provide much improvement even in wild flooding. Land leveling coupled with corrugations would provide for greater uniformity of irrigation, improved water management and should contribute toward improved yields. Yields must be increased if this practice is to be economical. Land leveling can also provide for the combination of small fields into single larger units for more economical operation - not only for wheat but for other crops in the rotation.

To Summarize:

1. Have a plan before starting - select sites requiring minimal leveling first - leave the most difficult and costly until last.

2. Level to fit the terrain - avoid heavy cutting if possible; however, do not leave too steep. Much of the land in the Valley will not present a major problem in this respect. Avoid leaving high and low spots in the finished field.

3. Don't level if sprinkler irrigation is planned.

Again, I recognize that land leveling is costly and can only be completed on a long-time basis as resources - money and equipment - become available. I also recognize that small farms, many averaging around 30 dunums, make leveling relatively difficult.

2. Use of Corrugations and Furrows.

As a replacement for wild flooding of wheat and barley, corrugations and/or furrows are suggested where possible. To be feasible the field will most likely require some leveling or fitting. And it might be possible to make these installations on the contour in many fields with even less fitting. This would have to be done with much care to avoid high and low spots because even corrugates will not cause water to run uphill. Mr. Shatanawi has plans to start this work on Deir Alla Station in 1976. The

site appears to be sufficiently level and with enough slope to make corrugate irrigation possible. He also has plans for furrow irrigation, with furrows to be spaced two meters apart and the wheat to be drilled between the furrows.

In addition to the site presently available, there is a large area immediately north of the barns which appears to have been previously leveled and/or terraced. This would be an ideal site where all possible improved irrigation practices could be researched and demonstrated. Hopefully, some of this area could be made available to Mr. Shatanawi's project.

Lack of suitable equipment may make some of this work difficult but not impossible. Whatever Mr. Shatanawi uses for his furrow trials can likely be adapted for the making of corrugations. Also, it should be possible to construct a simple device from some pipe and/or wood. Mr. Shatanawi's background experience in machinery maintenance and repair along with my personal suggestions to him should make this possible.

It also seems likely that similar work could be started at El-Yabis with the cooperation of Mr. Mustafa Abu-Zieb, agronomist at that station. He is interested in such a possibility.

A farmer field a short distance north of Deir Alla might be considered for a demonstration in the near future. It does not appear that a great deal of land leveling would be necessary at this site.

Some detailed suggestions for this work have been discussed with Mr. Shatanawi. To summarize: In the beginning corrugations spaced 60 cm. apart are suggested. Close observation and judgment of water penetration and lateral movement will determine whether the spacing should be altered. Depth of the corrugation should be 7.5 to 10 cm. on well leveled fields. Corrugations should be installed soon after the grain has been seeded - preferably by use of a grain drill. Corrugating <u>immediately</u> after drilling

is highly recommended. This is a distinct difference from the furrow type work in which the furrows are installed before planting. Harrowing the field with a spike-toothed harrow for both the furrow and corrugated site is suggested.

The initiation of corrugate and furrow research and/or demonstrations on suitably prepared sites as a possible improvement over wild flooding is strongly suggested.

Coupled with this proposal there may be need for improving the head ditch delivery system for the inlet end of the corrugations. Adequate control of the water is essential to provide for uniform distribution of the water to each corrugation. This is especially true for farmer fields. The delivery system at Deir Alla appears to be adequate.

One final suggestion; no irrigation system or practice is any better than the person doing the irrigating. Just turning the water on and coming back sometime later to turn it off is not enough. Water needs to be observed frequently to be sure it is going where the irrigator desires. A good irrigator is as diligent to his job as the shepherd is to his flock. Irrigator training has to be an integral part of any demonstration program.

3. Seedbed Preparation.

There is a real need for improved seedbed preparation for irrigated wheat to replace the present practice of plow, hand plant and cover by plowing again. Harrowing with a spike-toothed harrow (one is available) after plowing and planting with a grain drill would be the preferred method. Another method (second choice) would be to plow, hand plant and harrow to cover. Either method, particularly the first, should produce more uniform stands of wheat by holding the moisture near the soil surface and around the seed.

A possible hazard might be soil crusting or soil compaction if the soil is worked when too wet. Thus, this practice as a suggested change in management for irrigated wheat should be subjected to research and/or demonstration, checking for both advantages and disadvantages that might result.

My idea of a properly prepared field, one that has been properly leveled, for irrigated wheat would be:

1. Plow;
2. Harrow, more than once if necessary, to level and mulch clods;
3. Plant. Use a grain drill whenever possible;
4. I even like to harrow after drilling and before corrugating; however, this operation can be omitted;
5. Corrugate immediately after planting.

4. When to Begin Irrigating.
5. How much to Apply or How many Times to Irrigate.
6. When to Stop Irrigating.

These three factors are interrelated and will be discussed as a unit. Mr. Shatanawi's present research will most likely provide some detailed answers, particularly as to how much water to apply. However, the following general suggestions should be useful guidelines in the interim. These are what any good farmer could apply under his own conditions.

When to begin irrigating wheat is a judgment factor for the farmer. Wheat yields can be reduced by irrigating before water is actually needed. Similarly, they can be reduced by delaying too long. In practice I do not mind letting the wheat show some slight moisture stress before the first irrigation. By this I do not mean letting the wheat wilt or permitting the lower leaves to turn yellow. Another guide that can be used along with this one is to squeeze a handful of soil (from the five to seven cm.

depth) into a ball; if it falls apart readily it is likely the wheat needs water. Here again Mr. Shatanawi's research now under way will help to refine these simple guidelines. Well fertilized wheat will require water sooner than unfertilized wheat.

Once the first irrigation has been applied, however, the wheat should never be permitted to suffer for lack of moisture. This probably means irrigating every 10 days to two weeks. Local personnel know these requirements better than I.

I would suspect that a well fertilized crop of wheat in the Jordan Valley will require at least three and possibly as many as five irrigations per season. New and improved varieties sometimes have a higher moisture requirement. Local research and extension personnel should be able to develop more precise recommendations.

The duration of each irrigation will depend upon how long it takes to fill the soil profile which is determined by the soil intake rate and the water holding capacity. A good farmer guide is to irrigate until the soil surface is wet or nearly so. This may mean completely wet at the head end of the field and only half or two-thirds wet at the bottom end. It is easy to over-irrigate the upper end of the field if we try to completely wet the lower end. Again, Mr. Shatanawi's research will supply some better guides in the near future. He also needs to develop some guidelines as to when to stop irrigating.

When to stop irrigating is again a judgment factor coupled with the amount of soil moisture available when the wheat growth stage is somewhere between the stiff dough or soft kernel stage of maturity. This will vary from season to season, depending upon rainfall and weather conditions. It is far better to irrigate a bit longer than actually necessary than to stop too soon.

7. Date of Planting.

Some interest was found in date of planting studies in association with pre-plant irrigation. Some pre-plant irrigation demonstration work has apparently been done at El-Yabis.

Past studies in which I have been involved have shown that wheat yields can be greater when planted near a certain time rather than when adequate seedbed moisture becomes available from rainfall. This requires pre-plant irrigation to provide proper moisture for seed germination for each selected planting date.

Such a study is suggested as a research project. I would suggest planting at 10-day intervals for a total of at least eight planting dates providing irrigation water is available for pre-plant application to insure adequate moisture for each planting date. These dates should extend from a selected starting time earlier than the normal seeding time and extend through and beyond. This would probably mean from October through November and ending in December. Local personnel know far better than I what these dates should be. In my own work, one pre-plant irrigation late in the season provided adequate moisture for more than one planting date. Local people will have to make these decisions.

Data to be collected would be the same as from a variety trial with the comparative yields being of greatest importance.

This particular project may require the cooperation of both the irrigation specialist and an agronomist. Variety interaction with date of planting would be expected. Some of the new foreign semi-dwarf wheats may not be performing well because they haven't been planted early enough.

8. Equipment Needs.

Seldom is there enough equipment available for research, and this is true for a beginning project such as this one. It is reported that

some funds are available for the purchase of small items that might be needed in support of irrigation research and demonstration work. These could include moisture probes, soil augers, shovels, etc. It might also be possible to include additional attachments for the present furrowing equipment. Additional shovels or furrow openers for the making of corrugations should be considered. Research personnel should make their needs known to those who might be able to arrange for the necessary funds.

9. Comparative Costs.

I have commented about the high costs of certain recommendations and it is quite easy to reject these because of the cost factor. Before doing this, however, I would suggest that some thought be given to the costs associated with the present irrigation practices. No one told me, for example, how much it costs to prepare a field for zigzag or basin irrigation but it may be a sizeable cost. This is an annual cost as compared to a one-time cost such as land leveling. I was told that labor is becoming more scarce and wages are increasing.

Perhaps some comparative cost studies would be in order when considering the feasibility of new methods of irrigation, and keep in mind that these new methods should be equally effective for other crops now irrigated by zigzag, basin and wild flooding.

I have touched only briefly on the collection of data. It is recognized that much detailed data will be obtained from research phases of the irrigation project. From irrigation demonstration work it is suggested that as much data as possible be obtained. This should include comparative yields, labor saved, etc. Such information will be needed if results are to be satisfactorily extended from research and demonstration to farmer use. Anticipate what information they will want before they are willing to accept a new practice. They are likely to want more than what they can see.

SUMMARY

Maximum wheat production will not be attained in Jordan until all new and proven management techniques are used by farmers. These include new and improved varieties, weed control, chemical fertilizer, better equipment such as grain drills and improved irrigation practices. Much information has been accumulated by research and demonstration and many of the new practices are recognized by farmers as being better and are being used to some extent. The one area where technology has not been developed is the irrigation of wheat. Until this is done and combined with other improved technology, maximum wheat production will not be possible.

Suggestions offered in this report following a very short visit to the area are in support of a developing research project for irrigated wheat in Jordan. Some of these should be superior to present irrigation methods. There may be areas where, because of terrain, the present methods may still be the best way. Hopefully some of these suggestions will be helpful.

Again, I must emphasize that many of the foregoing suggestions are costly, necessary equipment is difficult to attain, and can only be accomplished over a long-time basis.

However, trained personnel are now available to provide the necessary leadership for the implementation of these potential improvements for irrigated wheat production in Jordan. Hopefully this program can move forward.

SOIL FERTILITY RESEARCH ON WHEAT IN JORDAN

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AGENCY FOR INTERNATIONAL DEVELOPMENT

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A. PURPOSE OF VISIT

The purpose of this visit to Jordan was to study the soil fertility research needs of the wheat project being conducted by the Agricultural Research and Extension Department of the Jordanian Ministry of Agriculture. The trip was undertaken as part of the USAID/OSU Contract for Wheat Research and Production in Jordan. I arrived in Jordan on 23 February 1975 and departed on 17 March 1975. During this time I observed the results of the current program of the wheat project, made numerous on-site evaluations of experiments and demonstrations, and discussed research methods and priorities with counterparts in the Department of Agricultural Research and Extension.

B. BACKGROUND

Because of the similarity between the dryland wheat areas of Jordan and the Pacific Northwest, the earlier stages of the wheat project were primarily concerned with determining the degree to which the production technology developed in the Pacific Northwest could be adapted to wheat production in Jordan. Both areas have a winter rainfall pattern, similar cropping systems (i.e., wheat-fallow) and somewhat similar soil problems. Several hundred demonstrations have been conducted in the past eight years, and these have conclusively shown that dryland technology can indeed be applied to increase wheat production in Jordan from a biological standpoint. When improved varieties are used and when modern methods of summer fallow (moisture conservation), seedbed preparation, seeding, fertilization and weed control are practiced, yields have been increased 50 to 100% over surrounding grower fields. While these results have been spectacular, further increases are entirely feasible through research.

As expected, the Pacific Northwest technology is not entirely transferable to Jordan since there are important soil and climatic differences between the two areas; thus research is needed to fill specific gaps in this technology as it is applied under Jordan conditions.

In the area of soil fertility, there are four problems identified requiring specific research information: nitrogen, phosphorus, sulfur, and potassium in that order of priority. Current research in Jordan indicates that nitrogen and phosphorus are the most critical limiting nutrient elements and initial emphasis should be placed on these. Sulfur responses are not likely to be prevelant until nitrogen and phosphorus needs are met and production levels substantially increased. Potassium supply in the few soils where data are available seems adequate in the near term. However, both sulfur and potassium should be monitored carefully since as production improves, greater stress will be placed on native supplies of these two nutrients in the soil over time. Each of these four nutrients will be discussed in detail in separate sections below.

C. NITROGEN

The key fertilizer element in dryland wheat production is nitrogen. Because moisture is usually limiting production the rate of nitrogen fertilizer must be balanced with the available moisture. Excess nitrogen results in excess vegetative growth which in turn uses up the available moisture before the crop matures and yields are thus reduced. The idea is to find the nitrogen rate that results in maximum production of grain with the water variable in each of the major rainfall zones where wheat is grown. In the rainfall range from about 225 to 375 mm, alternate crop-fallow is probably mandatory for a stable cereal production and the rate of nitrogen needed will have to be related to stored soil moisture plus

that which falls during the crop year. Therefore, determining the amount of moisture conserved by the fallow system is an integral part of this research.

In the 375 to 450 mm rainfall range, there is the possibility of alternate wheat-lentils (or some other crop that requires less water than wheat). Some moisture can probably be conserved in the deeper soils under the non-cereal crop and this moisture must be taken into account in determining the nitrogen rate for the following wheat crop.

Finally, in rainfall regions above about 450mm, annual cropping can be practiced and the nitrogen rate will be determined largely by the rainfall occurring during the current year.

These rainfall ranges are only approximate and it should be understood that there is no sharp break between them and there is a continual gradation. They are, however, useful guides for research planning and as more information is available the ranges can be more precisely defined. The approximate ranges are based on the current Jordan data and what we know from the Pacific Northwest. There is some indication that available moisture is somewhat more efficient in Jordan than in the Pacific Northwest, but this is only a guess without concrete data.

The basic approach is to divide the dryland wheat region into these three rainfall zones and to run a series of experiments over several years to determine the best nitrogen rate. These experiments should be run on the sites used in the demonstration program since these afford the best control over the land. The design should be as simple as possible so that more locations can be used rather than a few complex experiments on a few locations. All limiting factors other than moisture and nitrogen should be eliminated to the extent possible. A blanket application of banded

phosphorus should be used so that phosphorus is not limiting. The rate of P should be sufficient to insure adequate P is available, even though this may be a rate not in general use in the area. A blanket application of sulfur should also be applied unless single superphosphate is the source of P. If the soil test for potassium is below about 75 to 100 ppm then a blanket application of K might also be considered. Only those sites where a good stand is obtained and good weed control is practiced should be used for these experiments. Five rates of nitrogen, replicated at least four times will suffice to establish the yield curve at any location. There is no need for factorial experiments with other nutrients at this stage. The idea is to determine the nitrogen rate when all other factors except moisture have been taken care of.

Considerable year-to-year variation in nitrogen response can be expected since moisture will vary from year to year. Thus a number of years' data will be required to establish the optimum nitrogen rate to recommend. The recommended rate will be that rate which is optimum for the average moisture conditions in that rainfall zone. This means that in the dry years, there will be some excess of N and in the wet years some deficit of N since fertilization decisions are made prior to planting. Nothing can be done about the dry years but spring top dressing can be done in the wet years to take advantage of the available moisture.

After the initial series of experiments to establish the optimum nitrogen rate, a few experiments each year should be run to monitor the nitrogen needs to refine the recommendation and to keep it current as productivity hopefully increases through new varieties, etc.

The procedure is essentially the same for determining the nitrogen rate needed for irrigated wheat except that moisture is no longer limiting. Generally the problem under irrigation is to determine the nitrogen rate

that results in maximum yield without losses due to lodging.

Unfortunately, there is no reliable soil test for relating the nitrogen response to soil nitrogen. Thus the calibratoin of soil test information as a predictive tool for fertilization is not very likely at this stage in Jordan.

D. PHOSPHORUS

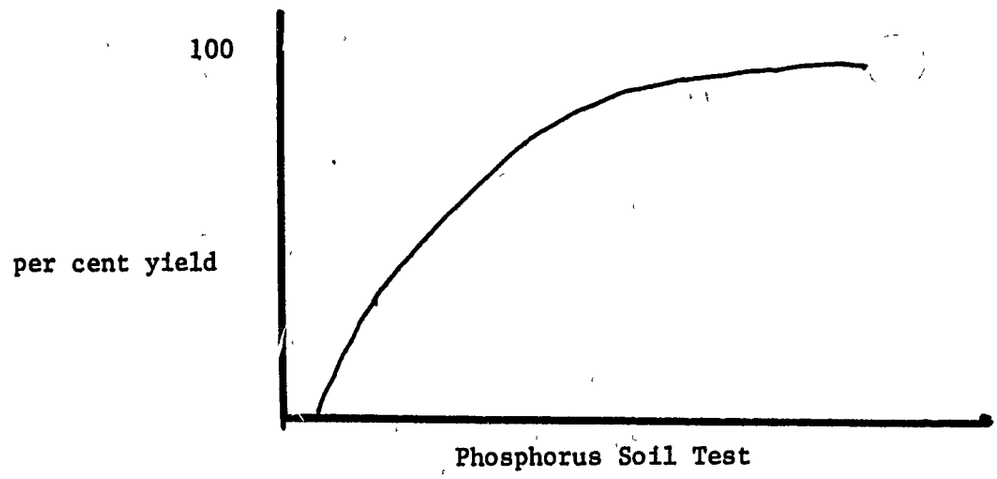
The limited soil test information and phosphorus response data in Jordan suggests that phosphorus deficiency may be widespread in the dry-land wheat areas especially in the red soils of the higher rainfall zone. The major emphasis of phosphorus research should be on calibrating a soil test so that predicting the areas where phosphorus responses are expected can be made on the basis of soil analysis rather than on extensive field experiments.

Again, a simple experimental design is preferred over the complex factorial type experiment since it yields the maximum calibration data for the cost. The simple experiment is designed to answer a single question, "Do I get a response to phosphorus?" Two treatments are needed: (1) no phosphorus and (2) a rate of phosphorus that will give a response if phosphorus is limiting. Sufficient replicatoin is needed to insure precision, about six or so replications should suffice. By using the simple design it is possible to run the experiments at many locations without excessive costs.

All factors other than phosphorus should be optimized as much as possible. The nitrogen-moisture balance should be maintained over the whole experiment. Sulfur should be applied over the area and potassium should be added if it is low. Only sites under good management should be

used where a good stand and good weed control is available. Again, the demonstration sites are probably the best.

The soil from the zero phosphorus plot is used for the soil test to relate response to phosphorus to the laboratory measurement. Each location will give a single data point to construct the calibration curve. The locations should cover a range of soil test values so that the critical soil test level can be identified. The data are plotted as follows:



Percent yield is the yield of the zero phosphorus plot divided by the yield of the phosphorus fertilized plot multiplied by 100 if the zero phosphorus yielded less than the phosphorus plot, that is, if a phosphorus response was obtained. If there was no response, the zero phosphorus plot yielded the same as the phosphorus fertilized plot and the percent yield will be 100. The objective is to determine the soil test value where soil phosphorus is adequate so that it can be used to predict the need for P fertilizer.

There may be a scatter of points around the curve especially at the low soil test levels; however, above the critical level it should be less variable. If the data are too variable to identify the critical soil test

value, then some factor other than phosphorus deficiency is involved. In this case, the other factor must be overcome or calibration is not possible. Severe drought years will probably need to be discarded since moisture limitation will be so severe that phosphorus response will not be seen even if the soil is phosphorus deficient.

Choice of the soil test to use is somewhat arbitrary. The important point is that whatever test is used must calibrate with the field response from phosphorus. The sodium bicarbonate method of Olson has been successfully used in calcareous soils and is the most logical one to use in Jordan. Other tests may be tried since the laboratory costs are relatively minor compared with the field costs. A value of 10 ppm on the Olson test has been used in the U.S. on wheat and this value can be used as a guide to base the initial work on in Jordan. Once a value has been identified for Jordan then that value is used to predict where phosphorus responses are likely to occur in Jordan.

Phosphorus should be banded near the seed at planting since broadcasting may not give the desired response even on a deficient site.

Additional experiments are needed to determine the optimum rate of phosphorus to apply. These experiments can be done on a relatively few responsive sites identified by earlier experiments or by soil test. These experiments should have four or five rates of phosphorus, replicated four times. Generally, the lower the soil test value the higher the rate of phosphorus needed, but this relationship should be verified for Jordan soils.

E. SULFUR

The most likely areas for sulfur responses are in the higher rainfall zone and where production is relatively high. Unfortunately, soil tests

for sulfur are not very good and the chances of a successful calibration are not high. A few experiments comparing zero sulfur with sulfur fertilization in a simple experimental design in the areas most likely to respond will show if sulfur is a major problem. If sulfur responses are rare, an occasional simple experiment can be run to monitor this nutrient without great expense. If a significant number of locations respond, then there needs to be a carefully planned series of the two plot type design in 5 or 6 replications used to delineate the geographical area that is responsive. These experiments should eliminate other factors such as nitrogen, phosphorus or potassium and be on sites with good stand and weed control so that sulfur is the only potential limiting factor. Only then can a valid sulfur response be measured.

Correction of sulfur deficiency is quite easy once a response is shown. Sulfur and nitrogen are both components of plant protein and occur in a ratio of about 12 or 15 parts of N to 1 of sulfur. The sulfur rate can thus be calculated if the nitrogen rate is known for those areas where sulfur is required. Usually 10 kg of sulfur is adequate for one or two crops of wheat. This can be verified by a few experiments. No extensive experimental program seems to be required unless sulfur responses are widespread.

In the area where lentils are grown, sulfur is more likely to be needed on the lentils than on the wheat. If lentils do not respond to sulfur then the wheat is most likely adequately supplied.

F. POTASSIUM

The potassium status of Jordan's wheat soils seems adequate on the basis of limited soil data available. Usually, ammonium acetate extractable potassium is a reliable measure of available K. The K levels should be monitored by soil test and if sites are found having less than

about 75 to 100 ppm K, then experiments can be put on a few of these sites. The simple zero K vs K fertilizer with other factors not limiting will tell whether there is a problem needing more extensive research. If K responses are found then an approach identical with phosphorus can be followed to calibrate a potassium soil test to determine the critical soil test value for Jordan wheat soils.

G. FACTORIAL EXPERIMENTS

Factorial experiments should be avoided in the initial stages of this program since they are complex, expensive, and do not yield as much information for the cost as a larger number of very simple experiments at a larger number of locations. This is not meant as a criticism of the very fine NXP factorial experiments established at Irbid, Madaba and Shouback by Mr. Abu-Rub. These factorial experiments were well designed and well carried out and, except for the unfortunate loss of stand at Shouback, will yield very useful informatoin. However, they result in only one point each on the phosphorus calibration curve for soil testing and thus are premature. When the nitrogen and phosphorus research outlined in C. and D. above is further along, then a few factorial experiments on known responsive sites will help work out the rate of these two nutrients more precisely. The factorial approach should be delayed until there are better predictive methods available to identify where nitrogen and phosphorus responses occur.

H. DISCARDING EXPERIMENTS

Any experiment that has a severe weed problem, poor stand, poor management, severe disease or other identifiable problem should be discarded. Including data from poor experiments will only reduce the chances of developing predictive methods of nutrient response. The

natural tendency for all of us is to attempt to salvage a bad experiment. Each of us has some bad experiments that fail through no fault of our own, and we should not hesitate to discard them. No one should criticize a researcher for abandoning a failure.

