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VERIFICATION AND ADOPTION OF WHEAT PRODUCTION TECHNOLOGY IN THE SUDAN

Proceedings

First National Wheat Coordination Meeting

3-5 August 1986, Wad Medani, Sudan

ICARDA/OPEC Pilot Project for Verification and Adoption of Improved Wheat Production Technology in Farmers' Fields in the Sudan

Proceedings of the
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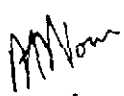
FOREWORD

Inspired by the successful model of implementation of the Nile Valley Project on Faba Beans, ICARDA's cereal researchers decided to employ the same model to improve wheat production in the Sudan. A proposal was developed in collaboration with the Sudanese national program and CIMMYT, to take the package of wheat production technology from the research station to the farmer's field, through the active involvement of the extension workers and researchers, with the leadership of the Project in the hands of the Sudanese national program. The proposal attracted the interest of the OPEC Fund to provide financial support. As a result, an ICARDA/OPEC Pilot Project for Verification and Adoption of Improved Wheat Production Technology was launched in 1985.

In the pages that follow, the results from the first year (1985/86 season) of the Project are reported. It is clear that the Project has succeeded in generating the active involvement of farmers, extension workers, researchers, and policy makers. A headway has been made in the right direction as demonstrated by the increased yields obtained on farmers' fields. An interesting work plan for the 1986/87 season has been developed and is included in this document.

I congratulate the Project participants for their dedicated efforts and the impressive progress they have made, and I wish them all success. We are grateful to the OPEC Fund for the generous financial support without which the Project would not have taken off. We are very pleased to see that the Project has generated a lively stimulus to increase wheat production in the Sudan, and CIMMYT and ICARDA will continue to provide their full support in every possible way.



Mohamed A. Nour
Director General

PREFACE

The first National Wheat Coordination Meeting held in the Sudan was funded by the ICARDA/OPEC Wheat Pilot Project for the Verification and Adoption of Improved Wheat Production Technology in Farmers' Fields in the Sudan. The meeting was held in Wad Medani, 3 to 5 August 1986. It was organized to review the work done during the 1985/1986 season and to develop a Work Plan for the 1986/1987 season. The meeting was well attended by policy makers, farmers, administrators, and scientists from throughout the Sudan.

The OPEC fund provided financial support (US$ 142,000) to strenghten ARC capabilities to verify research results under actual farming conditions through a system of on-farm trials in the major wheat-producing areas (Gezira, New Halfa, and the Northern Region) with the participation of farmers, extension workers, and production staff. Socio-economic surveys have also been carried out to specify the factors contributing to yield variability among farmers and to the considerable yield gap which exists between researchers' and farmers' yields. The project also includes back-up research at research stations in crop improvement, land preparation, water management, and crop protection.

During recent years, as the demand for world food supplies has risen, interest in wheat production in the Sudan has increased. This interest has been heightened by the development of new wheat varieties and by the help and encouragement of the International Center for Agricultural Research in the Dry Areas (ICARDA). These new wheat varieties potentially have very high yields but require specific growing techniques. Accordingly there has been a renewed interest in improved wheat agronomy, mechanized cultivation, irrigation and, above all, in the prevention of crop losses from pest attack.

This report attempts to assemble all aspects of agricultural practices and limitations and inform the reader as to how best wheat production in the Sudan can be tackled. It is hoped that this will stimulate continuation of the much needed work on this important crop to enable the Sudan to produce enough food to feed itself and the hungry world around it.

Dr. Osman Ibrahim Gameel
Director General
Agricultural Research Corporation
Wad Medani, Sudan

WELCOMING ADDRESS

Professor Osman I. Gameel
Director General
Agricultural Research Corporation

It gives me great pleasure to welcome you to the First Wheat Research Coordination Meeting in the Sudan which has been generously funded by the ICARDA/OPEC Pilot Project for Wheat Improvement in the Sudan. Last year the project provided funds to strengthen ARC capabilities to verify research results under actual farming conditions through a system of on-farm trials in the major wheat-producing areas (Gezira, New Halfa and the Northern Region) with the participation of farmers, and extension and production staff. These on-farm trials provided an excellent tool for extension activities as a number of field-days were attended by hundreds of farmers.

Socio-economic surveys were also carried out in the major wheat producing areas to specify the factors contributing to wheat yield variability among farmers and to the considerable yield gap which exists between researchers' and farmers' yields. The results of these surveys will form the basis for tuning wheat research efforts to farmers' needs.

The project also included some back-up research at research stations in the areas of crop improvement, land preparation, crop water requirement, entomology, and plant pathology. The promising results from these trials will be tested in on-farm trials to find their economic viability. Once the improved practices are verified both technically and economically they will be included in the farmer-managed trials. These trials take the character of on-farm demonstrations and are a final test of the farmers' acceptability of any new practices.

The observations during the first year of implementation of this methodology of transfer of improved wheat production technology are encouraging. We are very grateful to know that the OPEC Fund has lately approved a grant that will enable ARC to continue this work for another year.

Guests and colleagues, as you can see, the program for this meeting will continue for two days during which a number of papers covering important aspects of wheat production will be presented. Your active participation in the discussion of these papers will be greatly appreciated so that we can enjoy the benefits of a fruitful meeting.

I would like to take this opportunity to thank the OPEC Fund for providing a grant to execute this program and ICARDA and CIMMYT for their efforts in securing this fund and also for providing back-stopping through their frequent visits to the project areas.

I would also like to thank you for all the trouble you have taken to be with us here and to the organizing committee for their efforts in organizing this meeting.

Thank you.

OPENING ADDRESS

Delivered on behalf of the Minister for Agriculture and Natural Resources by:

Mr. Yousif A. Dash

Permanent Under Secretary for Agriculture

Distinguished guests and colleagues:

It is my pleasure to be amongst you today for the opening of this important conference, representing His Excellency Dr Omer Nour El Daiem, Minister of Agriculture and Natural Resources who could not come due to extenuating circumstances.

As you know, wheat has become an important nutritional staple in the Sudan due to the social changes that have occurred during the last 20 years. These have led to such a great increase in the consumption of wheat that the Sudan is no longer self-sufficient even though the area planted to wheat has increased from 45,000 feddans (1960/61) to about 350,000 feddans (1985/86). The Sudan is now importing more than 400,000 tons of wheat and wheat flour annually at a cost estimated at $56 million to bridge the gap between production and consumption. This amount is a large drain on the national treasury and a burden on the country's economy.

Sudan's extensive agricultural land and the easy availability of water qualify it more than any other country to be self-sufficient in agricultural products given the necessary resources. Agricultural research has long proven the economic feasibility of wheat production in most of the irrigated projects. Hence, wheat production has been extended to the Gezira, New Halfa and the Northern White Nile since the early 1960s.

Even with this extension in wheat production, yield per feddan has not increased with advanced agricultural practices. Yield per feddan at research stations exceeds 1 ton per feddan while in the farmers' fields it remains at 0.5 ton per feddan.

Economic and social surveys have shown a great discrepancy in production between farmers within one project and even between farmers within one location. There are only a few farmers whose wheat production is equal to or better than production in the research station fields. The great majority of farmers produce no more than 30% of the average research station fields. The main cause of this discrepancy is that farmers do not follow recommendations for wheat production. Therefore, in order to increase this low rate of production, we have to follow new methods of transferring agricultural research recommendations directly to the farmers through the different agricultural corporations. It was a great pleasure to see the ARC, in cooperation with ICARDA/OPEC, commence trials last season with this goal. I am also very happy to know that this program will continue for another year.

It is my sincere hope that this project will be successful in laying foundations for improving wheat production in the Sudan so that we may reach self-sufficiency in the shortest possible time. The Ministry of Agriculture is willing and able to help in any way possible to increase the land's production and to help the farmers reach a better economic situation so that they remain happily attached to the land and their profession, especially since agriculture will remain the main component of the Sudan's economy for a long time to come.

My thanks to all of you for attending, to those coming from afar to share in this conference, and special thanks to ICARDA and the OPEC Fund for the financial and scientific support for this program.

I wish you a successful and fruitful conference.

Thank you.

ADDRESS BY THE EXECUTIVE BUREAU OF THE GEZIRA AND MANAGIL FARMERS' UNION

Mr. Chairman and Conference Members:

On behalf of the Tenants of the Gezira Scheme and the Managil Extension I want to thank Mr. Chairman for his kind invitation to attend and include our opinions on the continuous decline in wheat production in the Gezira and Managil areas.

We think the major factors which lead to this reduction are as follows:

1. Land preparation problems
2. Irrigation problems
3. The absence of improved varieties of wheat
4. Weed infestation
5. Incorrect fertilizer application
6. The unavailability of combine harvesters during the harvesting season

The Gezira and Managil Farmers' Union request the scientists to find solutions to improve wheat production.

Finally we are grateful to ICARDA for its keen interest and participation in the issues of wheat yield decline in the Gezira and Managil Schemes.

Thank you.

BACKGROUND FACTS ON WHEAT IN THE SUDAN

For many thousands of years wheat has been grown in the northern parts of the Sudan where its inhabitants are traditional wheat consumers. However, since the 1960s production has spread to the Gezira Scheme in the Central Region and the New Halfa Scheme in the Eastern Region and the consumption of wheat has spread throughout the country. All wheat is grown under irrigation. In the Northern Region irrigating waters are taken from the main Nile, in the Central Region from the Blue Nile and in the Eastern Region from the seasonal Atbara river waters stored in the Khashm El Girba Dam.

The rainy season in the Sudan starts in July and continues until September. The cooler winter season is from November until February and it is during this time that wheat is cultivated. The length of the growing season is between 90 and 100 days. Individual seasons differ greatly both in temperature and humidity but relative humidity is considered to be low.

In the Northern Region soils are of the reverein types combining river silts, clay, and sand. Problems with salinity occur less frequently closer to the Nile than higher up on the terraces. In the Gezira and New Halfa regions the soils are of the heavy cracking clay types.

The most popular varieties grown are Condor, Debeira, Giza 155, and Mexicani. However, there are currently no organized seed distribution channels.

In 1960/61 the total area under wheat cultivation was 19,000 ha. (1 ha = 2.38 feddans) and by 1983/1984 this area had increased to 135,000 ha. Of this, 78% is in the Gezira Scheme, 12% in New Halfa, and 10% in the Northern Region. However, this increase in area cultivated did not bring about the expected increase in productivity. The cost of wheat production rose from LS40 per ton in the early 1960s to LS440 per ton in the 1984/1985 season. The expected production increase failed mainly due to the lack of transfer of technology and inadequate logistical support to farmers.

In the past 20 years there has been a rapid increase in the consumption of wheat. Factors contributing to this include rising urban populations and the rising prices of sorghum and its production costs (the traditional Sudanese grain). Wheat production has not managed to keep pace with demand, and meets only about 20% of it. Consequently, wheat imports rose by about 75% between 1961/1962 and 1983/1984. Accordingly, the value of this imported wheat rose from LS8 million to LS91 million (8% of all agricultural imports).

Most land under wheat cultivation is owned by the government with the exception of scattered free-hold ownerships in the Northern and New Halfa areas. Tenants of government land pay minimal rent and subsidized water rates. Traditional practices used in wheat cultivation include dry ridging, split ridging and rough levelling, seed broadcasting at a rate of 140 kg/ha, and basin irrigation.

In the Eastern Region there are infrequent outbreaks of rust and consequently farmers are advised to grow rust-resistant varieties. Aphids offer the greatest threat and can be responsible for up to 26% of losses to the crop although control through chemical spraying is easy. Weeds are also a serious threat but are currently controlled to some extent by cultural practices.

In order to stretch available wheat resources there have been attempts to blend wheat and sorghum flour on a ratio of 7 parts to 3. In the experimental stage this has proved successful but has yet to be widely introduced.

There are 9 flour mills throughout the Sudan with a total milling capacity of 450,000 tons per annum. This facility is considered adequate at the present time. However, farmers often prefer to sell to local merchants rather than to the government-controlled mills to avoid repayment of loans given to them for wheat production.

EXECUTIVE SUMMARY OF FINDINGS

The managements of the Gezira Scheme, New Halfa Scheme, and the Regional Agricultural Ministry of the Northern Region presented reports on the status of wheat production in their respective schemes. The areas cropped with wheat in the 1985/1986 season were as follows:

Location	Area (ha)	Average Yield (tons/ha)
1. Gezira Scheme	100,000	0.98
2. New Halfa Scheme	13,100	0.95
3. Northern Region	21,000	NA
4. White Nile Schemes	15,500	NA

I. On-Farm Research

A. *Farmer-Managed Trials*

The trials were carried out by farmers with advice from research and extension staff. They acted as on-farm demonstrations of improved cultural practices and were held at the Gezira and New Halfa Schemes and in the Northern Region. The trials provided an excellent tool for extension activities as five field days were held for more than 500 farmers in the three areas. In the Northern Region the trials also provided a good opportunity for the seed multiplication of the new variety Wadi El Neil (Giza 160) which is in the process of being released.

In the Gezira Scheme the package was very successful in two out of three locations giving an average yield of 1.9 and 2.1 tonnes per ha while in the third location it gave an yield of 1.2 tonnes per ha in comparison with the scheme average of 1.0 tonnes per ha. The marginal rates of return for the farmers in the two successful locations were more than 800%. Such high benefits give the package good stability.

