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VERIFICATION AND ADOPTION OF IMPROVED WHEAT PRODUCTION TECHNOLOGY IN FARMERS' FIELDS IN THE SUDAN

Proceedings of the Second
National Wheat Coordination Meeting
20-22 July 1987, Wad Medani, Sudan

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

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International Center for Agricultural Research in the Dry Areas
ICARDA
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FOREWORD

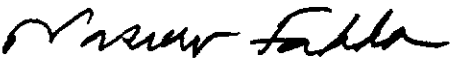
Results from large-scale farmer-managed demonstrations and trials indicated that 1986/87 was a second fruitful year for the OPEC-funded joint Sudan/ ICARDA Pilot Project for the Verification and Adoption of Improved Wheat Production Technology in the Sudan. Substantial yield increases were achieved where production technology was appropriately transferred from research stations to farmers' fields.

Scientists participating in the project held their second annual meeting on 20-22 July 1987, at Wad Medani, Sudan, to discuss the results from the 1986/87 season and develop a work plan for 1987/88. Although the results presented in these proceedings speak for themselves, I would like to congratulate the project's participants on the impressive achievements which could not have been possible without their devotion and dedication. The active role played by the farmers and extension staff is commendable and of major importance, and I am confident that their direct involvement in implementing the project will speed up the adoption and use of new or improved technology in their fields.

The project also supported the training of several young scientists on various topics of relevance as well as graduate studies; two senior scientists spent 3 months at ICARDA to work closely with their colleagues in the Cereal Improvement Program.

We at ICARDA are happy to see the progress the project is making under the leadership of the Sudanese national program towards its ultimate goal: self-sufficiency in wheat production. We congratulate the Sudanese authorities for their keen interest and painstaking efforts in implementing the project. OPEC's decision to extend its support to cover the 1987/88 season is an evidence of its deep concern for agricultural development in the area.

I hope these proceedings will be useful to all those involved in wheat production in the Sudan, as well as to others engaged in similar efforts in other developing countries.



Nasrat Fadda
Director General
ICARDA

WELCOMING ADDRESS

Professor Musa M. Musa
Deputy Director General
Agricultural Research Corporation

On behalf of the Director General, Agricultural Research Corporation, it is a great privilege and pleasure to welcome you all to the second coordination meeting of the ARC-ICARDA-OPEC project aimed at verification and adoption of improved wheat production technology in Sudan. The initiation of this project in 1985 was the outcome of appreciated involvement of both ICARDA staff and ARC leading scientists.

Wheat, as we all know, is a vital and strategic commodity in the Sudan and as such the country remained as a major importer over the past few decades. From data available, it is reckoned that production of wheat fluctuated over a wide range, amounting to 30,000 metric tons in the early sixties, reaching its peak of 290,000 metric tons in the mid-seventies, and averaging about 150,000 metric tons during the eighties. The area under wheat varied appreciably between seasons; but yield per feddan hardly exceeded 0.5 tons. Current in-country wheat production represents only about 25% of self-sufficiency target, and wheat imports posed a constant strain to the already aggravated foreign exchange situation. Furthermore, there is ample evidence that the gap between local production and estimated requirements for wheat and flour evidenced by growing urbanization, influx of refugees, and rising incomes and sophistication.

Previous development plans indicated that the potential for self-sufficiency in wheat is attainable in Sudan and that this can be achieved to a great degree within already existing production schemes in the Gezira, New Halfa, Northern Region, and White Nile without going into big development initiatives. This had been amply supported by other studies namely that of Arab Organization for Agricultural Development in the Northern Region in 1983. However, other study groups regarded in-country wheat production as uneconomic. This was based on already attained low yields and relatively high cost of production. It is against such a background that wheat research in production technology is considered very crucial and challenging, and ICARDA-OPEC Pilot Project for verification of research results in farmers fields is catalytic and vital at this turn.

Thus, upon request from ICARDA and Ministry of Agriculture, OPEC approved a grant to support research by ARC national scientists during season 1985-86, with technical backing of the Cereal Improvement Program and other ICARDA core-activities. Similarly, CIMMYT offered help to the program. Having sensed measurable and outstanding results, OPEC kindly agreed to foster reason-

able support for another season. There is common feeling now within ARC and the Ministry of Agriculture for the continuation and promotion of the type of collaborative efforts in wheat research having been guided and inspired by the model of working relations and achievements within this program. Already, the results achieved by ICARDA-IFAD Nile Valley Project for faba beans embracing three countries (Ethiopia, Egypt, and Sudan) are considered a model for which ICARDA was highly commended.

For years, agricultural research in the Sudan was dominated by on-station research translated into recommendations to enhance farm production under varied situations. Large scale and multi-location testing was also common practice. This model, though produced tangible results in many instances in the past, fell short of appreciating the real obstacles and constraints facing farming communities. The trend to go for on-farm research with farmer participation, therefore, emerged and continued to evolve and mature, taking full consideration of constraints, problems, decision making criteria, and risk awareness. It was felt that farmers should be allied with both extensionists and researchers due to the realization that proposed solutions to farmer's problems did not always achieve their objectives. Adoption of on-farm research involving a tripartite relationship between researcher, extensionist, and farmer is now considered an ARC target in crop improvement programs whenever logistics and technical manpower are available. A number of cooperative programs with ARC took to the same theme in their research endeavour. Its acceptance and promotion was greatly helped by the technical interface with ICARDA and other international research centres.

The impact, we judge, is extremely positive. You will be told in the coming sessions in some detail about results attained under farmer conditions using simple packages invariably involving combinations of land preparation, sowing methods, varieties, sowing date, fertilization, irrigation, and protection in the different wheat production areas of the country. Supportive research, either on-farm researcher-managed or on-station back-up, being an indispensable component, will be highlighted. The overall economic input with respect to wheat production remains a key factor in judging the success and adoption of any farming initiative; this will also be fully addressed. The overall multidisciplinary involvement and integration of research effort is a big achievement.

Technical back-up of ICARDA was indeed reflected in an unfailing effort during the past two years to sponsor fellowships and postgraduate studies, provide training courses and visits, and promote exchange of germplasm, publication, and information. It is viewed by ARC that this aspect of the project will increase chances of success in future cooperative efforts. The role of ICARDA and CIMMYT, and other international research centres, properly oriented, will achieve measurable catalytic support to Sudan's national agricultural research system in the long run.

All achievements obtained during the past season could never have been feasible without enthusiasm and cooperation of management and extention staff

in Gezira Scheme, and New Halfa and Northern Region Production Corporations. A number of demonstrations and field days involving farmers and extensionists had their measurable impact, and results obtained in farmers fields were extremely encouraging. Record yields of about 4.0 tons/ha in Derweesh block in Gezira, 2.3 tons in Argine, New Halfa, and 3.6 tons in Selaim, Northern Region, were obtained.

In conclusion, I would like to express our gratitude to OPEC for their continuous support. We are also extremely thankful for approved funding next season. Special thanks are due to Dr. Mohamed A. Nour, Director General, whose patronage and guidance were deeply felt since the project started. It is indeed an opportunity to wish Dr. Nour every success in his new well-deserved position. Thanks are also due to Dr. J. P. Srivastava, leader of the Cereal Improvement Program at ICARDA, and visiting colleagues, to the wheat national coordinator Dr. O. A. A. Ageeb, fellow scientists, and organizing committee who, together, managed to make this coordination meeting a success. My thanks are extended to those who travelled from afar to share with us this function.

I wish participants fruitful deliberations during the coming days of the meeting.

Thank you all.

OPENING ADDRESS

Mr. Yousif A. Dash
Permanent under Secretary
Ministry of Agriculture

Distinguished guests and colleagues:

It gives me great pleasure to be here amongst you to open the second national coordination meeting for wheat research in the Sudan.

As you know, wheat has become an important nutritional staple in Sudan. Consumption has continuously increased because of the profound changes in the people's modes of life, incessant migration from rural areas to cities, and increased immigration from neighbouring countries. Sudan is now importing about 75% of its needs of wheat; thus, putting a tremendous strain on the country's economy. The cost of imported wheat is second only to petroleum and petroleum products.

Sudan, with its huge natural resources, is eminently qualified to produce its needs of food commodities, especially wheat, if required inputs are available. Economic feasibility of wheat production in the irrigated schemes of central Sudan had been established by agricultural research, a quarter of a century ago. Accordingly, wheat was included as a major crop in the rotation of the Gezira Scheme and New Halfa Corporation, covering an area of over 250,000 hectares.

The expansion in area planted to wheat, however, was not accompanied by increase in productivity despite the availability of technical information which, if applied in farmer's fields, would more than have tripled yield. The current average wheat yield of about a ton per hectare is extremely low and at variance with what can be achieved if inputs required for the adoption of new technology are available.

I am pleased that your meeting will consider on-farm research aimed at improving yield through the transfer of new wheat production technology to farmer's fields. I noted, with great interest, your achievements last season. On-farm experiments confirmed that wheat yields in farmer's fields can be tripled when inputs required for the adoption of research findings are available. The Ministry of Agriculture commends and supports your new approach in conducting research in farmers' fields. By adopting this new methodology, you will interact positively with the real production environment; you will have more confidence in your results and recommendations; you will be more acquainted with problems facing production in the field; and, consequently, you will be better able to modify your research programs to solve new problems. All this will have favourable effect in promoting agriculture in the country.