I. USE OF SOILS LABORATORY

Mr. Abu-Run is a very capable soil fertility researcher, but he needs additional technical support to handle the number of locations where the experiments outlined above are to be conducted. He should also have help in sampling the soils at each location and the soils laboratory should provide the analysis before the experiment is put out if at all possible. Research in the soils laboratory on basic or pure research should not be done at the expense of the applied, problem solving type of field research. Jordan's needs are in increasing production of food and this needs immediate attention. In my visits with the soils laboratory staff, I was impressed with their technical knowledge of laboratory procedures, their willingness to learn, and their desire to produce. These attributes are badly needed to support the field program in soil fertility.

J. TRAINING AND ASSISTANCE

Mr. Abu-Rub could benefit from a counterpart training program for several months in the Pacific Northwest during the time that soil fertility experiments are being planned and established in the field. This would give him a chance to work closely with an established scientist on an active soil fertility program. The highest priority at this time, however, is for the wheat soil fertility program in Jordan to become fully operational before Mr. Abu-Rub is absent from the program.

I stopped in Beirut, Lebanon for one day of conferences with Ford Foundation personnel and with Dr. Antoine Sayegh of AUB. Dr. Sayegh has been working with the soils program in Jordan and is conveniently located and ably trained to help the Jordanian program. I discussed the contents of this report thoroughly with him and we fully agreed on the priority and strategy needed in the soils program in Jordan. He should be invited to Jordan at least twice a year to assist with this program. Without some outside technical assistance, the soil fertility program may not reach its full potential in a reasonable time frame, largely because of the limited base available on which to build a program. Mr. Abu-Rub is a dedicated researcher, a hard worker, knowledgeable, anxious to learn, but he needs the advice and help of an experienced soil fertility researcher to fully develop his talents.

K. GENERAL OBSERVATIONS

Although I was in Jordan to assist with the wheat soil fertility program, I did have the opportunity to see other aspects of the wheat project. Some observations are:

(1) A large number of demonstrations have been conducted and these show that a package of practices can be used in Jordan to substantially increase wheat yields. The biological feasibility has been adequately shown but only one grower in Jordan has adopted these practices. Farmers attend field days and are shown the results; therefore, some economic or structural constraint seems to be inhibiting adoption. This needs to be studied to identify the limiting reason for slow adoption of these practices. The use of herbicides has seemed to catch on; therefore, the growers are not reluctant to accept innovation.

(2) Animal use of wheat lands is not very compatible with developing a modern wheat technology. The animal grazing pressure must be dealt with if moisture conservation practices are to be successful. This will mean development of alternate sources of forages.

(3) Researchers on the wheat project and in the Soils Section need to be equipped with spades and soil augers so that each can have a set under his direct control at all times. The cost would be minimal. The researchers need to get into the habit of examining the soil below the surface when they are in the field since many problems can be diagnosed this way. For instance, the very poor stands on demonstrations in the Irbid area this spring were due primarily to overly deep seeding. This was not evident until examination of the soil in depth was undertaken.

(4) Mr. Amin Abushaer is a very capable leader of the wheat project. He should be relieved of other duties if at all possible so that he can concentrate on the wheat program. This is admittedly difficult since he is a dey senior man in the department. The wheat project is at the stage where it needs to move away from the demonstrations on such a large scale and move into researhc designed to fill the information gaps in the package of practices. Some demonstrations should continue as they are very useful for Extension functions.

The department if very short on experienced senior research personnel. A number of the young researchers have good potential but need the guidance of a man like Mr. Abushaer and senior technical assistance from some agency such as AID or a university. Mr. Abushaer would benefit from a Ph.D. program in the U.S., but it is difficult to see how he can get away for the three to four years needed. If, as the younger staff matures some, another leader can be identified for the wheat project, it is recommended that

Mr. Abushaer be given an opportuntiy to pursue a Ph.D. The department would benefit immensely by having him in a senior research leadership role.

COMMERCIAL HERBICIDE APPLICATION IN JORDAN

by Leonard Haldorson
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Agency for International Development

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This is the report of a commercial custom spray operator and herbicide dealer employed by Oregon State University to provide his services and experience to the Government of Jordan. This is the second trip to Jordan; a two-month period was previously spent in Jordan in late 1969. The purpose of both trips was to encourage and help develop custom herbicide spray businesses in Jordan and help farmers and co-operatives to do their own spraying.

PROGRESS SINCE 1969 TRIP

During the trip in 1969, political and business conditions were very unsettled. Farmers, herbicide dealers and potential custom sprayers were reluctant to make investments in new equipment and supplies. Now the attitudes of all have changed to a more positive position. Herbicide and equipment dealers have more adequate inventories and have asked many questions about methods and items to improve their services.

Weed seminars were given in four areas of Jordan. They were at Rabba, Irbid, Jubieah and Salt. New extension agents were instructed in sprayer calibration at Wadi Yabis. There were 265 farmers, 100 students, and 120 extension personnel at the five meetings. Other seminars were scheduled but heavy snowfall prevented completing them. At the end of this report is attached a typical talk given at the weed seminars.

PROCEDURE FOLLOWED

Cooperation of the people heading up the Wheat Project made it possible to visit the main wheat producing areas of Jordan. Visits were made to the Ministry of Agriculture, Department of Plant Protection, to most district extension offices, the Jordan Co-operative Association, the Co-operative district offices in Irbid, to many herbicide and equipment dealers in Amman

and Irbid, and many of the larger farmers. At each visit emphasis was to inform the audience how our experiences could be related to similar conditions in Jordan. One area of good business practice observed was that of making spray tanks in Jordan for their sprayers because of high shipping costs of bulky tanks. During this trip people that I worked with in the extension and research area and in the private sector were much more knowledgeable about the use of 2,4-D. Farmers I visited asked questions that indicated much greater knowledge of herbicides.

Many of the larger farmers own or are purchasing sprayers of their own. In Jordan there are few large farms and most of the production of wheat comes from small farms. To provide the opportunity for these small farmers to use sprayers to apply 2,4-D was our greatest concern. Progress in this area was noted in the Irbid district. Three new co-operative associations in the Irbid district have signed up 250 members. These members have 14,000 dunums of wheat planted and they intend to spray it all if needed. They have ample spray equipment to do this spraying. Also there are several contract sprayers operating in this district.

Many of the fields in the upland areas are very small and steep. Knapsack sprayers are used here. One dealer reported selling 100 knapsack sprayers last year mostly to be used for 2,4-D spraying. Many of these are equipped with a 2-meter boom which speeds the spraying to an efficient level on these steep and rocky fields. These booms are similar to ones described in my 1969 final report.

In the other districts of Jordan, co-operatives are just being formed but will do no spraying this year. It is hoped they will expand so the small farmers will have an opportunity to avail themselves to modern technology in wheat production. Several contract sprayers have started businesses in the Amman and Karak areas. It is hoped they will expand their business to keep pace with interest shown by the farmers in this service. These contract

sprayers will need continued help and education from the extension and research people as well as help from the chemical companies. These contract sprayers are handicapped by lack of business experience and poor history of collection policies from the farmers.

SPRAY EQUIPMENT

Observations of spray equipment in Jordan would indicate that ample equipment is available to do the job this year. Efficiency of the sprayers is limited by small fields and the rough and stony conditions of the fields. Sprayers with stronger frames and booms will be necessary until better tillage practices are adopted.

The importing of basic spray kits including pump, bypass, and control valves, and then building the rest of the sprayer in Jordan will give the dealers an opportunity to develop sprayers suited for the different conditions found in Jordan.

A lack of clean water close to the fields will make it necessary for the spray contractor or applicator to invest in supply tanks and pumps. The spray season is limited in time and good weather to spray. It is important then to have water available in the field for maximum efficiency of the spray equipment.

SUMMARY AND RECOMMENDATIONS

Much progress in the use and application of 2,4-D has been made since 1969. The number of dunums sprayed with 2,4-D has approximately doubled each year. With the drought conditions in 1973, fewer fields were seeded to wheat. The use of 2,4-D did increase even under these adverse conditions. Weather

conditions for seeding wheat in 1974 were very good and more areas are being seeded to wheat. The only problem of spraying in 1974 may be too much rain which will make the fields too wet for spraying before the wheat is too large to spray.

More research is needed in several areas. There should be continued research on time of spraying with 2,4-D and with other chemicals and combinations of chemicals. The Jordan Valley will continue to grow wheat and an alternative chemical to 2,4-D should be selected very soon. Bromoxynil alone or in combination with other low volatile chemicals should fit this situation. Research on time and rates of applications should be done as soon as possible so the use of 2,4-D can be phased out in this area of many 2,4-D susceptible crops.

Continued exchange of information between the extension and research people and the private chemical companies in private business, the University of Jordan and Extension and Research Department should be encouraged. As new chemicals are introduced to Jordan, problems of where, when, and how much to use will have to be resolved by all of these people cooperating jointly.

The education of the people inexperienced in the application of 2,4-D will have to be continued. Short courses for applicators of 2,4-D should be expanded as much as possible. These short courses should include business principles for new contract sprayers and new cooperative managers. In the near future simple tests to evaluate the knowledge of commercial applicators should be given at the beginning of the spray season. This should be done at the end of a short course session. From these tests future short course topics can be arranged to cover areas needing more emphasis.

1970 CALCULATIONS OF SPRAYING COSTS
(Does not include cost of chemical)

	Fixed Costs	Cost per Season	Cost/Dunum Based on 4000 dun/yr.	Cost/Dunum Based on 6000 dun/yr.
(a)	1. Int. on Capital	JD 20	.005	.0035
(b)	2. Depreciation	80	.020	.0135
	Direct Cost			
(c)	1. Labor	90	.0225	.015
(d)	2. Maint. & Repair	60	.015	.010
(e)	3. Water	80	.020	.0135
(f)	4. Fuel & Oil	42	.0105	.0065
(g)	5. Tractor Rent	180	.045	.030
	Gen. & Adm. Cost			
(h)	1. Adm. Cost	18	.0045	.003
(i)	2. Contingency	30	.0075	.005
	TOTAL	600	.150	.100

(a) 400 JD @ 10% divided by 2 = JD 20
(Sprayer, water tank and trailer cost JD 400)
(b) 5 yrs - 400 JD
(c) 45 days * 2 Man * JD i each
(d) 15%/year
(e) estimate
(f) for travel and water hauling
(g) 45 days - 4 JD/day
(h) 20% of labor cost
(i) 5% of total cost

(7 M sprayer @ 4 mph will spray 40 dun/hr. Sprayer operating 5 hrs. will spray 200 dun. 20 days will spray 4000 dun. 30 days will spray 6000 dun.)

This cost chart was developed to be used as a guide for custom sprayers and other interested people and is not intended to suggest final charges. Conditions in Jordan were considered in developing this chart but each operator will have to use his own computation to make a final cost determination. No profit is figured here but it is assumed that .050 would be an acceptable figure. Good and reliable service can be expected only when the businessman is making a profit. Competition will adjust these prices if they are found to be too high.

SEMINAR TALK AT IRBID

It is my privilege to talk to this group of people. I am a private businessman from America. I have sold and applied herbicides for almost 25 years. I have been invited to your country to share my experience with you. I was raised on a farm and have worked with farmers all my life. I have served on the Extension Advisory Council in my area, the Oregon Wheat Growers League, and helped extension research specialists to establish and evaluate research plots. Close cooperation with these people is very important for my business as well as for the farmers.

I am working very closely with the people involved in the Wheat Project. I am also working with the Plant Protection Division of the Ministry of Agriculture and with the dealers of chemicals and spray equipment in your country. Chemical weed control is just one of the package of practices being encouraged by the Wheat Project. Improved tillage, improved seed, summer fallow methods, the use of grain drills, the use of fertilizer, and the use of 2,4-D for weed control are some of the practices that will help increase wheat production in Jordan. I will explain later in my talk why many of these practices must be used together.

I am going to talk to you briefly today about the chemical 2,4-D for weed control in wheat. I will explain why the use of 2,4-D, how to apply it, how much to use, when to use it, and the benefits of its use. Later we will have time to answer questions from the audience.

The use of 2,4-D to control weeds in wheat was introduced to your country several years ago. High cost of labor for hand weeding and damage to the wheat and soil by laborers in the field has made this practice less useful. Also, weeds big enough to be pulled have used much moisture and nutrients that the wheat should have. Yields of wheat have been increased 25 to 50 percent when 2,4-D was used to control the weeds. Weeds rob soil moisture

and nutrients from the wheat even when the weeds are very small. It is important to remove the weed competition as early as possible. Spraying of 2,4-D should be done when the wheat has reached 15 to 20 cm in height and most of the weeds have germinated. Spraying of 2,4-D should never be done after wheat is in the boot stage or earlier than 15 cm in height. The use of grain drills is important to give even germination of the wheat. The wheat will be all the same size then so earlier spraying may be done without injury to the wheat. Wheat may be injured and yields reduced if sprayed at the wrong time. Farmers that use fertilizer on their wheat should certainly consider the use of 2,4-D so the fertilizer is available to the wheat and not to the weeds. Weeds like fertilizer and moisture even more than wheat, so 2,4-D can protect the investment in fertilizer.

Now we should talk about how to apply 2,4-D and how much to use. On larger fields a tractor-mounted or trailer-mounted boom sprayer can be used. Booms of 6 to 10 meters can be used. Spray nozzles are spaced about 50 cm apart along the boom to give an even application of the water and 2,4-D mixture on the weeds. An even application is necessary to make sure some chemical gets on every weed plant. Normally 18 to 20 liters of spray mixture per dunum will give good coverage on all weeds. Uneven soil conditions will make the booms bounce and swing and the application of the chemical mixture will not be the same to all weed plants. Also, there will be much breakage to the spray machine. Therefore, improved tillage methods to smooth the seed-bed and the use of grain drills will speed up spraying and give a more even application of chemical. On fields that are uneven, the tractor will have to travel very slowly. Fields that are too small or uneven for tractor sprayers can be sprayed with knapsack sprayers equipped with 1 1/2 to 2 meter booms. Tractor sprayers and knapsack sprayers are available from dealers in Amman and other major cities.

It is very important to use clean water in preparing the spray mixture. The spray nozzles have a very small orifice and will clog easily if water with

sand or foreign material in it is used. A strainer should be used when the water is put into the spray tank and another strainer used between the tank and spray pump. The spray nozzle should never be cleaned with a wire or metal of any kind. Use a stiff brush or small twig to clean the nozzle. Metal will deform the nozzle and cause an uneven application of chemical. Nozzles should be adjusted evenly on the boom and the boom at the proper height to give an even spray application through the full length of the boom.

Rates of chemical to use per dunum will vary according to the number or size of the weeds and the species of weeds. Three kinds of 2,4-D are available in Jordan. They are sodium salt, amine, and ester. Sodium salt is a powdered product with 80% active ingredient. The products should be used at the rate of 150 to 200 grams per dunum. Amine 2,4-D is a liquid and is sold in two formulations. One has 400 grams per liter and the other 600 grams active ingredient per liter. The 400 gram per liter product should be applied at the rate of 120 to 200 ml per dunum and the 600 gram per liter product at the rate of 80 to 120 ml per dunum. Ester formulations are usually a 600 gram per liter formulation and should be used at the rate of 70 to 100 ml per dunum. Before a farmer uses 2,4-D the first time, he should ask his extension agent or extension weed specialist to look at the fields with him so the extension personnel can make a recommendation to suit the fields.

The amine formulation of 2,4-D should be the most widely used in Jordan. The ester formulation is volatile and forms a vapor that can drift to adjacent crops. At no time should ester formulations of 2,4-D be used in the Jordan Valley. In other areas ester should not be used next to crops sensitive to 2,4-D such as lentils, tomatoes, and grapes. No spraying should be done when winds are 10 km per hour or greater regardless of the formulation used. Actual spray drift must be kept from drifting onto bordering crops. The product 2,4-D is capable of killing any broadleaf plant so you must use caution in using 2,4-D in areas where broadleaf crops are being grown at the time of spraying.

I will continue to encourage the Plant Protection Department to do further research with 2,4-D and with other weed killing compounds and to help the chemical dealers to keep informed of this research. All of you present will benefit from cooperation between research, extension, private sector, and the farmer.

Briefly, we have covered a very large topic. We have talked about the proper equipment to use and some of the care of the equipment. The proper time to spray and the rate to use have been covered. We should remember the hazards of 2,4-D as well as its benefits. The benefits are many and use of 2,4-D can mean much to help increase wheat production.

In summary, I know we are all aware of how important increased wheat production is to Jordan. It is important to all people of the country to have adequate food. Important to the government to reduce cost of imported food. Important to the farmer to make more money and have a better way of life. We hope the use of chemical weed control in wheat as well as the other practices we have talked about will help to give this necessary increase in wheat production. I want to thank all of the people who have made my visit to Jordan a very pleasant time of my life. Thank you again.

Economic Evaluation of Dryland Wheat Technologies Introduced in Jordan

Prepared
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INTRODUCTION

Since 1967 Oregon State University, USAID, and the Government of Jordan have participated in what is known as the Jordan Wheat Project. The fundamental objective of this effort is to increase domestic wheat production through the introduction of advanced dryland wheat production techniques. These techniques are basic to dryland wheat production in low rainfall areas of the Pacific Northwest. They include clean summer-fallow, fertilization, dryland grain drilling and chemical weed control.

On farm field demonstrations were selected to introduce production practices to Jordan's wheat farmers. These demonstrations were under the control and management of the wheat project staff. Educational efforts, generally field days, accompanied field demonstrations. Primarily, these efforts were employed to illustrate improved stand and field characteristics of introduced production practices. Demonstrations and allied education efforts were conducted in major wheat producing areas of Jordan on an extensive and continuous basis since 1967; yet the impact of this effort in terms of numbers of adopters of the introduced technologies appear minimal.

The preceding observation raised the questions: is it profitable for Jordan's dryland wheat farmers to adopt the introduced technologies and are the necessary technological inputs available. These issues prompted my visit to Jordan and provided the basis for this report. Observations and recommendations advanced in the report are based on insights gleaned during a four-week site visit in Jordan. As such, they

are subject to error since it is difficult to gain a thorough understanding of the country's dryland agriculture in this short a period of time. Much less would have been accomplished and greater error made if it were not for the valuable insights and assistance obtained from Mr. Gene Winters, Oregon State Wheat Project Coordinator in Jordan and Munther Azär, Agricultural Economist, Ministry of Agriculture, Hashemite Kingdom of Jordan. The errors in understanding and interpretation, however, remain mine.

On-Site Visit: Purpose and Procedure

The prime purpose of the on-site visit was to appraise why dryland wheat production technology was not being adopted by wheat farmers in Jordan. The appraisal was directed toward answering the questions: is it profitable to adopt introduced technologies, and are the necessary inputs available in Jordan's agricultural input markets. To address the profitability issue, the first 10 days of the on-site visit were spent obtaining information about the field demonstration work since this was the only data available which might prove applicable to the issue. Information was obtained in discussions with the wheat project staff and from observations made during visits to several field demonstration sites.

Input availability issues were addressed by interviewing selected organizations and firms supplying agricultural inputs. In these interviews the following areas were probed: current availability of inputs, supply outlook of inputs, competitive nature of the market, institutional constraints affecting the input market and input price. Relevant input markets surveyed included custom machinery services, farm equipment, fertilizer, and farm credit.

In the process of exploring profitability and input availability issues, a third concern was raised—what is required to increase Jordan's domestic wheat production through technology adoption. Recommendations relating to this question are considered necessary although not necessarily sufficient to achieve the objective of increasing Jordan's domestic wheat production through technology adoption. These recommendations are presented and discussed in the final section of this report.

Demonstration Work

Background Information

Since 1967 over 500 non-replicated, dryland wheat demonstrations were conducted in Jordan by the wheat project staff. Demonstrations were of two types--annual and summer fallow. Both types were conducted on a variety of different soils and in different rainfall areas. In some demonstrations, different wheat varieties were used and in some years the fertilizer portion of the demonstration was not conducted because fertilizer was unavailable at planting. All input rates used in the demonstrations were based on hypothesized yield maximizing levels as input-output relationships for wheat grown in Jordan are unknown. These input levels showed only minor variation among demonstrations and years. Demonstration yields were tabulated by new technology and traditional technology packages rather than by individual wheat production practices.

Fallow demonstrations were utilized in relatively limited rainfall areas where fallowing is part of the traditional cropping sequence. In these demonstrations, the advanced technology plot using fertilization, chemical weed control, dryland grain drilling, and clean fallow was compared to an adjacent farmer field cultured in a traditional manner. Clean fallowing typically included one sweep and two or three rodweeding operations during the fallow year. Late in the clean fallow year, a dryland grain drill was used to sow seed and place the fertilizer. In early spring the herbicide 2-4-D amine was applied with a field sprayer, and in mid-summer the plot was sampled and combined.

The adjacent farmer field, depicting traditional production practices was usually deep, disc plowed in the fall. After weed seed germination

in the spring, the field was light, disc plowed. These two tillage operations depict the traditional fallow practice which is commonly called "weedy fallow." After winter rains commenced, wheat was hand sown and covered by a light, disc plowing. If the wheat was unusually weedy, it was hand weeded when it was about 12-15 cm. tall. In mid-summer this plot was sampled and later combined.

Annual demonstrations were conducted in areas receiving sufficient rainfall to support an annual cropping pattern. In these demonstrations, the advanced technology plot using fertilization, chemical weed control, and dryland grain drilling was compared to a check plot which was neither sprayed for weeds nor fertilized but dryland grain drilled. The check plot, except for no herbicide or fertilizer use, did not represent traditional methods of production as new technology chisel and harrow operations and grain drilling of wheat replaced the traditional practice of sowing wheat by hand and then covering the seed by a light, disc plowing. The sequence of cultural practices used in the advanced technology plot included: fall disc plowing and chisel and harrow operations, in early winter wheat and fertilizer placement by a dryland grain drill, herbicide spraying in early spring, and summer harvest. Cultural operations used in the check plot included: fall plowing and chisel and harrow operations, wheat placement by a dryland grain drill in early spring, and summer harvest.

Limitations

Demonstration data only permits a rather crude economic comparison of newly introduced technology packages as the yield response to only one possible combination of inputs of each technology package was determined.

This limitation precluded estimating a production function relationship (yield curve) associated with either traditional or newly introduced technologies and determining the economic optimum combination of inputs of these technology packages. Other limitations associated with demonstration data are also evident. Some technology package comparisons were judged unusable while others might make an economic analysis based on that data difficult to interpret.

New and traditional technology package comparisons were not possible using annual demonstration data because in the so called traditional technology package new technology chisel and harrow operations and grain drilling of wheat replaced the traditional practice of sowing wheat by hand and then covering the seed by a light, disc plowing. This demonstration design did, however, permit measurement of the yield response to fertilization and chemical weed control. But, the response applied to grain drilled wheat and grain drilling of wheat is a newly introduced, as yet adopted, technology whose yield response much less profitability of adoption is unknown. These two limitations precluded a meaningful economic analysis of the annual technology packaged based on annual demonstration yield response data. With the existing demonstration design it is impossible to measure the yield response to fertilization-chemical weed control on hand sown wheat, the yield response of just grain drilled wheat, or the yield response to fertilizer-chemical weed control-grain drilled wheat.