At the New Halfa Scheme the package produced an average yield of 1.4 tonnes per ha as compared with the scheme average of 0.9 tonnes per ha.

In the Northern Region early sowing resulted in heavy bird damage as neighboring farmers sow their crop about three weeks later. At

Zeidab the average gain in yield through the introduction of the package was 272 kg per ha. In Selaim and Burgaig all plots except one were heavily damaged by birds. At the plot that escaped bird damage, the yield advantage of the package was 679 kg per ha.

B. Researcher-Managed Trials

At the Gezira Scheme water management and the addition of phosphorus had a highly significant effect on grain yield. Application of 9 irrigations instead of 5 resulted in an increase in grain yield of 758 kg per ha. Addition of 43 kg P_2O_5 per ha on average increased yield by 386 kg per ha.

In the New Halfa Scheme sowing during the first half of November compared with sowing during the first week of December increased yield by 383 kg per ha while shortening the irrigation interval from 21 to 14 days increased yield by 367 kg per ha. The addition of phosphorus had no effect on yield.

In the Northern Region at Zeidab and Selaim, nitrogen fertilization, frequent irrigation at 14-day intervals and aphid control significantly increased grain yield while sowing either in early or late November had no appreciable effect on yield.

C. On-farm Verification Yield Trial

The most promising eight cultivars from the Wad Medani and New Halfa breeding programs were included with two checks and the trial was conducted in 12 locations covering all wheat-producing regions in the country.

In the Central Region the check variety Debeira was significantly outyielded by four entries at only one site and was top ranking in three. In the Eastern Region, Debeira was outyielded by three entries in one out of three sites. In the Northern Region no entry was superior to Debeira.

Therefore, Debeira seems to be a variety with great potential and steps should be taken to multiply its seed to replace the existing commercial varieties.

II. Back-up Research

1. Crop Improvement

With the objective of screening as many genotypes as possible, a series

of yield trials were conducted at Wad Medani and New Halfa Research Stations. A number of entries were found to be superior in yield to the check Debeira and will be tested for another season before advancing them to the on-farm verification yield trial.

2. Mechanization

Tillage system had no significant effect on grain yield. Sowing by seed drill had a positive effect on crop establishment.

3. Water Management

The effect of irrigation intervals at three stages of wheat development indicated that shortening the irrigation interval to 10 days as compared to 14 days during the boot stage increased grain yield by 11%.

4. Crop Protection

(a) Plant Pathology

Screening the commercial and promising wheat cultivars for stem rust resistance showed that 16 varieties, including the important commercial variety Condor, had good levels of resistance.

(b) Pest Management

Tests were held to identify potent selective insecticides against aphids. Results indicated that the chemicals Danitol-S, Dursban, Reldan, and Marshal gave satisfactory performance and will be further tested before releasing them for commercial control.

III. Socio-Economic Survey

The survey results showed that wheat production is characterized by a diversity in the production techniques both among the various producing areas and within the individual areas of production. This diversity, in addition to the effect of soils, climate, and social, aspects, contributes to the great variability in yield.

Average yields among regions ranged between 986 kg per ha and 1,892 kg per ha, within regions the coefficient of variation ranged between 30% and 47% reflecting the substantial variability. Yield levels and

production practices affected profitability and were affected by production constraints and input levels. These aspects are related to family and farm structure, relative wheat importance, wheat profitability, production constraints, and possible improvements.

Farmers' ages ranged between 39 and 59 years with relatively high figures in Gezira. Farmers were predominantly illiterate with large families, most members of which were either students or laborers. The level of family help in farm activities was very low in Gezira. New Halfa and Zeidab. Generally, labor peaks were not problematic except in the Northern Region where reliance on labor was very high and expected to affect wheat production.

Wheat takes up about one-third of the farm area in all regions. However, its contribution to farm income ranges between 6% and 24%.

Net returns on wheat were generally low because of low yields and prices and high production costs. Material inputs such as fertilizers, water, seeds, and sacks constitute two-thirds of production costs.

Productivity constraints were as follows:

1. Poor crop establishment as a result of bad levelling and poor water management
2. Water stress
3. Late sowing
4. Seed rate and fertilizers

The sum of the individual effects of these factors was quite substantial. With the high level of inputs yield increases ranged between 409 and 1,854 kg per ha with increases in net benefits of between LS 53 and LS 1,854 compared with the average level of input.

Work Plan for the 1986/1987 Season

A work plan for the 1986/1987 season was developed for every project. Emphasis was placed on greater involvement of farmers, on-farm trials, and demonstrations. Areas that needed additional information and clarification were included in the back-up research for the next season. Scientists in charge were identified for each project.

Training

A one-day training course for extension and production staff was organized to acquaint them with the major findings of the research results. About 30 participants from the Gezira Scheme, six from New Halfa and two from the Northern Region, as well as 19 graduates from

the Agricultural Research Corporation (ARC) and young graduates from Gezira University, participated in the training course.

Budget

A Steering Committee, consisting of the following members, met to discuss the budget allocation and training program for the 1986/1987 season:

Dr. Osman I. Gameel, Director General, ARC
Dr. Musa M. Musa, Deputy Director General, ARC
Dr. Abdel Mageed Yassin, Director, Training and Publications, ARC
Dr. Ahmed Nasir Balla, National Coordinator Entomology Research, ARC
Dr. Ali T. Ayoub, National Coordinator Soil Science Research, ARC
Dr. Osman A.A. Ageeb, National Coordinator Wheat Research, ARC
Dr. J.P. Srivastava, Leader, CIP, ICARDA

SUMMARIES OF RESEARCH REPORTS

This section contains summaries of research reports presented at the ICARDA/OPEC Pilot Project for Wheat Improvement in the Sudan, 1985/1986 season. Should anyone wish to refer to the original papers they can be obtained from:

1. Dr. Osman A.A. Ageeb
   National Coordinator for Wheat Research
   P.O. Box 126
   Wad Medani
   SUDAN

2. ICARDA
   P.O.Box 2416
   Cairo
   EGYPT

3. Cereal Improvement Program
   ICARDA
   P.O.Box 5466
   Aleppo
   SYRIA

WHEAT PRODUCTION

New Halfa Agricultural Production Corporation

Prepared by: Technical Planning Office

The New Halfa Agricultural Production Scheme (NHAPC) is situated along the left bank of the seasonal Atbara river and irrigated by its waters collected in the Khasm El Girba Dam. The area receives minimal rainfall and therefore can be classified as desert. The soil is predominantly heavy swelling and cracking clay. The net area under irrigation is 384,700 feddans of which 110,000 is annually allotted to cereals. Of that, an area of 40,000 feddans in the southern part of the scheme is cultivated with wheat. Wheat is the staple food of the Nubian tenants of the NHAPC.

Cultivating Activities

The agricultural plan:
30,000 feddans[1] was allocated for the cultivation of wheat but the actual area planted amounted to 31,080 feddans.

Land Preparation:
Common land preparation practices include dry ridging, pre-watering, wet harrowing and finally seed broadcasting. To some extent bed-making and cross-ridging were practiced. Land preparation began in mid-September.

Varieties:
Varieties grown included Giza 155, Condor, and Debeira.

Sowing Date:
Between early November and the end of December.

Fertilizer Application:
Most tenants applied between 43 kg and 64 kg N/ha by hand before the second watering.

Pest Control:
Major wheat pests are aphids and the stem borer. Ekatin was used against the aphids on an average of 1.04 sprays per feddan.

Irrigation:
10.5% of the cultivated area received four irrigations, 36.5% five irrigations, 45.3% six irrigations and 7.7% seven irrigations.

Harvest:
Harvesting began in early April and continued unti mid-May.

Production:
Average production was 0.41 tons per feddan. (See Table 1.)

Cost of Production:
This season the total cost of production jumped to LS 303.70 compared with LS 138.20 for the 1982/1983 season and LS 155.68 for 1983/1984 (See Figure 1). With the price of wheat at LS 700 a ton and an average yield of 0.4 tons per feddan, NHAPC tenants made a loss of LS 23.70 per feddan.

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1. One Feddan = 0.42 ha

Table 1. Areas Sown, Harvested, Production, and Average Yield, NHAPC, 1985/86 Season.

Section	Area Sown (feddan)	Area Harvested (feddan)	Production (sacks)	Average Yield (t/feddan)
Debeira	10,285	10,270	43,022	0.42
Sheikh Omer	4,975	4,440	13,271	0.30
Sasarib	14,145	13,955	61,301	0.44
Sedira	190	185	483	0.26
Demiat	410	410	2,652	0.65
Raira	1,075	1,010	2,436	0.24
Total	31,080	30,270	123,165	0.41

Area harvested is 97% of area sown.

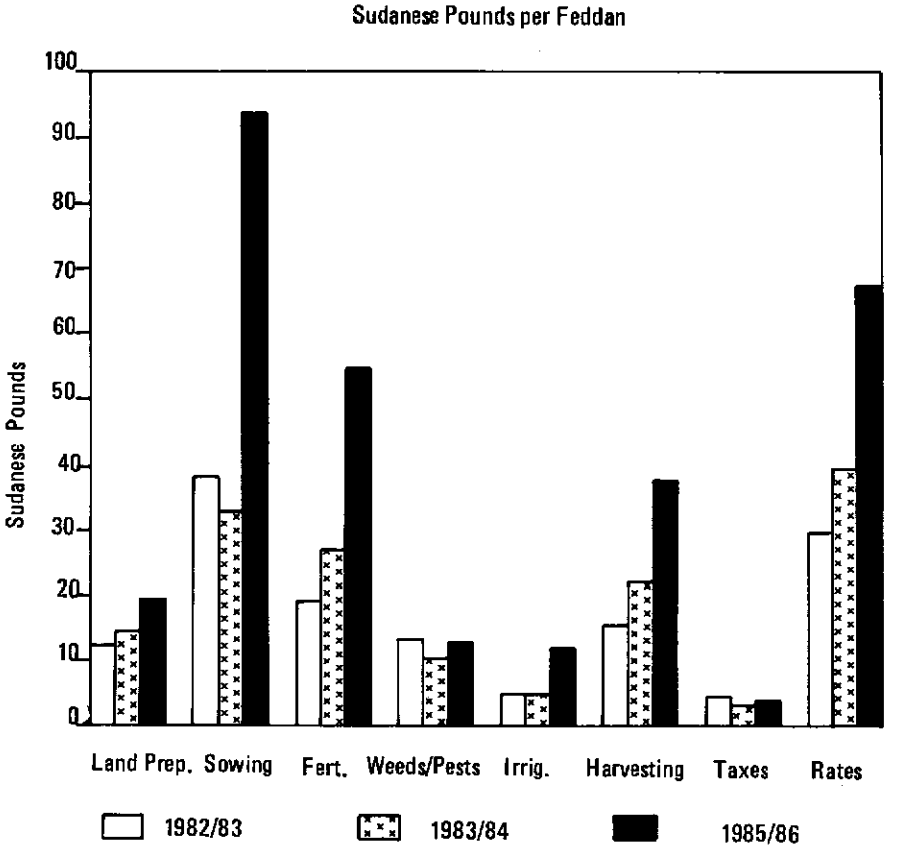

Fig. 1. Cost of Wheat Production, NHAPC.

Production Problems

The following have been identified as the major obstacles to increased production:

1. Inadequacy of irrigation water caused by continual siltation of the dam.
2. The poor condition of water pumps in the scheme.
3. Delay in the sowing date.
4. The unavailability of tractors and other implements at the necessary time.
5. Weed infestation.
6. The considerable increase in the price of inputs.
7. Delays in harvesting.

Improvement of the Production Techniques

The following, if applied, should improve production:

1. The provision of high yielding, drought-resistant, early-maturing varieties of wheat.
2. An improvement of cultural practices.
3. The provision of inputs at reduced prices.
4. Continuous supply of sufficient irrigation water throughout the growing season.

Gezira Scheme

Prepared by: Agricultural Administration, Sudan Gezira Board, Barakat

Wheat forms part of the crop rotation in the Gezira Scheme following on from cotton. The area allotted to wheat annually is 230,000 ha. However, actual annual cultivable area is far less, being dependent on the availability of irrigation water. This in turn is dependent on the degree of flood in the Blue Nile and the amount of water stored in the Rosereis Dam.

Areas to be grown with wheat were selected according to the following criteria. They should be easily irrigated and as free as possible from noxious weeds. Tenants should not be in debt to the Gezira Scheme or, if they are, be willing to pay for the inputs provided for wheat last season. A total of 102,000 ha was grown with wheat.

Cultivating Activities

Land Preparation:
87% of the land was prepared using the traditional methods of ridging, split ridging, and levelling with a heavy bar. The rest was prepared with a disc plow. (See Table 2).

Table 2. Land preparation up to 31st October Gezira Scheme, 1985/86 Season

Location	Proposed Area	Ridged Area	Split Ridged Area	Levelled Area	Disced Area
Gezira	163,889	137,484	128,943	110,183	20,145
Managil	111,144.5	76,754	65,403	47,273	33,076
Total	275,033.5	214,238	194,346	157,456	53,221

Varieties:
The varieties Condor, Mexicani, and Giza 155 were cultivated.