We are aware that the new methodology in conducting agricultural research is very costly, but we also know that it gives valuable results. In this regard, I like to express our indebtedness to OPEC for funding this project and to ICARDA for unfailing technical support.

As can be seen from your agenda, your meeting includes scientific papers covering most of the problems facing wheat production in the country. I hope during your discussions and in your proposals for the coming season, you give special attention to the following aspects which, I believe, will have profound effects on wheat production in Sudan:

1) expanding demonstration and on-farm research activities concerned with the transfer of wheat production technology;
2) selection of heat-tolerant cultivars adapted to the environmental conditions of central Sudan;
3) development of practical and economical land preparation methods conductive to good crop establishment;
4) determination of fertilizer and water requirements of the crop in the different production schemes; and
5) development of appropriate techniques to improve water management in farmers' fields.

I wish you all success in your deliberations and discussions and I wish those who came from afar, a happy return home.

Address By Dr. J.P. Srivastava

Leader, Cereal Improvement Program, ICARDA

Mr. Chairman,
Mr. Yousif A. Dash,
Ladies and Gentlemen:

I am greatly honoured and privileged to participate in the second national wheat coordination meeting. The fact that it is attended by farmers, policy makers, administrators, scientists working on wheat in ARC and universities, extension personnel, agricultural engineers and field staff of different agricultural schemes, and scientists from regional and international organizations is a testimony that this project has been successful in bringing the national and international scientists together to work for improving wheat production in farmers' fields.

During the wheat growing period, I was able to attend a couple of field days and witness the enthusiasm of farmers, field staff, extension personnel, and scientists; all were convinced that improved varieties and production practices were going to double or triple yields when compared to present farmers' yields. This has been proved by actual yields, and the economic analysis has shown that improved packages are viable and profitable to farmers. Therefore, I do hope that you will do everything possible to help farmers in adopting these packages.

However, I would like to remind you that, during the first national coordination meeting, the Gezira and Managil Farmers Union representatives pointed out six factors as problems in large scale adoption of the improved practices. They are:

1) land preparation problems;
2) irrigation problems;
3) lack of improved varieties of wheat;
4) weed infestation;
5) incorrect fertilizer use; and
6) crop losses due to delay in harvesting.

Union representatives requested scientists and administrators to find solutions to their problems. I do hope that in the next two days, these points will be discussed, and some solutions offered.

Ladies and gentlemen, on behalf of Dr. Mohamed A. Nour, Director General, ICARDA, and my ICARDA and CIMMYT colleagues, I wish to congratulate you for exemplary implementation of this project, for the successful demonstration of improved production technologies, for forging national manpower from different institutions into a multidisciplinary team targetted to improve wheat production in the Sudan, and, most importantly, for involving the farm-

ers themselves who are the ultimate beneficiary in whose fields fruits of our work are to be judged.

I have no doubt that you have done very well so far and, in only few years, Sudan could boast of its wheat revolution by doubling or tripling its production. The only case I know like this is Bangladesh.

I am pleased to inform you that, based on the good progress, the OPEC fund has extended its support for the project for the 1987-88 season. In the meantime, the Government of Sudan, in association with ICARDA, is trying to secure funds from other donors as well to keep this work going and to accelerate its pace.

ICARDA is pleased to extend its assistance in manpower development through visiting scientists, specialized and graduate degree training, and exchange of information. Germplasm to meet specific needs of agro-environmental conditions of Sudan, such as heat tolerance, drought tolerance, disease resistance, and aphid tolerance, will be developed in cooperation with other countries facing similar needs.

I look forward to hear your deliberations, recommendations, and 1987-88 work plan with great interest and admiration. I sincerely wish you every success and thank you for associating me in this highly challenging and rewarding task of improving wheat production in the Sudan.

I wish to take this opportunity to thank you, Mr. Dash, for your keen interest; my thanks are extended to Director General, ARC, to Dr. Musa, Deputy Director General, ARC, for their support, and to Dr. Osman A.A. Ageeb for his leadership and hard work and for the success of the project, and of course to all the participants in the project.

Thank you.

EXECUTIVE SUMMARY

I. On-Farm Research

A. Pilot Production and Demonstration Plots

In light of a comprehensive assessment of results obtained last season from farmer-managed trials, improved production packages were modified and demonstrated in farmers fields which also served as pilot production plots.

Gezira

The package in the Gezira provided good land preparation, mechanical sowing, mechanical fertilizer application, better management of irrigating water, and watering at 14-day intervals. The cultivar supplied by the administration to the block was used. The package increased grain yield by 55%, 39%, and 10%, and increased net benefits by LS 847, 517, and 19 per hectare at Derweesh, Dolga, and Debeiba blocks, respectively. Results showed that the package increased yields substantially and was acceptable to farmers. The key role of a variety responsive to better management was made clear by the low advantage of the package at Debeiba, where the cultivar Giza 155 lodged badly.

New Halfa

The cultivar Debeira, planting during the first week of November, irrigating every 12-14 days, and nitrogen application at the rate of 86 kg/ha constituted the improved package in New Halfa area. Adoption of the package increased yield by 56 to 351%. Despite this substantial improvement, two factors, poor land preparation and an inefficient irrigation system, reduced the potential benefits from the package.

Northern Region

The package consisted of an improved cultivar (Wadi El Neil), application of 86 kg N/ha, irrigating at 14-day intervals, and control of aphids. Yields increased by 401 kg/ha at Selaim and by 572 kg/ha at Zeidab, where the package was tested. Profitability was reduced because of the high cost of irrigation.

B. Researcher-Managed Trials

Highest grain yields in New Halfa were obtained by offset disc harrowing, levelling, and seed drilling at the rate of 160 kg/ha. In the Northern Region,

irrigating every 14-days increased yield significantly in comparison to irrigating every 21 days. Response to early planting, addition of more nitrogen, or aphid control varied with location.

Ten elite cultivars, including two checks, were tested in eleven locations covering the major wheat growing regions. One cultivar showed good performance, but this needs to be confirmed next season.

II. Back-Up Research

A. Crop Improvement

A large number of cultivars and breeding lines were tested for yield in the main wheat production regions. One cultivar was recommended for inclusion in the verification trial next season.

High yielding wheat genotypes were evaluated for salt-tolerance, water-use efficiency, response to phosphorus, and stem rust resistance. Promising lines will be tested further next season.

B. Production Technology

On-station experimental work investigated the effects of sowing date, water management, weed management, and mechanization. Interaction of variety with sowing date varied with location. Adverse effect of early planting on the cultivar Condor was confirmed.

Lengthening the irrigation interval from 14 to 21 days during the stage from planting to panicle initiation had no adverse effect at Hudeiba and Gezira Stations. Shorter watering intervals were required at subsequent growth stages. In the Gezira, basin irrigation and row planting significantly increased yield at one out of the three locations.

Effect of weed control on yield varied with location and conditions at the experimental site.

Investigations on land preparation methods in the Gezira indicated that methods much less costly than orthodox methods resulted in slight yield reduction.

Grain losses from mechanical harvest in the Gezira were low.

C. Plant Nutrition

Phosphorus application in the Gezira, in combination with nitrogen, significantly increased yield by 45% at one location and by 52% at another. In a third location, a non-significant increase of 4% was obtained. In the Northern Region, response to nitrogen was significant at one out of five locations.

D. Crop Protection

Investigations into the race virulence of stem rust on differential varieties indicated that none of the resistance genes conferred good resistance. The natural inoculum at New Halfa was probably a mixture of races.

Control of aphids by release of predators or by the development of resistant varieties was of limited success. Several chemicals provided satisfactory control. In the Northern Region, experimental results showed that nitrogen fertilization, delayed planting, and not applying control measures significantly increased aphid infestation. Wadi El Neil was more susceptible to aphids than other cultivars.

III. Concluding Remarks

Concluding remarks by Professor Abdel Muhsin H. El Nadi were mostly concerned with water relations. He made some useful suggestions to improve the quality of future work. Professor Musa M. Musa highlighted the achievements of the ARC-OPEC-ICARDA Project, and the impact of its methodology on ARC.

Dr. Srivastava commended the implementation of the program and raised several questions encouraging more scrutiny in selecting research problems and more contact with farmers.

IV. Workplan for 1987-88

The program of work for 1987-88 was discussed in detail. It covered on-farm research, back-up research, training, pre-release multiplication of new cultivars, and economic analysis of recommended production packages. Scientists in charge of projects and collaborators were nominated. Details of experimental work were discussed and approved.

SUMMARIES OF RESEARCH REPORTS

This part contains summaries of on-farm and back-up research conducted during the 1986-87 season. Original papers can be obtained from:

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

I. ON-FARM RESEARCH

A. Pilot Production and Demonstration Plots

Gezira

*By Osman A. A. Ageeb, Hamid El Faki, Abdel Aziz Fattan, Ahmed Musa, and Ibrahim Khalid**

The improved production package, successfully tested in farmer-managed trials last season, was modified to comprise the following:

1) harrowing to a depth of 15-18 cm with a tandem offset disc harrow and levelling with an automatic land leveller;
2) mechanical broadcasting of urea to give 86 kg N/ha;
3) seed drilling at the rate of 140 kg/ha in conjunction with placement of 43 kg P_2O_5/ha;
4) dividing farmers' fields (2.1 ha) into 70 plots to facilitate irrigation; and
5) irrigating the crop every 14 days.

The improved package was demonstrated in three blocks: Derweesh in the Central group, Dolga in Wad Habouba Group, and Debeiba in the Northern Group. In each block, nine farmers with contiguous fields participated in the demonstration.