Another limitation which just might be as serious as the preceding limitation applies to both annual and fallow demonstrations. Its consequences, however, appears to be greater in the summer fallow demonstrations. The limitation is that the advanced technology plot of the fallow

demonstration was managed by the wheat project staff while the control plot (i.e., the adjacent farmer yield) was managed by individual farmers. It is my opinion that management of the wheat project staff is far superior to that of most of Jordan's dryland wheat farmers. Accordingly, the yield response attributed solely to the technology package by these demonstrations should be more appropriately attributed to both technology and superior management. Or stated in another way, the yield response to the fallow technology package is somewhat overestimated considering the management skills of Jordan's dryland wheat farmers. The effect of the introduced management is most notably evident in the consistency of the fallow demonstration yield data as measured by yield variance. This statistic indicated that yield variance of the traditional or check plot was in most cases greater than the yield variance of technology plots. This is contrary to most research results on dryland wheat production throughout the world. Just the opposite yield variance situation was noted in annual demonstrations where both the technology and control plot were managed by the wheat project staff (See Appendix Figures A-1, A-2, and A-3). In my opinion the upward biased yield response to the fallow technology would not preclude economic analysis of the fallow technology package, however, the results of the analysis might be difficult to interpret since the magnitude of the biases is unknown.

Economic Analysis

Procedure and Data

A crude economic comparison is used here to provide a first estimation of the profitability of newly introduced technology packages. The standard of comparison is the traditional technology package. In this comparison if returns attributed to a new technology package are greater than the costs of technology adoption, it is concluded that it may be profitable to adopt the new package. This conclusion is based on the assumption that input levels of the traditional wheat production technology package, as used in the demonstrations, are optimal and the package is profitable. A profit comparison appears appropriate in the evaluation of technology packages as Jordan's dryland wheat producers tend to select wheat varieties and production techniques which maximize profits given expected yields, crop prices, production costs, risks, and production constraints.

Partial budgeting procedures are used to estimate additional costs and returns associated with a new technology package. Data limitations prevented using a complete budget approach. Additional returns are the product of wheat price and yield response attributed to a new technology package. This yield response was identified in demonstration comparisons. Additional costs include such direct costs as the additional machinery use and input cost required to adopt a new technology package and indirect costs reflected in opportunity costs. Crop value and input costs used in the analysis are specific to the 1974-75 crop year and to average to larger than average dryland wheat farms. These farms are of particular interest as it is hypothesized that they would be some of the first of Jordan's farmers to be able to profitability adopt new wheat production technologies.

Only yield data of fallow demonstrations are subject to economic analysis since it was concluded that introduced yield bias precluded a meaningful analysis of the fertilization-chemical weed control technology package. Furthermore, only fallow demonstration data from major wheat producing areas of Jordan are evaluated. These areas represent the governorates of Amman, Irbid, and Kerak. In preparation for analysis, fallow demonstrations by governorate were classified as to general soil type, rainfall area, wheat variety, and seeding, fertilizer, and herbicide application rate. Demonstrations conducted on similar soil types in comparable rainfall areas with similar or consistent input levels are analyzed. Input levels and yield results of these individual demonstrations are presented in Tables 1-3. Individual yields are averaged on an annual basis (kg./du.) by traditional and technology plot and annual average yield differences between technologies by governorate appear in Tables 4-6. Yield variability associated with these average annual yields by technology package and governorate are illustrated in Figures 1-3.

Changes in itemized and total additional cost of adopting the fallow technology package in Amman, Irbid, and Kerak governorate are shown in Tables 7-9. Direct costs include machinery use charges based on custom rates and fertilizer and herbicide costs. Custom rates rather than machine ownership plus variable operating charges were used to reflect machine costs as a preliminary analysis (see Appendix B) indicated that for almost all of Jordan's average to larger than average sized dryland wheat farms custom service purchase was the least-cost method of acquiring machine services. Indirect costs are reflected as opportunity costs. The assumption is that this cost is 10 percent

Table 1. Input Levels and Yield Results of Fallow Demonstrations Conducted in Amman Governorate, 1968-73.

Crop year	Village	Rainfall m.m.	Fertilization rates N kg./du.	Fertilization rates P_2O_5 actual	2-4-D rate gms./du.	Yield (kg./du.) New technology package	Yield (kg./du.) Traditional technology package	Incremental yield response to new technology kgs./du.
1968-69	TUNAIB	408	5.0	3.3	100	211	92	119
196[illegible]-70	HISBAN	232	3.6	2.9	100	238	157	81
1970-71	TUNAIB	416	2.0	1.7	100	151	97	54
	LIB	360	1.9	1.4	100	127	82	45
1973-74	HISBAN	---	3.6	2.1	100	295	197	98
	LIB	---	3.3	2.1	100	160	101	59
	SAHAB	---	2.6	1.7	100	191	178	13
Average Input			3.1	2.2	100			

Table 2. Input Levels and Yield Results of Fallow Demonstrations Conducted in Irbid Governorate, 1968-73.

Crop year	Village	Rainfall m.m.	Fertilization rates N kg./du.	Fertilization rates P_2O_5 actual	2-4-D rate gms./du.	Yield (kg./du.) New technology package	Yield (kg./du.) Traditional technology package	Incremental yield response to new technology kgs./du.
1968-69	RAMTHA	293	3.5	2.4	100	165	110	55
	RIHAB	318	5.0	3.2	100	125	80	45
1970-71	RAMTHA	330	4.0	2.1	100	99	60	39
	RIHAB	220	2.8	1.7	100	106	43	63
1972-73	RAMTHA	196	3.6	4.6	100	101	27	74
1973-74	NU'AMEH	220	2.4	2.3	100	151	144	7
	RAMTHA	250	1.8	2.0	100	125	94	31
	RAMTHA	220	1.5	1.9	100	185	150	35
	HUSSON	250	2.3	2.6	100	145	110	35
	KABAR	220	2.3	2.5	100	168	142	26
Average Input			2.9	2.5	100			

Table 3. Input Levels and Yield Results of Fallow Demonstrations Conducted in Kerak Governorate, 1968-73.

Crop year	Village	Rainfall m.m.	Fertilization rates N kg./du.	Fertilization rates P_2O_5 actual	2-4-D rate gms./du.	Yield (kg./du.) New technology package	Yield (kg./du.) Traditional technology package	Incremental yield response to new technology kgs./du.
1968-69	RABBA	247	3.6	2.5	100	216	163	53
	TAFILEH	225	2.6	1.7	100	141	131	10
1971-72	HUMUD	405	1.2	1.7	100	133	79	54
1972-73	RABBA	300	2.6	2.0	100	136	79	57
	HUJRA	250	3.3	3.3	100	179	54	125
1973-74	HUMUD	200	2.6	1.7	100	174	76	98
Average Input			2.7	1.8	100			

Table 4. Average Annual Yields of the Technology and Traditional Package of Fallow Demonstrations Conducted in Amman Governorate, 1968-73.

Crop year	Technology package	Traditional or check	Response attributed to technology
	kgs./du.		
1968-69	211	92	119
1969-70	238	157	81
1970-71	139	90	49
1973-74	215	159	56
Average Yield	201	125	76

Table 5. Average Annual Yields of the Technology and Traditional Package of Fallow Demonstrations Conducted in Irbid Governorate, 1968-73.

Crop year	Technology package	Traditional or check	Response attributed to technology
	kgs./du.		
1968-69	145	95	50
1970-71	103	52	51
1972-73	101	27	74
1973-74	155	128	27
Average Yield	126	76	50

Table 6. Average Annual Yields of the Technology and Traditional Package of Fallow Demonstrations Conducted in Kerak Governorate, 1968-73.

Crop year	Technology package	Traditional or check	Response attributed to technology
	kgs./du.		
1968-69	179	147	32
1971-72	133	79	54
1972-73	158	67	91
1973-74	174	76	98
Average Yield	161	92	69

Figure 1. Yield Variability, Fallow Demonstrations: Amman Governorate 1968-73.

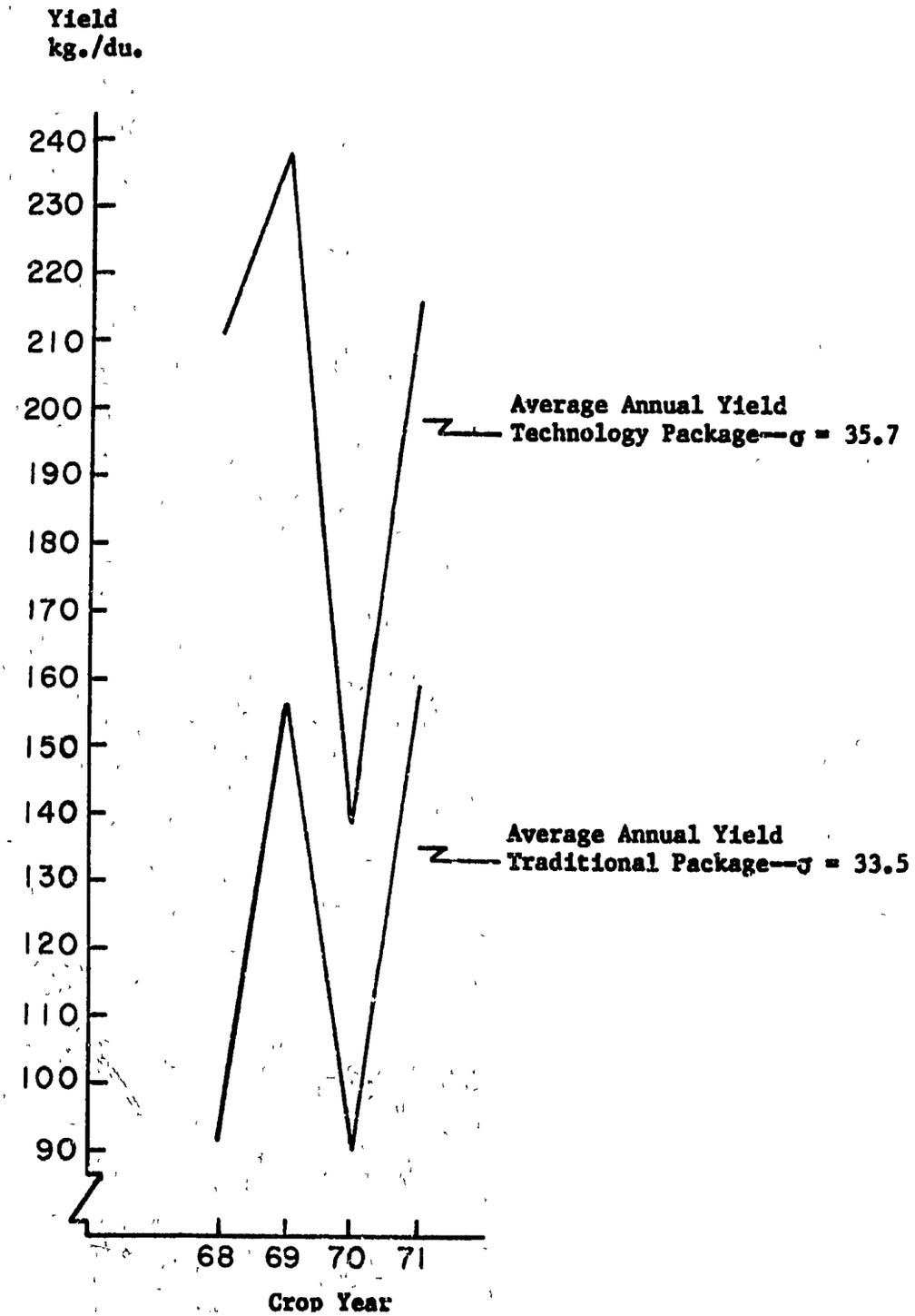


Figure 2. Yield Variability, Fallow Demonstrations: Irbid Governorate, 1968-73.

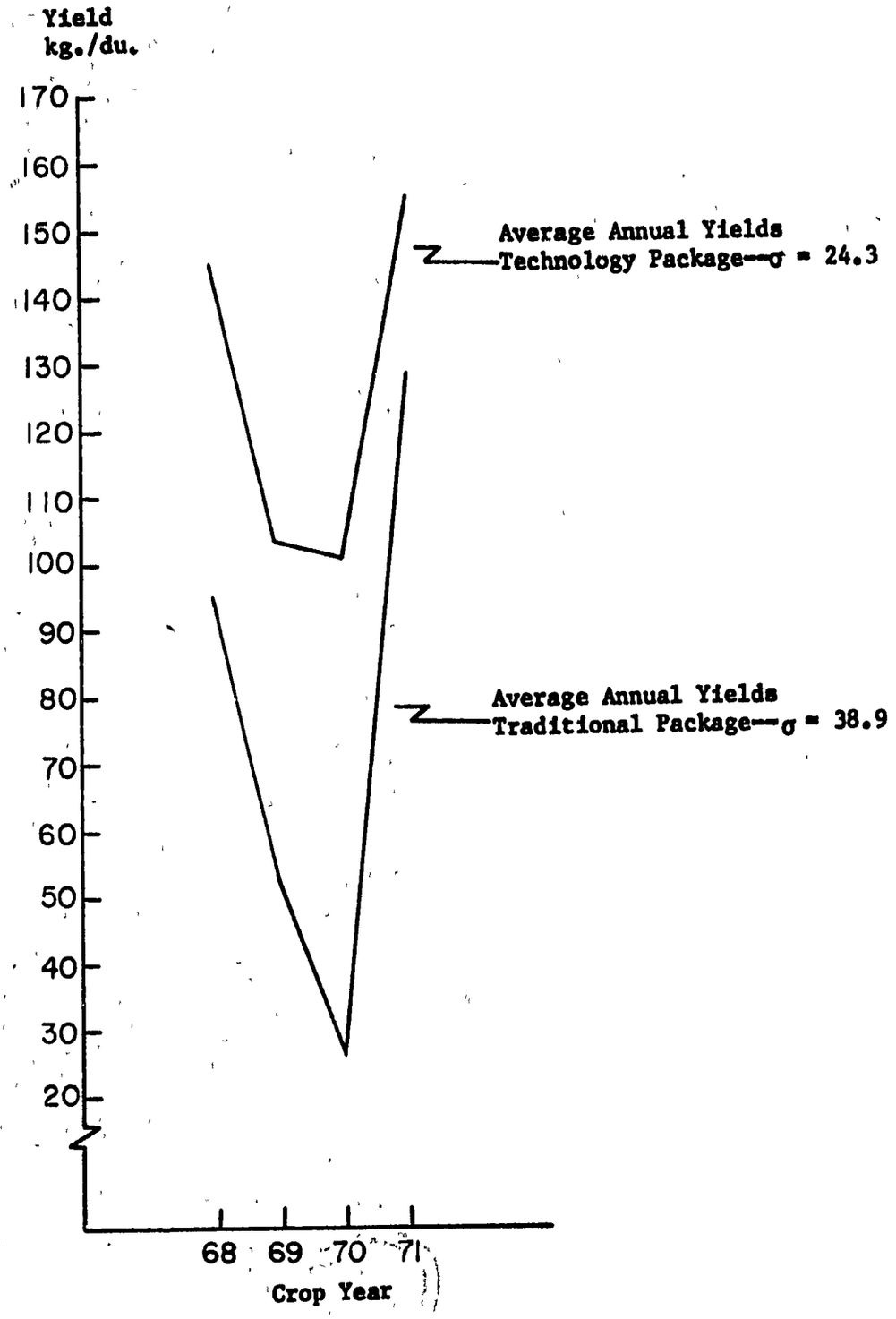


Figure 3. Yield Variability, Fallow Demonstrations: Kerak Governorate, 1968-73.

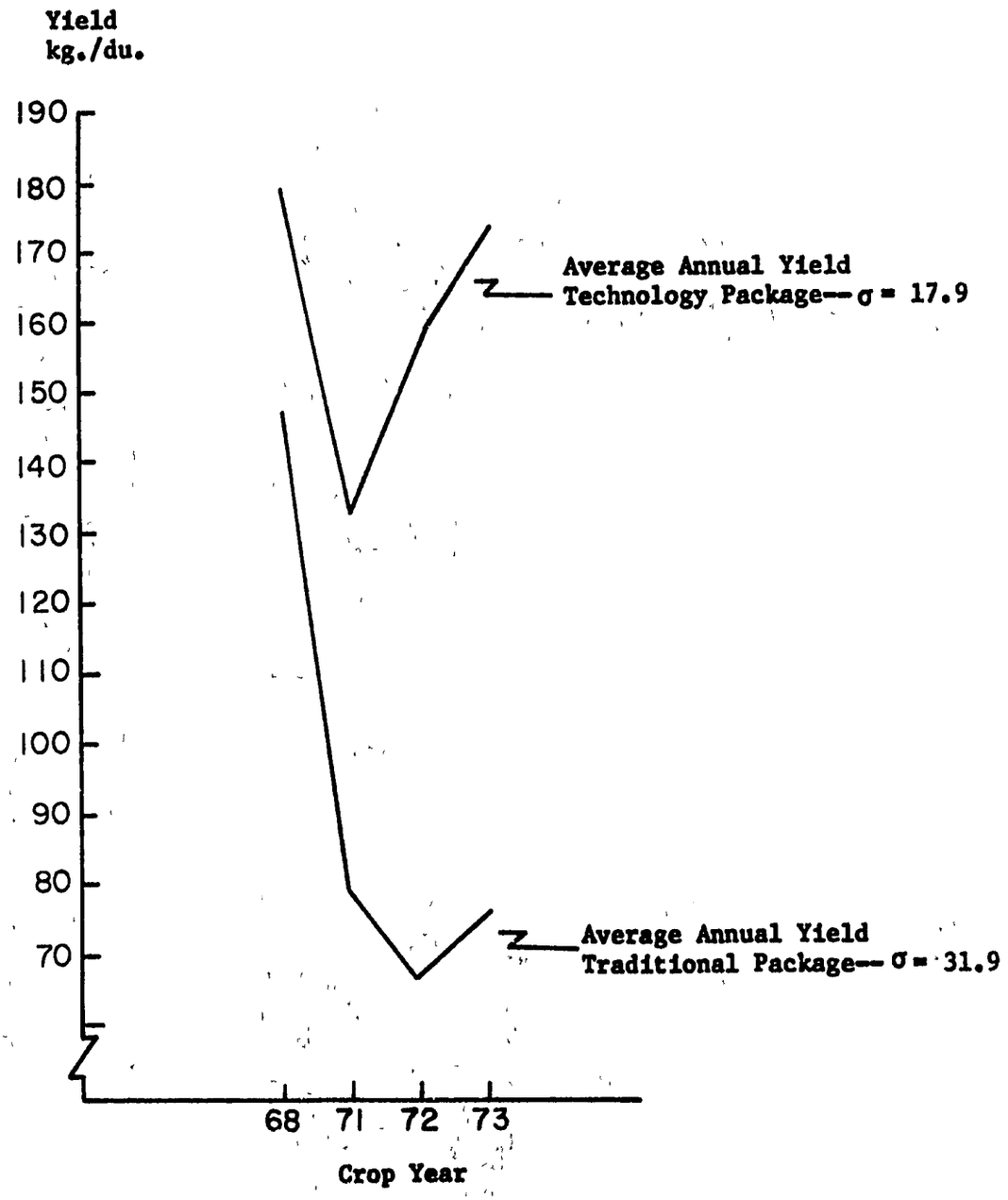


Table 7. Additional Costs Incurred by the Average to Larger Than Average Wheat Farmer in Amman Governorate in Adopting Clean Fallow, Fertilization, Chemical Weed Control, and Grain Drilling Technology Package: 1975 prices.

Item	Quantity	Change in cost/du.
Cost Increases		
Sweep	2X	0.872
Rodweed	2X	0.872
Grain drill		.791
Ammonium sulphate[a/]	15.5 kgs.	.946
Single super phosphate[b/]	11.0 kgs.	.220
Custom herbicide spray[c/]	100 gms. 2-4-D	.350
Opportunity costs[d/]	10%	.303
Cost Reductions		
Eliminate		
Plowing	2X	0.500
Hand seeding		.250
Light disc		.150
Seed savings[e/]	2.0 kgs.	.120
TOTAL		3.334 JD

a/ Charge is 0.061 JD per kg.

b/ Charge is 0.020 JD per kg.

c/ Cost of material is included in custom charge.

d/ Based on 10 percent of the additional direct cost incurred to adopt the technology package.

e/ Relative to hand seeding, grain drilling reduces the seeding rate about 25 percent. Seed cost 0.060 JD per kg.

Table 8. Additional Costs Incurred by the Average to Larger Than Average Wheat Farmer in Irbid Governorate in Adopting Clean Fallow, Fertilization, Chemical Weed Control, and Grain Drilling Technology Package: 1975 prices.

Item	Quantity	Change in cost/du.
Cost Increases		
Sweep	2X	0.872
Rodweed	2X	0.872
Grain drill		.791
Ammonium sulphate[a/]	14.5 kgs.	.885
Single super phosphate[b/]	12.5 kgs.	.263
Custom herbicide spray[c/]	100 gms. 2-4-D	.350
Opportunity costs[d/]	10%	.301
Cost Reductions		
Eliminate		
Plowing	2X	0.500
Hand seeding		.250
Light disc		.150
Seed savings[e/]	2.0 kgs.	.120
TOTAL		3.314 JD

a/ Charge is 0.061 JD per kg.

b/ Charge is 0.021 JD per kg.

c/ Cost of material is included in custom charge.

d/ Based on 10 percent of the additional direct cost incurred to adopt the technology package.

e/ Relative to hand seeding, grain drilling reduces the seeding rate about 25 percent. Seed cost 0.060 JD per kg.

Table 9. Additional Costs Incurred by the Average to Larger Than Average Wheat Farmer in Kerak Governorate in Adopting Clean Fallow, Fertilization, Chemical Weed Control, and Grain Drilling Technology Package: 1975 prices.

Item	Quantity	Change in cost/du.
Cost Increases		
Sweep	2X	0.872
Rodweed	2X	0.872
Grain drill		.791
Ammonium sulphate[a/]	13.5 kgs.	.837
Single super phosphate[b/]	9.0 kgs.	.198
Custom herbicide spray[c/]	100 gms. 2-4-D	.350
Opportunity costs[d/]	10%	.290
Cost Reductions		
Eliminate		
Plowing	2X	0.500
Hand seeding		.250
Light disc		.150
Seed savings[e/]	2.0 kgs.	.120
TOTAL		3.190

a/ Charge is 0.062 JD per kg.

b/ Charge is 0.022 JD per kg.

c/ Cost of material is included in custom charge.

d/ Based on 10 percent of the additional direct cost incurred to adopt the technology package.

e/ Relative to hand seeding, grain drilling reduces the seeding rate about 25 percent. Seed cost 0.060 JD per kg.

of the total additional direct cost incurred to adopt the technology package. This assumption was necessary because of a lack of more precise information.

Results and Conclusions

Results of the economic analysis of the fallow technology package are tabulated in Table 10. In this table the minimum annual yield response required to recoup annual costs of technology adoption is illustrated for average to larger than average size dryland wheat farms by governorate. Also indicated in this table are the percentage of years, based on fallow demonstration data, the annual yield response would likely fail to recover technology adoption costs. These tabulations indicate that adopters of the technology in Amman and Kerak governorate would incur losses in about one of every four years. In Irbid governorate the incidence of loss appears to be one of every two years. Although attitudes of Jordan's dryland wheat farmers toward this risk remains an open question, it is my opinion that this incidence of lose deters the adoption of the fallow technology package and is at least one reason why this technology is not being adopted by Jordan's dryland wheat farmers.