Seed Rate:
A seed rate of 120 kg per ha was used.

Sowing Methods:
Seed was mainly broadcast and covered with tine cultivations. Most of the wheat is grown on the flat and as the soil is not well-levelled, the crop usually suffers from water logging during the establishment phase. Some farmers have tried sowing on wet soil or sowing on the flat and then making ridges to facilitate furrow irrigation. Both methods have given good establishment.

Fertilizers:
The crop was fertilized with 86 kg N per ha in the form of urea. It was mostly applied during the second irrigation.

Sowing Time:
95% of the area was sown by the end of November. This year, because of the good rainy season, sorghum and groundnuts were sown on time and harvested by November. Therefore it was possible to plant wheat earlier than previous seasons and there was more water available.

Pests:
The crop was chemically treated for aphids by spraying with Ekatin an average of 1.58 times. There was an average of 0.28 stem borers per 100 plants. A campaign against rats was successful and a night count showed a drop from 0.5 to 0.1 rats per km after the campaign.

Harvest:
Combine harvesting began on 1 March but was hindered by the shortage of combine harvesters and dissatisfaction among the owners about harvesting and transportation rates. Negotiations that followed raised both rates and work then continued until the end of April. A total of 195 combine harvesters worked in the scheme. See Figure 2 for areas sown compared with areas harvested.

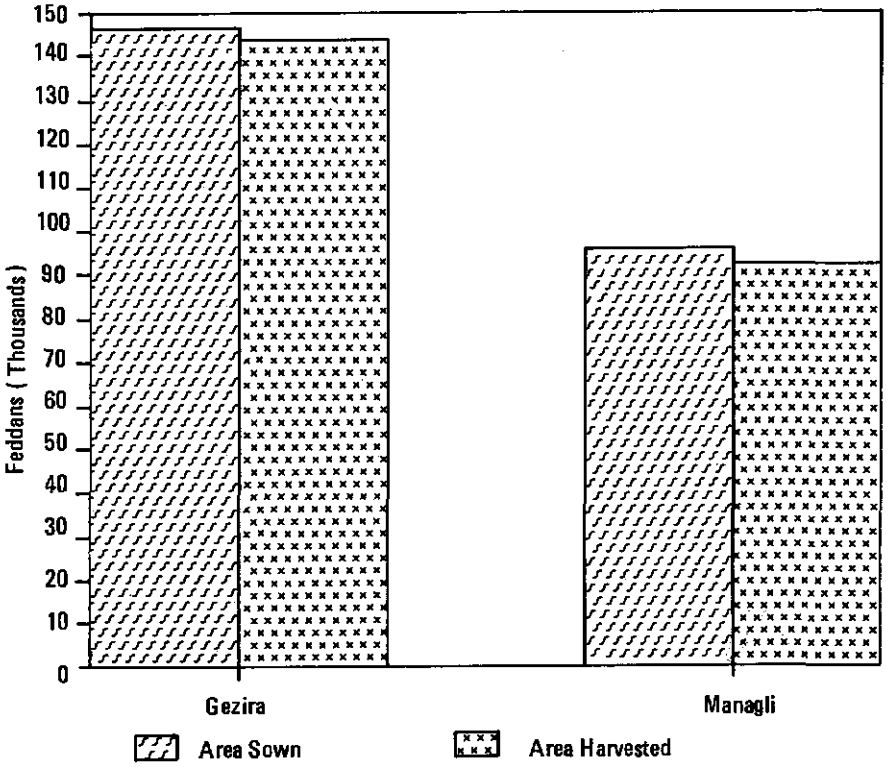

Fig. 2 . Areas Sown/Harvested, Gezira Scheme 1985/1986 Season

Yield:
The average yield was 0.98 tons per ha. The two cultivars Mexicani and Condor outyielded the Egyptian Giza 155 although the latter was grown in the better parts of the scheme. (See Table 3).

Table 3. Harvested Areas and Productivity Gezira Scheme, 1985/86 Season

Location	Sown feddans	Harvested feddans	Total production sacks	Average yield sack*/feddan
Gezira	146,416	143,957	661,820	4.597
Managil	96,082	92,794	312,055	3.363

* One sack = 100 kg grain

Cost of Production:
Cost of production was estimated at LS 476 per ha.

Sale Price:
The wheat price was fixed at LS 700 per ton on delivery to the flour mills.

Seed Production:
Wheat seeds are produced by contracted farmers. This season the varieties Condor and Mexicani were propagated. (See Table 4).

Table 4. Seed Propagation Gezira Scheme, 1985/86 Season

Cultivar	Area (ha)	Seed Produced (tons)
Condor	13,280	18,200
Mexicani	5,800	5,037

Northern Region

Prepared by: Mohamed O. Hamza, Director of Extension, Ministry of Agriculture, Northern Region

Agriculture is one of the main sources of income for the people of the Northern Province. Currently, approximately 300,000 feddans of good

land is cultivated. A further 400,000 feddans needs minimal reclamation and would then also be suitable for cultivation. The Province has plentiful water resources. At present 1.74 billion cubic meters of Nile water is used annually. In addition, of the estimated 47 billion cubic meters of subterranean water, only 16 billion cubic meters is used.

There are three areas of agricultural production:

- Government sector projects: 19,160 feddans
- Co-operative sector projects: 31,409 feddans
- Private sector project: 206,700 feddans

Wheat Production in the Region

The climate in the North is favorable to the production of wheat. Yield per feddan is 50% - 75% higher than in other wheat producing areas of the Sudan. Wheat is grown in an area ranging from 30,000 to 35,000 feddans annually depending on the availability of fuel, seeds, etc. The regional project for wheat production is attempting to increase wheat areas from the present 30,000 to 70,000 feddans and yield from 0.8 to 1.5 tons per feddan. The three phases of the project are:

1) To secure all agricultural inputs for wheat production such as seeds, fuel, fertilizers, etc.
2) To rehabilitate abandoned or crippled schemes of the region and to replace obsolete water pumps.
3) To reclaim 250,000 feddans of new virgin land.

Research Program on Wheat

An integrated program with the Arab Republic of Egypt is underway. Ten Egyptian varieties of wheat have been imported and tested under the climatic conditions of the region.

ON-FARM RESEARCH

Farmer-Managed Trials

The trials were carried out by farmers themselves with advice from research and extension staff. They served as an on-farm demonstration of improved technologies tested in researcher-managed trials. They are also a final test of farmers' acceptability. These trials provide an excellent tool for extension activities. A number of field days were organized for farmers and production personnel. In the Northern Region the trials also provided a good opportunity for the seed multiplication of the new variety Wadi El Neil (Giza 160) which is in the process of being released.

Farmer-Managed Trials, Gezira Scheme

Prepared by: Dr. Osman A.A. Ageeb, National Coordinator Wheat Research, ARC
Dr. Hamid H. El-Faki, Economist, ARC
Mr. Abdel Aziz Abdel Fattah, Economist, ARC

Twenty-seven farmers were selected to take part in the trial, 9 farmers from each of the following blocks. Each farmer cultivated 2.1 ha.

1. Debeiba in the Northern Group
2. Dolga in the Wad Habouba Group
3. Derweesh in the Central Group

The farmer-managed trial was made up of three improved factors:

(a) Good land preparation with a disc harrow and rough levelling with a heavy bar. The plot was then divided into 14 "angaia" (1 angai = 14 x 75 mm) and each "angaia" was divided into 4 plots to facilitate irrigation by gravity flow.
(b) The plots were sown early during the first half of November.
(c) The plots were irrigated at 14-day intervals. All fields received 7 irrigations.

Other cultural practices were left to the farmers. Wheat varieties used were Condor in Derweesh and Dolga and Giza 155 in Debeiba. A seed rate of 120 kg/ha was used and the soil was fertilized with 86 kg N/ha applied two weeks after sowing. Seeds were broadcast and then covered using a disk harrow or small tine cultivator.

The yields of the cooperating farmers were compared with neighboring farmers not included in the trial, socio-economic survey sample farmers (27), and an estimated block average (137 farmers).

Results

Rough levelling with a heavy bar was not adequate for the even distribution of the first irrigation water. Since the soils are heavy clay vertisol with a very low infiltration rate, water stood for a long period of time in low lying areas causing germination failure due to aeration impairment. This led to areas with poor stand establishment. The yields of cooperating farmers at Dolga were greatly affected by this problem. It seems the basin method of irrigating a dry soil is not suited to heavy clays with poor infiltration rates.

1. Debeiba Block

There were some harvesting problems. Harvest was carried out by privately owned combines which were run by inexperienced drivers who caused yield losses. In spite of this the wheat yields of the cooperating farmers ranged from 1.4 to 2.4 t/ha. The average yield of the 9 farmers was 1.9 t/ha.

Field inspectors did their best to improve the cultural practices of neighboring farmers who had been chosen for comparison with the cooperating farmers. They were under the impression that any big difference in yield between the two would mean that they were not doing their job properly. In spite of this, the yields obtained by the cooperating farmers were 19%, 33%, 36%, 75% and 97% higher than those of the neighboring farmers, socio-economic survey sample, estimated block average, group average, and the Gezira Scheme average, respectively.

Partial budget analysis indicated that adoption of the package produced an increase in net benefits to farmers of LS 151 per ha with a marginal rate of return of 308% when compared with neighboring farmers. However, the increased net benefits of package farmers as compared with the survey sample and block average were LS 231 and LS 251, respectively, with high marginal rates of return (797% and 866%, respectively).

2. Dolga Block

The farmers in this block were less cooperative and did not apply the packages to our satisfaction. As a result of bad water management, crop establishment was poor, weed infestation was high and wheat yields low. The yields of the cooperating farmers ranged from 0.9 to 1.6 t/ha; the average yield of the 9 farmers was 1.2 ton per ha which was 12% more than the block average.

3. Derweesh Block

The wheat yield of the cooperating farmers ranged between 1.2 and 2.8 ton per ha. The average wheat yield for the 9 farmers was 2.1 ton/ha which was 59% and 117% more than the average yield of the survey sample and the block average, respectively. The package proved highly profitable, increasing net returns to farmers by LS 390 and LS 588 per ha compared with survey sample and block average, respectively. The respective marginal rates of return were 591% and 871%. Such high net benefits give the package good creditability.

Farmers-Managed Trials, New Halfa Scheme

Prepared by: Dr. Mohamed S. Mohamed, Director, New Halfa Research Station, ARC
Dr. Hamid H. El-Faki, Economist, ARC
Mr. Abdel Aziz Abdel Fattah, Economist, ARC

Fifteen farmers participated in this trial in the three wheat-growing southern divisions of the New Halfa Scheme. Five farmers were selected from each of three blocks: Faras (Debeira Division), Argine (Sheikh Omer Division), and Medina (Sasereib Division).

The wheat production package consisted of:

i Land preparation by discing, harrowing, and levelling.
ii Sowing in early November
iii Irrigating every 2 weeks

All trial tenancies received 86 kg N/ha at sowing and were sprayed with Ekstin once against aphids in late January. The tenants used the varieties grown locally: Giza 155, Debeira, and Condor. Yields in the trial tenancies were compared with average yields in respective sections and the overall scheme average.

Results

Four farmers were dropped from the trial as they failed to comply with the recommendations of the package.

Although average yields of trial tenancies were relatively higher (49% more) than the scheme average, they fell short of expectations for several reasons:

(1) Package farmers did not pre-irrigate. This helps a great deal in crop establishment and weed control. It is a widespread practice in New Halfa.
(2) Inappropriate irrigation control. Most of the participating farmers failed to have their tenancies properly prepared for basin irrigation so that flooding was common in the first two irrigations. This adversely affected crop establishment.
(3) Problems associated with early planting led to:
    a) early aphid infestation with delay in control: Trial tenancies were infested by aphids in December and were not sprayed until late January when the whole wheat area was sprayed by plane.
    b) losses due to delay in harvest:
    Most trial tenancies matured in February but harvesting did not take place until late April.

Partial budget analysis (see Table 5) shows the effect of the package on farmers' income. Block averages were estimated from yields of 209 farmers in these blocks, package costs were taken from the socio-economic surveys. Compared with average yields and average farmers' practices in these blocks the package was profitable with an increase in net benefits of LS 101/ha with a marginal rate of return of 117%.

Farmer-Managed Trials, Northern Region

Prepared by: Dr. Musa B. Taha, Agronomist, ARC
Dr. Hassan Suliman Ibrahim, Director, Hudeiba Research Station, ARC
Dr. Hamid H. El-Faki, Economist, ARC

Farmer-managed trials were executed in Zeidab, Selaim, and Burgaig to compare the effect of a package of recommended practices with the farmers' practices. The package was made up of six factors:

Table 5. Comparison of Package Farmers and Block Averages, New Halfa, 1985/86 Season.