The cultivar supplied to the block by the management was used; thus, the demonstration plots at Derweesh and Delga were planted to Condor whereas plots at Debeiba were planted to the cultivar Giza 155. The crop was sprayed with

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* Full addresses of contributors are listed in the Appendix.

Ekatin against aphids. Eight irrigations were applied at Dolga and Debeiba, and six irrigations at Derweesh.

In December, a field day for farmers and field staff was arranged, mainly to demonstrate the effect of the package on crop establishment.

For economic evaluation of the improved package, variable costs, and gross and net benefits for farmers adopting the package and an equal number of neighbouring farmers, were calculated. In addition, lowest variable costs incurred by neighbouring farmers were used to compare the package with the block average.

Results

Excellent crop establishment was achieved because of good seedbed preparation, machine planting, and careful management, by farmers, of the first watering.

Average yields of the package farmers exceeded those of neighbouring farmers by 55, 39, and 10% at Derweesh, Dolga, and Debeiba, respectively. Rank growth of the cultivar Giza 155 at Debeiba caused heavy lodging just after heading; the advantage of the package at this location was therefore reduced (Table 1, Fig. 1).

Adoption of the package increased net benefits by LS 847, LS 517, and LS 19 per hectare at Derweesh, Dolga, and Debeiba, respectively, in comparison with neighbouring farmers (Table 1).

Table 1. Comparison of improved package technology and traditional practices at three blocks in the Gezira Scheme, 1986-87.

Block	Production technology	Yield (kg/ha)	Gross benefits (LS/ha)	Variable costs (LS/ha)	Net benefits (LS/ha)	Marginal rate of return (%)
Derweesh	Package farmers	3940	2770	404	2366	
	Neighbouring farmers	2549	1792	273	1519	647
	Block average	1833	1289	349	940	1396
Dolga	Package farmers	3470	2439	618	1821	
	Neighbouring farmers	2497	1755	451	1304	312
	Block average	1333	937	373	564	513
Debeiba	Package farmers	2343	1647	344	1303	
	Neighbouring farmers	2121	1491	207	1284	17
	Block average	1428	1004	196	808	335

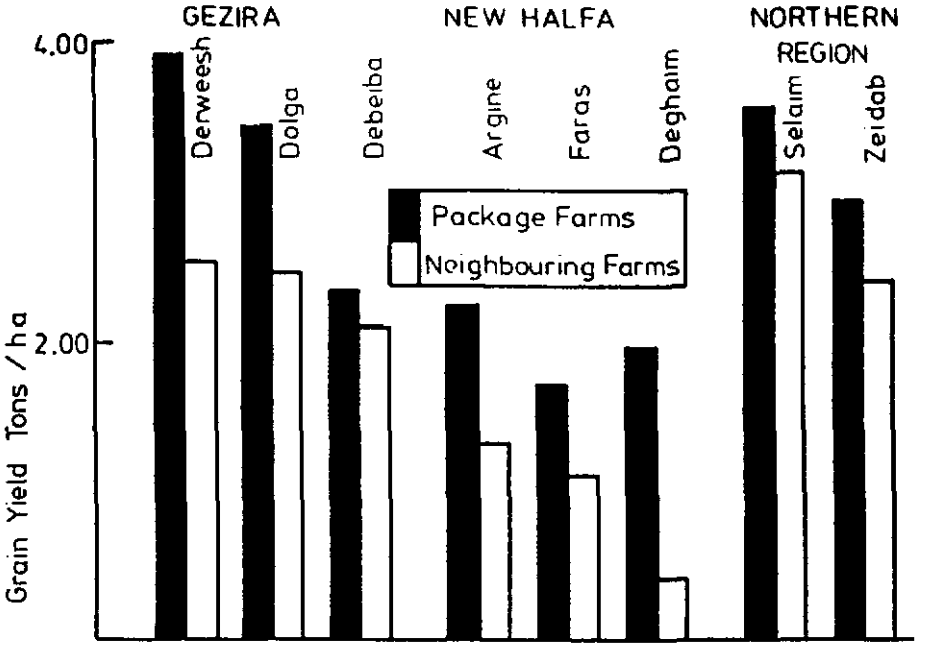

Fig. 1 Comparison of Package Farmers and Neighbouring Farmers

Conclusions

1) Very high wheat yields can be obtained in the Gezira when a complete improved technology package is adopted.
2) The package was acceptable to farmers and they requested wider application.
3) Results at Debeira showed convincingly that an adapted cultivar responsive to good management is a key factor in the success of an improved package.

New Halfa

By Mohammed S. Mohammed, Ahmed M. Ghorashi, Abdel Rahman B. Omer, Hamid H. El Faki, Gaafar A. Arman and Abdel Aziz Abdel Fattah

The improved technology package for New Halfa had the following components:

1) the wheat cultivar Debeira;
2) planting during the first week of November;
3) irrigating every 12-14 days; and
4) nitrogen application at the rate of 86 kg/ha.

Otherwise, traditional management practices were followed.

Sixteen farmers participated; five farmers from each of Argine (Sheikh Omer Section) and Faras (Debeira Section) blocks, and six farmers from Deghaim block (Sarereib Section).

Results

All recommended package factors were properly adopted by participating farmers except for irrigation interval which, because of circumstances beyond farmer's control, was not adhered to by the majority of farmers.

Yields from package plots were higher than those from neighbouring plots in all blocks; the increase was 69, 56, and 351% at Argine, Faras, and Deghaim blocks, respectively (Table 2, Fig. 1). Compared to the scheme's average yield, the increase from the package was 85%.

Economic evaluation showed that adoption of the package increased net benefits by LS 870, LS 259, and LS 23 per ha at Deghaim, Argine, and Faras, respectively, with high marginal rates of return (Table 3). Land preparation and weeding costs were much higher for package farmers than for neighbouring farmers; both factors were not included in the analysis.

Table 2. Mean grain yield (kg/ha) of package and traditional farmers at three blocks in New Halfa, 1986-87.

	Block			
Technology	**Argine**	**Faras**	**Deghaim**	**Mean**
Improved package	2247	1733	1968	1983
Neighbouring plots	1333	1114	436	961
Block average	1095	1285	952	1119
Section average	1000	1142	1142	1095

Table 3. Partial budget for package and traditional technologies in New Halfa, 1986-87.

Block	**Technology**	**Yield (kg/ha)**	**Variable cost (LS/ha)**	**Net benefits (LS/ha)**	**Marginal rate of return (%)**
Deghaim	Package	1968	137	1099	
	Traditional	500	85	229	1673
Argine	Package	2237	463	942	
	Traditional	1656	357	683	244
Faras	Package	1704	431	639	
	Traditional	1114	291	409	164

Conclusions

1) Adoption of the package improved yields and increased net benefits to farmers substantially under the status quo.
2) Despite the foregoing two-factors not treated as variables in the trial, the following are believed to have considerably reduced the potential benefits from the package:
   (a) poor land preparation; and
   (b) inefficient irrigation system.

Northern Region

By Musa B. Taha and Gaafar E. Mohammed

Ten farmers at Zeidab, and nine at Selaim participated in demonstrating a production package consisting of:

1) Wadi El Neil cultivar;
2) application of 86 kg N/ha in the form of urea;
3) irrigation at 14-day intervals; and
4) chemical control of aphids.

Data from an equal number of neighbouring farmers, following traditional practices, were obtained for comparison. At Selaim, traditional practices included delayed sowing, absence of aphid and weed control measures, fewer irrigations, and variable seed rate. A similar situation was evident at Zeidab.

Results

Adoption of the package significantly increased grain yield over that obtained by traditional practices, at both locations; the increase was 401 kg/ha at Selaim and 572 kg/ha at Zeidab (Table 4, Fig. 1). At Zeidab, the package increased net benefits by LS 619 per ha with a 558% marginal rate of return. At Selaim, profitability was low because of the very high cost of irrigation, especially when calculations were based on the current system under which irrigation water costs the farmers 3/7 of his crop's value (Table 4).

Conclusions

1) The package increased yield substantially, but profitability was reduced by the very high cost of irrigation.
2) Farmers were satisfied with package and willing to adopt it.
3) Farmers also stressed the need for: (a) adequate irrigation water and (b) combine harvesters.

Table 4. Yield (kg/ha) and partial budget of improved and traditional technologies in the Northern Region, 1986-87.

Location	Production technology	Yield (kg/ha)	Gross benefits (LS/ha)	Variable costs (LS/ha)	Net benefits (LS/ha)	Marginal rates of return (%)
Selaim	**a) Actual Cost**					
	Improved	3564	3044	1771	1273	
	Traditional	3163	2401	1520	1181	37
	b) Estimated irrigation Cost					
	Improved	3564	3044	1147	1897	
	Traditional	3163	2701	909	1792	44
Zeibad	Improved	2987	3814	483	3331	
	Traditional	2415	3084	372	2712	558

B. Researcher-Managed Trials

Northern Region

By Musa B. Taha and Gaafar E. Mohammed

Researcher-managed trials were carried out at Shendi, Zeidab, and Selaim to study the effect of sowing date, nitrogen level, irrigation interval, and aphid control. Each factor was at two levels as follows:

Factor	Recommended level	Farmers level
1. Sowing date	15 November	5 December
2. Nitrogen fertilizer	86 kg/ha	43 kg/ha
3. Irrigation interval	Every 14 days	Every 21 days
4. Aphid control	Applied	Not applied

Results

At the three locations, irrigating every 14 days increased yield significantly in comparison with irrigating every 21 days. Early planting on 15 November significantly increased yield over delayed planting on 5 December, at Selaim and Shendi. The additional 43 kg N/ha increased yield significantly only at Selaim. Aphid control had a significant effect only at Zeidab (Table 5).