Table 10. Technology Profitability Influenced by Yield Variance

Governorate	Farm size	Minimum annual yield response required to recoup annual technology adoption costs (kg./du.)	Percentage years annual yield response will not recoup adoption costs
Clean fallow, fertilization, chemical weed control, and grain drilling:			
Kerak	Large	49	25
Irbid	Large	51	50
Amman	Large	51	25

Input Market Evaluation

Custom Machinery Services

Custom machinery service appears to me to be an important factor in the further mechanization of Jordan's dryland wheat production as small land holdings make machine ownership relative to custom hire high cost for all but Jordan's largest dryland wheat farms. This agricultural service sector appears to be a viable and competitive economic activity in at least the major wheat producing areas of Jordan. Basic services relating to wheat production include disc plowing, spraying herbicide, and combining. Presently, the quality of these services seem to be rather low; yet I would anticipate that competition among custom service operators would foster long-run improvements in service quality. Although new technology custom services (i.e., grain drilling, rodweeding, and chiseling) are presently not available in Jordan, neither does there appear to be a significant demand for these type of services. Hence, I concluded that the custom service sector is presently not hindering the adoption of newly introduced dryland wheat technologies.

Farm Equipment Sales and Service

In my opinion a competitive situation also exists in the farm equipment sales and service sector in the major dryland wheat producing areas of Jordan. The competitiveness of this sector has shown some recent improvements as a result of the establishment of several new equipment lines and dealers. Improvements were noted in price of equipment, service after sales, and availability and selection of equipment. In fact, some dealers are stocking dryland grain drills in anticipation of future demands for these drills. These observations indicated to me that

this agricultural service sector is presently not hindering the adoption of newly introduced dryland wheat technologies.

Fertilizer

Jordan's internal fertilizer market is undergoing adjustment which can be directly attributed to recent increases in the world market price of fertilizer. Many local private dealers have discontinued merchandizing single nutrient fertilizers primarily because the Jordan government started marketing in regional outlets and at below world prices single nutrient fertilizers. This market adjustment situation has in effect severely reduced the number of market outlets within Jordan for single nutrient fertilizers. This supply limitation is in my opinion hindering the adoption of fertilizer technology in dryland wheat production areas of Jordan. Yet, the long-run outlook appears more favorable as I anticipate that many local dealers will again market single nutrient fertilizers as the government appears to be giving a clear, strong signal that it is only interested in keeping internal fertilizer prices low relative to world fertilizer prices and not competing with private dealers for sales. Once the adjustment process is completed, low cost fertilizer should be readily available and in sure supply in the major wheat producing areas of Jordan.

Farm Credit

Farm credit with the exception of the local commercial man and extended family members is relatively new to Jordan. New sources of credit include custom service operators, private fertilizer dealers, farm equipment dealers and the Agricultural Credit Corporation (ACC). Credit terms vary among sources. The ACC provides long, intermediate, and short-term credit at interest rates of 6, 6, and 7 percent respectively. Slightly

higher cost loans are available from farm equipment dealers and fertilizer dealers. Little is known about credit terms available from other sources. Little is also known about the demand for agriculture credit except that it appears to be directed toward the local commercial man and extended family members. Because of these limited insights, agricultural credit's impact on technology adoption is presently unknown.

Recommendations

Recommendations relating to the general objective of increasing Jordan's domestic wheat production through technology adoption are presented here. They are purposely limited in scope being what is preceived as the next important step. These recommendations are considered necessary although not necessarily sufficient to achieve the above objective. Recommendations are of two general types—extension and research oriented. They are advanced in a general form since details could be easily developed by individuals more familiar with Jordan's agricultural situation and/or extension and research capability. Proposed research seeks to:

(a) Identify the wheat production response relationship associated with both traditional and new technology packages.

(b) Determine costs (direct and indirect) of wheat production under alternative technologies and compare these to costs and returns under traditional technology.

(c) Determine the impact which a variety of technology packages may have upon:

    (1) their compatability with farmer resources and

    (2) the degree of uncertainty and risk they afford relative to traditional packages.

Proposed extension efforts seek to provide potential adopters as well as custom service operators with:

(a) Information relating to the proper management, including operation and maintenance of equipment, of wheat production technologies in the setting of farmer conditions rather than demonstration conditions.

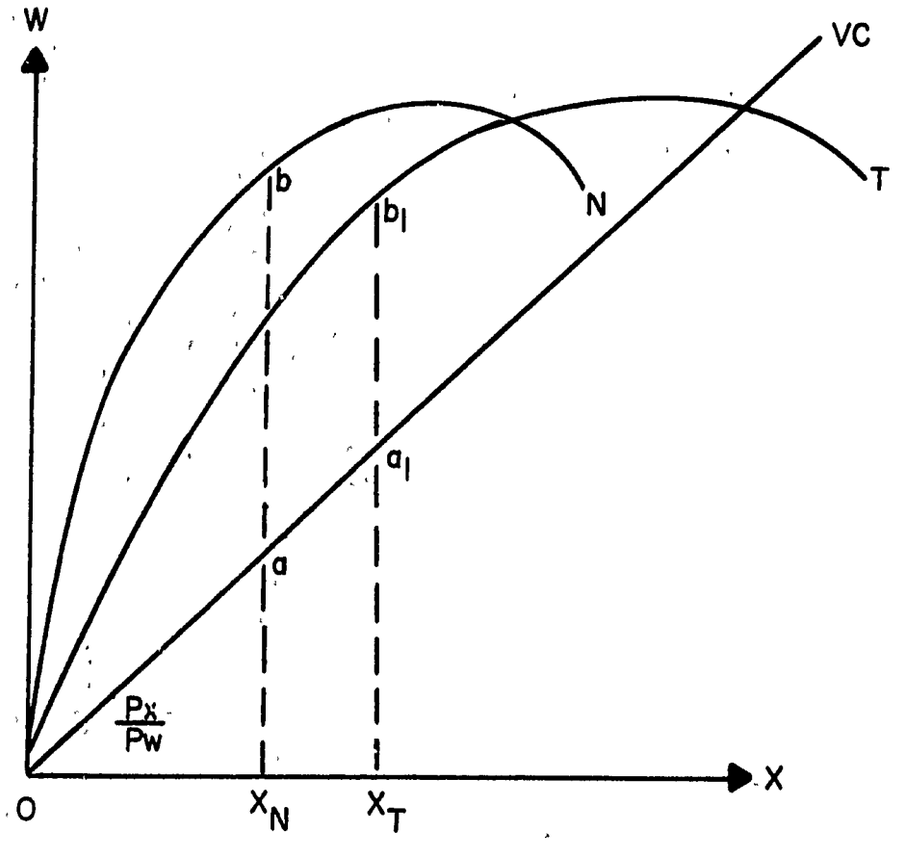
(b) Information about Jordan's rapidly changing agricultural input markets.

To accommodate the issues identified above in an operational research and extension program, three major efforts are proposed.

Determination of the Economically Optimum Technology System

The problem of determining an economically optimum dryland wheat technology package can be conceptualized in terms of yield response relationships in which variable resources in combination with some fixed resources are used to produce wheat. Two possible yield response relationships are indicated in Figure 4--one using new technology (N) and the other using traditional technology (T). Given cost (or price) per unit of variable resource (Px) relative to the price of wheat (Pw), the optimum level of x or the quantity of variable inputs which maximize returns above variable costs is X_N and X_T. The vertical distances ab and a_1b_1 indicate the return above variable costs obtained with new and traditional wheat technology respectively. The difference between ab and a_1b_1 represents on a one year basis the value in terms of wheat of the new technology over that of traditional technology. If the difference between the fixed cost of the new technology and traditional technology is less than $ab-a_1b_1$ the dryland wheat farmer can increase his net return by adopting new technology, if less, the farmer maximizes his return with traditional technology and uses X_T units of variable inputs.

Figure 4. Hypothetical Wheat Yield - Technology Response Relationships with Optimum Levels of Variable Input.



At the present time, some information is available from wheat project agronomic experiments which might be used to estimate new technology wheat production relationships. To the best of my knowledge, there is no information available concerning the traditional technology function. Consequently, it is not possible to determine if newly introduced technologies are profitable or even if variable resources of traditional technology are being employed in an economical optimum fashion.

To address these questions, the new technology agronomic experiment series being conducted by the wheat project staff should be carefully planned and closely monitored. Experimental design should accommodate analysis of complete new technology sets and analysis of new technology practices in association with traditional practices. Monitoring is needed in terms of the quantities of the various physical inputs, e.g., labor requirements, fuel consumption, etc., and yields. Experiments should be conducted on plots varying in size representative of fields typically found in major wheat producing areas of Jordan as there may be economics of size associated with these technologies.

Sufficient information to develop a wheat yield traditional technology relationship can also be obtained from a series of agronomic experiments like those proposed above. Yet, there might be a lower cost alternative of collecting this data such as a farm survey approach. A farm survey could be conducted in the major dryland wheat areas. Different size and type (i.e., annual or fallow cropping) of farms could be surveyed. The survey would develop data on the physical resources employed in producing wheat by the traditional technology. Input cost

and output price data could also be collected. To the extent possible, it would also be useful to collect the same type of data for a other cropping activities thereby providing at least one approach to estimating farmer opportunity costs.

Information collected in this research program could be used to determine an economical optimum dryland wheat technology package. This information would also be a part of the information package extended in the next phase—extension program.

Evaluate the Compatability of Alternative Technologies With Farmer Resources and Farmer Attitudes Toward Risk and Uncertainty

The adoption of "new" technology by farmers involves a break or change in the use of existing resources, and sometimes the acquisiton of new resources. Almost always associated with change is risk and uncertainty. The extent of the break or change and risk and uncertainty affect technology adoption. Yet only limited insights are available about the bundle of resources either possessed or readily available to Jordan's dryland wheat farmers. To my knowledge no information is available concerning farmer attitudes toward risk and uncertainty. Also, as noted previously, resource requirements of alternative technologies, including the traditional package, are unknown. The probability distributions of yield associated with these technologies are also unknown.

A survey of dryland wheat farmers could provide information about their existing resource situation and explore farmer attitudes about change, risk, and uncertainty. The previously proposed agronomic experiment series could be monitored to provide estimates about the resource requirements of

various technologies and could be replicated sufficiently to estimate the probability distribution of yield associated with the technologies. The yield distribution applicable to traditional technology might be best estimated from a limited number of agronomic experimental plots. A comparison of this type of information may identify other constraints affecting technology adoption.

Extension of Management and Agricultural Input Market Information

Sufficient information at the decision-making level is a prerequisite to change in farming practices and possible changes in wheat production. Accurate and timely distribution of production recommendations, machinery operation and maintenance tips, and input market information could possibly reduce risk and uncertainty attached to production changes and thereby accelerate profitable production practice changes.

The format of a information extending program is deserving of careful study as it is anticipated that like the proposed research program a significant resource commitment will be required to successfully complete the effort. Reporting research results should be an important part of the information program.

Appendix A

Figure A-1. Yield Variability, Annual Demonstrations: Amman Governorate, 1967-73

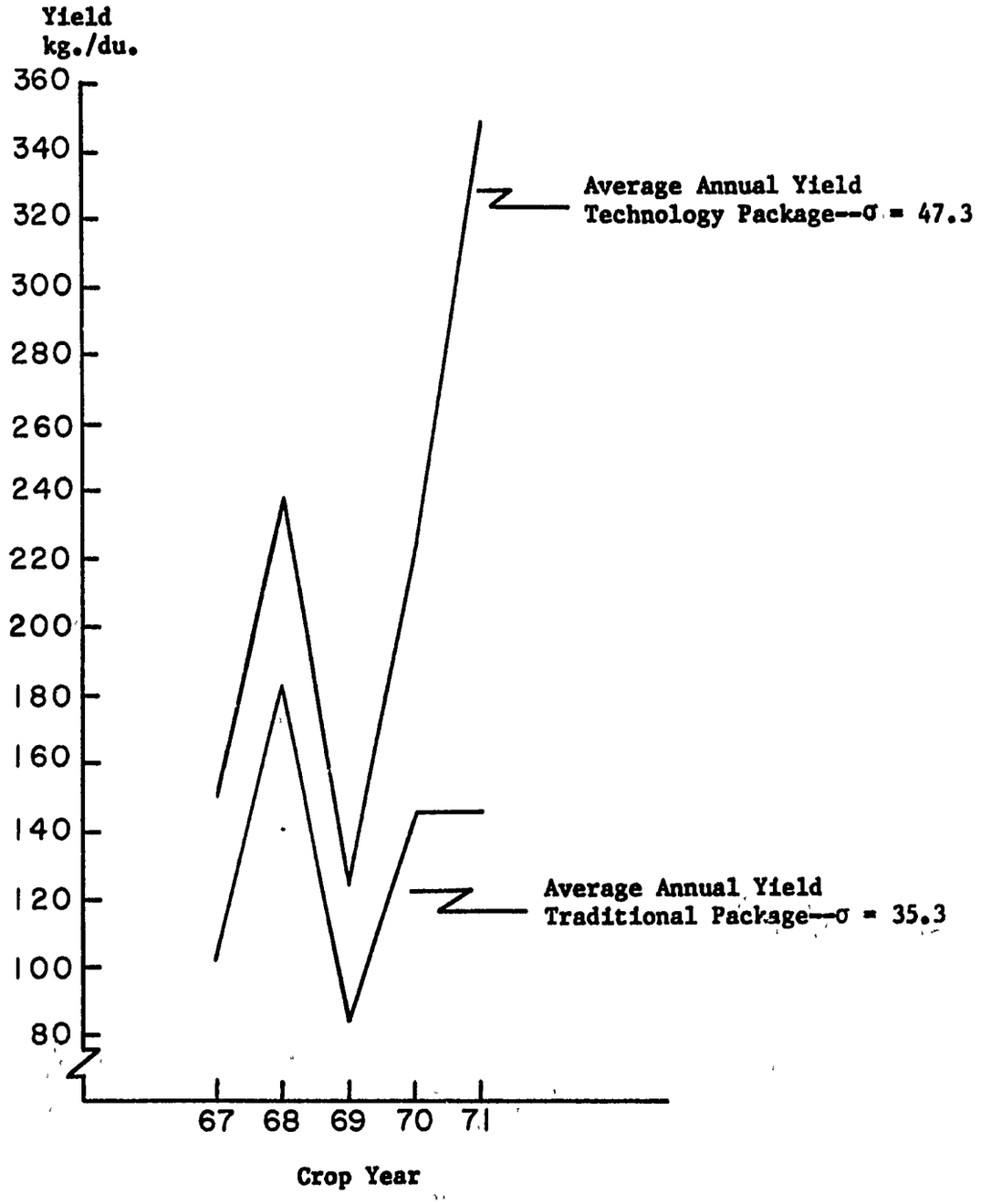


Figure A-2. Yield Variability, Annual Demonstrations: Irbid Governorate, 1967-73.

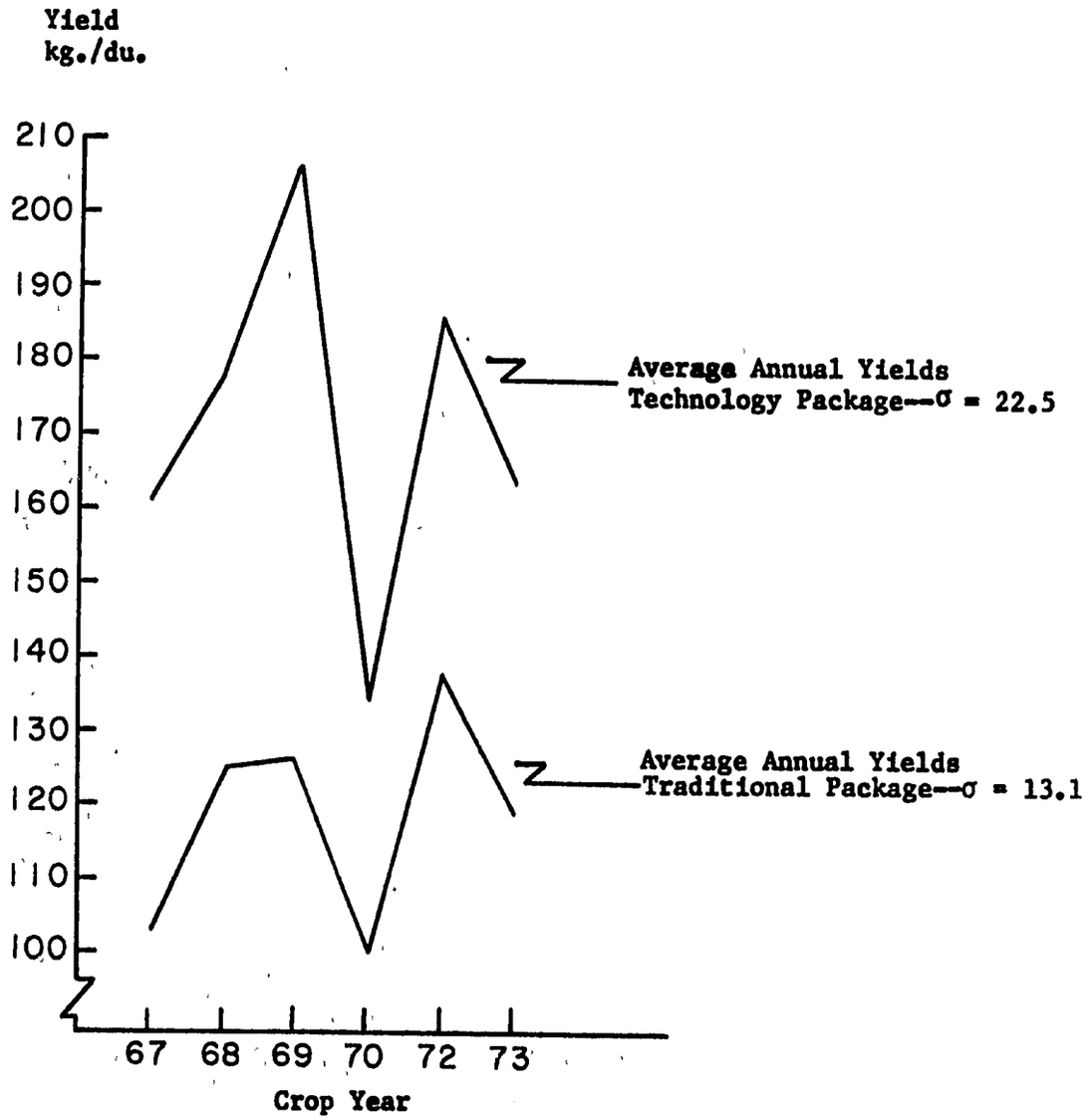
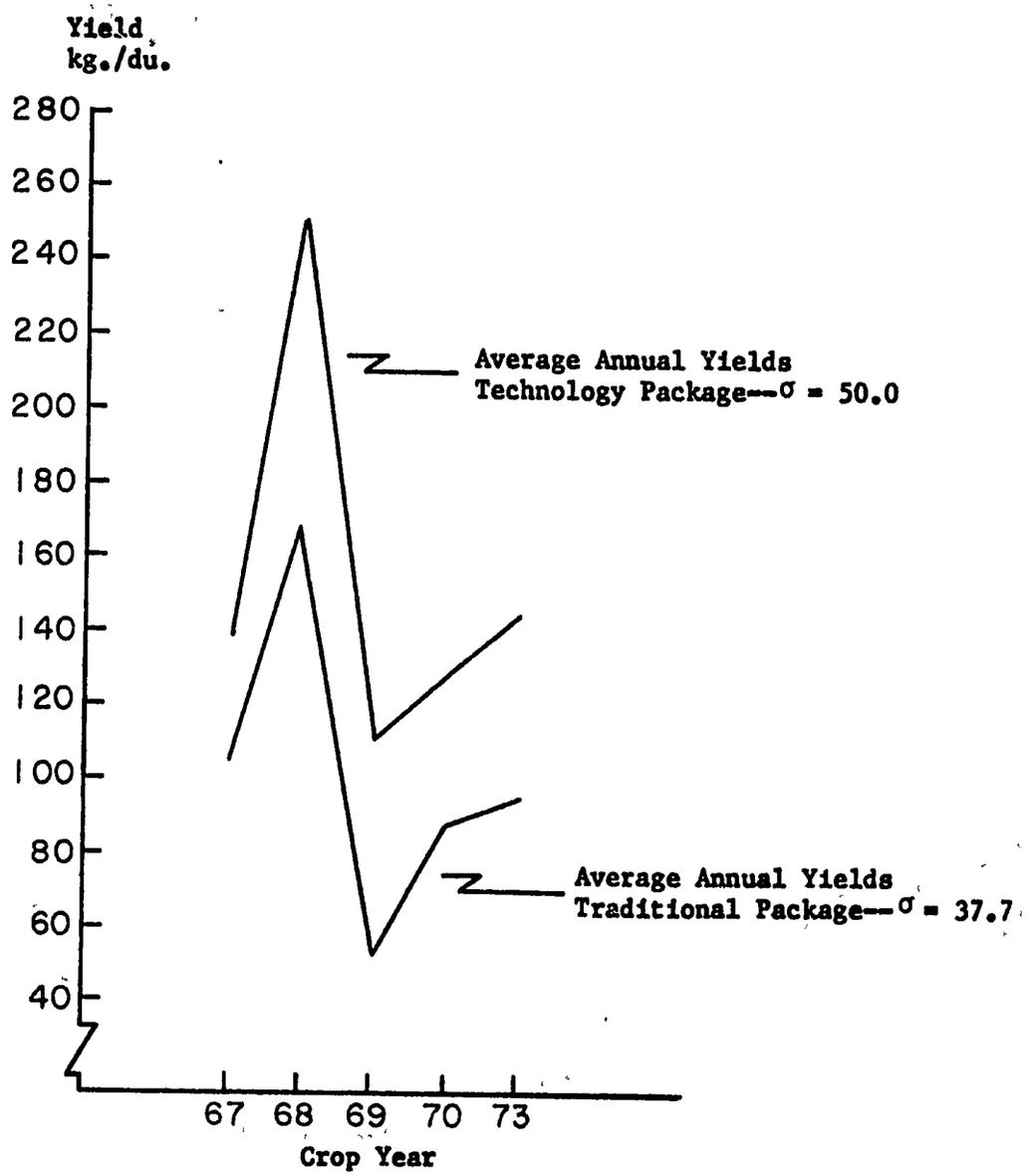


Figure A-3. Yield Variability, Annual Demonstrations: Kerak Governorate, 1967-73.



Appendix B

In this appendix section machine ownership and operating costs are compared to custom service charges. The unit measurement is cost per dunum (du.). Ownership costs are based on capital investment required to purchase farm machinery in Jordan, in 1975. Operating costs are based on estimated machinery performance rates, diesel fuel and lubricant costs for 65-75 drawbar horsepower tractors, labor costs, and estimated equipment repair costs. Ownership and operating costs per dunum are calculated based on a farm size of 400 dunums. Ninety-eight percent of Jordan's farms are 400 dunums or less. Custom rates are those prevailing during the 1974-75 crop year.

Table B-1. Custom Rate and Ownership Cost Comparisons: Jordan, 1975.

Equipment	Custom charge	Ownership cost
	JD/du.	
Plowing	0.250 JD	0.381 JD
Seeding	0.250[a/]	.791
Cover seed, disc	0.150	---
Spray[b/]	0.350	.715
Sweep	[c/]	.436
Rodweed	[c/]	.436

a/ Hand seeding cost while ownership cost reflects grain drilling.

b/ Includes spray material.

c/ This operation is not available on a custom basis. The custom rate is approximated by ownership costs.

Table B-2. Annual Ownership and Operating Costs of a Tractor

Specifications: Diesel, 65-75 dbhp. 3-point hitch, PTO, wheel and front end weights, water ballast in tires: 3500 JD.