	Variable Costs (LS/ha)	Average Yield (kg/ha)	Gross Benefits (LS/ha)	Net Benefits (LS/ha)	Diff. in Benefits (LS/ha)	MRR (%)
Medina						
Package	204	1191	724	520		
Block	183	907	552	369	151	719%
Faras						
Package	234	1726	1049	815		
Block	140	1419	863	723	92	98%
Argine						
Package	286	1333	810	524		
Block	130	957	582	452	72	46%
Average						
Package	241	1417	861	620		
Block	151	1094	666	515	105	117%

1) Sowing date: First week of November.
2) Variety: Giza 160.
3) Seed rate: 142 kg per ha.
4) Nitrogen fertilizer: 86 kg N/ha.
5) Irrigation: Not more than 14 day intervals.
6) Aphid control: Sprayed with Ekatin.

Ten farmers in Zeidab, four in Selaim and six in Burgaig were initially selected to test the package in an area of one feddan each.

All selected farmers in Zeidab executed the package as scheduled except two farmers, one of whose plot became waterlogged early in the season and the other who experienced delays in watering. In Selaim one farmer was unable to comply with the package and was thus excluded. In Burgaig three farmers' crops suffered from heavy bird attacks causing considerable damage and were also excluded.

Results

The effect of the recommended package at Zeidab was significant ($P = 0.05$). In eight locations it recorded yield gains ranging from 114 to 857 kg/ha while in the two other locations losses of 79 kg/ha and 290 kg/ha over the general practice in neighboring fields were recorded.

The negative response in these two locations was due to waterlogging and soil moisture stress as mentioned earlier. The overall mean yield gain in the 10 locations was 272 kg/ha. Package farmers grew the improved variety Giza 160 during the first week of November at a seed rate of 142 kg/ha, and applied 86 kg N/ha, 8.6 irrigations and 1.1 sprays to control aphids. On the other hand neighboring farmers planted their crops between mid-November and the third week of December, and used seed rates ranging from 81 kg/ha to 235 kg/ha and nitrogen fertilizer from 26 kg N/ha to 111 kg N/ha, 6.6 irrigations and no spraying to control aphids.

Application of the package resulted in an average of LS 49 per ha net benefit over traditional practices. On average package farmers netted LS 322/ha as compared with the LS 273 netted by neighboring farmers.

In Selaim the effect of the package was not significant. Its implementation resulted in a yield improvement of 679 kg/ha in one location and yield losses of 194 kg/ha and 130 kg/ha in the other two locations compared with the neighboring farmers. The overall mean gain for the three farmers was 18 kg/ha. The negative results in the two locations were due to heavy bird damage as the trials were sown about one month earlier than neighboring farms. Neighboring farms received low rates of N fertilizer, no aphid control, higher seed rate and an equal number of irrigations compared with the farmer-managed plots. The only farmer-managed plot that did not suffer from bird damage produced a net benefit of LS 409/ha compared to the neighboring farm, while the other two, which suffered from bird damage, incurred losses of LS 152/ha and LS 99/ha.

In Burgaig the implementation of the package produced an overall negative result compared with the neighboring fields. This was mainly due to the heavy bird damage in spite of the effort to control them. Farmers in Burgaig give priority to growing faba beans and garlic and thus the sowing of wheat was delayed until late December and sometimes early January.

Table 6 shows the effect of the package on overall yield in the three areas.

Conclusions

The implementation of a package involving an early sowing date is impractical as these early-sown plots are susceptible to bird attack. As isolated plots cannot be guarded it is important to persuade farmers in the locality to sow the crop at the same time to minimize the effect of bird damage.

Table 6. Farmer-Managed Trials in Zeidab, Selaim, and Burgaig. Effect of Recommended Package of Practices on Yields (kg/ha), 1985/86 Season.

	Location: 1	2	3	4	5	6	7	8	9	10	Average
Zeidab											
Package	446	2,000	560	1,761	1,438	1,885	1,468	1,575	2,072	2,316	1,552
Farmers											
Neighboring	525	1,756	850	1,501	925	1,439	839	718	2,041	2,202	1,280
Farmers											
Difference	-79	244	-290	260	513	446	629	857	31	114	273

	Location: 1	2	3	Average
Selaim				
Package	3,406	2,079	2,870	2,785
Farmers				
Neighboring	3,600	1,400	3,000	2,667
Farmers				
Difference	-194	679	-130	118

	Location: 1	2	3	Average
Burgaig				
Package	1,062	1,056	1,309	1,142
Farmers				
Neighboring	2,188	2,400	1,500	2,029
Farmers				
Difference	-1126	-1344	-191	-887

Researcher-Managed Trials, Gezira and New Halfa Schemes

Prepared by: Dr. Osman A.A. Ageeb, National Coordinator Wheat Research, ARC
Dr. Mohamed S. Mohamed, Director, New Halfa Research Station, ARC
Dr. Hamid H. El-Faki, Economist, ARC

Full Factorial Trial

Four factors, each at two levels (recommended and farmer levels) were tested at Wad Medani, El Turabi and New Halfa to find their separate and interacting effects on the grain yield of wheat. These factors were:

Factors	Recommended Level	Farmer Level
1. Land preparation	Disc plowing	Split ridging
2. Irrigation	9 irrigation at 14-day intervals	5 irrigations at 21-day intervals
3. Sowing time	1st week of November	Last week of November
4. Phosphorus Fertilizer	43 kg P_2O_5 per ha	Zero

The experiment was set up as split-split plots, 2^4 factorial in randomized complete blocks with two replications at Wad Medani and El Turabi and three at New Halfa. Land preparation was assigned to the main plots, while irrigation interval was assigned to sub-plots with the factorial combination of sowing date and phosphorus occupying the sub-sub-plots. The sub-sub-plot size was 4.0 x 60.0 m of which 2.0 x 48.0 m was harvested for yield at Wad Medani and El Turabi and 160.0 m^2 at New Halfa.

Results

A. Wad Medani

Land preparation using split-ridging compared with discing resulted in a significantly better grain yield. This increase in yield reflected better crop establishment. The difference between the two methods of land preparation was significantly affected by irrigation and sowing

date. Under soil moisture stress the crop yielded 68% more when the land was prepared by split ridging. This big difference was greatly reduced when the crop was frequently irrigated to the extent that the late-sown, frequently irrigated crop yielded significantly better when the land was prepared with a disc plow.

Irrigation had a tremendous positive effect on wheat yield. (See Table 7). On average, giving the crop 9 irrigations at 10- to 14-day intervals, instead of 5 irrigations at 21-day intervals, resulted in an 89% increase in yield. The increase in grain yield was 758 kg/ha.

The addition of P fertilizer increased grain yield by 270 kg/ha. The response was even greater (386 kg/ha) when the crop was frequently irrigated.

Unexpectedly this season, late planting on November 28 resulted in a significantly better grain yield than planting the crop on 5 November. It was observed that during the critical stage of panicle development, the early sown crop was exposed to heat stress from a high average daily temperature (26.3 vs 23.6°C) compared with the late-sown crop. This resulted in fewer heads per unit area and fewer kernels per head. On the other hand the early sown crop was exposed to cooler temperatures (24.0 vs 26.0°C) during the grain filling stage which helped in better grain filling. Kernel weight from the early sown crop was 13% more. From this trial it is quite apparent that seed yield is more affected by kernel number than by kernel weight.

Detailed budget analysis has clearly shown that the highest net benefits were realized from preparing land by discing, giving 9 irrigations, addition of 43 kg P_2O_5 per ha and sowing the crop at the end of November. Net benefits were LS 1,093 and variable costs were LS 288 per ha.

B. El Turabi

Both land preparation and sowing date had no significant effect on wheat yield. Frequent irrigations at 10- to 14-day intervals resulted in a significant grain yield increase of 745 kg/ha as compared to irrigation at 21-day intervals. The increase in grain yield was even more when the land was prepared by split-ridging (1,094 kg/ha).

The addition of P fertilizer significantly increased grain yield by 370 kg/ha. The interaction between phosphorus and irrigation was also positive. Addition of P fertilizer coupled with adequate soil moisture resulted in an increased seed yield of 637 kg/ha.

Detailed partial budget analysis shows that the highest benefits (LS 1,340/ha) were obtained by frequent irrigation (9 irrigations), addition of 43 kg P_2O_5 per ha, land preparation by split ridging, and sowing the crop at the end of November. The variable costs were LS 263/ha.

Table 7. Effect of Land Preparation, Irrigation Interval, Sowing Date and P-Application on Grain Yield Wad Medani, El Turabi and New Halfa, 1985/86 Season.

	Land Preparation			Irrigation Interval			Sowing Date			Phosphorus Application		
Location	Disc Plow		Split Ridging	14-days		21-days	1st Week of Nov		Last Week of Nov	43 kg P205/ha		Zero
Wad Medani	1132	+/-1	1326	1608	+/-58	850	1151	+/-30	1307	1367	+/-30	1097
El Turabi	1592	+/-36	1676	2006	+/-57	1261	1611	+/-36	1657	1819	+/-36	1448
New Halfa	2868	+/-149	2600	2967	+/-80	2600	2975	+/-56	2592	2771	+/-56	2796

C. New Halfa

Land preparation and the addition of P fertilizer had no significant effect on grain yield. Shortening the irrigation interval from 21 to 14 days increased yield by 367 kg/ha.

Advancing the sowing date from December 1 to November 15 increased grain yield by an average of 383 kg/ha.

Detailed partial budget analysis showed that the highest net benefits were obtained from research levels of land preparation, irrigation and sowing date and with no phosphorus application (farmer's level). The net benefit was LS 1,935/ha at a variable cost level of LS 350/ha.

Conclusions

1) In all the three sites the wheat crop benefited a great deal from frequent irrigation at 14-day intervals compared with irrigation at 21-day intervals. The crop needs about 9 irrigations to give a satisfactory yield.
2) Addition of 43 kg P_2O_5/ha in Gezira increased yield on average by 325 kg/ha. An even greater increase can be brought about by the presence of adequate soil moisture (500 kg/ha). Since the size of the response is site-specific, more on-farm trials are needed before recommendations are made for adoption on the farmers' fields.
3) The method of land preparation significantly interacted with the frequency of irrigation and sowing date to influence grain yields. The results were site specific. Back-up research is needed in this area to produce more convincing data to be used in on-farm trials.
4) The results from the sowing date treatment have clearly shown that the commercial variety Condor is highly sensitive to heat stress The farmers in some years could risk low yields if they keep to the recommended sowing time for wheat (mid-October to mid-November). Therefore more back-up research is needed to:
   i) Find genotypes tolerant to heat stress e.g. genotypes with little vernalization requirements.
   ii) Manipulate cultural practices to obtain a cooler micro-climate more favorable for wheat growth and development (e.g. frequent irrigations, high plant densities, etc.).

Researcher-Managed Trials, Northern Region

Prepared by: Dr. Musa B. Taha, Agronomist, ARC
Dr. Hassan Suliman Ibrahim, Director, Hudeiba Research Station, ARC
Dr. Hamid H. El-Faki, Economist, ARC

Researcher-managed trials were carried out in Zeidab and Selaim to study the effects of sowing date, nitrogen level, irrigation, and aphid control. Each of these four factors were examined at two levels and combined factorially in a randomized complete block design with four replications. The levels of the factors were as follows:

Factor	High Level	Low Level
1. Sowing date	7 November (D1)	21 November (D2)
2. N fertilizer	86 kg/ha (N1)	None (N2)
3. Irrigation	Every 14 days (R1)	Every 21 days (R2)
4. Aphid control	Sprayed (C1)	None (C2)

Results

Grain yield at Selaim was about 1.5 times higher than at Zeidab, probably due to a relatively cooler and longer winter season.

At both sites grain yield was significantly affected by sowing date, nitrogen fertilizer, irrigation, and aphid control. The sowing date 21 November gave a significantly higher grain yield than the 7 November sowing date. The lower levels of nitrogen fertilizer, irrigation and aphid control gave significantly lower grain yields than the corresponding higher levels.

Aphid control was more pronounced in the first sowing date and with the higher level of nitrogen. Also at the high nitrogen level the crop benefited more from frequent irrigations when aphids were properly controlled. (See Table 8).

Conclusions

Nitrogen fertilization, frequent irrigations and chemical control of aphids resulted in higher grain yields. Although earlier sowing (1-15 November) was established at Hudeiba Research Station to be the

Table 8. Effect of Sowing Date, Nitrogen Fertilizer, Irrigation Interval and Apid Control on Yield, Zeidab and Selaim, 1985/86 Season.

Location	(---Sowing Date---)			Nitrogen Fertilizer			Irrigation Interval			(---Aphid Control---)		
	7 Nov		21 Nov	86 kg N/ha		Zero	14-day		21-day	Control		No Control
Zeidab	1980	+/-40	2369	2286	+/-40	2061	2447	+/-40	1901	2404	+/-40	1944
Selaim	3243	+/-52	3452	4121	+/-52	2574	3537	+/-52	3157	3501	+/-52	3194

Grain yield shown in kg per ha.

Table 9. On-farm verification yield trials 1985/86 season.