Table 5. Effect of irrigation interval, nitrogen application, sowing date, and aphid control on grain yield of wheat (kg/ha).

	Location		
Treatment	**Selaim**	**Zeidab**	**Shendi**
Irrigation interval:			
14-day	3682	3257	1806
21-day	2613	2574	702
Nitrogen level:			
86 kg/ha	3326	3019	1221
43 kg/ha	2968	2812	1287
Sowing date:			
15 Nov.	3250	2919	1447
5 Dec.	3044	2912	1061
Aphid control:			
Applied	3184	3094	1308
Not applied	3111	2736	1200
S.E. ±	31.7	98.5	62.4

Conclusions

It is concluded that irrigation interval was the major factor influencing production this season. Response to other factors varied with location.

New Halfa

By Abdel Rahman B. Omer and Eldiredeiry Osman

The effects of land preparation, sowing method, and seed rate on grain yield and other attributes were investigated in this trial. Each factor was at two levels. A split plot plan with three replications was used. Land preparation methods were assigned to the main plots and the four treatments obtained by the combination of sowing methods and seed rate occupied the sub-plots. The treatments were as follows:

Factor	Level 1	Level 2
1. Land preparation	Offset disc harrowing, harrowing and levelling	Pre-watering, harrowing, levelling
2. Sowing method	Broadcasting by wide level disc	Drilling by seed-drill
3. Seed rate	120 kg/ha	160 kg/ha

Recommended practices were followed in respect of other operations. The used cultivar was Debeira.

Results

Grain yield, number of plants/m^2, and weed population eight weeks after sowing, were not affected by the treatments significantly. Heavier seeds were obtained with offset disc harrowing. Pre-watering reduced weed population four weeks from planting. The highest grain yield was obtained from offset disc harrowing and drilling seed at the rate of 160 kg/ha (Table 6).

Table 6. Effect of land preparation, sowing method, and seed rate on grain yield (kg/ha) of wheat at New Halfa, 1986-87.

Seed rate and sowing method	Land preparation	
	Level 1	Level 2
120 kg/ha, broadcast	1538	1809
160 kg/ha, broadcast	1853	1540
120 kg/ha, drilled	1935	1406
160 kg/ha, drilled	2014	1714

On-Farm Verification Variety Trial

By Abdalla B. El Ahmadi, Mohammed S. Mohammed, Abdalla I. Sheikh Mohammed and Gaafar E. Mohammed

The objectives of this multi-location variety trial remain as stated in the first coordination meeting.

Eight cultivars, four from each of the Gezira and New Halfa wheat breeding programs, were selected on the basis of previous evaluation for on-farm verification trial. The cultivars Condor and Debeira were included as checks. The trial was conducted at four locations in the Gezira, one location in the White Nile Province, three locations in New Halfa Agricultural Production Corporation (NHAPC), and three locations in the Northern Region. A randomized complete block design with four replications was used in all locations. The trials were managed according to currently recommended cultural practices.

Results and Conclusions

Variation in yield was significant in five locations. Debeira was significantly outyielded only at Tebub, in the Gezira. Cultivar S948-A-Se7 gave better yields than Debeira at seven locations; differences ranged from 3 to 27% and averaged 5% (Table 7). The good performance of this cultivar, however, needs to be verified next season.

Table 7. Grain yield (kg/ha) at eleven locations during on-farm wheat verification yield trial, 1986-87.

No.	Variety	Wad Medani	Turabi	Ghob--Shan	Tebub	Kosti	NHAPC Village 3	NHAPC Res. Farm	NHAPC Village 15	Shendi	Hudeiba	Selaim
1	Debeira	2126	3407	3088	1471	1005	2780	3068	2556	4168	3370	3962
2	Condor	1943	3245	3255	1474	1010	2765	3053	2320	3865	3321	3587
3	S948-A-Se7	2369	3693	3188	1869	1143	2737	2428	2896	4136	2946	4100
4	Wadi El Neil	2145	3431	2964	1579	860	2666	1968	2539	4176	3057	3987
5	Jup 73/Fury	2464	3355	3021	1921	986	2830	2504	2670	3933	3482	3662
6	L.1439xG156	2095	2907	2707	1702	879	2625	3205	2399	3661	3049	2622
7	Nd Sel 101-Pv'S'	2324	3448	3219	1974	1110	3087	2984	2430	3288	3531	4200
8	Sel 129F6-78079	2357	3421	3355	1807	1098	3156	2956	2780	3370	3386	3562
9	Sel 73F7-79-80	2324	3495	2969	1750	998	3330	2970	2566	3416	3035	4062
10	NH-101	2179	3162	3438	1671	895	3375	2956	2666	3218	3558	3187
	S.E. ±	126	193	174	93	55	153	146	187	294	234	158
	CV. %	11	12	11	11	12	10	10	14	16	14	8

II. BACK-UP RESEARCH

This part contains abstracts of on-station research conducted in response to feedback from on-farm research.

A. Crop Improvement

Wheat variety trials at the Gezira Research Station

Abdalla B. El Ahmadi

Selections from the wheat breeding program are annually evaluated for grain yield and other agronomic characters in a series of trials at three levels;

preliminary, intermediate, and advanced. During this testing process, only elite material is retained for further evaluation. This season, the preliminary trial comprised 46 lines and the two commercially grown cultivars, Condor and Debeira. Eleven cultivars ranged in yield from 1966 to 2589 kg/ha, and significantly outyielded the better check, Condor; of these lines, only early maturing entries will be advanced. Twenty-two previously tested cultivars, Condor, and Debeira were tested in an intermediate trial. Variation in yield was not significant. The two top-yielding lines were sister selections and gave identical yields of 2454 kg/ha outyielding Debeira by 16% and Condor by 24%. These cultivars and two others may be tested next season. The advanced trial comprised 12 cultivars including Condor and Debeira. Variation in yield was highly significant. One cultivar outyielded Debeira by about 10% which, though not significant, was consistent with this cultivar's previous performance; the cultivar is recommended for on-farm verification trial.

Wheat variety trials at New Halfa Research Station

Mohammed S. Mohammed

Twenty-four new wheat lines and cultivars, including Condor, were evaluated in a preliminary trial. Grain yield varied from 1550 to 3337 kg/ha, and four cultivars significantly outyielded Condor by 27 to 39%. At the intermediate level of testing, twenty-four entries, including Condor, were evaluated. Yields ranged from 1450 to 4063 kg/ha; variation among cultivars was significant. Four cultivars gave yields significantly higher than that of Condor; the superiority of two of them exceeded 40%, and both cultivars were also highly resistant to stem rust. The advanced trial comprised ten cultivars including Condor. Mean yields ranged from 2686 to 3288 kg/ha, but variation was not significant. All entries in this trial exhibited good resistance to stem rust.

Advanced wheat variety trial at Hudeiba Research Station

Abdalla I. Sheikh Mohammed and Abdalla B. El-Ahmadi

The advanced trial conducted at the Gezira Research Station was repeated at Hudeiba Research Station. Yields ranged from 1864 to 3000 kg/ha; Condor and Debeira yielded 2692 and 2583 kg/ha, respectively. Variation in yield was not not significant.

Screening promising wheat lines for salt tolerance

Hassan S. Ibrahim

Five cultivars, four breeding lines, and the commercially grown cultivar Giza 155, were tested for tolerance to salinity in a pot experiment. Four levels of salinity, obtained by dissolving different quantities of sodium chloride in the irrigation water, were used. Electric conductivity values of the solutions were 0.35, 2.0, 4.0, and 8.0 mmho/cm. Variation among lines in

grain yield and in salt content of grain and straw was significant. One breeding line consistently suffered the lowest grain yield reduction and also had the lowest sodium content in straw and grain.

Evaluation of promising wheat genotypes for water-use efficiency

Saeed M. Farah and Abdalla B. El-Ahmadi

Two elite wheat selections and the cultivars Debeira and Condor were subjected to three watering regimes:

1) watering at 14-day intervals throughout the season;
2) watering every 21 days until panicle initiation, and every 14 days thereafter; and
3) watering every 21 days until 50% flowering, and every 14 days thereafter. Data were recorded for grain yield, total biological yield, yield components, crop factor, and protein content. The highest grain yield was obtained from the second watering regime. Effects due to genotypes, watering regimes, and their interaction were not significant for any of the measured attributes except for one thousand seed weight.

Screening of promising wheat lines for phosphorus response under two soil types in the Northern Region

Hassan S. Ibrahim

Ten promising breeding lines were tested for response to phosphorus fertilization in High Terrace and Karu soils. Application of 43 kg P_2O_5/ha did not significantly affect grain yield in either soil type. Addition of 86 kg P_2O_5/ha depressed yield of all lines in the Karu soil, and of seven lines in the High Terrace soil. Some lines will be selected for further experimentation on the basis of straw yield and phosphorus uptake.

