PROCEEDINGS

OF

WHEAT WORKSHOP

AND

INAUGURAL BIENNIAL MEETING OF

AGRICULTURAL SCIENCE ASSOCIATION OF ZAMBIA

EDITED BY J.A. Toogood
CIDA COOPERANT, UNZA

March 1981

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PROGRAM

March 9
- 1730 - Registration and Reception

March 10
- 0925 - Opening of Workshop/Meeting, Mt. Makulu
  - CHAIRMAN: Mr. W. Chibasa, Assist. Dir. Agr. Research
  - Welcome: The Minister of State for Agriculture and Water Development, Mr. J. Mukando
- 0930 - Theme Address: Dr. G. Kingma, CIMMYT
- 1030 - Coffee
- 1045 - Status of Research and Production
  (Speakers nominated by delegations to give 10-15 minute talks)
  - Kenya – Tanzania – Malawi
  - Zimbabwe – Madagascar – Zambia
- 1220 - Lunch
- 1400 - ASA: Association Papers
  - CHAIRMAN: Mr. W. Chibasa

March 11
- Wheat Workshop – Pathology/Breeding
  - CHAIRMAN: Dr. G. Kingma
- 0900 - CIMMYT’s Approach to Pathology, Dr. M. Prescott
- 0920 - Problems and Progress in Disease Resistance and Breeding
  (Delegated speakers - 15 minutes/country)
  - Zambia – Zimbabwe – Tanzania – Arusha, Njombe – Madagascar
  - Coffee break when appropriate
- 1200 - Discussion: Disease Resistance and Breeding
  - LEADER: Dr. R. Baker, Canada
- 1230 - Lunch
- 1400 - Tour: Mount Makulu Wheat Research
  - LEADERS: Mr. R. Raemaekers, Mr. D.S. McBean & Dr. G. Kingma
- 1900 - Dinner: Ridgeway Hotel

March 12
- Wheat Workshop – Soils/Agronomy
  - CHAIRLADY: Ms R.K. Chungu, Chief Agricultural Research Officer, Mount Makulu
- 0900 - Cultural Practices
  (Delegated speakers - 15 minutes each)
  - Tanzania – Kenya – Madagascar – Zimbabwe – Malawi
  - Zambia: Zam Can, Mpongwe
  - Coffee Break when appropriate
1130 — Discussion: Cultural Practices
- LEADER: Mr. A. Ridley
1220 — Lunch
1400 — Wheat Workshop — Wheat in Settlement
- CHAIRMAN: Mr. P. Commissaris
1420 — A Philosophy of Settlement: Mr. L. Holland
1420 — Wheat Schemes
(Delegated speakers, 15 minutes each)
Tanzania — Zambia — Zam-Can, Adaptive Research, — Zaire
1600 — Discussion: Wheat Schemes
K. Edwards

March 13 — Farm Tour: Organized by Commercial Farmers Bureau,
Tour leader: J. Woods
- 0930 — Leave Hotel
- 1300 — Lunch
- 1630 — Return to Hotel
WELCOMING ADDRESS

J. Mukando
MINISTER OF STATE FOR AGRICULTURE AND WATER DEVELOPMENT

Firstly, I would like to express my sincere thanks for this great honour bestowed on me in being called upon to open this first ever Wheat Workshop being held here at Mount Makulu Central Research Station, and which has been jointly organized by the wheat researchers in my ministry and the Agricultural Science Association of Zambia.

Secondly, Mr. Chairman, on behalf of my Ministry, and indeed on my behalf, I wish to extend to all our visitors and especially the workshop delegates and observers who have come from 11 countries our heartmost felt warm welcome.

Mr. Chairman, as we know, wheat is now becoming a basic food for more people in the world than either maize or rice — although, in Zambia as well as in the rest of the African continent, maize remains the main basic food. World statistical figures reveal that wheat consumption is increasing in many countries by about 5 to 15% per year. This is an alarming trend which has to be arrested by increased production rather than importation.