No	Variety	Wad Medani	Turabi	Maatug	Sennar	Kosti	Village 3	N Halfa Res Farm	Village 15	Hudeiba	Shendi	Seleim
1	Debiera	1,784	2,168	1,147	1,371	1,257	3,787	2,442	2,382	2,942	2,821	2,940
2	Condor	1,586	1,842	1,001	1,145	1,081	3,732	2,371	2,433	3,388	2,964	2,660
3	D6923x(Cno's'*15)	1,637	1,906	906	1,250	1,224	4,182	2,367	2,538	2,504	2,520	3,393
4	Wadi El Nil	1,854	2,020	931	1,307	1,021	3,156	2,261	1,929	3,165	2,219	2,494
5	D6923x7C	1,580	1,918	835	1,582	1,090	3,723	2,633	2,793	3,375	2,923	2,704
6	L 1439/4581xG.156	2,096	2,070	1,103	1,008	1,110	3,175	2,559	2,069	3,009	2,031	2,685
7	Nd Sel 101-Pvn's'	1,969	1,925	861	759	1,186	4,401	2,435	2,506	2,942	2,367	2,602
8	Sel 129 F6/78-79	1,902	1,937	950	1,320	1,174	4,227	2,469	2,548	3,129	2,173	2,691
9	Sel 73 F7/79-80	1,956	2,144	1,052	1,314	976	4,479	2,310	2,554	3,286	2,592	2,309
10	Veery's'	1,822	2,097	695	1,091	905	4,661	2,308	2,571	2,790	2,459	2,443
	S.E.	85	124	64	81	94	181	179	165	206	157	244
	C.V. %	9.2	12.4	23.5	13.0	17.0	9.0	14.8	13.6	13.0	13.0	18.0

Yield shown in kg/ha

optimum time for higher yields, the results this season showed that late sowing outyielded earlier sowing. This discrepancy could be attributed to bird attack on the earlier sown crop.

At Zeidab net benefits of the individual factors showed that, except for fertilizers, the effect of the improved factors followed that of yield - positive in the case of irrigation and aphid control and negative for the sowing date. In spite of the positive effect of fertilizer on grain yield, higher net benefits resulted from no fertilizer application due to the unproportional increase in gross benefits compared with fertilizer costs. As a consequence the treatment with improved levels of irrigation and aphid control, and traditional sowing date and fertilizer application is the most encouraging, resulting in an increased net benefit of LS 218/ha compared to the control (all factors at low level).

At Selaim the effect of individual factors on net benefits followed that of yield where positive benefits were realized with improved irrigation, nitrogen and pest control and negative benefits from an early sowing date. Highest net benefits (LS 1,198) were obtained from a combination of an improved level of irrigation, fertilizer, and aphid control with the farmers' practice of sowing date.

On-Farm Verification Yield Trial

Prepared by: Dr. Abdalla B. El-Ahmadi, Head of Plant Breeding Section, ARC

The objectives of the trial were twofold: to increase the efficiency of screening and to demonstrate to farmers the performance of new varieties and improved cultural practices. The most promising eight cultivars from Gezira and New Halfa breeding programs were included with two checks. The trial was conducted in twelve sites which were chosen to cover all the wheat-producing regions of the country.

Yields were generally low in the southern Gezira and White Nile sites (one ton per ha) while they were moderate (2 tons per ha or more) in the other regions (Northern Gezira, New Halfa and Northern Regions).

The performance of the cultivars in the different regions was as follows (see also Table 9).

(1) In the Central Region significant variation among cultivars was detected in three out of five sites. However, the check Debeira was significantly outyielded by four entries at only one site and was top ranking in three.
(2) In the Eastern Region, Debeira was outyielded by three entries in one out of three sites.

(3) In the Northern Region variation among the cultivars reached a significant level at one site (Shendi). No entry was superior to Debeira.

From this season's results none of the entries under test could be nominated as a replacement for the check Debeira.

BACK-UP RESEARCH

Crop Improvement

Gezira

Prepared by: Dr. Abdalla B. El-Ahmadi, Head of Plant Breeding Section, ARC

A series of yield trials were conducted at Gezira Research Station with the objective of screening as many genotypes as possible. They were grown using the recommended cultural practices. Data on yield and some agronomic characters were collected for each trial.

1.1 Preliminary Yield Trial - Experiment 1

Forty-six entries were tested against two checks in a randomized complete block experiment. A wide variation in yield was shown by the genotypes under test (ranging from 1,436 to 2,981 kg/ha). Although some entries outyielded the better check Debeira by more than 500 kg/ha, none of them reached a significant level.

Studies on some of the agronomic characters (DH, DM, P1.H) revealed that some genotypes were affected more than others by the exceptionally warm conditions during this season. None of the agronomic criteria, including some yield components (1,000 grain weight and number of grains per spike), could be correlated to yield.

On the basis of yield and desirable agronomic characters, ten cultivars were recommended for further tests.

1.2 Preliminary Yield Trial - Experiment 2

In this yield test a set of 22 entries was included with two checks. The highest yield obtained was 2,781 kg/ha. Three cultivars

significantly outyielded the better check Debeira which gave a yield of 2,141 kg/ha. Studies on days to heading, days to maturity, plant height and number of grains per spike showed that all of them were significantly and negatively correlated to yield. On the basis of yield and the other agronomic traits, two cultivars will be advanced to a higher level test.

2. Intermediate Yield Trials

Twenty-two genotypes were included with two checks in a randomized block test. Variations in yield among the cultivars were large ranging between 1,595 and 1,871 kg/ha. However, only two entries were significantly superior to the high-yielding Debeira. As in the Preliminary Yield Trial - Experiment 2 set of genotypes, the correlation of the agronomic characters with yield was negative considering all aspects. Three entries will be included in the advanced yield trials.

3. Advanced Yield Trial

Ten cultivars proven to be superior in previous tests were included with two checks in a randomized block experiment. Variations in yield among the cultivars were significant. The only cultivar that significantly outyielded the better check Debeira has the disadvantage of nonsynchronized and late tillering. This characteristic would have an adverse effect on late-sown crops. There was only one entry that showed desirable agronomic characters but it was not significantly superior in yield to Debeira.

New Halfa

Prepared by: Dr. Mohamed S. Mohamed, Director, New Halfa Research Station, ARC

Selections evolving from the breeding material in the New Halfa Wheat Improvement Programme are usually evaluated in a series of 3 consecutive yield trials with micro-plot (preliminary), macro-plot (intermediate), and standard-plot (advanced) sizes. Although this sequence of testing is followed in order to allow convenient seed increases of selections, it is not always necessary to keep to it in the case of selections showing outstanding performance. Generally, the testing of lines in each trial is done for one season so that the flow of breeding material is facilitated to the overlapping and continuous process of breeding activities.

The yield trials were conducted using the standard cultural practices of:

Land preparation with disc harrowing and levelling, sowing on the flat in rows 20 cm apart, using seed rates of 120 kg/ha and 86 kg N/ha. The crop is irrigated at 2-week intervals, weeded twice, and sprayed with Ekatin against aphids. The experimental design is randomized complete blocks with four replications.

Based on the results of the performance of the entries in the Intermediate Yield Trial and Advanced Yield Trial, the line Sel 73 F4/77-78-2, which was top yielding in both trials, is recommended to be promoted to the Verification Yield Trial. In addition to yielding ability it is superior to Condor in grain size, number of grains per spike and plant height.

Mechanization

Prepared by: Mr. Abdel Rahman Bushara, Agricultural Engineer, New Halfa Scheme

Effects of Tillage Systems and Sowing Methods on the Grain Yield of Wheat

The experiments consisted of the following treatments:

a) Tillage Systems
   i) Disc plowing, clod crushing and levelling
   ii) Dry ridging, pre-watering, harrowing and levelling
   iii) Light disc harrowing and levelling
   iv) Pre-watering, light disc harrowing and levelling

b) Sowing Methods
   i) Broadcasting with a wide level disc harrow
   ii) Seed drilling with a wide level disc harrow using hoses
   iii) Seed drilling using the conventional tractor-mounted seed drill

The experiment was laid out in split-plot, randomized complete blocks with four replications. Land preparation and tillage system were assigned to the main plots while sowing methods occupied the sub-plots. The sub-plot size was 10 x 30 m. The test variety was Condor.

Results

Tillage systems had no significant effect on crop establishment or grain yield. On the other hand seed drilling with a seed-drill had a positive effect on crop establishment but none of the sowing methods had a significant effect on grain yield.

Water Management

Prepared by: Dr. Saeed M. Farah, Head of Agronomy Section, ARC

Effect of the Irrigation Interval at Three Stages of Wheat Development on Yield

The variety Condor was subjected to three irrigation treatments at three development stages as follows:

1) Irrigation every 14 days, 21 days and 10 days, and then 14 days from planting to boot.
2) Irrigation every 10 days or 14 days from boot to milk.
3) Irrigation every 14 days or 21 days from milk to maturity.

Mean grain yields of the treatments were below yield potential mainly because of the warm weather during the growing season which hastened crop development.

Grain yield indicated that irrigating the crop 10 days after the planting irrigation (to break the crust) resulted in a slight decrease of the grain yield. Shortening the interval to 10 days during the boot stage increased the grain yield by about 11% compared to 14 days, whereas lengthening the interval to 21 days from the milk stage to maturity decreased the yield by only 5% compared to 14 days. There was a tendency for an increase in protein percentage with longer irrigation intervals at all three development stages.

There was a reasonably good relationship between total DM at the 5-leaf stage and the grain yield at harvest.

The highest yield of 1,272 kg/ha was obtained with eight irrigations. However, yields of 1,257, 1,213, 1,174 and 965 kg/ha were obtained with the application of 7, 6 and 5 irrigations respectively. These yields are not significantly less than the highest yield and the reduction in irrigations is clearly of economic value as far as labor and cost considerations are concerned.

Crop Protection: Plant Pathology

Prepared by: Dr. Mohamed S. Ahmed, Pathologist, ARC

Screening of Commercial and Promising Wheat Varieties for Stem Rust Resistance Under Natural Field Conditions

The objective of this experiment was to determine the resistance rating of the varieties or lines in the advanced selections of the wheat breeder and to detect any changes in resistance of the commercial varieties.

Forty-six varieties were tested. These included the commercial varieties Debeira, Condor, Giza 155, and Mexicani and the imported variety Sakha 69 from Egypt.

The susceptible variety Beladi was sown on the borders to act as disease trap and source of inoculum. Two observations were made of infection type and disease severity on February 10-11 and February 24-25, 1986.

The results of the first observation showed that 43 varieties had good resistance and three had fair resistance.

In the second observation two weeks later, 16 varieties showed good resistance, 6 varieties fair resistance, 5 varieties marginal resistance, and 19 varieties poor resistance.

The varieties showing good resistance included the important commercial variety Condor. Giza 155 had fair resistance. The varieties showing poor resistance in the second observation included the commercial varieties Debeira and Sakha 69. The resistance rating of Debeira was unexpectedly low and showed a relatively fast infection rate (from 5% to 50% in 2 weeks) and a moderately susceptible disease reaction.

Crop Protection: Insect Management

Prepared by: Dr. Nasr Eldin Sharaf Eldin, Entomologist, ARC

Although aphids are the main wheat pest in the Sudan, the crop is also attacked by the stem borers, *Sesamia critica* and *Chilo partellus*, and termites. Heavy outbreaks of rats and birds can also cause heavy losses.

The population of aphids annually reaches sprayable levels. When the percentage of infested plants reaches 35%, about 1.5 sprays are applied by aircraft. Failure to apply chemical control results in yield losses of about 25% - 30%.

Basic studies pertaining to the ecology and biology of the aphids have been conducted before. Investigations undertaken in this study addressed some control approaches as a prelude to an integrated control strategy.

Research work carried out on wheat aphids in this season was oriented to finding a satisfactory means of integrated control of the two aphid species, *Rhopalosiphum maidis* and *Schizaphis graminum.* To achieve this goal, three areas of research were addressed:

1) To identify potent insecticides

A number of chemicals at different dosage rates were screened in the Gezira Research field to identify potent selective insecticides against the two aphid species. Twelve treatments, including a control and the standard chemical (Ekatin), for comparison, were tested. The chemicals were applied twice. Aphid population, the percentage of infested plants and grain yield were the criteria for determining the effectiveness of the different treatments.

Results indicated that Danitol-S, Reldan and Marshal gave satisfactory performance. Further investigations are needed to release these chemicals for commercial use.

2) To monitor Coccinellid predators to assess their role in the control of the aphid infestation in the field.

Two levels of the predator plus a chemical treatment and a control were to be assessed for their effect on the natural infestation of the two aphid species. Unfortunately, due to a very early and heavy infestation with the aphid and the late appearance of the predator, the required number of the latter could not be collected to be applied at the appropriate time. Accordingly the experiment was terminated.

3) To identify aphid-resistant lines.

A number of breeding lines of durum and bread wheat and barley were tested in three locations (Gezira Research Station, Turabi, and Hudeiba) for possible resistance factors. All entries showed varying degrees of susceptibility and none of them were immune. However, earliness in maturity was a very important characteristic which helped to escape peak infestation of the aphid.

SOCIO-ECONOMIC SURVEYS

Prepared by: Dr. Hamid H. El-Faki, Economist, ARC
Mr. Abdel Aziz Abdel Fattah, Economist, ARC
Agricultural Economists, ARC

Socio-economic surveys were carried out in the three main wheat producing areas with the following objectives:

1) To identify wheat production conditions and practices.
2) To estimate the role of wheat in farm structures, farmers' income and its relative importance.
3) To estimate wheat profitability in the various producing areas.
4) To quantify production factors that lead to variability in productivity and to estimate costs and benefits associated with possible improvements in those production factors.