Ownership Conts:	
Depreciation st. line 20 yrs. no salvage	175.000 JD
Interest 10% of average investment[a/]	175.000
Repairs 8%[b/]	280.000
Opportunity costs of cash repairs 10%	28.000
Total Ownership Costs	658.000
Operating Costs (per dunum)	
Lubricants and diesel[c/]	0.017
Labor, operator[d/]	.025
Opportunity cost of operating cost 10%	.004
Total operating cost per dunum	.046
Ownership and Operating cost per dunum per operation[e/]	0.276

a/ Interest rate reflects opportunity costs.

b/ Repair costs reflect lower management skills.

c/ Diesel fuel consumption estimated at 1 liter per dunum increased 15% to cover cost of lubricants and filters Diesel price about 0.015 JD per liter.

d/ Experienced operator assumed to cost 3.000 JD per 8 hour day; performance rate 15 dunums per hour.

e/ Cost per dunum per operation are based on an average of 5 cultural operations per year on 400 dunums. Costs also assume that 30% of tractor use is for off-farm purposes (transportation); therefore, ownership costs are reduced by 30 percent.

Table B-3. Annual Ownership and Operating Costs of a Field Sprayer

Specifications: Pull type, 1140 liter tank with 12 foot booms, PTO pump, hoses and nozzles: 700 JD.

Ownership Costs	
Depreciation st. line, 15 years, no salvage	46.667 JD
Interest 10% average investment[a/]	35.000
Repairs 5%[b/]	35.000
Opportunity costs of cash repairs 10%	3.500
Total Ownership Costs	120.167
Operating Costs (per dunum)	
Tractor[c/]	0.276
2-4-D amine 100 gms. @ 0.126 JD	.126
Opportunity cost of herbicide 10%	.013
Total operating cost per dunum	0.415
Ownership and operating cost per dunum based on 1 spraying operation per year on 400 dunum	0.715 JD

a/ Interest rate reflects opportunity costs.

b/ Repair costs reflects lower management skills.

c/ Derived from Table B-2.

Table B-4. Annual Ownership and Operating Costs of a Basic Tool Bar with Sweep, Rod Weeder and Chisel Attachments.

Specifications: 3-point hitch, 4 inch box beam - 8 feet long guage wheels, standards, 7 sweeps and chisels and ground drive rod weeder.

JD 1360

Ownership Costs	
Depreciation st. line, 20 yrs., no salvage	68.000 JD
Interst 10% average investment[a/]	68.000
Repairs 8%[b/]	108.800
Opportunity cost of cash repairs 10%	10.880
Total Ownership Costs	225.680
Operating Costs	
Tractor per dunum per operation[c/]	0.276
Total operating cost per dunum	0.276
Ownership and operating cost per dunum per operation on 400 dunums[d/]	0.436 JD

a/ Interest rate reflects opportunity costs.

b/ Repair costs reflect lower management skills.

c/ Derived from Table B-2.

d/ Costs per dunum per operation are based on 4 cultural operations per year per dunum on 400 dunums.

Table B-5. Annual Ownership and Operating Costs of a Dryland Grain Drill.

Specifications: Pull-type 14-16 inch row spacing with press wheels, fertilizer attachments: 1200 JD.

Ownership Costs		
Depreciation st. line 15 yrs., no salvage	80.000	JD
Interest 10% average investment[a/]	60.000	
Repairs 5%[b/]	60.000	
Opportunity cost of cash repairs 10%	6.000	
Total Ownership Costs	206.000	
Operating Costs (per dunum)		
Tractor[c/]	.276	
Total operating cost per dunum	.276	
Ownership and operating cost per dunum planting 400 dunums per year	.791	

a/ Interest rate reflects opportunity costs.

b/ Repairs costs reflect lower management skills.

c/ Derived from Table B-2.

Table B-6. Annual Ownership and Operating Costs of a Disc Plow

Specifications: 3-point hitch, 3 discs: 450 JD.

Ownership Costs	
Depreciation st. line, 20 years, no salvage	22.500 JD
Interest 10% average investment[a/]	22.500
Repairs 8%[b/]	35.000
Opportunity cost of cash repairs 10%	3.600
Total Ownership Cost	84.600
Operating Costs	
Tractor per dunum per operation[c/]	.276
Total operating costs	.276
Ownership and operating cost per dunum per operation on 400 dunums.[d/]	.381

a/ Interest rate reflects opportunity costs.

b/ Repair costs reflect lower management skills.

c/ Derived from Table B-2.

d/ Cost based on 2 plowing per dunum per year.

WHEAT RESEARCH AND EXTENSION

PROGRAM IN JORDAN

PHASE II

An End of Tour Report
Prepared for
U.S. Agency for International Development

Eugene P. Winters
Oregon State University

U.S. AID/O.S.U. Contract AID/sa-C-1024

November 27, 1973 to September 1, 1975

PREFACE

In Jordan, as in other countries in the Middle East, there has been increasing concern with the deficit in food production despite the national agricultural development programs and the aid from a number of agencies. The Jordanian government's desire to double wheat production and achieve near national self-sufficiency in wheat led to the establishment of the Wheat Production and Research Project in 1967. Since then with support from U.S. AID and the agency's sponsorship of a Contract with Oregon State University in 1968-1970 the "Wheat Project" has demonstrated on farmers' fields throughout the wheat producing areas ways to increase wheat production.

However, the new methods and techniques demonstrated were, for the most part, developed in the Pacific Northwest under a different soil condition and where a different class of wheat is produced. Yield increases averaging about sixty percent have been shown to be obtainable, but any substantial additional increase will probably depend upon locally developed technology. In this respect Jordan is fortunate in having a small number, but enthusiastic Wheat Project staff to assist in the wheat research effort and to carry the results to wheat farmers of the country through the Agriculture Extension organization.

The report that follows represents an appraisal of the existing wheat research and extension eductional programs and the opportunities for increasing wheat production through these programs. I have avoided reporting in detail the compelling reasons for increasing wheat production and have concentrated upon those aspects related to the potential for change under the existing climatic and edaphic regimes existing in Jordan.

My first tour to Jordan was as a member of the Oregon State University team during the period of September 1968 to September 1970, when I served as an advisor to the extension members of the Wheat Project. The second assignment during November, 1973 through September, 1975 was devoted primarily as an advisor to the Wheat Project Supervisor in matters pertaining to wheat research. The effective date of the contract at August 27, 1973 and the October war causing additional delay made it neccessary to depart from the Operational Plan scheduled to begin in July. Consequently, it was necessary for me to make a review of the Directorate of Research and Extension to determine those factors limiting a wheat research program without the help of the specialists scheduled. Out of this came a plan designed to implement coordinated wheat research under the direction of the Wheat Project Supervisor.

My thanks are due to the many people in Jordan who helped me fulfill my mission. I am especially grateful to Mr. Fuad Qushair of AID/JORDAN; Mr. Amin Abushaer, Wheat Project Supervisor; Mr. Raouf Nabulsi, Project Manager and Mr. Mustupha Aweida, Improved Seed Specialist all who were active in our joint effort to increase wheat production in Jordan.

Eugene P. Winters
Oregon State University

I. INTRODUCTION

1. General Background Information

Wheat is the most important crop cultivated in Jordan. Each year about 210 thousand hectares are planted to wheat. Average total production from this area is about one-half the domestic requirement. The area of wheat planted, the area harvested and the total production can vary substantially from year to year depending upon the amount and distribution of rainfall.

Wheat is grown extensively under dryland conditions from the edge of the desert receiving less than 250 mm annual rainfall to the western highlands where an excess of 400 mm annual rainfall is received. In irrigated areas some wheat is grown. Most of this is in the Jordan Valley.

Areas producing wheat have been delineated by the Ministry of Agriculture into four areas primarily upon the basis of rainfall. Rainfall patterns and soils fit in well with this particular classification. The desert wheat area has been designated as those lands planted to wheat receiving less than 250 mm rainfall on the average. The eastern wheat area is a band receiving between 250-300 mm rainfall while the western plains areas receives between 300 and 400 mm average rainfall. The uplands or western highlands normally receive in excess of 400 mm precipitation.

The eastern area and western plains account for nearly three-fourths of the wheat production and are the areas best suited because the soils, topography and field sizes are favorable to modern mechanized wheat farming Where rainfall exceeds 300 mm wheat is normally grown in rotation with spring and summer crops. Below 300 mm an alternate rotation of wheat or barley and fallow is the common practice.

Moisture is the primary limiting factor in dryland wheat production. The extreme variation of precipitation around the mean and the distribution during the relatively short winter rainy season can make cropping hazardous in two years out of five.

The culture of wheat in Jordan includes both ancient and modern methods. Most of the land is plowed by tractor with a disc plow mounted upon a three point hitch. Wheat seed in broadcast by hand on a rough seedbed and covered to various depths by a tractor-mounted one-way disc harrow. Most of the wheat crop is harvested by self-propelled combines, but large areas are still cut by hand and processed on the threshing floor. Threshed wheat is normally put in burlap sacks holding 100 kg when hauled or stored. Chemical weed control is becoming more popular as spray facilities become more readily available. However, the usual method of controlling weeds weeds is pulling by hand and carrying them from the field for livestock feed. The use of chemical fertilizer has received some acceptance by farmers in the higher rainfall areas, but little has been used since the recent price increases and their limited availability in the country.

With few exceptions the modern machinery and implements in popular use are not being adjusted or operated properly. Most plowing is poorly done and at the wrong time for best results. Considerable grain is lost from combines by poorly adjusted reels and separators.

2. Improving Wheat Production 1968-1970

In 1968 Oregon State University in contract with U.S. Aid agreed to assist the Ministry of Agriculture in its effort to increase domestic wheat production. To carry out this program a fulltime agronomy specialist

and a full-time soils specialist were assigned to advise extension and research workers in the Ministry. Short term specialists with responsibilities in summer fallow, weed control, grain storage and marketing and a senior advisor were also assigned during the contract period.

Modern wheat technology from the Pacific Northwest was introduced successfully in several farmers' fields by the estension directorate during the first year. The interest shown by farmers in new methods and the increased yield provided the motivation needed by extension staff to expand an extension education program for wheat growers throughout the country. Both rural and urban residents were kept aware of wheat project activities such as demonstrations, farm tours, wheat fairs, wheat machinery fairs through television and radio programs, newspaper items and other mass media.

II. CONSTRAINTS TO WHEAT RESEARCH

1. Personnel

The shortage of skilled and experienced personnel to undertake wheat research activities is a serious restraint to undertaking and maintaining a research program. This became apparent early after my arrival in Jordan when attempting to locate individuals in the Research Directorate who could be counterparts with specialists provided in the Operational Plan of the Contract. The staff limitation was responsible for most of the delay in getting research underway in the field.

Over the years many Jordanians have been well trained in agronomy, soil science and weed science. Most of them have left the country for better paying positions or are now in governmental service where this training has little application or use. Personnel management policies of the Ministry have tended to encourage the exportation of technology in the form of agricultural scientists.

It is not unusual for the Ministry of Agriculture to transfer personnel with due consideration of the status of the person's work. This practice has been wasteful not only of Jordan's personnel, time and materials, but equally wasteful of resources of donor-agencies. With the few people involved in wheat research and the lack of any back-up personnel the arbitrary transfer of two research workers threatened to cancel out two years of training and field work. The transfer policy has in effect tended to discourage workers from starting research which they may not be able to complete.

A high percentage of new graduates assigned to the Research Directorate have had little training and experience with research in the field. Their training generally has been in Europe or in Egypt and has been based upon

the tradition of the particular country visited. While such training may be relevant to some cropping in Jordan, it is certainly not relevant to dryland wheat production in Jordan. Therefore, it is extremely important that training in wheat production and research be given by agricultural scientists from relevant wheat producing areas such as the Pacific Northwest and Southern Australia.

2. Facilities

Wheat research work has been handicapped with the loss of experimental areas, inadequate transportation, limited equipment, a high incidence of equipment break down and a poor spare parts procurement program.

Protected experimental areas lost during the past two years to the University, the Irbid governate and the Rabba School were not replaced. The losses at Jubeiha and Irbid limited the quality and quantity of advanced line testing and weed control research. These losses have not been appreciated fully at the higher administrative level.

Field research work frequently has received a lower priority for transportation than some of the service type work which is less demanding as to timing of treatments or the taking of yield data. Transportation is provided from the Ministry motor pool, UNDP/FAO vehicles and private vehicles. Frequently without advance notice the authority to use private vehicles is withdrawn. This restricts travel dramatically and has lowered the quality of research by limiting timely data collection. Organizations such as FAO do not have this problem.

There continues to be a shortage of items needed for field research with wheat and a general lack of care and maintenance of equipment on hand. Procurement procedures for equipment spare parts and ultimate delivery appears to be more of the problem than availability of outside assistance or Ministry budget support.

3. Communications

There is evidence indicating that a substantial amount of research with wheat has been undertaken in Jordan during the last three decades. This is reflected by what appears to be sound recommendations being made in fertilizer use, rates of seeding and varieties. Few reports are available to substantiate the basis for these recommendations.

Much of the recent research results have not been published or even discussed with other workers. There appears to be limited professional communication among the research workers of the Ministry of Agriculture. Little benefit can be expected until research findings are interpreted and the results are published. Total staff awareness will occur only after the research findings are further disseminated through seminars and training meetings.

4. Relevancy

Much of the research underway has little application towards solving the Jordan wheat farmers' production problems. There is a need to confine wheat research to relevant and urgent production research suitable for both statistical and economic analyses. A closer relationship between the research worker, the field extension staff and the farmer will help direct the research effort twoard solving farmers' problems. With a complete and reliable researhc base, a change in agricultural practices can be achieved more rapidly through the extension of factual and timely information.

Advanced training by research staff is needed in those disciplines of most relevance to increasing cereal production in Jordan.

III. ESTABLISHING PRIORITITES FOR WHEAT PRODUCTION RESEARCH

1. General Considerations

In preparation of the Review Report called for in the Contract Operational Plan a study was made of the status of wheat research in Jordan. My previous Jordan wheat project experience permitted me some basis for evaluating the progress made in the last seven or eight years.

Field research with wheat has been extremely limited. An active wheat breeding and testing program and involvement with the regional and international nursery programs has been underway for several years. Many new lines and varieties are under test and a seed increase program has been established. Few varieties have been released to replace those recommended for many years. A primary reason for this is that the new lines are being tested against the old varieties under a cultural system which favors the established varieties. The culture of wheat is changing fast. Farmers are adopting new practices which provide more moisture to the growing plant, a higher level of fertility and less weedy competition. Improved high yielding varieties respond better to the new cultural systems than the indigenous varieties in popular use.

The use of chemical fertilizer materials with wheat in Jordan is a new practice receiving limited acceptance by farmers. Demonstrations on hundreds of farmers' fields have shown wheat responded with sixty percent higher yields to applications of nitrogen, phosphorous and sulfur carrying materials when moisture was not the limiting factor! Little factual information is available for use as a basis when recommending optimum amounts of nitrogen. The phosphorous requirement and the need for sulfur on the various wheat producing soils needs investigating. The relationship between

soil analysis values and wheat response to phosphate fertilizer nutrients has not been established. Changes underway in the fertilizer industry will have some impact upon the availability and costs of chemical fertilizer materials now available and will encourage the use of other materials.

Wheat yields under irrigation in Jordan have been substantially lower than those reported in most other irrigated wheat producing countries. The place of wheat in irrigated crops rotation has not been established.

Wheat farmers in Jordan have generally accepted the idea of controlling weeds in wheat with the phenoxy herbicide 2,4-D. Actual use has been limited by the spraying services available to treat fields at the proper time. As the use of 2,4-D increases weeds resistant to this compound will become more of a problem requiring alternate materials for economic weed control. With new developments taking place in soil moisture storage, seed bed preparation and the use of chemical fertilizers, weedy growth may be enhanced. Control will require herbicides which can be applied safely at the earlier stages of wheat growth. New materials are being released for use to solve weed problems in other wheat producing countries and well may have some economic use in Jordan.

Moisture has been identified as the primary factor limiting wheat production in Jordan. More than one-half the wheat producing area lies in a rainfall belt receiving an annual average precipitation of between 250-300 mm. In most of this area annual cropping is an extremely hazardous operation. A non-crop fallow has become an common practice with weedy growth being utilized by livestock. Clean summer fallow techniques introduced from the Pacific Northwest on many farmers' fields have demonstrated that yields can be increased from the more efficient storage of soil moisture. In drier than average years this technique has made the difference between an economic crop and a complete failure. In the winter rainfall

Pacific Northwest summer fallow wheat growing areas the efficiency of soil water storage during fallow is greatly affected by tillage timing and the tillage methods used. Distinct differences in climate, soils, and wheat growth caracteristics exist in Jordan. A tillage system to reduce precipitation losses, run off, evaporation from the soil surface, and transpiration from weedy plants under Jordan wheat producing conditions must be developed.

In Jordan there is a clear need for problem-oriented research to asses the biological possibility and potential for increased wheat production while concurrent researhc studies are being made to show the social and economic practicability of the new production systems. It is apparent that technological research is wasted when the results cannot be applied or adopted, or are unacceptable because of cultural, social, or economic constraints.

For an effective program of research on wheat production to meet the increasing demands of the human population in Jordan, multi-disciplinary research involving specialists in soil fertility, soil water, crop agronomy and socio-economics is required. In this respect it is essential to insure coordinated agricultural research in Jordan. It is apparent that more liason and coordination effort is needed among the national groups and between national and international groups to insure the full benefits of locally developed research.

2. Research Programs and Priorities

A plan for wheat project research in Jordan was prepared to provide the necessary direction for expanded experimentation with wheat by the departments within the Research Directorate of the Ministry of Agriculture.

The plan presented broad objectives to the Department heads and the research workers involved in those areas of investigation needed to solve many of the important agronomic problems limiting wheat production. It was intended that the research be relevant to Jordan and provide a basis for making recommendations to wheat farmers through agricultural extension eductional activities.

In the formulation of the Jordan Wheat Project Research plan I relied upon my previous Jordanian wheat project experiences and those of the Project Supervisor gained from the projects demonstration program over the previous six years. The effective date of the contract and the inability of the Research Director to assign suitable counterparts did not permit the use of a soil fertility specialist and an irrigation management specialist as provided for in the contract operational plan to assist in preparing the review report and designing a research plan. However, Jordan tour reports from Oregon State University staff members Dr. Norman Goetze, Dr. Thomas Jackson and Mr. Merrill Oveson were extremely helpful in identifying those research areas needing attention in Jordan.

A research plan was designed to outline the ways the Research Directorate and the Wheat Project, which has both extension and research responsibilities with wheat within the Ministry of Agriculture, could coordinate an applied research program. Broad objectives were presented as a guide for several years planning. More specific objectives were indicated for the first year by the area of activity. The primary planning goal was to provide information the farmers can use to increase wheat production.

To assist the Wheat Project Supervisor in his major role of coordinating the planning and conduct of trials it was recommended that a special wheat research committee be established. Such a committee would assist in getting

adequate support from the Directorate in the form of personnel, materials and services. It could also serve a useful role in the evaluation of research and in establishing meaningful goals.

For Jordan as a whole, the eight broad research objectives listed below are the most urgent ones related to increasing wheat production. Most, if not all, involve multi-disciplinary studies and are interlinked. This is particularly relevant in the drier wheat producing areas where two approaches are used to increase crop water use efficiency. One involves the methods or practices to increase the total water supply available to the crop through more effective storage of rainfall. The other approach involves making more efficient use of the stored water. Both approaches are used in the plan.

The broad objectives for wheat research in Jordan are:

1. to determine the most practical combination of tillage procedures which will most efficiently conserve moisture for maximum wheat production under summer fallow conditions in each of the low and medium rainfall areas;

2. to determine the response by wheat from applications of nitrogen, phosphorous and sulphur on different wheat producing soils of Jordan;

3. to develop a soil testing program for use in predicting phosphorous needs of wheat;

4. to ascertain those herbicides which will be effective in controlling weeds in wheat grown under the different growing conditions found in Jordan;

5. to ascertain which cultural practices or combination of practices can be used for effective weed control in the wheat producing areas of Jordan;

6. to ascertain the best combination of tillage, fertility, weed control practices and variety to use under summer fallow, annual cropping and irrigated conditions for optimum yields of wheat;

7. to expand the variety testing program to farmers fields as a means to hasten the release of mproved yielding varieties found to be adapted to the different growing conditions; and

8. to ascertain the value and benefits from including wheat in the irrigated crop rotation.

3. Suggested Research Projects of Practical Importance in Jordan

Earlier in this report the broad objectives for a wheat research program were presented. It was intended that annual research plans would be evaluated on the basis of progress towards reaching the long range goals. Limited resources in the way of staff, materials and services dictated that the first year of coordinated wheat project research be kept relatively simple experimentation. It was believed after one year's experience in planning, conducting trials, collecting data and evaluating the years results and involved staff with more adequate support would be ready for more sophisticated experiments.

A few research projects of direct relevance and of practical importance in Jordan were suggested as follows:

(a) Summer Fallow Tillage to Conserve Soil Moisture

PROBLEM

More than one half the wheat producing area lies in a rainfall belt receiving an annual average of between 250-350 mm precipitation. Annual cropping is an extremely hazardous operation in most of this area because of the winter rainfall pattern as well as the erratic rainfall from month to month and year to year in the rainy season. The growing season is

determined by the beginning and ending of significant rainfall. The decline of rainfall at the end of season occurs at a time when wheat is in the period of highest transpiration and plants are entering the reproduction stage of growth.

Fallowing of land to store moisture in the rootzone for the next years crop is a common practice. In other winter rainfall wheat growing regions soil water storage during fallow is greatly affected by tillage methods. In Jordan the usual or common methods of fallow have not proved efficient compared to other methods used in winter rainfall semi-arid wheat growing regions. Clean summer fallow techniques adopted from the Pacific Norhtwest have been demonstrated on many farmers fields. Yields have been increased from the more efficient storage of moisture and in drier years the difference between a crop and a complete failure has been noted.

Distinct differences in climate, soils and wheat growth characteristics found in Jordan from those found in the Pacific Northwest require that a tillage system be found to reduce precipitation losses to run off, drainage, evaporation from the soil and transpiration by weedy plants under local conditions.

OBJECTIVES

The objectives of a summer fallow tillage trial are:

1. to determine the effect of fall tillage on the conservation of precipitation falling during the rainy season following harvest.

2. to determine the effect of spring tillage implements in the conservation of soil moisture.

3. to determine the effect of summer tillage implements in the conservation of soil moisture.

4. to find the amount of soil moisture that can be used by a wheat plant in the summer fallow area.

PROCEDURE

Select three suitable sites on typical soils of the summer fallow wheat growing area of Irbid, Amman and Karak districts.

Gather basic soils information as to physical and chemical characteristics of trial area.

Arrange for the recording of precipitation as close to site as possible.

Design a trial including fall, spring and summer tillage methods within the recognized procedures for experimentation.

Establish trial.

Take soil moisture measurements during the summer fallow season from each plot.

Made frequent observations and record any visual discernable differences.

Report results and evaluation up to planting time in written form for use in discussion and for record purposes.

Plant to wheat.

Log wheat growth characteristics.

Take yield data.

Take soil moisture samples at harvest.

Analyze results and evaluate trial.

Prepare a written report including all moisture observations, plant responses and yield results.

Plan for the next summer fallow tillage trials.

(b) The Effect of Controlling Weeds on Wheat Production

PROBLEM

Wheat farmers in Jordan have generally accepted the practice of controlling weeds in wheat with the herbicide 2,4-D. With changes taking

place in the timing and method of tillage there may be a different set of weed problems. The conservation of soil moisture and the use of chemical fertilizer materials may enhance weed growth which will require herbicides that can be applied safely at earlier stages of wheat growth. As 2,4-D resistant weeds infest sprayed fields, farmers need alternate materials to use for economic weed control. New pre-emergent and post-emergent herbicide materials have given good results in other wheat growing areas and may have adaption for use in Jordan. New improved superior wheat varieties may be susceptible to herbicide use.