The Food and Agricultural Organisation and other experts' forecasts indicate that the population of the world is growing at a faster rate than the increase in food production. This will definitely lead to shortages of food and much higher prices of basic cereals. This shortage of cereals including wheat, could begin within a few years. This brings me to the question I find most difficult to answer — where will our countries get the wheat from if we do not begin to grow enough of our own?

Mr. Chairman, Zambia used to be self-sufficient in wheat in the 1940's and 50's, but at that time, very little bread was eaten. Now Zambia uses over 100 000 metric tonnes of wheat per year and the national mills estimate that if flour and bread were readily available all the time, Zambia could easily use 180 000 metric tonnes per year. The present consumption of wheat in Zambia is around 5 times as much per capita as some of our neighbouring countries. We believe that part of the reason we eat so much wheat in the form of bread lies in our high urban population which now stands at around 40%. The resultant effect is that we are importing wheat at a very high cost of the scarce foreign exchange. This situation, I have no doubt, applies to many of our neighbours. Mr. Chairman, high consumption of wheat bread is also unfortunately becoming a habit in the remote rural areas. This compounds Zambia's problem as far as wheat demand is concerned. In the late 1970's we produced here at home about 5 or 6% of our requirements. However, in 1980 with improved management and a slight increase in the area planted to wheat, we produced about 10% of our total wheat demand figure. The bulk of this came from the irrigated crop. Our main objective is to become self-sufficient in wheat as quickly as possible. Mr. Chairman, I believe that it is with this background of increased importance of wheat in Zambia and throughout this part of Africa that our wheat researchers have planned for this meeting. I do know that some of the countries represented here have been growing wheat on a large scale for many years and have had continuing back-up research to
support the production. There are, however, some others including my own, which are new in this crop and the main objective of the Planning Committee for this workshop was to bring together representatives of as many countries as possible from Southern, and Central Africa to pool together their wisdom and map out a strategy for solving common problems in a bid to reduce this serious cereals deficiency which has been forecast by the Food and Agricultural Organisation by 1985. The workshop must come up with definite strategy on how to overcome, problems affecting wheat production in our region.

I am pleased to hear that the response has been very good, and that nearly every country contacted has shown some interest in getting together. Even though some countries have not been able to send delegates this time, they would, however, like to obtain copies of the proceedings and hope that there will be another such meeting in a year or two. It is my sincere belief that you will all have a chance to exchange experiences, knowledge and in future share material which will go a long way in avoiding each of us “Re-inventing the Wheel”.

Lastly but not least, I would like to acknowledge most heartily the assistance rendered to my ministry in hosting this workshop by the various business communities, especially those serving agriculture and in particular the wheat industry. Notable amongst these are the Indeco through the National Milling Companies and Supaloaf, the Banks, The Agricultural Chemical and Machinery Companies and the Commercial Farmers’ Bureau. I want to say to all these groups thank you very much for a most generous assistance and hope for such continued support and cooperation in the future in our national struggle to increase food production.

To you workshop participants, I say best wishes in your deliberations. Even though, I will not be able to physically sit with you at your round tables — I will try to follow up the day to day deliberations through the workshop organisers, and with these few words, I wish to declare this workshop officially open.
THEME ADDRESS FOR THE WORKSHOP
Dr. G. Kingma
A CIMMYT LOOK AT WHEAT IN THE 1980'S

INTRODUCTION

Transfer of research findings from one region of the world to another continues to appeal to many planning officers and governments in the world.

The Consultative Group for International Agricultural Research, CGIAR has now 12 or 13 research centres under its financial wings. These centres concentrate on the major food crops. One of the principles is that in close cooperation with researchers of each country, technology can be transferred horizontally. CIMMYT, the International Centre for Maize and Wheat Improvement concentrated in its plans for the 1980's on the possibilities of spreading available germplasm and knowledge more widely.

What can we safely accept as facts for the next 20 years?
(a) More people,
(b) Available land limited, yields must be raised per land area,
(c) Food production must be expanded to maintain 1980 levels,
(d) Capital for improved productivity will be very limiting,
(e) Mining of resources, rather than building up, and
(f) Lack of communication between agriculturists and policy makers.