The results give indicators for productivity improvement through on-farm and back-up research and identify farmers' and institutional constraints.

Sampling:

Samples of farms were taken from five wheat-producing areas. The sampling structure was as follows:

Table 10. Structure of farm sampling socio-economic survey, 1985/86 season

	No of blocks or sections	No of farms
Gezira/Managil	4	108
New Halfa	6	36
Zeidab	4	20
Sclaim	3	20
Burgaig	3	20
Total		204

The sampling was based mainly on the geographical location of farms and their relation to the water supply. Within these strata randomization was followed. Farmers were interviewed twice - once

after crop establishment and once after harvest. Additional information was collected from individual fields in the Gezira-Managil area concerning the level of crop establishment.

Data were collected on the following:

- farmers' family structure.
- costs and returns of wheat production.
- wheat cultural practices.
- farmers' opinions on wheat production practices, available inputs, problems and production bottlenecks and possible improvements to increase productivity.

Due to time limitations it was not possible to analyze all information collected. However, the most important aspects are considered in this report. The analysis was done on a micro-computer, applying farm analysis and regression methods separately for each area and, within the Gezira-Managil area, the individual blocks.

General Characteristics of Wheat Production

The survey results showed that there is a great diversity of production techniques. This is true both among the various producing areas and within the individual areas of production. Table 11 illustrates this diversity among producing areas with regard to land preparation, sowing dates, cultural practices, level of inputs, and harvesting methods.

This diversity, in conjunction with the effect of soil types, climate and social factors contributes to yield variability among producing areas as well as within these areas. Average yields and their coefficients of variation are shown in Table 12. Among regions, average yields ranged between 986 kg/ha and 1892 kg/ha - by about 100%. Within regions, the coefficients of variation ranged between 30 and 47 reflecting the substantial variability.

Wheat yield levels were affected by production and input constraints. In turn these levels and production practices affected profitability. Such aspects are discussed below in relation to family and farm structure, relative importance of wheat, wheat profitability, production constraints, and possible improvements.

Table 11. General characteristics of Wheat Production in Sudan, Socio-Economic Survey, 1985/86 Season.

Practices	Gezira	New Halfa	Zeidab	Selaim	Burgaig
Prewatering	0	XXX	XX	0	0
Disc Plowing	X	XXX	XXX	0	0
Split Ridging	XXX	0	0	0	0
Animal Plowing	0	0	X	XXX	XXX
Water Ties	X	X	XX	XXX	XXX
Sowing Dates	**Gezira**	**New Halfa**	**Zeidab**	**Selaim**	**Burgaig**
Before Oct 25	X	0	0	0	0
Oct 25 - Nov 7	XXX	0	0	0	0
Nov 7 - Nov 21	XXX	XXX	XXX	X	0
After Nov 21	X	XXX	X	XXX	XXX
Hand Sowing	XX	0	XXX	XXX	XXX
Machine Sowing	XX	XXX	0	0	0
Animal Sowing	0	0	0	XX	X
Sowing on Flat	XXX	XX	0	XXX	XXX
Sowing on Ridges	X	X	XXX	0	0
Sowing on Mustaba	0	X	0	0	0
Seed Rate	XX	XX	XX	XXX	XXX
Fertilizer Rate	XXX	XXX	XX	XX	XX
Pest Control	XXX	XXX	0	0	0
Machine Harvest	XXX	XXX	0	0	0
Manual Harvest	0	0	XXX	XXX	XXX

Key: 0 = Nil, X = Low, XX = Medium, XXX = High.

Table 12. Wheat Yield Variability, Socio-economic Survey, 1985/86 Season

	Average yield (kg/ha)	Coefficient of variation (%)
Debeiba	1,419	42
Dolga	986	37
Darwish	1,297	25
Murad	1,497	34
New Halfa	1,231	47
Zeidab	1,300	32
Selaim	1,892	38
Burgaig	1,494	30

Family Structure

Farmers' family structures are shown in Table 13. Farmers' ages ranged between 39 and 59 years with relatively high figures in the Gezira-Managil area. Most of the farmers have long experience in farm work with a long period on the same site. Farmers were predominantly illiterate or with minor levels of education (Khalwa). Family sizes were relatively large with most of the family members as students and laborers. This large family size, age and occupation distribution allowed participation of family members in farm activities. In some areas up to 85% of the farmers received some help from family members. The level of help was, however, very low in Gezira, New Halfa and Zeidab. Generally labor peaks were not problematic except in Northern Sudan where dependence on family labor and farmers' cooperation was very high. This reliance on labor was expected to affect wheat production particularly during crop establishment and harvesting.

Relative Wheat Importance

The relative importance of wheat in farm structure is shown in Table 14. About one-third of the farm areas in almost all regions is taken up by wheat. However, its contribution to farm income is variable and low ranging from 5% to 24%. In Northern Sudan and New Halfa farmers grow wheat predominantly for consumption while in Gezira it is mainly a cash crop. The low contribution of wheat to farm income and the reasons for production (cash or consumption) contribute to the level of preference for wheat among farmers. Wheat ranks as a priority in most cases in Northern Sudan and New Halfa but has low priority in the Gezira-Managil area. Apart from low yields this low priority explains to a great extent the limited contribution of wheat in the areas. Pricing policies for both production factors and the sale price of wheat would add incentives to the growing of wheat and cause an increase in production.

Wheat Profitability

Table 15 shows the profitability of wheat production. Net returns on wheat were generally low. This is accounted for by low yields, low prices and high production costs. Particularly in Northern Sudan high production costs resulted in low profitability compared with the relatively high gross returns. Again, the high production costs were

Table 13. Farmers' Family Structures. Socio-Economic Survey, 1985/86 Season

	Debeiba	Dolga	Darwish	Murad	N Halfa	Zeidab	Seleim	Burgaig
Age (Yrs)	55	59	53	47	47	39	49	47
Min.	24	23	24	15	27	25	29	21
Max.	75	80	82	80	67	55	69	74
Exp in Agr	33	39	34	25	32	21	30	33
Exp in Site	27	27	29	23	19	18	26	
Education								
Khalwa	48	44	35	19	14	6	5	5
Elementary	15	15	27	15	53	5	15	21
Intermediate	7	15	4	4	11	3	0	26
Secondary	0	0	4	4	8	0	0	0
Illiterate	30	26	30	59	14	86	80	48
Family Size	8.4	4.9	6.4	5.2	5.0	4.3	7.2	7.6
Males	3.7	2.6	3.2	3.3	3.2	2.3	3.9	4.5
Females	4.7	2.3	3.2	1.9	2.8	2.0	3.3	3.1
Occupation (%)								
No work	11	10	18	13	14	23	22	13
Students	31	29	39	41	64	46	30	38
Laborer	19	15	14	19	8	9	27	20
Employee	2	13	2	9	5	6	3	9
Businessman	3	4	2	2	3	0	1	0
Immigrant	0	6	1	0	0	3	0	3
House-keeper	34	23	18	13	6	13	17	17
Help (%)	63	48	80	67	53	56	85	85
Labor Peaks								
Nov - Jan	44	0	8	4	20	80	80	75
Jan - Mar	41	11	0	15	17	40	50	56
Jun - Aug	74	7	8	15	33	0	--	--

Table 14. Farm Structure and Income Survey Results. 1985/86 Season

	Debeiba	Dolga	Darwish	Murad	N Halfa	Zeidab	Seleim	Burgaig
Wheat Area (ha)	2.10	2.10	2.10	2.10	2.10	0.89	0.79	0.89
% of Farm Area	33%	33%	33%	33%	33%	15%	29%	37%
Gross Return on Wheat (LS)	2,261	1,376	1,399	2,218	1,550	619	1,271	1,481
Gross Return of Farm (LS)	10,023	6,406	9,087	0,960	6,760	6,346	23,129	6,214
% of Wheat to Gross Returns	23%	21%	15%	20%	23%	10%	5%	24%
Wheat Preferability (% of Farmers)								
Consumption	7%	7%	30%	4%	86%	90%	95%	100%
Cash	70%	70%	68%	59%	3%	10%	5%	0%
Preference for Wheat as First Crop (% of Farmers)	4%	11%	16%	0%	86%	15%	50%	100%

Table 15. Wheat Profitability, Socio-Economic Survey, 1985/86 Season

Region	Gross Return (LS/ha)	Production Costs (LS/ha)	Net Return Return (LS/ha)	Break-even Yields (kg/ha)
Debeiba	993	622	371	886
Dolga	690	598	92	854
Darwish	908	622	286	886
Murad	1,047	637	410	910
New Halfa	861	667	194	953
Zeidab	694	730	(36)	1,367
Seleim	1,608	1,174	434	1,381
Burgaig	1,270	930	340	1,094

conducive to the high break-even yields which, although attainable, resulted in a limited margin of profit. The distribution of production costs is shown in Table 16.

The main contributors to high production costs are the material inputs such as fertilizers, water, seeds, and sacks which accounted for almost two-thirds of the costs. The next highest cost is harvesting.

Table 16. Distribution of Production Costs (%), Socio-Economic Survey, 1985/86 Season

Region	Land Preparation	Cultivation Operation	Harvesting	Materials
Debeiba	8%	4%	23%	65%
Dolga	9%	5%	19%	67%
Darwish	10%	5%	24%	61%
Murad	7%	5%	25%	63%
New Halfa	5%	3%	15%	77%
Zeidab	19%	4%	32%	45%
Seleim	18%	4%	34%	44%
Burgaig	23%	8%	18%	51%

Productivity Constraints and Possible Improvements

Wheat yield variability within regions (refer to Table 12) was related to production factors and production practices by simple regression

analysis. Table 17 shows the individual contribution of these factors to yield and the increase in net returns over the averages in each area. These differences represent the potential for wheat improvement using existing facilities and environments.

The impact of the individual factors was substantial. The effect of the sowing date and land preparation, particularly levelling, was apparent in almost all areas. Crop establishment was effective in the Gezira region where it was possible to measure the contribution of weeds and patchiness. Irrigation contributed significantly in most areas. The effect of the seed rate and fertilizer was shown in the areas where variability in their application existed i.e. Northern Sudan and New Halfa. These factors should be tested in the Gezira-Managil area. Other important factors, the effects of which were not possible to quantify due to lack of variability, included pest control in Northern Sudan, pre-watering in most of the regions and varieties in all regions.

The resulting effect of all these individual factors was quite substantial. Yield increases with the high levels of input ranged between 409 kg/ha and 1,854 kg/ha. This results in an increase of net benefits of between LS 53 and LS 1,854 per ha.

Factor interaction was not considered at this stage as the individual effect of factors was being tested. The sum of the individual factor effects does not neccessarily equal the total factor effects due to interactions. It was therefore necessary to adjust the sum of the individual factor effects so as to match the difference between average and highest yields in each region. Highest yields were represented by their upper limits at 95% probability. Adjusted total factor effects on yield are shown in Table 18.

The above analysis shows that, even within the existing environment, farmers' yields and incomes could be raised substantially by improving individual factors. Yet further improvements are possible by using improved practices. Figure 3 shows the relationship between average farmers' yield, highest attained yield and research yields. It shows the yield gaps and the potential improvement from the current average to research yields. Research yields are represented by maximum yields obtained from the Researcher-Managed Trials at Wad Medani, Turabi, New Halfa and Selaim in the 1985/86 season. In some of the areas such as Debeiba and Murad the highest yields attained were approximately at the same level as those of research. In all other areas, yield gaps existed which are possible to bridge through continuing improvements.

Table 17. Estimated Effects of Production Factors on Wheat Yields and Net Benefits, Socio-Economic Survey, 1985/86 Season

Locations	* Sowing Date	Seed Rate	* Levelling	* Weeds	* Patches	Plowing	* Cost of Plowing	* 2nd Plowing	Irrigation	* Ridging	Cost of Ridging	* Pre-Watering	Fertilizer	Total per ha
Debeiba														
Yield Increase	331	-	133	245	374	-	364	-	407	-	-	-	-	1854
Extra Net Benefits	231	-	69	148	238	-	221	-	224	-	-	-	-	1131
Dolga														
Yield Increase	33	-	119	-	151	-	997	100	340	-	-	-	-	1740
Extra Net Benefits	24	-	60	-	82	-	319	46	205	-	-	-	-	736
Darwish														
Yield Increase	43	-	81	60	226	-	171	-	-	-	-	-	-	581
Extra Net Benefits	31	-	33	19	136	-	86	-	-	-	-	-	-	305
Murad														
Yield Increase	43	-	81	60	226	-	171	-	-	-	-	-	-	1673
Extra Net Benefits	38	152	-	-	-	-	-	-	88	31	274	-	-	583
New Halfa														
Yield Increase	64	286	-	-	-	-	-	-	252	64	476	-	-	1142
Extra Net Benefits	38	152	-	-	-	-	-	-	88	31	274	-	-	583
Zeidab														
Yield Increase	174	469	133	-	-	267	-	-	397	-	-	95	-	1535
Extra Net Benefits	93	226	36	-	-	95	-	-	157	-	-	31	-	638
Seleim														
Yield Increase	-	98	-	-	-	-	568	-	-	-	-	-	495	1161
Extra Net Benefits	-	-12	-	-	-	-	44	-	-	-	-	-	350	382
Burgaig														
Yield Increase	-	112	29	-	-	-	185	-	-	-	-	-	83	409
Extra Net Benefits	-	19	-23	-	-	-	117	-	-	-	-	-	-60	53

* Treated as dummy variables in the regression

(The inputs of quantitative variables were kg for seeds, LS for costs of plowing and ridging, kg for urea for fertilizers and number of irrigations).