OBJECTIVES

The objectives for a weed control program in wheat for the 1974-75 crop year are:

1. determine the influence of herbicides on weeds and wheat varieties.

2. isolate chemical and agronomic methods that appear promising in exploratory research and determine effectiveness in control, selectively and safety, and time of application.

PROCEDURE

Establish herbicide phytotoxicity screening trials in cooperation with the Agronomy Department using promising lines or varieties of wheat and herbicides registered for use with wheat.

Locate three suitable sites on summer fallow demonstrations for herbicide screening trials on wheat.

Establish a properly designed experiment.

Observe, measure and record any visual differences.

Harvest plots for yield and quality.

Prepare a report in written form evaluating the results for discussion with extension and research people.

Plan for the next year's testing programs.

(c) The Effect of Chemical Fertilizer on the Production of Wheat

PROBLEM

The use of chemical fertilizers in Jordan wheat production is a relatively new practice. Demonstrations on farmer's fields have shown that wheat has responded to applications of nitrogen, phosphorous and sulphur carrying materials when moisture was not the limiting factor. The optimum amounts of nitrogen, the phosphorous requirement and the need for sulfur on the various dryland wheat producing soils have not been established.

With improved soil moisture conserving techniques and chemical weed control; superior yielding varieties can make more efficient use of available moisture when fertilized.

Many changes are underway in the fertilizer industry which may have some impact upon the availability of some fertilizer materials and encourage the use of others.

The relationship between soil analysis values and response from fertilizer nutrients by wheat has not been established in Jordan.

OBJECTIVES

The objectives for the wheat fertility testing program for the 1974-1975 crop year with three varieties of wheat (a recommended variety, a new variety and the high yielding potential variety Mexi-Pak) are:

1. to obtain information to serve as a basis for improving the fertilizer recommendation for the summer fallow wheat growing area.

2. to generate fertilizer response data for use in the calibration of diagnostic soil tests for phosphorus.

3. to gather information about the response of wheat to the different nitrogen and phosphorous carrying fertilizer materials.

4. to determine the role of sulfur in a wheat fertilization program.

PROCEDURE

Select locations for wheat fertility trials on summer fallow demonstrations in Irbid, Amman and Karak districts.

Take soil samples for soils analysis.

Establish a properly designed randomized - replicated trial with different levels of nitrogen and phosphorous and three varieties of wheat in the sub-plots. Include the recommended variety for the area, a newly released variety and a recognized variety having high yielding potential.

Observe, measure and record characteristics of growth during the season.

Harvest for quantative and qualitative data.

Resample soils for analysis.

Prepare results in report form for discussion with research and extension personnel.

Plan for future cropping season's wheat fertility program preferably in the same field.

Make visual observations or measurements of response from residual fertilizer carryover in the following crop.

(d) The Effect of Improved Practices on Wheat Yields

PROBLEM

A wheat breeding and testing program has been underway for several years. Many new lines and varieties of durum and bread wheats have been evaluated each year. Few varieties have been released to replace recommended varieties.

The culture of wheat is changing. Farmers are now adopting new practices such as moisture conserving summer fallow, the use of fertilizer,

the use of chemical weed control, the use of grain drills, etc. Improved varieties may respond better to soil moisture, fertilizer and the chemical control of weedy competition than the varieties now recommended.

OBJECTIVES

The objectives of expanding variety testing to farmers fields in cereal nurseries for 1974-1975 are:

1. to determine which varieties of durum and bread wheat are superior to recommended varieties.

2. to speed up the testing and release procedure so that better varieties will be available sooner to farmers.

PROCEDURE

Select 15 to 20 durum and bread wheat varieties that have shown promise under the Agronomy Section screening trials in Jordan and other trials in the region.

Plant these in a properly designed randomized-replicated plots on three wheat project summer fallow demonstration locations in Irbid, Amman and Karak districts.

The trial area to receive the smae tillage and fertilizer treatments as applied to the demonstration area.

Determine yield and adaptation. Measure and record data on maturity, height, straw strength, shattering and other agronomic characteristics.

Report results in written form.

Present information from thials to selected extension staff and research worker in seminar.

Plan for 1975-1976 cereal nurseries.

(e) The Effect of Fertilizer, Irrigation Water and Varieties on Wheat in an Irrigated Crop Rotation Plan

PROBLEM

Wheat yields under irrigation in Jordan have been substantially lower than those reported in most other irrigated wheat growing countries.

There is some question about the normal crop rotation making the best use of growing season, land, soil, and water. It has been shown in many regions that crops grown in systematic sequence can help farmers manage lands and conserve the soil and reduce pest problems. The benefits of wheat in an irrigated crop rotation in Jordan have not been measured.

OBJECTIVES

The objectives for irrigated wheat research for the 1974-75 crop year are:

1. to find the necessary factors of fertilizer, irrigation water and varieties needed to bring wheat yields up to acceptable economic levels.

2. to determine the role of wheat in irrigated agriculture rotations to make better use of the land and water reserve during the winter season and to ascertain any soil and crop improvement benefits with its use.

PROCEDURE

a. Establish a properly designed irrigated crop rotation study with wheat and other crops on the two experiment stations in Jordan Valley.

Observe and measure differences among the various treatments.

Prepare a report in written form for discussion with research and extension worker.

b. Locate experimental sites on farmers fields.

Sample soils for soils analysis.

Establish a properly designed trial including treatments of different levels of nitrogen and phosphorous with two high yielding wheat varieites.

Observe, measure and record characteristics of growth during the season.

Collect yield data and make quality determinations.

Prepare a written report for discussion with research and extension personnel.

Evaluate the research program and plan for the coming season. Investigate the possibilities to test date and rate of seeding, depth of seeding, improved irrigation practices, methods of seeding, etc. with better varieties as they become available.

IV. IMPLEMENTATION OF THE WHEAT RESEARCH PROGRAM

1. General

Upon my arrival in Jordan the wheat project professional staff was composed of the Wheat Project Supervisor, the Project Manager and the Improved Seeds Specialist. The supervisor had been appointed to that position recently to provide the leadership for an expanded wheat research as proposed in the project document. He and his staff have been the backbone of the Wheat Demonstration Program since 1967, but in his particular case in different capacities such as Agronomist Amman Governate, Agriculture Director, etc.

The Wheat Project Manager and the Improved Seeds Specialist continued in their respective capacities with the conduct and management of personnel and machinery in cooperation with the various governate agriculture directors in the extension education wheat demonstration program. Project machinery and field staff were located at the Rabba experiment station, the station at Irbid and at the Extension and Research Directorate headquarters at Jubeiha.

My primary role was to work with the Project Supervisor in helping the Directorate reach the goals as outlined in the project documentation. I was advised officially by the Director of Extension and Research that all my requests and communications were to be directed through the supervisor.

The Project Supervisor's main concern was to work out the details with department heads where they would provide personnel and facilities to plan, conduct, evaluate and report on a coordinated wheat research program.

After priorities were established for research and inventory was made of the department to locate personnel to conduct research. At the same time, an attempt was made to identify what commodities would be needed that were not available in the region. Some of these were provided by

the commodity component of the contract schedule.

2. Procedure

a. Agronomy Department. The Agronomy Department was adequately staffed and had a n ongoing breeding and testing program. The testing program was limited primarily to experiment stations under one level of management. It was believed that the Agronomy Department could expand advanced line testing into project demonstration field locations under a high level of management where the results would be more meaningful in testing yield potential. It was also believed that before varieties are ready for release they should have a wider exposure in farmer field verification trials established on the principal wheat growing soils of the country.

One serious factor limiting the amount and results of testing wheats was that all seeding was done by hand. To correct this an effort was made to provide a plot drill with the commodity funds provided for in the contract. This was not possible because those drills recommended for use were of foreign manufacture.

b. Plant Protection Department. The Plant Protection Department assigned a weed scientist to assume major responsibilities for a weed control program with wheat. The department was adequately supplied with herbicides and application equipment for the first year's work.

c. Soils Department. The personnel requirements from the Soils Department were more extensive. Soil scientists trained in soil physics, soil fertility, irrigation, and a soils laboratory technician were needed. One working with irrigated wheat in the Jordan Valley was assigned project responsibilities. A newly assigned soil laboratory technician was assigned for wheat project soil sampling and analysis. He was given

additional training in the United States and Oregon to become familiar with field and laboratory methods and techniques used in soil-water-plant research. At that time there was no one available to do the field aspects of soil fertility work. Later a well trained soil scientist returned to Jordan and assumed the responsibility for this work. The soil physics position could not be filled. The Wheat Project Supervisor took over research activities with tillage and soil moisture storage. An agronomist with a good soils background later became available and was assigned directly to the project to lead the tillage research and give technical assistance to the supervisor.

To support the wheat soils research effort soil laboratory equipment and soil sampling equipment were provided from contract commodity funds.

d. Participant Training. During the recruiting process with the department heads it became apparent that communications between departments about research activities was extremely limited. In an effort to encourage a multi-disciplinary approach to wheat research and in the future foster a wheat technical panel, a training program was set up for several weeks in Oregon by the Campus Coordinator. The training was designed specifically to meet the needs of Jordan with the services of Oregon State University staff and others, who had been involved with wheat in Jordan. In addition to providing a learning experience with coordinated research programs it was hoped that with their diverse backgrounds it would help develop their common interests and encourage them to examine the relevance of their research.

Participants by position who received the training were the Wheat Project Supervisor, Head of Soils Department, Head of Agronomy Department, Weed Scientist from the Plant Protection Department and the Agronomist from Jordan University Agriculture faculty. With the Univeristy of Jordan

undertaking a wheat research program a coordinated planning effort could be undertaken to eliminate duplecation by including the University wheat scientist.

After the broad objectives for wheat research had been outlined, a few research projects of direct relevance and of practical importance in Jordan were suggested to the plant and soil scientists selected to work with the wheat project. Individuals were assisted in the planning and design of experiments. Here the amount of help needed was dependent upon his previous training and experience. This was also the situation in preparing a work plan. Care was taken to make sure that the plan was the research workers plan. Assistance was given only when requested or it was obvious there was no department expertise available.

3. Tillage Effects on Fallow Water Storage

The first experiment established was one to determine the tillage effects on fallow water storage in the summer fallow wheat producing areas; This trial consisted of three parts: (1) effect of fall tillage on overwinter water storage; (2) effect of spring tillage on retaining overwinter water storage; (3) effect of tillage on oversummer water retention. Results of treatments would be measured by total soil water at planting time and by wheat yield.

One randomized replicated tillage trial was established in each Irbid, Amman and Karak governates respectively. Some differences exist between these because of soils experimental error or that different tillage tools were used. The different season treatments were superimposed on the preceding treatments.

Considerable interest was shown by international wheat workers with the tillage trials in Jordan because rainfall conditions were less favorable than in other countries in the region doing this work.

At the time of my departure from Jordan the results from the tillage trials or continuation were in doubt because of the unanticipated and unannounced transfer of the agronomist conducting the trials to another position in a more remote part of the country.

4. Variety Testing

The wheat variety testing program was conducted by the Agronomy Department and by an agronomist assigned to the Project Supervisor directly. In addition to a number of different cooperative trials located upon experiment stations, one regional nursery including barley and wheat was established by the department upon a summer fallow wheat demonstration location at Madaba. This trial received considerable attention from CIMMYT and ALAD staffs because this was the first observation of many lines under moisture stress in a low rainfall area under a high level of management. The wheat project staff established two farmer field verification trials which included sixteen promising and check varieties of wheat and two barleys. The one on a summer fallow demonstration location east of Madaba was lost to birds. The annual cropping location east of Naur was harvested and yield data collected. Statistical analysis and interpretations had not been completed prior to my departure.

5. Irrigated Wheat

The irrigated wheat trials consisting of two varieties with fertilizer variables and a standard irrigation treatment were continued for the third year in the Ghor at the Dier Alla station. From this work there will be

some basis for recommending fertilizer treatments in the production of Mexi-Pak and Dier Alla No. 1 varieties.

6. Weed Control

Three chemical weed control trials in wheat were established. Locations were on a sumemr fallow demonstration site near Irbid, on the Rabba station and on an annual wheat demonstration site east of Naur. Ten treatments including pre-emergent and post-emergent chemicals were used. Because of experimental error and no animal protection yield were not taken. Observation notes taken during the season may have some value if retained by the research worker.

7. Fertility

A nitrogen-phosphorous-three variety of wheat interaction trial was established at teh Rabba station, on summer fallow demonstration fields near Madaba and near the Jerash-Irbid highway junction. In each trial the recommended variety (Hurani Nawawi or F-8) was tested against the promising new variety Dier Alla No. 2 and the proven high yielding variety Mexi-pak.

Five levels of nitrogen and four levels of phosphorous (triple super phosphate) were applied.

Yield data were collected. Statistical analysis and interpretation was underway at the end of my tour. Preliminary information from Madaba trial indicated no significant difference among the varieties at any fertilizer level. There was a phosphorous-variety interaction. There was an increase of wheat yields from all fertilizer treatment with the yield curve still rising at the heaviest rate of nitrogen (30 kg of Ammonium Sulfate/dunum) and phosphorous (40 kg of triple super phosphate/ dunum). Advance information indicated that the additional yield even at

the lowest level was not an economical increase at the current fertilizer prices and prices received for 1975 crop wheat at harvest.

This particular trial should be especially valuable in that the results will help define more clearly the needs for soil fertility research.

V. TECHNICAL EXPERT SUPPORT

1. Operational Plan Requirements

The Operational Plan of the Contract called for short term visits of a soil fertility specialist, an irrigation wheat management specialist and a visit by a herbicide sprayer specialist. Visits were scheduled for the soil fertility specialist for the period of July - September, 1973 and again in 1974 for the same time period. The irrigation specialist was scheduled for a like period in 1973 and a return in 1974 for the period April - June. The herbicide sprayer specialist scheduled for the period November, 1973 - January, 1974 was not affected by the delay in the Contract signing or the October war.

A series of events and lack of Jordanian Counterparts necessitated a departure from the Contract Schedule Operational Plan. The effective date of the Contract, August 27, 1973, and additional delay caused by the October war did not permit any possible counterpart recruitment in time to plan for field research with the 1974 wheat crop.

Consequently, I assumed their responsibilities with the Review Report and training and planning of their counterparts for the 1975 crop. The soil fertility specialist and the irrigation management specialist visited Jordan early in 1975 to evaluate the research underway and to make recommendations for future work. Their reports are on file.

2. Amended Operational Plan

A contract amendment authorized additional expert assistance in the area of economics and agri-business. The Research Economist made an economic evaluation of dryland wheat produciton practices introduced in field demonstrations. The results of the study will indicate those areas of production requiring more intensive investigation.

VI. EXTENSION DEMONSTRATION PROGRAM

1. General

The extension education program in which the wheat project staff demonstrated improved methods designed to increase wheat yields has been underway since 1969. Since that time more than 500 fields having a total area of more than 15,000 dunums have been planted on farmer's fields under this program. The total average increase under all prevailing conditions of weather and soils over the traditional production methods is aobut sixty percent.

During this period of time numerous farmer training meetings have been held to tell and show farmers better ways to increase wheat yields. Numerous bulletins have been prepared for distribution. Many press releases have been prepared. Radio and television shows with farmer's cooperation have been broadcast.

2. Farmer Adoption

Most wheat farmers have had theopportunity to visit project sponsored demonstrations, farmers' meetings and seminars. As a result they are adopting the practice of controlling weeds in wheat chemically and the use of improved treated seed wheat. The use of fertilizer materials has been adopted to a lesser extent and few faremrs are using improved tillage tools and grain drills.

The reasons for non-adoption are not fully known at this time. However, farmers have indicated the capital investment involved is beyond their financial means. The economic evaluation mentioned above explores this constraint. Until such a time that the problems of adopting modern methods of wheat culture are solved, the farmers must be shown how to make the best use of those facilities now available to him. This would include

the use of some items less costly than those that have been demonstrated, but ones that can do work better and cheaper than traditional methods.

3. Suggested Extension Demonstration Project

The demonstration program previously required little of the cooperative land owner other than theuse of his land. In the annual cropping demonstrations, the farmer also did the primary tillage. The wheat project did the other farming operations up except harvest. For this increased production the farmer returned to the project the amount of seed used in planting the crop.

It is believed that more rapid adoption of new methods would take place with more personal involvement by the farmer and the extension agent and a greater contribution on the farmer's part. Emphasis should be placed upon a program making better use of the facilities the farmer has available to him. Less sophisticated implement than demonstrated in the past should be tried as a more practical means to increase wheat production.

Rather than establishing field size demonstrations it is suggested that the treatments only be parts of fields where the results of the practice or combination of practices can be easily compared with the farmers normal method. This type of demonstration would be primarily an extension agent activity with support from wheat project staff and departments of the Directorate.

Examples of method and result demonstrations suggested are:

(a) better prepared seed beds using properly adjusted tillage tools now in common use in an approved manner.

(b) introduce locally fabricated spring tooth harrows for better tillage and seed coverage.

(c) the use of fertilizer spreaders and distribution to broadcast seed wheat.

(d) the use of new varieties.

(e) the use of fertilizer materials.

(f) the use of herbicides to control weeds.

(g) shaping and grading irrigated wheat seed beds.

It is believed that a few demonstration sites in the important wheat growing area should be continued much as in the past under control of the wheat project. Such locations would provide sites for research and would continue to show the results from a high level of management, requiring inputs which may be available to a few of the larger farms.

VII. CONCLUSIONS AND RECOMMENDATIONS

1. There is a great potential for increasing wheat production in Jordan through the general adoption of a modern wheat culture developed in the country upon the sound base of the one successfully demonstrated from the Pacific Northwest.

2. To achieve the potential increase in production the cultural, social or economic constraints hindering research and the adoption of improved methods and techniques of producing wheat will need to be minimized.

3. The Research Directorate has shown with assistance that with suitable leadership and a staff having relevant planning and training, and when adequate logistical support is provided a successful wheat research program with wheat is possible. There is a need to insure that research with wheat receives the priority and full support of the government in direct proportion to theimportance of wheat in the lives of the people in Jordan.

4. Technical assistance and some commodity support is needed by the Extension and Research Directorate to continue the research program started. Plant scientists, soil scientists and agriculture economists could provide most of the technical assistance and training needed. Commodity needs could be limited to those few items required by research and for parts for equipment already in place needing repair.

5. While there are many urgent measures that can be taken to insure the success of increasing wheat production in Jordan there is a need to accelerate and broaden the base of the coordinated wheat research program underway. Because of the nature of research and the need for answers to production problems emphasis should first be placed in the areas of tillage, soil fertility, weed control, irrigation and variety testing components.

6. Most of the wheat farmers have had the opportunity to be cooperators or visitors to the field size wheat project demonstrations. The program has served its purpose by testing and showing improved methods of improving wheat production throughout the wheat producing areas of Jordan. The program should change emphasis from the maximum use of introduced modern machinery and equipment in field size plantings to that of emphasizing the results obtainable from the proper adjustment, maintenance and use of machinery now in popular use by the farmer. The use of fertilizer spreaders and distributors to broadcast seed should be demonstrated as a replacement to had sowing. An extension program such as this will need a heavy input of agricultural engineers with field training in farm machinery. Demonstrations should show methods and results from proper seed bed preparation, the use of improved treated seed, method of seeding, ways to control weeds, the use and application of fertilizer and the use of a properly adjusted combine harvester.

7. Finally to insure that wheat production will be increased it is essential that there be an organized coordinated multi-disciplinary research program that is amenable to both statistical and economic analysis. Proper coordination of the research effort will require better communications between the departments and institutions doing research with wheat. An organization of professional wheat workers of all disciplines would provide a vehicle for professional improvement and could be helpful in designing a wheat research program meeting the needs of Jordan and having a minimal duplication effort. Because of the ministry, directorate, and departmental structure it is important that there be designated a professional agriculture scientist who as a program leader with wheat will have status and

and be designated official responsibility for leadership with the wheat research and the wheat extension education program. These coordinated activities should help insure that the extension staff and, most important, ultimately the wheat farmer has the necessary information to make intelligent decisions about most efficient wheat production.

AVAILABILITY OF GOODS AND SERVICES FOR IMPROVED WHEAT PRODUCTION IN JORDAN

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Introduction and Objectives

A program to increase wheat production in Jordan began in 1967. Oregon State University, USAID and the Government of Jordan have participated in an effort to introduce dryland wheat production techniques of the Pacific Northwest to the farmers of Jordan. These techniques include clean summer fallow, use of fertilizer, chemical weed control, grain drills and improved seed. The number of farmers adopting these new techniques has been minimal despite a large number of on-farm field demonstrations and educational efforts. Identifying and measuring constraints to the adoption, by the Jordanian farmer, of the modern wheat producing techniques is being undertaken by USAID. The primary objective of this report is to help evaluate the adequacy of the private sector, including cooperatives, in supplying goods and services to the Jordanian wheat farmer. Specific attention was devoted to fertilizer, farm machinery, seed production and the role of JCO in providing inputs to the Jordanian farmer.

Procedure of Information Gathering

Interviews with managers and owners of Agribusiness firms provided much information included in this report. Inspections of facilities for maintenance and repair as well as retail sales stores were included. Visits to JCO, ACC, the Agriculture Marketing Organization, Jordan Tobacco Company, the Amman Vegetable Market and with many employees of the Ministry of Agriculture provided insight into Agribusiness needs of Jordanian farmers. Many cooperative societies were visited and managers and farmer members were interviewed. Many extension agents were visited and questioned. Many blacksmith shops were visited and observations made of facilities and locations. Cooperation from all people was excellent and seldom was information difficult to obtain.

SUMMARY

Agribusiness firms in Jordan do have the capability to supply the goods and services for modern farming techniques within the framework of business practices present in the country. Business in Jordan is characterized by small shops operating with limited capital. Delegation of responsibility is very limited in business and government. Distance from suppliers hinders quick availability of many goods. Political and business uncertainty in the past tends to make business men conservative.

Fertilizer imports and sales are conducted by business long established in the field. Government purchases and interference in pricing schedules has limited free market pricing of some fertilizers. Ample supplies of fertilizer are available from amny small dealers in the private sector and the cooperative societies.

Tractor sales companies are very well operated businesses with large inventories of tractors. Service facilities are very adequate. This area of agribusiness needs little improvement.

Seed production is conducted as a government function by the Ministry of Agriculture and JCO. Seed increase is being encouraged as rapidly as possible. Production of larger quantities of certified seed is being expanded rapidly. Considerable investment is required for this expansion and qualified personnel to supervise this certified seed production will be required.

Farm implement sales are conducted by many small firms with no one firm aware of the sales potential that could soon develop in Jordan. Implement sales companies need to be informed of new implement needs. Tractor sales companies presently associated with world wide implement

sales companies are the potential suppliers of new farm implements. Local blacksmith shops have the ability to manufacture many of the new implements such as tool bars, that will soon be in demand in Jordan. Technicians to train the operators of new implements in care and operational principles will be as important as availability of the implements.

The cooperative societies have been selected by the Ministry of Agriculture to provide many of the goods and services necessary to increase wheat production in Jordan. Cooperative societies, having close relations with the small and uneducated farmers, can organize and motivate many farmers that the Extension and Research Department has been unable to assist because of poor communication with small farmers.

It should not be assumed that JCO can provide all agribusiness and extension services; therefore, continued communication by the Ministry of Agriculture with the private sector is essential. The Extension and Research Department functions need to be expanded at the research level as well as the "grass roots" farmer level.