Screening of commercial and promising wheat cultivars for stem rust resistance under natural field conditions

Mohammed S. Ahmed and Mohammed S. Mohammed

Thirty-seven cultivars and lines were scored for resistance to stem rust at New Halfa Research Station. The susceptible cultivar "Beladi" was planted around the experimental blocks. Observations on rust severity and type of infection were made on 22 January, 1 February, and 15 February. Based on the last observations, two lines showed good resistance, three showed fair resistance and, the rest marginal to poor resistance. Of the commercial varieties, Condor and Debeira showed fair resistance, Giza 155 and Mexicani marginal resistance, and Wadi El-Neil poor resistance.

B. Production Technology

1. Sowing Date

Response of three wheat cultivars to sowing date at Gezira, new Halfa, and Hudeiba

Osman A. A. Ageeb, Ahmed M. Ghorashi and M. B. Taha

A trial on the effect of five sowing dates, starting 15 October and at 14-day intervals thereafter, on the wheat cultivars Condor, Debeira, and Wadi El-Neil was carried out at the Gezira, New Halfa, and Hudeiba Research Stations. At the Gezira Research Station, a significant variety x sowing date interaction was detected. Condor was more adversely affected by early heat stress (early planting in October) than either Debeira or Wadi El Neil; heading occurred sooner, tillering was reduced, and, consequently, yield was significantly depressed. With late planting, Condor, on average, gave higher yield than the other two cultivars.
Similar results were obtained at New Halfa. In contrast, October planting at Hudeiba delayed heading of all cultivars; Condor was less affected by variation in sowing date, and gave better yields than the other two cultivars at all sowing dates, except one.

2. Water Management

Effects of different irrigation intervals at three stages of wheat development on growth, grain yield, and water-use efficiency

Saeed M. Farah

The cultivar Condor was subjected to three irrigation intervals at three developmental stages: 1) every 14 or 21 days from planting to panicle initiation; 2) every 10 or 14 days from panicle initiation to heading; and 3) every 10, 14, or 21 days from heading to maturity. The highest grain yield of 1955 kg/ha was obtained from eight irrigations applied at 14, 10, and 14-day intervals during the first, second, and third developmental stages, respectively; water-use efficiency was 4.11 kg/mm/ha. A non-significantly lower yield of 1887 kg/ha was obtained with six irrigations applied at 21, 10, and 14-day intervals during the tested developmental stages; the water-use efficiency was 6.57 kg/mm/ha. This latter practice, implied that two irrigations could be saved without any appreciable loss in yield. In all treatments, the 14-day interval during the third developmental stage had more favourable effect than the 10-day interval on grain yield and protein content.

Effect of different irrigation intervals at three stages of wheat development on yield and water-use efficiency

Hassan S. Ibrahim

The irrigation treatments in this experiment were identical to those in the preceding experiment (reported in these proceedings), the cultivar used was Wadi El Neil, and the experiment was conducted at Hudeiba Research Station. Long irrigation intervals during the stage from heading to maturity reduced yields considerably. The highest yield was obtained by irrigating every 21 days from emergence to panicle initiation, every 14 days from panicle initiation to heading, and every 10 days from heading to maturity.

The yield advantage over the control (irrigating every 14 days until harvest) was 27%; water use efficiency was also highest with this treatment. Differences among treatments, however, were statistically not significant.

Effect of irrigation and planting methods on crop establishment and grain yield of wheat

Osman A. A. Ageeb

The objective of this experiment was to identify a practical method of irrigation that would improve water distribution and, consequently, enhance crop establishment. The trial was conducted at the Gezira Research Station (GRS), El Turabi, and Wad El Nau. Three of the irrigation treatments provided channels of various sizes and the fourth treatment was the traditionally-practised basin method. Results showed that irrigation and planting methods had no significant effect on grain yield at GRS and Wad El Nau. At El Turabi basin, irrigation and row planting resulted in yields significantly better than those from the other treatments. Furrow irrigation by forming ridges spaced out 80 cm apart resulted in the lowest yields and the lowest plant densities at all sites.

3. Weed Management

Effect of weeding time on growth and yield of two wheat cultivars

Aldirdiery G. Osman

The objective of this experiment was to provide information on the effect of a single weeding given 15, 30, or 45 days after planting, full season competition, and frequent weeding, on the performance of the two wheat cultivars Condor and Debeira. No significant differences were found among the treatments in grain yield. These results were probably specific to the experimental site which was not cropped for the last two seasons, and was unintentionally pre-watered this season.

Effect of weeding regimes on wheat yield

El Tahir Omer El Badawi

An experiment to study the effect of time and frequency of weeding on wheat yield was conducted at Selaim in the Northern Province. The treatments comprised a weedy check; one weeding, 15, 30, or 45 days after sowing; and two weedings, one 15 days and the second 30 days after sowing. Differences in yield were significant; the weedy control gave the lowest yield of 1281 kg/ha, and two weedings gave the highest yield of 2295 kg/ha. One weeding, effected 30 days after planting, gave yields comparable to those obtained with two weedings; whereas weeding once, 45 days from sowing, resulted in yields similar to those from the unweeded plots.

4. Mechanization

Effect of land preparation system on wheat grain yield

Ahmed Salih and A. Musa

The following four land preparation methods were compared at El Turabi, Northern Gezira: (1) disc plowing, harrowing, and levelling; (2) harrowing twice and levelling; (3) rotovating and levelling; and (4) ridging, split riding, and levelling. Yields obtained were 2.49, 2.18, 2.00, and 2.38 t/ha, at a cost of 124, 95, 65, and 54 Sudaneese pounds, respectively. Mean yields, however, were based on only two replications, and are therefore of low precision.

Assessing seed losses from combine harvesters

Ibrahim K. Mahdi and A. Musa

Grain losses from mechanical harvest of wheat were assessed at three locations in the Gezira. A hessian-covered frame was placed under the moving combine between the front and rear wheels. Material collected on the frame was used to assess threshing and separation losses; unthreshed heads under the frame were collected to determine cutter-bar losses. Harvest losses were low and amounted to 1.17% and 1.95% at two locations, but reached 4.56% at the third location due to lodging.

C. Plant Nutrition

Response of wheat to nitrogen and phosphorus fertilization

Hassan H. Abdalla and Abdel Hamed Izzat

Response of wheat to different nitrogen and phosphorus combinations was compared at three locations in the Gezira, with the currently adopted practice of applying 86 kg N/ha and no phosphorus. The combinations per ha were 86 kg nitrogen and 43 kg P_2O_5, 43 kg nitrogen and 43 kg P_2O_5, and 129 kg nitrogen

and 64.5 kg P_2O_5. Methods of application were also tested. Results showed significant response to phosphorus in combination with nitrogen at El Turabi (45%) and at the Gezira Research Station (52%), but not at Wad El Nau (4%). Highest yields were obtained when fertilizer application was by placement in a band.

Varietal response to nitrogen fertilizer on the major soil types in the Northern Region

Hassan S. Ibrahim and Gaafar E. Mohammed

The response of three wheat cultivars, Condor, Debeira, and Wadi El Neil to nitrogen was tested at five locations representing different soil types in Ed-Damer and Shendi district; Wadi El Neil gave the highest response (177%). Two other locations in this district had high total soil nitrogen, and response to added nitrogen was mostly negative.

D. Crop Protection

1. Plant Pathology

An investigation into the race virulence of stem rust natural inoculum on stem rust differential varieties and lines

Mohammed S. Ahmed

The objective of this experiment was to investigate the virulence pattern of the stem rust races prevalent in New Halfa area, and to identify the genes conferring resistance. Twenty-nine stem rust differential varieties and lines were grown in a non-replicated observation plot surrounded by a belt of the susceptible 'Beladi' cultivar. Observations on rust severity and type of infection were made on 22 January, 1 February, and 15 February. Only one entry had good resistance; five entries showed fair resistance, seventeen had marginal resistance, and six entries had poor resistance. Although none of the stem rust resistance genes conferred good resistance, most of them conferred some degree of resistance. The intermediate infection type observed in most of the entries indicated that the natural inoculum at New Halfa area was probably a mixture of races.

2. Insect Management

Investigations into aphid problems on wheat in the Sudan

Nasr Eldin Sharaf Eldin

Studies conducted on aphids this season were designed to collect basic information on (i) field infestation and natural enemies, (ii) biological control, (iii) identification of resistant wheat germplasm, and (iv) life table of

Schizaphis graminum. Levels of natural infestation of the two wheat aphids *Schizaphis graminum* and *Rhopalosiphum maidis* and of their natural enemies were highest at Gezira, followed by Hudeiba and New Halfa. Natural enemies appeared late in the season and had no checking effect on the pest.

Release of predator resulted in some positive effects reflected in the high predator recovery and the comparatively low pest infestation. Screening about nine hundred genotypes for resistance indicated susceptibility of all entries, except for three bread wheat cultivars and one durum cultivar. Chemical control with eleven treatments involving seven insecticides showed that Danitol-S, Reldan, Dursban, and Marshal gave satisfactory performance. Preliminary information was obtained on the differential effect of 20 and 30°C constant temperatures on the development, fecundity, and longevity of *Schizaphis graminum.*

Incidence of wheat aphids in the sowing date and variety experiment

A.G. Bushara

The variety and sowing date experiment conducted at Hudeiba was utilized to investigate incidence of aphids as affected by the different variables. For each treatment, percentage of plants infested with aphids and the number of aphids per plant were determined. Results showed that, early in the season, aphid infestation was heavy in early plantings, but, late in the season, infestation was heavier in late plantings, indicating that aphids preferred young plants to old ones. The cultivar Wadi El Neil was significantly more susceptible to aphid infestation than either Condor or Debeira.