Table 18. Adjusted total factor effect on yield (kg/ha) socio-economic survey, 1985/86 season

Area	Adjusted Improvement (kg/ha)
1. Gezira/Managil	
Debeiba	2,577
Dolga	1,859
Darwish	2,068
Murad	2,486
2. New Halfa	2,596
3. Zeidab	2,116
4. Selaim	3,315
5. Burgaig	2,367

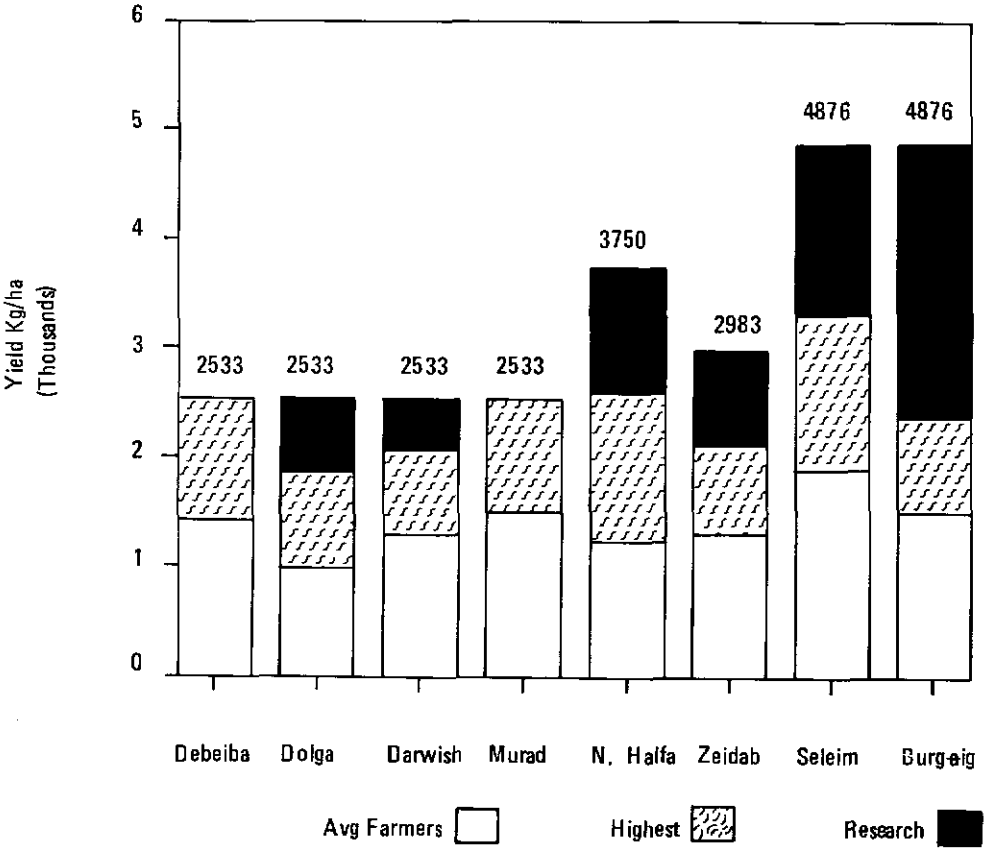

Fig. 3 Wheat Yield Gaps 1985/1986, Main Producing Areas in Sudan

PROGRAM OF WORK 1986/1987

I. Farmer-Managed Trials

This work will be done in cooperation with extension and production personnel in the agricultural schemes concerned.

A. Gezira Scheme

Package to be tested:

1. Adequate land preparation through disc plowing and levelling.
2. Eight to nine irrigations during the growing season at 14-day intervals during the vegetative stage and 10- to 12-day intervals during the reproductive stage.
3. Application of 43 kg P_2O_5 per ha (18 kg P_2O_5/feddan).

The package will be tested in the following locations:

i Derweish block in the Centre Group
ii Dolga block in the Wad Habouba Group
iii Debeiba block in the Northern Group

A total of 27 farms will be involved.

The results obtained will be compared with comparable farms not implementing the package. Economic analysis will be made to assess the profitability of the package and field days will be organized during the growing season for farmers, and extension and production staff.

Scientist in Charge:
Osman A. A. Ageeb, National Coordinator Wheat Research, ARC

Cooperating Scientists:
A. T. Ayoub, National Coordinator Soil Science Research, ARC
Ahmed Musa, Agricultural Engineer
Ibrahim Khalid, Agricultural Engineer
Hamid H. El-Faki, Economist, ARC

B. New Halfa Scheme

Package to be tested:

1. Sowing the crop during the first half of November.
2. Adequate irrigation at 14-day intervals.

3. Cultivating the wheat variety Debeira.
4. Nitrogen fertilizer applied during sowing at the rate of 86 kg N per ha (36 kg N/feddan) in the form of urea.

The package will be tested in three locations and a total of 15 farmers will be involved. Economic analysis will be done and field days will be held.

Scientist in Charge:
Mohamed S. Mohamed, Director, New Halfa Research Station, ARC

Cooperating Scientists:
Ahmed M. Gorashi, Agronomist, ARC
Abdel Rahman Bushara, Agricultural Engineer, New Halfa Scheme
Hamid H. El-Faki, Economist, ARC

C. Northern Region

Package to be tested:
1. The variety cultivated will be Wadi El Neil.
2. Nitrogen fertilizer will be applied at a rate of 86 kg per ha in the form of urea.
3. Adequate irrigation will be provided at 14-day intervals.
4. Aphids will be controlled by chemical spraying.

Scientists in Charge:
Musa B. Taha, Agronomist, ARC
Abdel Gadir Bushara, Entomologist, ARC
H. Suliman, Soil Scientist
Hamid H. El-Faki, Economist, ARC

II. Researcher-Managed Trials

A. Gezira Research Station

1. Irrigation methods

Poor crop establishment is a major problem facing wheat production in the Gezira scheme. This problem arises from the poor distribution of the first irrigation water in an allegedly levelled field of heavy clay soil with a very low infiltration rate. The irrigation method in use is basin irrigation. Due to micro-relief this method results in surface ponding and poor crop establishment.

A number of irrigation and land farming systems will be compared with basin irrigation:

1. Furrow irrigation in 80 cm ridges.
2. Corrugations by combing the soils with small tines.
3. 120-cm beds by making small furrows.
4. Good land preparation, levelling and basin irrigation.

The trial will be replicated at El Turabi.

Sowing Date:
First week of November.

Seed Rate:
120 kg/ha

Fertilizer:
86 kg N and 43 kg P_2O_5/ha

Irrigation:
At 14- to 10-day intervals (9 irrigations)

Experiment Design:
RCB with 3 replications.

Data to be Recorded:
Crop stand, weed infestation, yield and economic analysis.

Scientist in Charge:
Osman A. A. Ageeb, National Coordinator Wheat Research, ARC

Cooperating Scientists:
Ahmed Musa, Agricultural Engineer
Abdel Gabbar T. Babiker, Weed Control, ARC
Hamid H. El-Faki, Economist

2. Wheat Response to P Fertilizer

Economic combination of N and P in farmers' fields.

Previous studies have clearly indicated that the addition of P fertilizer increased wheat yield by 15% - 25%. Other studies have shown that the addition of 43 kg N + 43 kg P_2O_5/ha give comparable yield to 86 kg N/ha. The present study is to evaluate the economic response of three combinations of N and P in farmers' fields in Gezira and Managil.

Treatments:
1. 86 kg N per ha (control)
2. 86 kg N + 43 kg P_2O_5/ha
3. 43 kg N + 43 kg P_2O_5/ha

The trial will be held in five farmers' fields in Murad (Managil) and the Derweish block (Gezira).

Scientist in Charge:
A.T. Ayoub, National Coordinator Soil Science, ARC

Cooperating Scientists:
Osman A.A. Ageeb, National Coordinator Wheat Research, ARC Extension Officers

B. New Halfa Research Station

Wheat Land Preparation, Sowing Methods, and Seed Rate

Land Preparation:
1. Off-set disc harrowing, harrowing, and levelling.
2. Pre-watering, harrowing, and levelling.

Sowing Methods:
1. Broadcasting with a wide-level disc.
2. Drilling using a tractor-mounted seed drill.

Seed Rate:
1. 120 kg per ha.
2. 160 kg per ha.

Eight treatment combinations will be tested in a split plot RCB with land preparation occupying the main plot and a combination of sowing methods and seed rate occupying the sub-plots with 3 replications.

Data to be Recorded:
Plant stand, weed infestation, seed yield and economic analysis.

Sceintist in Charge:
Abdel Rahman Bushara, Agricultural Engineer, New Halfa Scheme

Cooperating Scientists:
E. Osman, Weed Scientist, ARC

C. Hudeiba Research Station

The Researcher-Managed Trial will consist of the following factors:

Factors	Improved Level	Farmer Level
1. Irrigation	8-9 irrigations at 14-day intervals	5-6 irrigations at 21-day intervals
2. Fertilizer	86 kg N/ha	43 kg N/ha
3. Aphid Control	Chemical spraying	None
4. Sowing Date	During first half of November	During first half of December

The trial will be carried out at Zeidab and Shendi and also possibly at Burgaig and Selaim if transport facilities are available.

Scientist in Charge:
Musa B. Taha, Agronomist, ARC

Cooperating Scientists:
Gaafar El Sarag, Shendi
Abdel Gadar Bushara, Entomologist, ARC
H. Suliman, Soil Scientist

On-Farm Verification Yield Trial

Eight cultivars and two checks will be tested in 12 locations in the Sudan:

6 locations, Central Region (Gezira and White Nile)
3 locations, Northern Region (Nile and Northern Province)
3 locations, New Halfa Scheme

Data to be Recorded:
Plant stand
Days to flowering and maturity
Seeds per head
100-seed weight
Yield per unit area

Scientist in Charge:
Abdalla B. El-Ahmadi, Head of Plant Breeding Section, ARC

Cooperating Scientists:
Mohamed S. Mohamed, Director New Halfa Research Station, ARC
Abdulla Ibrahim, Plant Breeder
Gaafar El Sarg, Shendi

III. Back-Up Research

A. Crop Improvement

To secure the continuity of the on-farm verfication yield trial, support will be given to yield testing of advanced lines in a series of variety trials. They will be carried out at Wad Medani and New Halfa.

1. Preliminary Yield Trial

Entries: 50
Repetitions: 3
Design: RCB
Plot size: 8 rows, 4-m long and 20-cm apart

Data to be Recorded:
Days to heading and to maturity, plant height, disease resistance, lodging, shattering, and yield.

Scientists in Charge:
Abdulla El-Ahmadi, Head of Plant Breeding Section, ARC
Mohamed S. Mohamed, Director New Halfa Research Station, ARC

2. Intermediate Trial

Entries: 24
Repetitions: 4
Design: RCB
Plot size: 8 rows, 8-m long

Data to be Recorded:
Days to heading and to maturity, plant height, disease resistance, lodging, shattering and yield.

Scientists in Charge:
Abdalla El-Ahmadi, Head of Plant Breeding Section, ARC
Mohamed S. Mohamed, Director New Halfa Research Station, ARC

3. Advanced Yield Trial

Entries: 12
Repetitions: 4
Design: RCB
Plot size: 16 rows, 8-m long

Data to be Recorded:
Days to heading and to maturity, plant height, disease resistance, lodging, shattering, and yield.

Scientists in Charge:
Abdalla El-Ahmadi, Head of Plant Breeding Section, ARC
Mohamed S. Mohamed, Director New Halfa Research Stations, ARC
Abdalla Ibrahim, Hudeiba

B. Water Management

1. Effect of Different Irrigation Intervals at Three Stages of Wheat Development on Growth, Seed Yield, and Water-Use Efficiency

Treatments will consist of:

Three stages of plant development:
a) from plant emergence to panicle initiation
b) from panicle initiation to heading
c) from heading to maturity

The irrigation intervals will be as follows:
a) 14 or 21 days
b) 10 or 14 days
c) 10, 14 or 21 days

The resulting 12 treatments will be randomized in RCB with 3 replications.

Data to be Recorded:
Water use, growth, and yield.

Scientists in Charge:
Saeed M. Farah, Head of Agronomy Section, ARC
Hassan Suliman Ibrahim, Director Hudeiba Research Station, ARC

2. *Screening of Promising Wheat Genotypes for Soil Moisture Efficiency*

A number of promising wheat genotypes will be tested under different levels of soil moisture stress to select those with high soil moisture efficiency for future use in places where drought is of common occurrence due to the limited supply of irrigation water.