The impact of the expanded cooperative movement on the private sector at the present time is minimal. Most purchases by cooperatives have been from the private sector and are additional sales for the private sector. Proposed plans by the cooperatives to make large purchases directly from foreign suppliers would discourage expansion of the private agribusiness sector. The private sector will always have a function in Jordan because cooperatives are not strong enough to serve all Jordanian farmers.

Fertilizer Distribution in Jordan

Fertilizer is imported by five companies in Jordan, all having a main office in Amman. The two major importers, Yordan Obegi Co. and Bakr Shanti, operate mainly as importer-wholesalers. They sell to small dealers in most agricultural areas of Jordan. Most fertilizer sales are in the vegetable growing areas. There are at least 20 small dealers in the Jordan Valley who keep small inventories of fertilizer. Other vegetable growing areas have similar small dealers. Three other importers of fertilizer are the Agricultural Materials Co., Jordan United Farmers and Usef Marto. These importers are mainly retail type operations with branches in Irbid and Zerka as well as Amman. The Jordan Valley is served by Irbid or Amman stores or sub-dealers in the Valley.

All importers of fertilizer are also importers of pesticides and vegetable seeds. All but Bakr Shanti employ agronomists - salesmen. These men appear to be well trained for Jordan conditions and do call on many of the farmers, offering advise on the use of new and old products and taking orders. Approximately 20 agronomists are employed by these dealers with most involved in fertilizer sales as well as seed and pesticides sales. Samples of new products are given to the Ministry of Agriculture for testing and use. The dealers make trial applications of the new products on farmers fields in several areas of Jordan to demonstrate advantages of the new products. The agronomists then carry this information to the farmers by direct on-the-farm calls. Mass media advertising is not used by Agri-Business dealers in Jordan. There are no farm magazines in Jordan and many farmers cannot read or write.

Major importers now active in the Jordan fertilizer market seem to have no problem getting ample supplies of fertilizer other than the three to four month delay in transportation from Western Europe. Most of the fertilizers from Europe are mixed compounds used by vegetable growers. Fertilizer from Kuwait takes two or three weeks for delivery and is almost all ammonium sulphate. Approximately one half of the 15,000 tons of fertilizer used yearly in Jordan is ammonium sulphate. Wheat farmers in Jordan have been using less than 1,000 tons of ammonium sulphate, and similar amounts of phosphate fertilizers yearly.

Fertilizer sales companies on the distributor level and the retail level seem to be competitive considering business conditions in Jordan. All dealers in both levels extend seasonal credit at no interest but prices must be higher to cover the added cost of doing business. Uncertain political and business atmosphere in the past few years did make business ventures more risky. Higher profit margins were required under these conditions and still are reflected somewhat under more stable conditions now present. Recent tenders for fertilizer by the government by the government did receive many bids from local suppliers. Prices seemed in line with world prices.

The price of ammonium sulphate in Jordan is higher than it should be. Last year the Ministry of Agriculture made a purchase of 4,000 tons of ammonium sulphate from Kuwait and did not sell all of the product. World fertilizer prices are now much lower but prices charged by the government are being kept at a high level until the old stocks are disposed of. The price of 63 JD charged by the cooperative societies now, should be 10 to 15 JD per ton less than this. Prices charged by the private sector are usually five to seven JD more than that charged by

cooperative societies because freight charges in the country are paid by the Ministry of Agriculture and the price mark up by the cooperative societies is usually only two JD. per ton.

Until the government has some well trained people familiar with every day world prices and supplies as well as local demands, fertilizer purchases on the world market should be left to experienced businesses working in this area every day.

The use of urea in Jordan is very limited for two reasons. The first constraint is that because of the high analysis of nitrogen (46% N.), only small amounts of product are applied to a given area. Farmers using hand spreading or poor quality mechanical spreaders, cannot get even distribution of small amounts of urea on the soil surface. Ammonium sulphate with an analysis of 21% N, is applied at twice the rate of product as urea is, making it more visible on the soil surface. Until more sophisticated fertilizer spreading equipment is available, the use of urea in Jordan will be somewhat limited. The second reason urea is not widely used in Jordan is because of the use of an old tariff schedule developed in Europe many years ago that said urea with an analysis of more than 45% N. is an industrial product and in Jordan has a duty of 28%. All urea produced in the world now has an analysis of more than 46% N. Because of less shipping costs and cheaper manufacturing cost urea has become the "world" fertilizer. This fact should be recognized in Jordan and tariffs brought up to date.

In many areas of Jordan urea with a lower cost per unit of N. could be used successfully to reduce total fertilizer costs. It's possible volatilization from high pH soils should be monitored by field tests.

The cost of fertilizer in Jordan is greatly affected by the high shipping costs from Western Europe which are about 25 JD. per ton. This is about 50% of the cost of low analysis fertilizers and 25% of high analysis fertilizers such as urea and some mixed compounds. Freight charges from Kuwait or Iraq are only about 7 JD. but initial costs are higher making the delivered price about the same regardless of point of shipment. Most of the fertilizers from Europe are mixed compounds which are not available from the Persian Gulf area.

Plans to build a fertilizer plant at Aqaba to produce diammoniated phosphate are being studied. This plant could not be in production until 1978. It will not have an impact on the local market for several years. Increased production of urea and anhydrous ammonia in the Gulf States could have some effect of lowering fertilizer prices in Jordan, but because small amounts of these fertilizers are used in Jordan, the effect will be small.

Although Jordan has extensive deposits of phosphate rock and large amounts of phosphate rock are exported, less than 5,000 tons of fertilizer for local use is manufactured per year. The product produced is a low quality single super phosphate. Equipment used is very old and inefficient. Also, health and environmental hazards are very great at the plant site. The equipment had not been used for several years but fertilizer shortages caused the government to ask the Phosphate Company to again produce single super phosphate. The use of this plant should be discontinued as soon as possible. Some triple super phosphate is now imported from Europe to fill the needs of the country and additional imports could be made easily.

Many farmers did indicate they wanted to use fertilizer on their wheat this year if easily available and rains were timely. They have

seen benefits from the use of fertilizer, especially in areas receiving over 350 mm of rainfall. 2,000 tons of ammonium sulphate was carried over by the government for use this year. An additional 1,000 tons of ammonium sulphate, 500 tons of triple super phosphate and 500 tons of mixed compounds have been purchased this year for distribution by JCO. The low rate of interest charged by JCO and easy availability of fertilizer by cooperative members appear to have greatly increased the use of fertilizer by wheat farmers.

Continuing research investigating the rate of fertilizer to be used economically on wheat is badly needed. Because all nitrogen fertilizer is imported, the economic benefits of fertilizer have to be studied very closely to be sure maximum economic return is obtained.

Fertilizer consumption in Jordan seems to increase slowly each year. Education of the farmers to the benefits of fertilizer and availability of financing and supply should see a more rapid increase in the use of fertilizer. One example of the amount of fertilizer that could be used by wheat farmers follows. If one-fourth of the 2,000,000 dunums of wheat were fertilized at the recommended rate of 10 Kg. of ammonium sulphate and 5 Kg. of triple super phosphate/D, a total of 5,000 tons of ammonium sulphate and 2,500 tons of triple super phosphate would be required each year.

The private sector is doing a reasonable job of providing adequate supplies of fertilizer when and where needed. The large number of small dealers selling fertilizer sometimes limits the stock of fertilizer at any one location. Credit needed by most farmers makes financing a part of fertilizer sales in Jordan. This situation along with more risks in

doing business in Jordan does justify higher profit margins. Cooperative societies providing low interest financing, low cost fertilizer and furnishing transportation should have a great competitive advantage in fertilizer sales. This is not true in many areas of Jordan. Cooperative societies are active in only a small portion of Jordan and management ability is limited in many societies. The Ministry of Agriculture is depending on JCO to provide all the inputs necessary for increasing wheat yields in Jordan. The private sector will be needed to provide much of this effort and must be encouraged to expand their services to farmers of Jordan. Continuing dialogue between JCO and the private sector is important in supplying the necessary inputs for all farmers in Jordan.

It would appear that cooperative societies are more active in areas that are some distance from Amman. This may suggest that easy availability of inputs is an important factor in getting farmers to quickly adopt new practices. Farmers of Jordan are handicapped by having to depend on public transportation for moving all inputs. The further the farmer is from sources of inputs, the easier it is for him to postpone using new technology. The educational process is limited in the same manner, indicating the need for greater extension services by the private sector as well as by government.

Tractor Sales in Jordan

Each tractor sales company in Jordan performs the multi-function of importer, wholesaler and retailer. The main office of every company is located in Amman. At least eight major tractor brands are sold in Jordan. The name of each company visited, location and brand of tractor sold is included at the end of this report. Every company maintains a sales office, major repair facilities, and spare-parts supply in Amman. Outlying areas of Jordan are served by branch offices or agents. Irbid and Zerka are the only areas served by branch offices at the present time. Zetor and Massey-Ferguson dealers closed branches in Karak two years ago because new tractors were difficult to obtain. New tractors are now readily available and these two dealers indicated they may reopen the branches in Karak. No company has a branch office in the Jordan Valley or indicated interest in opening a branch there. The large number of tractors in the Jordan Valley should justify some tractor company branches. The past uncertain political situation has not provided a good business climate for major investments in the Jordan Valley. Any extra capital available to the tractor companies is apparently invested in Amman where risk of investment is less. Three of the tractor sales companies visited are building new tractor repair facilities in Amman.

Tractor sales in Jordan have increased during the last year indicating optimism by Jordan farmers. Also, availability of long-term credit from ACC and JCO has provided some badly needed financing to the farmer. Most farmers have very limited saving and require long-term credit for capital investments. The lack of investment capital for agriculture has been the greatest single constraint to mechanization of agriculture in Jordan.

Purchases of tractors by cooperative societies have increased greatly and group ownership of equipment is a means for small farmers to participate in using equipment too expensive for individual ownership. Cooperative societies involved in wheat production purchased 15 tractors this year. Total tractor sales in Jordan this year were 400 to 500 units.

Tractors are available from all dealers. All dealers visited have 12 to 50 tractors in stock. The Zetor tractor sold by the Khalil Salem Khoury Company has not been available from Chekoslavakia for several years but is now assembled in Iraq under the name Antor and will be available in Amman this month. Parts for the older Zetor tractors have continued to be in good supply.

The 70 H.P. tractor is the size most common in Jordan. Prices range from 3100 JD. to 3500 JD. The units are equipped with hydraulics and three point hitch. The 80 H.P. tractor is also available from some dealers at a cost of 4000 JD. or over. In most cases, this is more horsepower than can be utilized for tillage purposes by the farmers because of small implements presently owned and available in Jordan. Many tractors are used for transportation purposes as well as for tillage. It is possible that higher horsepower tractors would be useful for transportation purposes because in Jordan at least 30% of the tractor use is for transportation.

Most tractors do not have fluid in the tires or ballast of concrete or iron added to provide sufficient traction for heavy tillage usage. Removable ballast of iron or concrete should be available for use when the tractor is performing major tillage operations and removed when the tractor is used for transportation purposes.

Repair facilities and spare parts stocks of the major tractor sales companies that have been in business over five years seem to be very adequate. The John Deere and International Harvester dealers have just recently become active in tractor sales. Spare-parts for these two brands of tractors are not adequate at the present but they do have good repair facilities because of long established automotive and industrial tractor sales forces. All major repair facilities are located in Amman. All cities of over 10,000 population have small automotive repair shops which also do minor tractor engine repair. Most major repairs are performed in Amman. All major tractor manufacturers send factory service representatives to Jordan several times each year to train and update key service personnel. Spare-parts availability from the factories has become much better in the last six months period. All dealers place stock orders several times each year but have to air-freight some emergency parts from time to time. Delivery of stock orders of parts takes two to four months which requires local dealers to have large stocks of parts. Investment in parts is for long periods of time. Spare parts for agriculture have a duty of about 35%. The added investment in spare parts and the cost of duty account for the higher cost of spare parts in Jordan compared to America.

Automotive and hardware type spare parts are also available from several spare parts dealers in Amman such as the Khalil Hamarneh Company. Fast moving spare parts such as belts, bearings, rings and spark plugs are available from these spare parts companies at costs lower than the tractor dealers charge. Lower quality products and fast turnover items contribute to lower costs of doing business by the spare parts companies.

The tractor sales companies are well established businesses and appear to be competitive in the tractor market. All offer financing plans for tractor purchases. Most have branches in other areas of Jordan and do have good repair facilities. All of the companies have a weak farm implement business. As yet no company seems to realize the business potential of the allied farm implement business. Most tractor sales companies are more familiar with the automotive sales business than the agricultural implement business. Recent inquiries from some farmers and from JCO may influence the tractor sales companies to become more effective in the related implement field.

During the early period of tractor sales in Jordan, most tractors were purchased by contract farmers normally called custom farmers or custom operators. The individual farmer is now the largest purchaser of tractors. Some of the individual farmers do custom farming as well as their own work so are a source of some custom farming services. Bedouins have purchased many tractors. At first the bedouins used the tractors for transportation purposes only, transporting water and feed and moving their camps. A few years ago, they purchased plows and now are tilling some of the low areas of the desert and planting cereal crops. Most years the crop is very poor and if the areas cannot be harvested, the areas are grazed by the bedouin flocks.

Contract farmers and individual farmers doing contract farming probably still perform well over 50% of the tillage of farm lands in Jordan. Prices for custom farming in Jordan are very low in comparison to U.S. prices. Small parcels of land to be farmed and the distance contract farmers must travel to the fields makes tractor usage very inefficient. Therefore,

prices should be higher. As an example, contract farmers charge .150 JD./D for light plowing often called covering disk. This would convert to about $2.00 U.S. per acre. Cost in U.S. would be at least $3.50. Unless the farmer has large holdings, ownership costs could be as much as 50% higher. Contract farmers can till more area per season and labor costs are low in relation to machinery costs. For these reasons contract farmers can operate with some profit by charging low prices. Tillage performed by most contract farmers is very poor by western standards but seems to satisfy the farmers of Jordan. Poor adjustment of plows causes much ridging of the soil and many large stones in the fields must be plowed around.

In contrast to the trend of more tractors being purchased by individual farmers, well over 50% of combines and sprayers are purchased by contract farmers and cooperatives. It is assumed this same pattern will be followed in the purchases of grain drills and sweep plows. These implements are more expensive per unit of use because they are used only for a short period of time each year. Therefore, contract farmers and cooperatives, making longer use of these implements, can reduce the cost per unit of use. As farmers become more aware of benefits and the importance of proper time of use of these implements, more units will be purchased by individual farmers. Contract farmers will continue to provide an important service to farmers in Jordan because of the land fragmentation and the time required for cooperative societies to become effective. Group ownership of farm equipment through membership in cooperative societies and blocking of several land ownerships into one field will increase efficiency of farm equipment. Perhaps 50% of the wheat land of Jordan can be farmed this way but it will be five to ten years in becoming a reality.

Farm Implement Sales in Jordan

Farm implement sales in Jordan are much different than the pattern of sales in the U.S. In Jordan, farm implements other that combines are not generally sold by the same companies selling tractors. Only two brands of combines are sold in Jordan. They are the John Deere sold by the Jordan Tractor Company and the Clauson sold by the Khalil Salem Khoury Company. Field sprayers and three types of turning plows are the only other major implements readily available in Jordan at the present time. The three types of turning plows are the moldboard plow, most of which are manufactured and sold by blacksmith shops in Amman, the disk plow imported by some spare parts dealers and some tractor sales companies, and the poly-disk or covering disk which is manufactured and sold by blacksmith shops in Amman. Field sprayers are also manufactured by blacksmith shops in Amman using an imported kit consisting of a pump, control valves and nozzles with the tank, frame and booms made in Amman. These blacksmith shops are rather crude by western standards but produce a very usable product. The locally manufactured implements are priced cheaper than imported items

Visits were made to blacksmith shops in Madaba, Karak, Irbid and Jarash. They had spare parts in stock for plows that are manufactured in Amman and were performing major repairs to these plows. Blacksmith shops were observed in many villages as visits were made to other parts of Jordan. As in Amman, these shops were small but appeared to have the basic tools and craftmanship to do major blacksmith repairs.

At the present time, several blacksmith shops are interested in tooling up to manufacture spike tooth harrows and tool carriers to be used as chisel and sweep plows. These same blacksmith shops have been

producing many spare parts for farm implements when parts are not readily available from the dealers. Some sweeps for the sweep plows have been produced in Jordan. Probably the local blacksmith shops could produce a simple type of grain drill that would meter the proper amount of seed and give uniform seed placement. The seed box and seed metering portion of the drill would have to be imported as it is a precision type of equipment. This type of drill could use the frame of the chisel plow making the cost much less. This type of drill has been investigated by AUB at Beirut, Lebanon and perhaps communication with them could provide further information of value to local blacksmith shops.

Technical help would be of considerable aid to local blacksmith shops. Information should be provided to explain basic operational principles of new implements as well as potential markets. Some components of these new implements will need to be imported and information on availability, types needed and quality of material required would be helpful to manufacturers of local implements. Further investigation and continuing observations of the possibility of expanding the local manufacturing facilities should be strongly considered.

Very few grain drills have been imported by farm machinery dealers because the dealers are not aware of the type of grain drills needed in Jordan. Many different types of grain drills are manufactured by the major implement companies of the world. Over 25 different possible types are available. A grain drill with 25 cm to 33 cm row spacing and using a hoe type furrow opener should be the most useful and popular in Jordan. This type of drill should give the most consistent seed placement with

the least machine breakage. In a few areas where stones are not a problem in the soil and the soil tillage is good, a drill with disk type furrow openers could be used successfully. The hoe type of drill is also the most expensive drill costing over 1,200 JD. for a two and one half meter unit. Less than 20 grain drills are in use in Jordan at the present time with most of them John Deere with hoe type furrow openers.

A visit was made to the John Deere dealer, Jordan Tractor Company, to observe the spare parts inventories for grain drills. These inventories were very inadequate. Conversations with the company management indicated a lack of knowledge of the spare parts sales potential and the need for providing adequate inventories of spare parts necessary to service the drills. Continuing encouragement will be necessary to convince this company that good parts availability is essential if continued sales of drills is expected. Perhaps personnel from the FAO dryland wheat project at Irbid and from the wheat project of the Ministry of Agriculture, both using mostly John Deere equipment, should be encouraged to continue hard line dialogue with the Jordan Tractor Company about the importance of good spare parts inventories.

Most of the demand for grain drills has been from cooperative societies. A delegation from JCO and the Ministry of Agriculture visited Spain recently and purchased seven grain drills for this season's use by the cooperative societies. This action was necessary because local dealers could not guarantee delivery of drills for use this season. Local dealers indicated delivery time for drills would be five to eight months. Local implement dealers are waiting for delivery of these drills from Spain to JCO to study acceptance of them by local farmers. Information received

at the end of tour in Jordan indicates that the Spanish grain drills will not be available for use until late in this planting season. This further indicates the great need for better communication by the Ministry of Agriculture and JCO with local implement dealers. Also, the services of agricultural engineers or technicians employed by the Ministry of Agriculture are badly needed. They could provide comprehensive education in principles of operation, care of machinery and timely ordering of farm equipment. In a developing country where the farmers have no experience in the use of machinery, continuing education in this area is of great importance.

A field day for implement dealers to see the several types of grain drills and new tillage equipment used by the wheat project, in operation, should be encouraged. Observations of drills and tillage equipment in operation and explanation of principles of operation would help dealers to have better recognition of the requirements for drills and tillage equipment to be used in Jordan. Education of farm implement dealers is of great importance to speed up their capability to provide necessary farm machinery inputs for increasing wheat production in Jordan.

Observations were made of many stones in the fields that will hinder the proper use of modern farm machinery. The use of grain drills and sprayers in fields with many stones would be difficult and much breakage of machinery will result. Conversations with people associated with wheat production in Jordan in both the government and private sector indicated little awareness of the problems associated with the operation of modern farm machinery in stony fields. A hydraulic operated front end loader on a farm tractor could be used in conjunction with several

laborers to place the smaller stones in the bucket so they may be transported from the field with the tractor or placed in a trailer and transported from the field. Larger stones could be scooped up by the bucket or a chain placed around it and lifted from the soil and transported from the field. Stones less than six cm in diameter need not be removed from the fields. Cost of stone removal from most fields would be minimal in comparison to continued machine breakage expenses. Perhaps a program similar to the terrace construction program, where much of the salary of laborers was paid in food items, could be used to encourage stone removal from the wheat fields. Front end loaders would have many other labor saving uses such as loading gravel for concrete on trailers and lifting machinery and heavy loads. In many fields the successful use of modern farm implements is dependent on removal of these stones.

SEED PRODUCTION

Improved seed production in Jordan is now being performed only by the Ministry of Agriculture and the JCO. Low prices established for improved seed does not allow private seed companies enough profit to justify private seed production. Some farmers have kept supplies of improved seed from previous crops for seed increase and do offer small quantities of seed to neighboring farmers.

The price of improved seed this year is 72 JD./Ton or 12 JD./Ton above the 60 JD./Ton price established by the government for high quality milling wheat. The Ministry of Agriculture and JCO had asked for 78 JD./Ton for improved wheat seed but Ministry of Supply reduced this to 72JD./Ton.

This year 855 tons of improved seed will be distributed by the Ministry of Agriculture to the JCO. There will be 70 tons of the variety F8 and 785 tons of the variety Horani Nawawi, both durum type wheat. Any farmer wanting improved seed must belong to a cooperative society which will be the only source of improved seed. The local cooperative manager and the District Director of Agriculture are to do the allocating of this seed to individual farmers. The Karak district, with four cooperatives, is to receive 130 tons of Horani Nawawi and 20 tons of F8. Madaba district with one cooperative will receive 50 tons of F8. Irbid district, with ten cooperatives will receive 655 tons of Horani Nawawi. The Amman, Balqa and Ma'an districts have only diversified agriculture cooperatives and wheat growers in these districts may receive some improved seed if demand is made by the member wheat farmers for the improved seed.

The improved seed will be charged out to the cooperatives at 72 JD./ton. They have the option after next harvest to return like amounts of wheat or pay for it in cash. The individual farmer has this same option. No interest is charged during this period of time.

The 855 tons of improved seed being distributed this year is sufficient to plant 100,000 D. It is hoped that 10,000 tons of improved seed will be produced by the 1976 crop. This would provide enough seed to plant 1,000,000 D. for harvest in 1977 or approximately one-half the normal wheat planted area of Jordan.

In visits to several cooperative societies it was apparent that there is a greater demand for improved seed than can be supplied for this planting season. Improved seed from some farmers that kept seed from previous years may supply a portion of this excess demand. The Ministry of Agriculture is suggesting that the available seed be allocated to areas having above 300 M.M. of rainfall.

Farmers are not required to return the improved seed they produce to the JCO. The price of 72 JD./ton, which is 12 JD./ton above the 60 JD./ton price for milling wheat, is supposed to provide incentive enough to the farmer to sell his wheat for seed purposes rather than milling. If the farmers wheat does not clean out 85% or more clean seed, there is no price advantage in producing improved seed. Most farmers keep two years supply of seed on hand in case of drought so they probably will not return all of their seed wheat to the cooperatives.

The improved seed being produced at the present time does not maintain complete varietal purity. This is due to the need to produce

as much improved seed as possible in the immediate future, and the absence of facilities and education in its production. The improved seed now being used is a major improvement over local varieties and is encouraged until the next step in seed production, that of certified seed production, can be fully implemented. Wheat researchers credit 25% of the increased wheat yield obtained on early demonstration plots in Jordan to the use of improved seed. This would be 10 to 15 Kg./D increase contributed by using improved seed alone.