Incidence of wheat aphids as affected by sowing date, irrigation, fertilizer, and aphid control

A.G. Bushara

A researcher-managed on-farm experiment, conducted at Zeidab, was used for this study. In the first count, the only significant effect was that of fertilizer which increased aphid infestation. Results of the second count showed that nitrogen fertilization, delayed planting, and not applying control measures, significantly increased infestation.

CONCLUDING REMARKS

Professor Abdel Muhsin H. El Nadi
Faculty of Agriculture, University of Khartoum

After expressing his appreciation of the efforts devoted to research on wheat, Professor Abdel Muhsin made the following suggestions and remarks:

- In experiments concerned with irrigation, at least two of the three components of the soil-plant-atmosphere continum need to be monitored e.g. soil moisture, a parameter of moisture status in plant tissue or evaporative potential of the atmosphere.
- Simple field techniques could be used in farmers' fields or in experimental plots to measure actual quantities of water used for irrigation, e.g. V-notch in field channels, and, to maintain the water head, a weir can be placed before the V-notch. Water flow can be calibrated once and then used throughout the season. Only duration of water delivery needs to be recorded, using a normal or stop watch.
- Water-use efficiency values, to be realistic, must be coupled with economic levels of yield.
- Cooperation between soil physicists, irrigation engineers, and irrigation agronomists can result in multipurpose experiments to answer all round aspects of water relations.
- Universities can contribute in future programs, if required, by engaging M.Sc. students.
- Use of simple meteorological equipment in the experimental fields is helpful in describing the micro-environment e.g. pluviometers, thermohygrographs, minimum-maximum thermometers, evaporation pans, and radiometers.
- More attention should be given to experimental designs with a view to improving precision.

Professor Musa M. Musa
Deputy Director General, ARC

Professor Musa stated that it is important at this juncture to highlight the outstanding successes this program achieved in such a short time:

- The multidisciplinary nature of the project brought into focus the type of working relationships needed and at the same time exposed the deficiencies in the scientific cadre of ARC. There is need for more train-

ing, more cooperation with education institutions in conducting joint work, and more efficient mobilization of national research manpower.

- The on-farm research model is accepted by scientists and is being happily extended to other improvement programs.
- There is need to go ahead with concrete recommendations, namely phosphorus application. At the same time, work on effects of soil type, soil management, and cultivar should continue with a view to elucidating response to phosphorus.
- The need for crop improvement and variety testing is evident. The agroclimate, the farmer, and the level of inputs should be given due consideration when varieties are recommended for the different production regions. Stability of yield across environments should be an important selection criterion.
- The program discussion tomorrow will take the form of a round-table session. The ICARDA/OPEC-funded activity will be discussed as part of the national program. Hopefully, the discussion will address the pertinent issues, taking full note of all points raised during the working sessions.
- Activities of Global-2000 Inc. are to be commended, and ARC should make use of available facilities to extend on-farm work.
- Once again, thanks are due to ICARDA/OPEC, universities, production corporations, departments of agriculture, Global-2000 Inc., and fellow scientists who contributed actively.

Dr. J. P. Srivastava

Leader, Cereal Improvement Program, ICARDA

Dr. Srivastava expressed his gratification in attending the second coordination meeting for the ARC-OPEC-ICARDA Pilot Project. In his view, the workplan developed for the 1986-87 season was very well implemented. Dr. Srivastava then raised some questions worthy of pondering over:

- Farmer-managed trials showed that fertilizer application, good land preparation etc. increased yields substantially but what did we learn from best farmers?
- Do we need to continue studying land preparation methods? In irrigation experiments should we study crop needs?
- What role have we envisaged for graduate students?

Dr. Srivastava then offered some potentially productive ideas:

(i) The synergistic effects of variety x management interaction could be utilized to achieve higher levels of yield.

(ii) If the geographical wheat production regions constitute different agro-ecological zones, shouldn't we develop specific packages and varieties for each zone ?

(iii) The genetic vulnerability of cultivated crops had been illustrated in many occasions; we ought not to put all our eggs in one basket; we should develop varieties to meet specific needs.

Dr. Srivastava then drew the attention of participants to the excellent quality of some of the presentations and suggested that efforts be made to publish results in appropriate scientific journals.

WORKPLAN 1987-88

I. ON-FARM RESEARCH

A. Pilot Production and Demonstration Trials

These trials are a prelude to a much wider adoption of the improved package that proved to be technically feasible and economically viable in small areas in farmers' fields.

Gezira Scheme

Package components: (i) Adequate land preparation through disc ploughing and levelling. (ii) Planting by a seed drill. (iii) Application of 43 kg P_2O_5/ha. (iv) Eight irrigations during the growing season.

Other cultural practices, common to all fields, include nitrogen application at the rate of 86 kg/ha and sowing at the rate of 140 kg/ha during the first half of November; the cultivar will be Condor.

Demonstration unit area: 37.5 hectares
Number of locations: 6
Total number of farmers: 54
Data: (i) Cost of all operations; (ii) Realized yields. Data will be obtained for demonstration plots and from an equal number of neighbouring farms. Profitability of the package will be assessed.
Scientist in charge: Dr. Osman A. A. Ageeb, Wheat Agronomist.
Cooperating scientists: Mr. Ahmed Musa, Agricultural Engineer; Mr. Ibrahim Khalid, Agricultrual Engineer; Mr. Abdel Aziz Abdel Fattah, Economist.

New Halfa Scheme

Package components: (i) Adequate land preparation through pre-watering, disc harrowing, and levelling. (ii) Seed drilling. (iii) Sowing during the first half of November. (iv) Application of 86 kg N/ha. (v) Seven to eight irrigations per season. (vi) Use of the variety Debeira or Condor.

Number of farmers: 24
Number of locations: 3
Data and analysis: Same as for the Gezira.
Scientist in charge: Dr. Mohammed S. Mohammed.
Cooperating scientist: Mr. Abdel Rahman Bushara.
Agricultural Engineer: Mr. Abdel Aziz Abdel Fattah, Economist.

Northern Region (Nile Province)

Package components: (i) Variety used: Wadi El Neil. (ii) 86 kg N/ha. (iii) Irrigation at 14 day intervals. (iv) Aphid control with Ekatin.

Number of locations: 2
Unit area: 0.42 hectare.
Number of units per location: 10
Data and analysis: Same as for Gezira.
Scientist in charge: Dr. Musa B. Taha, Agronomist.
Cooperating scientist: Mr. Abdel Aziz Abdel Fattah, Economist.

B. Researcher-Managed Trials

Gezira Scheme

1) Variety and sowing date

This trial is based on results obtained last season (see back-up research, these proceedings). Specifications are:
Varieties: Debeira and Condor.
Sowing dates: 3rd week of October, 3 November.
Locations: Gezira Research Station, and five groups: Northern, Messellemiya, Centre, Southern, and El Huda groups.
Scientist in charge: Dr. A.A. Ageeb, Agronomist.

2) Wheat fertilization on Gezira vertisols

Treatments: (i) 86 kg N/ha, (ii) 43 kg N/ha + 43 kg $P_2 0_5$/ha, (iii) 86 kg N/ha + 43 kg $P_2 0_5$/ha, (iv) 129 kg N/ha, and (v) 86 kg N/ha + 43 kg $P_2 0_5$/ha + 60 kg $K_2 0$/ha.
Locations: Farmers' fields located on the main soil types in the Gezira: Hosh Series in the Southern Group, Suleimi Series in the Center and Messellemiya Groups, and Turabi Series in the North and North-West Groups.
Sites within locations: At least three.
Data: (i) Site characterization, (ii) total dry matter production, (iii) grain yield and yield components, and (iv) uptake of nitrogen, phosphorus, and potassium.
Scientist in charge: Dr. Hassan Hag Abdalla.
Cooperating scientist: Dr. Osman A.A. Ageeb.

3) On-farm verification yield trial

Treatments: Eight cultivars and two checks.
Locations: Thirteen (Five in the Gezira, two in the White Nile, three in the Northern Region, and three in New Halfa).

Data: Grain yield and other agronomic attributes.
Scientist in charge: Dr. Abdalla B. El Ahmadi, Plant Breeder, Gezira Research Station.
Cooperating scientists: Dr. Mohammed S. Mohammed, New Halfa; Mr. Abdullah I. Sheikh Mohammed, Hudeiba; Dr. Gaafar El Sarrag, Shendi; Mr. Sheikh Eldin A. El Awad, Maatug.

New Halfa

1) Land preparation and sowing methods:

Treatments: Two land preparation methods after pre-watering: (i) offset disc harrowing and levelling; and (ii) dry ridging, pre-watering, split ridging, and levelling. These are to be combined with two sowing methods: (i) broadcasting with wide-level disc; and (ii) drilling with a tractor-mounted seed drill.
Design: Split plot plan with land preparation methods as main plots and sowing date in subplots, in a randomized complete block (RCB) design replicated in three farmer's fields (no replication within field).
Data: Grain yield, stand, and economic viability.
Scientist in charge: Mr. Abdel Rahman Bushara, Agricultural Engineer.
Cooperating scientist: Mr. Abdel Aziz Abdel Fattah, Economist.

2) Variety and sowing date:

Treatments: Three varieties, Giza 155, Debeira, or Condor, and two sowing dates, 20 October or 19 November in a 3 x 2 factorial combination.
Design: RCB, four replications.
Locations: Three sites.
Data: Grain yield and attributes of agronomic and economic value.
Scientist in charge: Dr. Ahmed M. Ghorashi.