Scientists in Charge:
Saeed M. Farah, Head of Agronomy Section, ARC
A.B. El Ahmedi, Plant Breeder, ARC

C. Agronomy

The response of three newly released wheat cultivars to sowing date at Gezira, New Halfa, and Hudeiba

Treatment will consist of:

Cultivars:
Condor, Wadi El Neil, and Debeira

Sowing Dates:
Oct 15, Oct 29, Nov 26, Dec 10

Fifteen treatment combinations will be put in split plot RCB with six replications, where variety occupies the main plot and sowing date occupies sub-plots. The sub-plot size will be 2.4 x 8.0 m.

Data to be Recorded:
1. Plant stand at 2 weeks from sowing and at maturity
2. Plant height at maximum growth stage
3. Ground cover at heading, milk stage
4. Dry-matter accumulation at 14 day intervals
5. Days taken to reach panicle initiation, heading and maturity
6. Seed yield and yield components

Scientists in Charge:
Osman A.A. Ageeb, National Coordinator Wheat Research, ARC
Musa B. Taha, Agronomist, ARC
Ahmed M. Gorashi, Agronomist, ARC

D. Plant Nutrition

1. Varietal Response to N Fertilizer at the Three Major Soil Types in the Northern Region

Treatments:
- 2 varieties: Condor, Wadi El Neil
- 4 N levels: 0, 43, 86 and 129 kg N/ha
- 3 soil types: silt loam (Gureir)
  heavy clay (Karu)
  high terrace soil

The trials will consist of 8 treatments (N x V) replicated in three soil types.

Locations:
Zeidab and Shendi

Data to be Recorded:
N uptake
Seed yield

Scientists in Charge:
Hassan Suliman Ibrahim, Director Hudeiba Research Station, ARC
Gaafar El Sarrag, Shendi

2. *Screening of Promising Breeding Lines to P Response and Salt Tolerance*

Location:
Hudeiba Research Station

Scientists in Charge:
Hassan Suliman Ibrahim, Director Hudeiba Research Station, ARC
A. Ibrahim, Plant Breeder, ARC

E. Mechanization

1. *Effect of Different Tillage Systems on Selected Soil Physical Properties, Crop Establishment, and Wheat Grain Yield*

Treatments:
i) 3-bottom disc, harrowing, and levelling
ii) Harrowing twice
iii) Chiselling and harrowing
iv) Split ridging and levelling

Observations:
a) Tillage depth
b) Bulk density

c) Crop stand
d) Weed infestation
e) Yield
f) Economic analysis

Scientist in Charge:
A.A. Salih, Gezira University

Cooperating Scientists:
Ahmed Musa, Agricultural Engineer
Ali Adeeb, Irrigation Engineer, Gezira University

2. Estimation of Harvesting Losses in Farmers' Fields

Scientist in Charge:
Ahmed Musa, Agricultural Engineer

Cooperating Scientists:
Ibrahim Khalid, Agricultural Engineer

F. Plant Protection

I. Pest Management

The research program will consist of the following items:

1. Biological Control of Aphids

To investigate the degree of aphid control by natural enemies (Coccinellids) as compared with the standard chemical control.

Treatments:
4 augmentation levels starting with 50 coccinellids per plot as compared with one spray of Ekatin at the 30% level of infestation and an untreated check.

Design:
RCB with 4 replications. Plot size 5 x 10 m.

Observations:
Weekly counts of infested plants, aphids and predators, grain yield.

Location:
GRS

Scientist in Charge:
Nasr Eldin Sharaf Eldin, Entomologist, ARC

2. *Screening of New Insecticides Against the Two Aphid Species*

Treatments:
12 new insecticides will be compared with the standard chemical Ekatin and an untreated check.

Design:
RCB with six replications. Plot size 15 x 10 m.

Observations:
The percentage of infested plants, aphid population, predators, grain yield.

Location:
GRS

Scientist in Charge:
Nasr Eldin Sharaf Eldin, Entomologist, ARC

3. *Screening of Breeding Lines of Wheat and Barley Against the Two Aphid Species*

To find out any source of resistance to breeding lines supplied by ICARDA, CIMMYT, Egypt, and Sudan.

Methods:
All lines will be planted in single rows 2.5-m long at optimum sowing time.

Observations:
Percentage of infested plants, aphids, plants.

location:
GRS

Scientist in Charge:
Nasr Eldin Sharaf Eldin, Entomologist, ARC

Cooperating Scientists:
Abdel Gadir Bushara, Entomologist, ARC
Faisal M. Ibrahim

4. *Life Tables for the Two Aphid Species and the Two Main Natural Enemies*

Methods:
Biology of 50 individuals will be studied in potted plants at recorded temperature and relative humidity.

Location:
GRS

Scientist in Charge:
Nasr Eldin Sharaf Eldin, Entomologist, ARC

II Weed Control

1. *Survey of Weeds in Farmers' Fields in the Gezira Scheme to Determine Their Species and Economic Importance*

Scientist in Charge:
A.T. Babiker, Weed Scientist

Cooperating Scientist:
Statistician

2. *Weed Competition at Different Stages of Plant Growth*

Effect of different weeding regimes on the yield of wheat at New Halfa and Hudeiba Research Stations.

The crop will either be left unweeded or weed-free for the following periods:

1) from planting to 15 days
2) from planting to 30 days
3) from planting to 45 days
4) weed-free from planting to maturity
5) unweeded from planting to maturity

Observations:
Weed species, density, seed yield and dry matter of weeds.

Scientists in Charge:
E. Osman, Weed Scientist, ARC
E. El Bedawi, Hudeiba Research Station, ARC

3. Tolerance of Wheat to Residues of Some Selected Cotton Herbicides

To investigate the possibility of carry-over problems following herbicide application to cotton as wheat follows cotton in the rotation.

Scientist in Charge:
E. Osman, Weed Scientist, ARC

III Plant Pathology

1. Identification of Races in the Country

This line of research involves growing susceptible cultivars to trap the spores in the atmosphere and the use of standard differentials in isolation to determine the race found.

Scientist in Charge:
Mohamed S. Ahmed, Pathologist, ARC

2. Screening for Resistance in Collaboration with the Breeder

Introduction and evaluation of breeder material for rust resistance in the field.

Scientist in Charge:
Mohamed S. Ahmed, Pathologist, ARC

IV Quality

Evaluation of Sudanese Wheat for Quality and Marketing Methods

Methods:
i) physical and chemical analysis of breeders' and farmers' samples
ii) milling and baking qualities of breeder advanced lines
iii) utilization
- bread making
- composite bread
- kisra and qurasa (local food)

Scientist in Charge:
Sit El Nafar Badi

Cooperating Scientist:
Paul L. Bureng, Food Research Centre, Khartoum North

V Socio-Economic Survey

This will be carried out at:

1) Selaim - Burgaig area
2) White Nile Schemes

VI Training

1. Visiting Scientists

Two visiting scientists will spend 3 months at ICARDA, Aleppo, Syria
1) Dr. Musa B. Taha, Crop Physiology, ARC
2) Mr. Abdalla Ibrahim, Plant Breeder, ARC

The visit will be from 1 April 1987 to 30 June 1987.

2. Field Days

Field days will be conducted at Gezira, New Halfa and Zeidab, Shendi and Hudeiba for farmers, and extension and production staff to see the discuss the outcome of on-farm trials with scientists in charge.

VII Pre-release Seed Multiplication

VIII Economic Analysis of Recommended Packages

APPENDIX

LIST OF PARTICIPANTS

Ministry of Agriculture and Natural Resources:

Mr. Yousif A. Dash	Permanent Under Secretary for Agriculture
Mr. Abdel Moneim Kafeil	Director, Soil Survey Administration

Regional Government, Central Region:

Mr. Abdel Ati M. Abdel Ati	Acting Governor
Dr. Abdel Moneim Abdel Razik	Director, Regional Ministry of Agriculture

ICARDA Aleppo:

Dr. J.P. Srivastava	Leader, Cereal Improvement Program

Ministry of Irrigation:

Eng. Kamal Abdu	Director of Irrigation Services
El-Disougi A. Hashim	Assistant Director of Irrigation for Gezira

Sudan Gezira Board:

Mr. Abdalla El-Zubeir	Managing Director
Dr. Nasr Eldin M. Nasr Eldin	Deputy Managing Director
Mr. Izzel-Din O. El-Mekki	Agricultural Manager
Mr. Galal Hamid	Deputy Agricultural Manager
Dr. Ghamer El-Khateib	Director, Crop Protection
Mr. Abdel Hai Ibrahim	Deputy Agricultural Manager, Gezira
Mr. Wageih Samuel	Director, Seed Production
Mr. Galal Mahmoud	Agronomist
Mr. Ibrahim Musallum	Director, Economics and Planning
Mr. Ali B. Hamid	Director, Extension
Mr. El-Fatih Satti	Group Inspector, Centre
Mr. Mustafa Musa	Group Inspector, Wad Haboub
Dr. Abdel Galil Abdel Gabbar	Director, Rehabilitation Project, Irrigation Sector, World Bank

University of Gezira:

Dr. Osman A.A. Fadl	Dean, School of Agricultural Sciences
Dr. Hussein Adam	Academic Secretary
Dr. Yahia B. Sarrag	Head, Plant Science Department
Dr. Mudathir A. Ahmed	Economics
Dr. Fatthi M. Khalifa	Crop Production
Dr. Ali Salih	Forage Production
Dr. Ali Adeeb	Irrigation Engineer

Agricultural Research Corporation:

Dr. Osman I. Gameel	Director General
Dr. Musa M. Musa	Deputy Director General
Dr. El-Tigani M. El-Amin	Director, Administration & Finance
Dr. Abdel Mageed Yassin	Director, Training & Publications
Dr. Mahmoud A. Mahmoud	National Coordinator, Sorghum
Dr. Hassan M. Ishag	National Coordinator, Groundnuts
Dr. Ibrahim A. Babiker	Director, Gezira Research Station
Dr. Farouk A. Salih	Director, Shambat Research Station
Dr. Badr A. Saleem	Cotton Agronomist
Dr. Abdalla M. Hamdoun	National Coordinator, Pathology
Dr. Ahmed Nasir Bella	National Coordinator, Entomology
Dr. Nasr Eldin Sharaf Eldin	Entomologist
Dr. Abdel Moneim B. El-Ahmadi	Plant Breeder
Dr. Ibrahim El Jack	National Coordinator, Cotton
Dr. Ahmed A. Geneif	National Coordinator, Horticulture
Dr. A.T. Ayoub	National Coordinator, Soil Science
Dr. Saeed M. Farah	Head of Agronomy Section
Dr. Nouri O. Mukhtar	Head of Soil Science Section
Dr. Mohamed El H. Omer	Head of Plant Pathology Section
Dr. Mirghani Khogali	Head of Horticultural Research Station
Dr. Maghboul El-Hadi Lazim	Cotton Agronomist
Dr. Mohamed A. Kheiry	Forage Agronomist
Dr. Abdel Gabbar T. Babiker	Weed Control
Dr. Asim A.A. Rahman	Coordinator, I.P. Management Project, F.A.O.
Dr. Gaafar Zurghani	Head of Entomology Section
Dr. Abdalla B. El-Ahmadi	Head of Plant Breeding Section
Dr. Hamid H. El-Faki	Economist
Mr. Abdel Aziz Abdel Fattah	Economist
Dr. Badr Eldin	Statistician

Dr. Osman A.A. Ageeb	National Coordinator, Wheat Research
Dr. Dafalla A. Dafalla	Director, Western Sudan Agricultural Research Project, World Bank
Dr. Hassan Suliman Ibrahim	Director, Kadeiba Research Station
Dr. Musa B. Taha	Agronomist
Dr. Abdel Gadir Bushara	Entomologist
Mr. El-Tahir O. El-Bedawi	Weed Scientist
Dr. Mohamed S. Mohamed	Director, New Halfa Research Station
Dr. Mohamed S. Ahmed	Pathologist
Dr. Ahmed M. Gorashi	Agronomist
Dr. El Dirdeiri Osman	Weed Scientist
Dr. Mustafa M. Hussein	Pathologist
Dr. Awad El Fahal	Director, Shendi Research Station

New Halfa Scheme:

Mr. Abdel Rahman Bushara	Agricultural Engineer
Mr. Abdel M. Gasim El Saeed	Agricultural Engineer
Mr. Abdel Rahman M. El-Amin	Agricultural Engineer
Mr. Ahmed B. El-Bedawi	S. Field Inspector
Mr. Mustafa M. El Azhari	S. Field Inspector
Mr. Gaafar A. Arafat	Extension Officer

Ministry of Agriculture, Northern Region:

Mr. Mohamed O. Hamza	Director, Extension

Arab Organization for Agricultural Development:

Dr. Faisal M. Ali	Head of Plant Production
Dr. Suleiman Sid Ahmed	Economist

Farmers' Union, SGB:

Mr. Mohi Eldin M. Ahmed	Vice President
Mr. Sheikh El-Amin A. El-Faki	Secretary

Others:

Dr. Abdel Galil Imam	Wheat Plant Breeder (Retired)
Dr. Marko Quinones	Global 2000
Dr. George Ghobrial	USAID

المركز الدولي للبحوث الزراعية في المناطق الجافة
ايكاردا
ص. ب. 5466 ، حلب، سورية

INTERNATIONAL CENTER FOR AGRICULTURAL
RESEARCH IN THE DRY AREAS
Box 5466, Aleppo, Syria