During this planting season varietal pure seed production by the Ministry of Agriculture will be greatly expanded. Several closely controlled steps are required in producing certified seed, the final pure seed produced for seeding by farmers. First, foundation seed is produced by plant breeders at the Rabba Agricultural Experiment Station near Karak. In the second step, to be implemented this year, 1,800 D. (1,200 D. near Ramtha, 400 D. at Irbid, and 200 D. at Rabba) will be seeded with foundation seed. The production from this 1,800 D. is called registered seed (if quality standards are met). In the third step, to be implemented next year, the registered seed will be given to the JCO for planting and this production will be certified seed. The fourth step is then allocating the certified seed to farmers for planting. If this schedule is maintained, 180 ton of certified seed should be available to farmers to be planted for harvest in 1978. Seeded area should be 18,000 D. and should produce 1,800 tons of varietal pure improved seed. This would plant 180,000 D. for harvest in 1979. Purchases of new lands this year for certified seed production could double the amount of seed available in 1980.

The training of several seed production technicians is strongly urged to help oversee the production of the foundation, registered and certified seed. The maintaining of varietal purity is very important in these stages of production. A person experienced in seed production in developing countries should be used in supervising seed production for the next several years. As new higher yielding varieties become available in Jordan, these steps of seed production will need to be repeated many times.

The standards or grading system for improved seed wheat is based mainly on saving the largest kernels for seed increase and is probably wasteful of many kernels satisfactory for seed. This year the Ministry of Agriculture has relaxed the size standards and made at least 50% or more seed available. It is not known if this policy will continue and what standards will be used in certified seed production. Perhaps the adoption of U.S. wheat seed standards could be coordinated with the beginning of the new seed production program in Jordan. This will not be easily done as the present method of seed selection has been customary for generations. Acceptance of seed cleaned and treated by two Barber cleaner - treaters purchased by the Ministry of Agriculture from the U.S. is dependent on ordering of different screens from the U.S. Seed size acceptable in Jordan can be produced by these new cleaners if proper screen sizes are available for the cleaners. These screens should be ordered soon so they may be used next season. The new cleaners are much faster than the rotary sizers presently used and labor costs could be reduced by at least 50%.

The production of registered seed by the Ministry of Agriculture may not be the most economical means of seed production. Many people of the Wheat Project and Department of Research and Extension will be involved in day to day operation of these lands. People from the FAO Dryland project in Irbid are being involved at the present time. Research people should have more important tasks to perform in the area of research and extension. An amount of 300,000 JD. has been budgeted to purchase additional lands near Amman for registered seed production, Investments in buildings and facilities will add more cost. Land costs have risen very rapidly in the last year and are too high to justify agricultural usage. A better approach may be to contract the registered seed productions to qualified farmers under technical supervision, helping them in leasing additional lands if necessary and offering long term contracts if performance standards are met. Some cooperative societies may be able to also provide this service if well supervised. The seed lab division which is under the direction of the plant breeding department could be expanded to provide the technical assistance needed by this approach.

The JCO and Inputs to Wheat Farmers

The Jordan Cooperative Organization has been selected by the Ministry of Agriculture to implement the adoption of modern wheat growing technology by the farmers of Jordan. The JCO is to furnish the necessary inputs to the cooperative societies organized by farmer members. The JCO could be considered as a sub-contractor employed by the Ministry of Agriculture to dispense the inputs deemed necessary such as improved seed, fertilizer, herbicide and farm machinery. Also included are technical assistance, credit and management.

A combination of methods are used in providing the various inputs. All available improved wheat seed is allocated to the JCO by the Ministry of Agriculture for exclusive distribution to cooperative society members. Fertilizer is purchased by bid by the Ministry of Agriculture and provided to the JCO for sale to cooperative society members. Transportation costs are paid by the Ministry of Agriculture. Herbicides are purchased by the Ministry of Agriculture or purchased by the cooperative societies for sale to society members at low cost. Sprayers purchased by the societies are rented to the members. Machinery is purchased by the JCO for cooperative societies to be repaid by ten year loans at 6% interest. Tractors, plows, drills, sprayers and combines are some of the types of machinery being purchased. Cooperative societies rent this equipment to the farmer members.

Loans of four types are available to cooperative members. Short term or seasonal loans are for less than one year. Medium term loans are for not over five years. Long term loans are for as long as ten years and are mainly for machinery. In-kind loans such as for seed wheat are repaid at the end of season with no interest. Also available

to individual cooperative societies are 15 year loans to build stores and offices.

A manager and an agronomist are provided to each cooperative society by the JCO. Storekeepers are paid by the individual societies. Agronomic decisions of each society are made in cooperation with the District Director of Agriculture. Loans to members of cooperative societies are subject to approval by the District Directorate. Membership requirements varies with each cooperative society because each have their own by-laws. Most require a member to be over 18 years of age, of good character and must purchase a minimum of 35 to 50 shares in the local society at one JD. per share. Most have a limit of 15 to 20 percent of the total shares to be owned by one member. Many have a limit of five JD. to be borrowed per share of stock so that a member with 50 shares would have a limit of 250 JD. that he could borrow. The member is usually required to mortgage his land as security. Non-land owners are permitted to join most societies but have a limit of borrowing of 150 JD to 180 JD and many require a co-signer. Members of the Military or other government bodies are not eligible to join cooperative societies. A board of directors is elected from the members and conducts the business of the society with help from the manager and other technical people provided by the JCO.

The overall impact of the cooperative societies in providing the inputs for improving wheat yields in Jordan is difficult to assess. There is a large variation in the effectiveness of each cooperative society. Cooperatives in the Irbid district are the oldest and have been in operation for over three years. There are now ten wheat cooperatives in this area with 2,000 members and includes 50 villages.

Members have about 450,000 dunums with about one-third planted to wheat each year. Societies in the Irbid area use all of the inputs provided by the JCO. This year nine new tractors and plows and seven combines have been purchased. Improved seed will be used on about 100,000 D. They own several field sprayers and are considering buying more if the season is good. They also wanted several grain drills but will not receive them in time for use this season. The Karak district formed four new wheat cooperatives this year with 240 members. They have purchased three tractors and will have some improved seed and fertilizer to distribute. Madaba district has had a wheat cooperative for several years but accomplishments have been limited to distributing some improved seed and fertilizer. Amman and Balqa districts have some cooperative societies but are diversified agriculture types and do not have strictly wheat cooperatives. Inputs for wheat are hard to separate in their records.

At the present time, less than ten per cent of the wheat farmers of Jordan belong to cooperative societies but in the last year membership increased at a very high rate. If the rate of growth continues as in the last year, membership could involve close to 50% of the wheat farmers in another five years. This goal will require tremendous inputs of trained manpower and capital investment. Some funds for this are being channeled through the JCO by the Ministry of Agriculture and the A.C.C. but additional funds will be required. The low rate of interest charged by JCO and the low profitability policy of the JCO will not attract capital from other sources. A large percentage of loans are for long periods of time and many inputs such as seed wheat are provided at no interest for one year and longer in years of poor crops. Many other

types of cooperative societies are handled by the JCO and are in competition for the JCO efforts.

It is recognized that some incentives in the form of low cost inputs are required to encourage early use of improved technology by the farmers of Jordan. The farmers of this country are not organized and do not have the ability to do so without some help from some source. The cooperative organizations can improve communication with the farmer and is actually operating as an Extension Service for the Ministry of Agriculture. The farmers are not easily motivated and are slow to accept change. They are being attracted to join cooperatives by incentives of low cost inputs and at the present time have a price advantage by producing improved seed for higher than market price. In some areas the small parcels of land ownership are being blocked into a large parcel for plowing, seeding and spraying. Each parcel of ownership is harvested separately. This is necessary to make efficient use of modern farm machinery and should be highly encouraged.

The JCO is providing an invaluable service to farmers by providing the necessary inputs to increase wheat production in Jordan. Policy changes to improve business management will be required in the near future if the JCO is to become an effective and strong organization in the next few years. Profits to the farmer are increased by using most of the newer production methods. This should make it possible to change business management policy in the future when cooperatives become more experienced in the management area.

Cooperative societies operating in the Agri-business field need much help to survive. They need the help and expertise of the private sector that is well established in Jordan and should not be expected to completely replace the private sector.

Farm Tractor and Implement Sales Companies

	Company Name	Brand Equipment Sold
1.	Mohammed Asfour Co.	Volvo
2.	Arab Resources Co. (Kamal Mango, Manager)	International Harvester
3.	Shahadeh Twall Co.	Ford, Case, David Brown
4.	Khalil Salem Khoury Co.	Zetor (Antor) Tractors Clauson combines
5.	Jordan Tractor Co.	John Deere Tractors John Deere Combines
6.	Suleiman Tannous & Sons	Massey - Ferguson
7.	Khalil Hamarneh	Farm Implements and Spare Parts

Fertilizer and Pesticide Sales Companies

1.	Agriculture Materials Co. (Makdadi Co.) Rafat Qashu - Manager	Fertilizer and Agricultural chemicals
2.	Ghaleb Bisharat	Agricultural chemicals and small tractors
3.	Jordan United Farmers	Fertilizer and Agricultural chemicals
4.	Eastern Company (Usef Marto - Manager)	Fertilizer and Agricultural chemicals
5.	Yordan Obegi Co. (Maurice Kalisse - Manager)	Fertilizer and Agricultural chemicals
6.	Bakr Suleiman Shanti	Fertilizer and Agricultural chemicals

Blacksmith Shops and Implement Manufacturers

Mr. Bajjali	Madaba Road
Mr. Sattary	Madaba Road

Constraints of Adoption of Improved Wheat Production Practices in Jordan.

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The biological technologies of producing dryland wheat have been successfully demonstrated to be transferable from the Pacific Northwest to Jordanian conditions. The major similarity allowing this transferability is the annual distribution of winter rainfall in limited total amounts. In such regions, wheat is the major competitively adapted crop. The basic soil characteristics are quite different but have not been a major limitation to these transfers. There are several major technological refinements which would enhance the efficiency of Jordanian wheat production but are not thought to be of significant importance in limiting the initial adoption of the practices.

Most individuals who have been associated with the wheat project are convinced of the suitability of the general principles of the modern procedures most likely adapted to Jordanian conditions. Furthermore, they have personally experienced some of the shortcomings of the procedures and are aware of the research programs that would improve the procedures. Whether or not the Jordanian organizations are adequately staffed and supported to accomplish these goals is, however, of concern.

It is estimated that 25% of the wheat area that should be sprayed in terms of economic returns from weed control is being sprayed. Additional areas will be sprayed as the inputs become more readily available to the individual farmer. Ever-increasing amounts of stock seed of improved varieties are being made available and farmers are using them. Two major wheat variety screening and development programs are serving as sources of potential new varieties. Farmers are just now starting to use nitrogen and phosphorus fertilizers. Thus, it can be said that farmers have and are adopting these practices as a direct result of wheat project activiites since 1968.

It must also be pointed out that adoption of the combine harvester and the tractor occurred either before the wheat project or in no direct relation to the wheat project.

Farmer adoption of other practices, such as seeding with the grain drill and tillage practices to conserve moisture, have been disappointingly slow. Detailed studies of farmer reaction to these practices have shown that farmers are aware of them and have postponed their acceptance for one or more of the following reasons: (1) They don't understand the technology and are therefore skeptical; (2) They don't perceive a positive benefit from the practice; (3) The inputs are not available; (4) They have limited or no access to capital; or (5) The government of Jordan might subsidize the inputs at a later date.

RESEARCH PRIORITIES

The success in transferring modern dryland technology to Jordan conditions is beyond dispute from a biological standpoint. It has been adequately demonstrated that a package of practices can be adapted to Jordan conditions to substantially increase wheat production. None-theless, because of differences in temperature, rainfall distribution, length of dry season, type of wheat grown, and soils, technology transfer is not complete and significant knowledge gaps have become evident. It is expected that additional adaptive research under local conditions would fill these gaps and could provide a base for greater efficiencey, higher production or both.

A. Stand Establishment: In the traditional production system, poor stands are a severe yield limitation. The grain drill is, at present, the only known reliable method of seeding to insure adequate stand establishment.

Because of the high cost of the grain drill, an interim, intermediate technology would be useful but none has been devised. Perhaps some thought should be given to developing an interim technology such as a seed spreader and a harrow system to incorporate the seed to the desired depth.

Relatively minor knowledge gaps exist in use of the grain drill in Jordan and these gaps could be easily filled with the resources and personnel available within the Directorate of Research and Extension. If problems not foreseen develop, TDY assistance should be made available to assist the Directorate.

Some TDY support may be needed on machinery problems in the early stages. Research problems are: (1) best type of drill for various soils, (2) seeding rate, (3) seeding depth and (4) row spacing. These studies can be completed in 2 to 4 years. Because of the critical nature of stand establishment and the slow adoption of the drill, problem (1) is high priority; the others are somewhat lower priority.

B. Variety: Lack of high yielding, adapted varieties is a severe limitation to wheat production in Jordan. Current varieties are probably well adapted to the low level of technology of the traditional farming methods, but as new technology is adopted, variety could be a major constraint. Variety development and testing should be geared to the technology expected to be in use 5 to 10 years in the future because of the long lead time involved in plant breeding. The breeding project should evaluate germ plasm from other breeding programs to identify superior material adapted to the range of conditions found in Jordan. Efforts should be made to move new varieties into farmer hands as soon as they

are available. This will require strengthening the seed increase and distribution system since this is probably not now able to handle a greatly increased program.

Variety development and testing is probably adequately funded and staffed at the present time especially when both the efforts of Jordan University and the Directorate are considered. Leadership in this area is good and will be further strengthened when Mr. Gosheh returns from his Ph.D. studies. This program is high priority for the long term and should be maintained at its present level of activity. Expansion of the program is not required and TDY support is probably not required.

C. Weed Control: Success of weed control technology transfer is quite good and the adoption of chemical weed control practices is proceeding. Interest in the technology is high among farmers and adoption is slowed because of lack of services, not for lack of information. The current level of activity in research devoted to wheat is too low and about 0.5 of a weed scientist's time should be devoted to weed control problems on a continuing basis. As weed control becomes widely adopted, a second generation of weed problems will almost certainly emerge. A research effort needs to be in place in order to deal immediately with these problems. TDY support is desirable if a Directorate scientist can be identified as responsible for a substantial effort on weed control in wheat. Research problems are: (1) new weed pests as they arise and (2) new chemicals for control. Weed control research is a continuing need but expansion of this program is probably not as high a priority at this time as is other more critical areas. Current research spray equipment is not particularly well suited to wheat project needs and purchase of portable sprayers is recommended. This would allow a greater mobility for field research.

D. Cropping Sequence: Moisture is the single most dominant factor in wheat production in Jordan. The amount of rainfall varies greatly over short distances and from year to year making it very difficult to predict potential production at any given location. To maximize production, it is mandatory that cropping systems and tillage methods be optimized for the amount of moisture available to grow a crop.

Average annual rainfall ranges from 200 mm to over 600 mm in the dryland production areas. Furthermore, year to year variations result in complex cropping conditions ranging from annual cropping in the higher rainfall zones to frequent crop failures in the areas bordering the desert.

Three major cropping sequences are possible (and to some extent practiced) over the wide range of moisture conditions: (1) where sufficient rainfall comes annually, cropping sequence is not limited; (2) in the intermediate zone, wheat - summer vegetable or lentils - summer vegetables; (3) in the extreme dry zone, wheat - fallow, barley - fallow or seeding a cereal crop only when there is a good rainfall year. These possible sequences are determined by the amount of available moisture either from direct rainfall or conserved by an appropriate tillage system. The advantage of the wheat - summer vegetable and lentil - summer vegetable sequence is that the summer vegetable may not use more soil moisture than would normally be lost through fallow, thus there may be some moisture conserved for the alternating wheat crop. In the extreme dry zone cereal - clean fallow sequence may be advantageous and in some areas mandatory (or at least superior to the system of planting only in wet years).

A serious information gap exists in determining which of the possible sequences best fits the available moisture zones and in determining which cropping systems will maximize the return from the limiting factor, moisture.

A series of experiments needs to be done to get this information. Because of the extreme year-to-year variation in rainfall, these experiments will need to run continuously for 5 to 10 years in order to obtain reliable data. Comparisons need to be made between wheat - wheat, wheat - lentils, wheat - summer crop, wheat - fallow, barley, and the traditional "opportunity" system in each of the rainfall zones. The data need to be collected in such a way that an economic analysis can be made.

The Ministry staff will need to be augmented and strengthened to do this work and may need either a full-time advisor or a series of TDY visits. The trials will necessarily include a tillage variable since this is an integral part of moisture conservation and thus some equipment may be needed. Mr. Amin Abu Shaer is capable of providing leadership to this work provided he is not given other assignments.

It is strongly recommended that this work be given highest priority and that economic analysis of the data be undertaken by the development economist identified below.

E. Fertilization: In order to eliminate the question of fertility, earlier demonstrations routinely included both nitrogen and phosphorus fertilizers. Thus the individual benefit of these inputs to the total package are not generally known except that benefit is highly probable in the wetter zones. Only a few experiments to test the need specifically of these nutrients have been done and optimum rates are not known. This is a severe knowledge gap, especially since fertilizer input is relatively expensive.

A large number of simple experiments (as outlined in Moore's 1975 report) over 3 to 5 years is needed to determine (1) where fertilizer is needed, (2) the optimum rate, and (3) the economic return. These experiments should

be carried out so that meaningful economic analysis can be done in each of the major rainfall zones.

These are high priority experiments because of the high potential return and the high cost of input. The Ministry has the capability of carrying out this work if (1) Mr. Abu Rub can devote at least half of his time to this project, (2) mobile equipment and transportation is assigned to the project and (3) sufficient technical help is provided. Several TDY visits of short duration may also be desirable. A major effort over the next few years would be better than a modest effort over a longer time.

IMPROVING EXTENSION'S EFFECTIVENESS

The history of agriculture development has always included a simultaneous promotion of currently known-to-be improved practices coupled with the further refinement of existing procedures or elimination of current constraints. When considering the ever-accelerating need for agricultural development even in a country like Jordan, we can not afford the luxury of waiting for complete development of each technology. We must "run" with what is known to be effective and then add additional technologies as they become adapted.

The vigorous demonstration program coupled with related farmer field days and mass media releases have been effective in terms of making the farmers aware of the over-all wheat project. However, in its zeal to conduct a large number of demonstrations throughout the various wheat growing regions, the project tended to be centrally conducted with little meaningful inputs by the local extension staff or cooperating farmers in the absence of central project personnel. Consequently, wheat project staff have become very knowledgeable and well experienced in growing wheat with the new

technologies. And, unfortunately, the local district staff, farmers and other private and public agency personnel have not learned the simple details of the new technology. Since it is very difficult to win the respect of farmers without having these experiences and since one cannot teach what one does not know, it is not surprising to find that the local agricultural leaders have been ineffective in assisting in the adoption of these technologies in the absence of wheat project leaders.

Therefore, it is imperative that local agents, cooperative society technical employees, and private industry employees receive in-depth wheat technological training and practical wheat management experiences [illegible] all the current wheat technologies being promoted and tested. This training effort should logically be centered in the Ministry of Agriculture with assistance from the wheat project staff, Jordan University, and cooperating regional and international agencies. Consideration should be given to the over-all capabilities of these agencies and to the Ministry's staffing capabilities to field this program.

Regardless of the approach taken, this training program should be organized as soon as practical because it seems to be the major institutional constraint. A University, PASA, or private contract program involving extension training personnel experienced in this type of training could probably be most effective. The team should consist of an extension training officer, an extension agronomist, an experienced dryland cereal extension agent, a small cooperative manager, a private agri-business service manager, and an equipment supply and maintenance man. This total training effort should be of one years duration with overlapping service of the above personnel not to exceed three months each. Each phase of the instruction should include basic principles coupled with in-field experience so that the

trainees know both the reasons behind each component of the technology package and the actual practices they are teaching. Only with this experience can the agent or field man have personal confidence and only they can he obtain the respect of his audience.

Obviously, all field men and agents cannot be trained and become experienced in one year. This first year program could serve as a concentrated initial effort which could be continued later by a stronger input from within Jordan.

ECONOMIC POLICY

Whether all the currently suggested technological inputs are economic from a management viewpoint is subject to controversy. Larger farms which are profit motivated are adopting some of the practices with modifications to suit their individual operations. Medium sized farms which make wheat sales when production exceeds their needs are showing interest in some portions of the wheat improvement package. Subsistence farms generally cannot risk inputs they don't have nor can they afford the risk of failure during a dry year. There also is an underlying national philosophy which says that the traditional subsistence farmer should be assisted or subsidized by the paternal central government through its agencies. A retail pricing policy on bread applies the subsidy through the flour miller. The total subsidy payment does not reach the farmer who therefore, is not encouraged to maximize production as if he should receive the subsidy directly by a supported wheat price.

Alternative methods of encouraging better supplies of technological supplies for the farmers need critical evaluation both in terms of short term innovation and in terms of long term development of service industries

to supply the inputs in an acceptable manner and at a profit. All of these and other socio-economic problems could best be attacked by a permanently assigned international agricultural development economist. He might also be able to use additional supplementary inputs from other agencies as his program is developed. There is sufficient background information and enough current interest in this phase of the wheat project to warrant expansion into this area. Furthermore, it appears that both GOJ and USAID are mutually agreed that this phase should be strengthened. Again, this effort could be equally well handled by PASA, direct hire, or university contract. However, if handled by university contract there would be advantages in incorporating the research, extension, and agricultural development phases into one package. On the other hand, present staffing levels at the USAID mission could conceivably allow for more effective mission leadership and program coordination than has been possible in the past. Regardless of the method of staffing, this advisor should be permanently assigned in order to provide continuity to the program and to be most effective in helping solve the long term economic problems associated with the wheat industry.

RECOMMENDATIONS

Practices such as chemical weed control and use of improved varieties are being well received by Jordanian farmers and are being adopted at a satisfactory rate. Parctices such as improved tillage and use of chemical fertilizers are being reasonably well received by the progressive wheat farmer but additional continuing adaptive research is needed to accelerate the rate of acceptance. Alternate wheat fallow rotations and use of the grain drill are still being questioned by most farmers. Additional research information is needed to clearly deliniate the areas were the wheat fallow rotation might be best suited. A stronger extension program is needed to promote the advantages of the grain drill. The wheat project in Jordan is perhaps the strongest project within the Ministry of Agriculture and could well serve as an example for improving the overall program for the entire Ministry. Therefore, this project should be continued in order to take advantage of the gains made so far and in order to recapitalize the investment of the inputs to it through earlier periods. To abandon the project at this time would be a serious tactical mistake.

The wheat project should continue to strengthen its adaptive research program in the field of soil fertility, tillage methods, irrigation techniques, and seedbed preparation. Various alternative crop rotations at different levels of average annual rainfall should also be investigated. All of these adaptive research programs need to be designed so that more definitive economic information can be obtained from them.

The extension program needs to be strengthened in terms of more technical training for the district extension agents, local managers of the cooperative societies and employees of the agribusiness firms. The very successful demonstrational program has clearly shown that most of the new

technologies are adapted to Jordanian conditions. Some of the effort that has gone into their conduct can be rechanneled to either adaptive research programs or to more effective extension programs.

There are clearly some political or sociological constraints to the adoption of the new wheat technologies. Any further wheat program must include a component which will further investigate these constraints and develop a course of action to minimize their effect if the Ministry of Agriculture is to reach its goal of expanded domestic wheat production.

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