Northern Region (Hudeiba Research Station)

Treatments: The research-managed trial will consist of the following factors and levels:

Factors	Improved level	Farmer level
Sowing date	15 November	5 December
Nitrogen fertilizer	86 kg N/ha	43 kg N/ha
Variety	Wadi El Neil	Condor

Design: RCB, four replications.
Observations: Plant stand, days to flowering and maturity, pest and diseases,

yield, and yield components.
Locations: Zeidab, Hassan, and Kelly.
Scientist in charge: Dr. Musa B. Taha.
Cooperating scientists: Dr. Gaafar El Sarrag, Agronomist;
Dr. Abdel Gadir Bushara, Entomologist;
Dr. Hassan Suliman, Soil Chemist;
Dr. Mohamed El Fatih, Pathologist;
Mr. Abdel Aziz Abdel Fattah, Economist.

II. BACK-UP RESEARCH

A. Gezira Research Station

1) Agronomy

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

Treatments: Three cultivars: Condor, Debeira, and Wadi El Neil; and five sowing dates: 15 October, 29 October, 12 November, 26 November, and 10 December.
Experimental design: Split-plot plan in RCB design with six replications where varieties occupy the main plots and sowing dates occupy the subplots. The gross subplot size will be 2.4 x 8.0 m and yield area, 2.0 x 7.0 m.
Data to be recorded: (i) Plant stand at 2 weeks from sowing and at maturity; (ii) plant height at flowering; (iii) dry matter accumulation at 4 weeks from planting, at flowering, and at maturity; (iv) detailed observation on phasic development; (v) grain yield and yield components; and (vi) pests and diseases.
Scientists in charge: Dr. Osman Ageeb, Gezira; Dr. Ahmed M. Ghorashi, New Halfa; Dr. Musa B. Taha, Hudeiba.
Cooperating scientists: Dr. Abdel Gadir Bushara, Entomologist; Dr. Mohammed S. Ahmed, Pathologist.

2) Water Management

Effect of irrigation interval at two stages of plant development on growth, seed yield, and water-use efficiency.

Treatments: (i) Irrigating the crop at 14-day interval to boot stage and then at 10-day interval to maturity; (ii) irrigating the crop at 14-day interval from planting to maturity; (iii) irrigating the crop at 21-day interval to

boot stage and then at 10-day interval to maturity; and (iv) irrigating the crop at 21-day interval to maturity.
Plot size: Angaia (14 x 75m).
Design: RCB with 3 replications.
Data to be taken: Crop water requirement, growth, and yield.
Scientist in charge: Dr. Saeed M. Farrah.

3) Mechanization

Effect of different tillage systems on selected soil physical properties, crop establishment, and grain yield.

Treatments: (i) bottom disc + harrowing + levelling; (ii) ridging + harrowing + levelling; (iii) harrowing twice + levelling; and (iv) ridging, split ridging + levelling.
Data: Tillage depth, soil moisture, plant stand, weed density, moisture depletion, root density, yield, and economic analysis.
Scientist in charge: Dr. Ahmed A. Salih, soil physicist.
Cooperating scientist: Mr. Ahmed Musa, Agricultural Engineer.

4) Entomology

a) 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 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.
Locations: Gezira Research Station.
Scientist in charge: Dr. Nasr Eldin Sharaf Eldin, Entomologist.

b) Screening of new insecticides against aphids.

Treatments: Twelve 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, and grain yield.
Location: Gezira Research Station.
Scientist in charge: Dr. Nasr El Din Sharaf Eldin, Entomologist.

c) Screening of breeding lines of wheat and barley against aphids, and to find out any source of resistance in 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, and aphids per plant.
Locations: Gezira, New Halfa, and Hudeiba Research Stations.
Scientist in charge: Dr. Nasr Eldin Sharaf Eldin, Entomologist, Gezira Research Station.
Cooperating scientists: Dr. Abdel Gadir Bushara, Hudeiba, Dr. Faisal M. Ibrahim, New Halfa.

d) Life tables for the two aphid species on wheat and their two main natural enemies.

Methods: Biology of 50 individuals will be studied in potted plants at recorded temperature and relative humidity.
Location: Gezira Research Station.
Scientist in charge: Dr. Nasr Eldin Sharaf Eldin.

e) Field infestation of aphids and their natural enemies.

Methods: A field of wheat will be planted with the commercial variety in the area. It will be weekly surveyed throughout the season.
Locations: Gezira, Hudeiba, and New Halfa Research Stations.
Scientist in charge: Dr. Nasr Eldin Sharaf Eldin, Gezira Research Station.
Cooperating scientists: Dr. Abdel Gadir Bushara, Hudeiba Research Station; Dr. Faisal M. Ibrahim, New Halfa.

f) Differential susceptibility of the recently released wheat varieties to the two aphid species.

Treatments: The commercial varieties and a few of the most promising varieties to be released shortly will be used in one experiment. A spray treatment will be included to observe the response of each variety to such practice.
Design: RCB.
Observations: Weekly counts of the two aphid species throughout the season and grain yield.
Locations: Gezira, Hudeiba, and New Halfa Research Stations.
Scientist in charge: Dr. Nasr Eldin Sharaf Eldin.
Cooperating scientists: Dr. Abdel Gadir Bushara, Hudeiba; Dr. Faisal M. Ibrahim, New Halfa.

5) Crop Improvement

For the continuity of the on-farm verification yield trial, support will be given for testing advanced lines in a series of variety trials. The trials will be conducted at Gezira, New Halfa, and Hudeiba Research Stations.

a) Preliminary yield trials

Entries: 46 + 2 checks.
Replications: three.
Design: RCB.
Plot size: eight rows, 4-m long, 20 cm apart.
Number of trials: will depend on the number of entries available.
Data to be recorded: Days to heading and maturity, plant height, disease resistance, lodging, shattering, and grain yield.
Scientists in charge: Dr. Abdalla El Ahmadi, Head of Plant Breeding Section, Gezira Research Station; Dr. Mohammed S. Mohammed, Director, New Halfa Research Station; Mr. Abdalla I. Sheikh Mohammed, Hudeiba Research Station.

b) Advanced yield trial

Entries: 24.
Replications: four.
Design: RCB.
Plot size: eight rows, 8-m long and 20 cm apart.
Data to be recorded: Days to heading and maturity, plant height, disease resistance, lodging, shattering, and grain yield.
Scientists in charge: Dr. Abdalla El Ahmadi, Head Plant Breeding Section, Gezira Research Station; Dr. Mohammed S. Mohammed, Director, New Hafla Research Station; Mr. Abdalla I. Sheikh Mohammed, Hudeiba Research Station.

B. New Halfa:

Plant Pathology

a) Screening of commercial and promising varieties and lines of wheat for stem rust resistance

Treatments: 40 varieties and lines.
Design: RCB with four replications.
Plot size: two rows, 7-m long.
Observations: Disease severity and infection type.
Scientist in charge: Dr. Mohammed S. Ahmed.

b) Stem rust race virulence on stem rust differential varieties of wheat

Treatments: 29 SR differentials.
Design: RCB with four replications.
Plot size: two rows, 7-m long.
Observations: Disease severity and infection type.
Scientist in charge: Dr. Mohammed S. Ahmed.

c) National survey of wheat diseases

Activities will include visits to selected sites within each region, diagnosis of the disease, isolation and identification of the causal pathogens, pathogenicity tests, assessment of the level and distribution of each identified disease, and preparing maps showing distribution and level of each disease.
Scientists in charge: Dr. Mohammed S. Ahmed, New Halfa; Dr. Gaafar I.M. Ali, Gezira Research Station; Dr. Mohammed E. Khalid, Hudeiba Research Station.

C. Northern Region (Hudeiba Research Station)

1) Water Management

Effect of different irrigation intervals at three stages of wheat development on growth, grain yield, and water-use efficiency.

Treatments: Watering at 14, 21, or 28-day interval from emergence to booting; at 10 or 14-day interval from booting to heading; and at 10 or 14-day interval at heading to maturity in a 3 x 2 x 2 factorial arrangement.
Design: RCB with three replications.
Data to be taken: Water use, growth, and yield.
Scientist in charge: Dr. Hassan S. Ibrahim.

2) Plant Nutrition

a) Varietal response to N-fertilization at three major soil types in the Northern Region

Treatments: Three varieties: Condor, Debeira, and Wadi El Neil, and four N-levels: 0, 43, 86, and 129 kg N/ha.
Locations: Hudeiba and Shendi at three sites representing Gureir, Karu, and High Terrace soils.
Data to be taken: N-uptake and yield of grain and straw.
Scientist in charge: Dr. Hassan S. Ibrahim, Hudeiba.
Cooperating scientist: Dr. Gaafar E. Mohamed, Shendi.

b) Screening of promising lines to P-response under two soil types, Karu and High Terrace

Treatments: 0, 43, and 86 kg $P_2 0_5$/ha; ten breeding lines; and two soil types, Karu and High Terrace.
Design: Split plot with P in the main plots and the lines in subplots replicated four times.
Scientist in charge: Dr. Hassan S. Ibrahim, Hudeiba.

c) Effect of the time and rate of nitrogen and phosphorus application on the yield and N and P-uptake by wheat under two soil types in the Northern Region

Treatments: Nitrogen at 0, 86, or 129 kg/ha, phosphorus at 0 or 43 kg P_2O_5/ha applied as a single dose at sowing or split-applied at sowing and tillering, sowing and booting, or tillering and booting.
Locations: Hudeiba and Shendi, on Karu and High Terrace soils.
Data to be taken: Yield, and N and P uptake.
Scientist in charge: Dr. Hassan S. Ibrahim, Hudeiba.
Cooperating scientist: Dr. Gaafar E. Mohammed, Shendi.

d) Screening of promising lines for tolerance to salinity

Treatments: Four types of irrigation water, tap water (control), water with electric conductivity of 3.0, 6.0, or 12.0 mmho/cm, and seven wheat breeding lines.
Design: RCB with 4 replications.
Scientist in charge: Dr. Hassan S. Ibrahim, Hudeiba.