What can we expect to achieve?
(a) Better horizontal transfer — we will understand limitations of available technology better,
(b) Improved crop management and yield dependability,
(c) By a worldwide approach food prices will not rise so sharply as for oil — adding to political stability.

With what facilities on hand can we approach the future? The Center in Mexico (CIMMYT) has observed millions of different wheats, and nearly all were discarded. Nevertheless the selected ones have spread to developing countries and developed countries alike covering at least 35 million hectares of land. These wheats have brought remarkable production increases, often in fields of small farmers.

Five types of cooperation have proven instrumental in spreading improved technology around the world:
(a) Germplasm development, a yearly flow in and out of Mexico of new wheats and data on performance,
(b) Development of manpower,
(c) Procedures for conducting research,
(d) Consultation on the organization of relevant research and production programs, &
(e) Information transfer regarding crop improvement.
Let me review these five different areas briefly, with special emphasis on the relevance of Eastern and Southern Africa.

(a) **Improved germplasm**

CIMMYT uses information from more than 100 countries in the world to recombine available wheats, in order to obtain lines that can be selected in widely different soil and climatic conditions. Regional programs are established in different parts of the world—Chile, Ecuador, Turkey, Thailand, Portugal and Kenya.

Results of tests and screening nurseries are returned to Mexico by the cooperating countries and Regional staff. Special interests are discussed and materials can be used to solve a special situation. An example may be H. resistance in wheat. Results from screening large numbers of wheat lines in Zambia, India, Iran and Mexico are combined in new cycles of crosses and resultant hybrids can be distributed again to cooperating countries. Progress made in one country is horizontally transferred to other countries around the world with no delay.

(b) **Training for staff**

Cooperation in education and training is a widely accepted way of transfer of new technology. Within the wheat system young men and women that usually have already seen the cooperative wheat tests under their local conditions, are sent to Mexico or a Regional base. There they learn the simple methods of handling large numbers of experimental wheat material. Together with senior and junior wheat workers from many countries the principle of cooperation across barriers of language, culture, educational levels, etc., is demonstrated.

Over 1000 young colleagues have passed through this learning and doing training system established by Dr. N.E. Borlaug in Mexico. They are the key participants in the evaluation of new lines and usually they are the people putting the best selections to work on the farms in their country. This network of people around the world is something of an envy to other crop specialists. Regular contacts based on frequent travel of certain CIMMYT staff members keep the network functional.

(c) **Research methods**

In wheat improvement certain techniques like planting during two seasons in a year, selection under optimal growing conditions in contrasting environments have resulted in widely adapted, highly fertilizer-responsive plant types. When such potentially "highly charged" wheats are sent to 100 locations around the world growing conditions are often much less than optimal.

Still, the best lines are identified. And these have the high potential built in plus a tolerance to rough conditions—they stand periods of drought, of heavy weed competition etc.

The methods of creating variability and then screening under many often contrasting conditions have helped to identify the widely adapted wheats that are now grown all through the spring wheat areas of the world.

Currently further refinement of these methods include inter crossing winter wheats and spring wheats. These widely different gene pools have undergone breeding often quite separate from each other. Recombination of the best from the winter wheats in USSR or China with the best spring types from the Mediterranean or Mexico already has resulted in new spring wheats like Veery that beat all earlier created wheat varieties when tested over a wide range of conditions.
So we see how we have the three elements joining together, the germplasm development, the training of young colleagues and the full exploitation of intensive breeding methods.

(d) **Research organization towards production**

One of the factors in the cooperative network in wheat research as it exists in the beginning of this decade is the accent on personal contacts.

CIMMYT's travel budget of its senior staff is relatively large, and in an average year key staff members probably hold discussions and wheat reviews in 20 or 30 countries. Many national program leaders have called on this experience by requesting counsel for their own research organization.

Not only methods of research are discussed, but also strategies to organize the many input factors. Successful production campaigns in one country are analysed in another country, and relevant parts are transferred in the new situation. This requires judgement based on experiments and results in many different environments, biological and socially contrasting situations.