III. TRAINING

A. Field days

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

B. Visiting scientists

1) Dr. Gaafar Ibrahim Mohammed, Plant Pathologist, to spend 2 months at ICARDA, Aleppo, April-May 1987.
2) Dr. Mohammed S. Ahmed, Plant Pathologist, to spend 3-4 weeks at the Agricultural Research Institute, Giza, Egypt.

IV. PRE-RELEASE SEED MULTIPLICATION

V. ECONOMIC ANALYSIS OF RECOMMENDED PACKAGES

APPENDIX

LIST OF PARTICIPANTS

Ministry of Agirculture and Natural Resources:

Headquarters, Khartoum:

Mr. Yousif A. Dash	First Permanent Under Secretary
Mr. Mohammed A. Ali	Advisory Unit for Agric. Corp.

National Seed Administration:

Dr. Ahmed Abu El Gasim	Director General, Khartoum
Dr. Omer Abdel Fadeel	Director, Plant Propagation Administration, Sennar

Soil Survey Administration, P.O. Box: 388, Wadi Medani

Mr. Abdel Moneim Kafeel	Acting Director
Dr. Abdel Karim Obeid	Head, Laboratories Section
Dr. Osman Abdel Rahman El Tom	Head, Land Evaluation Section
Dr. Omar Khodary Eissa	Acting Head, Soil Classification and Correlation Section
Mr. Abdel Rahman Abdalla	Acting Head, Applied Research and Investigations Section
Dr. Shama El Amin Daw El Beit	Senior Soil Chemist

Regional Ministries of Agriculture

Northern Region:

Mr. Abdel Moneim Gumma Suleiman	Extension Officer
Mr. Abdel Gadir Ibrahim Ahmed	Extension Officer

Central Region:

Mr. El Hadi Mohammed Nour	Director of Extension, Sennar
Mr. Abdel Mahmoud Ahmed Ali	Extension Officer, Kosti

Gezira Scheme:

Administration

Mr. Abdalla M. El Zubeir	Managing Director
Dr. Nasr Eldin Mohamed	Deputy Managing Director
Mr. Galal Hamid Osman	Deputy Agricultural Manager
Mr. Abdel Hai Ibrahim	Deputy Agricultural Manager for Gezira
Mr. Kamal Amin El Sayed	Manager, North Group
Mr. El Fateh Satti	Manager, Centre Group
Mr. Ahmed Dafalla El Kebbashi	Chief Editor, Gezira Newspaper
Mr. Ahmed El Beshir Ahmed	Deputy Manager, Plant Propagation Department.

Mr. Mohamed Sid Ahmed	Deputy Manager, Extension Department
Mr. Idris Hassan Ahmed	Manager, Horticulture Department
Mr. Omer Abdel Wahab	Horticulture Department
Mr. Abdalla Babkier Marai	Extension Department
Mr. Omer Ali Mohamed	Extension Department
Mr. Ahmed Yousif Ahmed	Extension Department
Mr. El Rayah Musaad El Rayah	Extension Department

Tenants Union:

Mr. Abdel Galil Hassan A/Galil	Secretary, Gezira and Managil Farmers' Union.

Individual Farmers: (Derweesh Block)

El Amin El Mubarak
Mustafa M. Siddig
Mohammed B. Al Awad
Yousif Musa
Ahmed A. El Shafie
Mohammed I. El Hag
Musa Dereisa

New Halfa Agricultural Production Corporation

Mr. Abdel Rahman Bushara Omer	Agricultural Engineer
Mr. G. Abdel Rahman Arman	Field Administration
Mr. Mohammed Suleiman Amin	Field Administration
Mr. Mohammed Kabbar Mohammed	Field Inspector

ICARDA-CIMMYT

Dr. J.P. Srivastava	Leader, Cereal Improvement Program, ICARDA, Box: 5466, Aleppo, Syria.
Dr. G. Ortiz Ferrara	Wheat Breeder, CIMMYT/ICARDA
Mr. Isam Nagi	Agronomist, ICARDA

Global 2000 Inc.

Dr. Mareo A. Quinones	Asst. Director, Sasakwa African Association, P.O. Box: 7071, Khartom.

Arab Authority for Agric. Develpoment

Dr. Mohammed Osman El Karouri	Soil Scientist

University of Khartoum

Prof. Abdel Mushin H. El Nadi	Faculty of Agriculture, Shambat.
Dr. Mohammed Kheir Abdel Rahman	Faculty of Agriculture, Shambat.

University of Gezira

Prof. Osman Ahmed Ali Fadl	Dean, Faculty of Agricultural Sciences.
Dr. Yahia Beshir Sirraq	Head, Crop Science Department
Dr. Sami O. Freigoun	Crop Science Dept. (Pathology)
Dr. El Tayeb Abdel Malik	Crop Science Dept. (Soils)
Dr. Hashim M. Babiker	Crop Science Dept. (Soils)
Dr. Adam S. Suliman	Crop Science Dept. (Soils)
Dr. Muddathir A. Ahmed	Economist

Agricultural Research Corporation

Headquarters, P.O. Box 126, Wad Medani.

Prof. Musa M. Musa	Deputy Director General
Prof. El Tigani Mohed El Amin	Director, Administration and Finance
Prof. Abdel Mageed Yassin	Director, Publication and Training

Gezira Research Station, P.O. Box: 126, Wad Medani

Dr. Osman A.A. Ageeb	National Coordinator, Wheat
Dr. Ahmed Nsir Balla	National Coordinator, Entomology
Dr. Hassan Hag Abdalla	National Coordinator, Soil Sci.
Dr. Ibrahim El Jack	National Coordinator, Cotton
Dr. Asim Ali/Rahman	Coordinator ARC/FAO IPC Project
Dr. Mohamed El Hilo Omer	Head, Plant Pathology Section
Dr. Saeed M. Farah	Head, Agronomy Section
Dr. Abdalla B. El Ahmadi	Head, Plant Breeding Section
Dr. Nuri Osman Mukhtar	Head, Soil Science Section
Dr. Ahmed Salih Fadl Alla	Head, Cotton Breeding Section
Dr. Mirghani Khogali Ahmed	Head, Hort. Research Section
Dr. Nasr Eldin Sharaf El Din	Entomologist
Dr. Faisal Mirghani Ali	Agronomist
Dr. Abdel Moneim B. El Ahmadi	Plant Breeder
Dr. Gaafar Ibrahim	Plant Pathologist
Mr. Abdel Latif M. Nur	Plant Breeder
DR. Naiem A. Ali	Soil scientist
Dr. Osman El Obeid Ibrahim	Plant Breeder
Dr. Abdel Azim B. Abdalla	Plant Breeder
Dr. Mugboul El Hadi Lazim	Agronomist
Dr. Mohmmed Ahmed M. Kheir	Agronomist
Dr. Ahmed Ali Salih	Soil Scientist
Dr. Gad Alla El Hassan	Microbiologist
Mr. Abdel Rasoul F. Mustafa	Silviculturist
Mr. Kamal Mohamed Adam	Agricultural Engineer
Mr. Salagh Bilal	Asst. Breeder
Mr. El Geneid I. Hamadain	Asst. Entomologist

Mr. Ali Hasab El Rasoul	Asst. Economist
Mr. El Tahir Siddig Ali	Asst. Plant Breeder
Mr. Ismail El Siddig	Asst. Entomologist
Mr. Hyder Abdel Gadir	Asst. Entomologist
Ms. Khadeija Khidir Ali	Asst. Extension Officer
Ms. Sit El Banat Khidir	Asst. Extensino Officer
Mr. Mohmmed Izz Eldin Mahgoub	Asst. Extension Officer

Hudeiba Research Station, P.O. Box: 31, Ed-Damer

Dr. Hassan S. Ibrahim	Soil Scientist and Director of Station.
Dr. Musa B. Taha	Agronomist
Dr. Abdel Gadir Bushara	Entomologist
Dr. Mohamed El Fatih Khalid	Plant Pathologist
Mr. El Tahir O. El Bedawi	Weed Scientist
Mr. Abdalla I. Sheikh Mohammed	Plant Breeder

New Halfa Research Station, P.O. Box: 17, New Halfa

Dr. Mohammed S. Mohammed	Breeder and Director of Station
Dr. Mohammed S. Ahmed	Plant Pathologist
Dr. Ahmed M. Ghorashi	Agronomist
Dr. Al Dirdeiry G. Osman	Weed Scientist
Dr. Faisal M. Ibrahim	Entomologist

Shendi Research Station, P.O. Box: 33, Shendi

Dr. Gaafar El Sarrag Mohammed	Agronomist

Shambat Research Station, P.O. Box: 30, Khartoum North.

Dr. Farouk Ahmed Salih	Breeder and Director of Station

Western Sudan Agricultrual Research Project

Dr. Dafalla A. Dafalla	Agronomist and Project Director.

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