CIMMYT has advocated the strategy of early testing under farmers' conditions to verify recommended parts of a certain production package. This brings people together from various disciplines. What has worked in one country is used to formulate a strategy in another similar country.

(e) **Transfer of information**

Each year many results from the specialised breeding tests arrive in Mexico and in Regional programs. These must be summarized and be made available to wheat colleagues around the world. Timeliness is the key word on this level of data exchange. Another level requires the description of research findings for different audiences. The formulation of new approaches, based on small plot data, is extremely interesting to policy making administrators. Often detailed wheat reports are not available to these managers of budgets or research program administrators. Communication with such audiences requires different approaches. Non-technical language and color pictures have helped to bridge these gaps. A wide distribution of publications on germplasm improvement, on training, research procedures, on policy related issues have also helped to make available the progress from one area to the next area.

What are the necessary improvements in this work?

We have said earlier that the world wide land resources are rather limited. But we are experiencing now, how certain land areas are used more intensively. In Bangladesh there is an enormous expansion in wheat production and consumption. During the cool season a quick maturing wheat is grown in the rice fields. In five years time, 1975-1980, the area under rice-wheat double cropping has increased from 100,000 ha to 800,000 ha and is rising rapidly. This is a rice loving population going through many adjustments after independence. And the changes do occur. What were some key factors?

1. The government wanted more food locally produced,
2. Transfer of techniques from similar growing areas was possible,
3. Seed production was rapidly speeded up with young recently trained farm managers,
4. Agronomic restraints were identified and addressed vigorously. It is a dramatic venture that we will hear more about,

How can we intensify land use?
Our best wheat varieties have much more genetic yield potential than we see realized in nearly all countries. Many factors are involved in this large gap between potential and actual yields. Agronomic studies will help to identify these factors. We want to follow up the germplasm introduction work, with better evaluation under widely different conditions. Limiting factors may cause proneness to disease. Acidic soils often have shortages of important plant nutrients.

In the next years agronomists will be required to identify the weak links in the current efforts. CIMMYT's staff in wheat is expected to grow from 30 to 38 over the next five years. Especially agronomists are needed in the Regional programs. Base staff will remain around 20 senior posts.

Throughout this presentation, up to this point I have used wheat as the principal crop. But within the International wheat program in CIMMYT much work will continue on durum wheats that cover some ten percent of the world's wheat lands. Also a modest breeding effort will be placed on barley improvement. Results from the breweries are among other things, very high tax revenue, especially in tropical countries. CIMMYT is working towards barleys that can yield very well in a wide range of conditions. Its emphasis is on highly nutritious barley that can be grown in poorer soils at high altitudes. Some of the world's poorest people live in these difficult conditions, and barley can help them. Besides genes for good protein quality, genes for free threshing in barley have been crossed into wide adaptation types. Barley is an efficient water user.

By using breeding methods from spring wheats, recently developed barleys now combine good plant type with earliness and wider adaptation. Much work is required in barley diseases. But copying the breeding models used in wheat, has already given promising results.

Very few countries have utilised these barleys so far. And I am told that breweries can make beer from practically any kind of barley now, using enzymes or certain concentrates.

I have waited with triticale until the last. Since 1968 CIMMYT has worked intensively on this manmade cereal, a cross between tetraploid wheats such as durum wheat and diploid rye.

For the last five years in Regional tests in Eastern and Southern Africa, we have tested Triticales together with the best bread wheats and durums we could find.

It appears that Triticales can produce on average at least 20 percent more than the best bread wheat. Especially in acidic soils, yields can be twice as high as for wheat. Countries in the Region are all waiting to capitalize on this new resource.

There are some questions yet about grain quality. It does not look like wheat yet. There are some diseases that are uncommon to most wheat growers. Bacterial diseases and Fusarium can be devastating in Triticale. But the rusts are so far unable to do much damage in Triticale. Some developed countries have begun to produce Triticale on a small scale. Kenya has announced a policy of encouragement of Triticale. It has decided on a price, the first country to do so.

The general observation on lack of suitable land for expansion of food production is so far not as valid in this Region as in other parts of the world. With Triticale some land unsuitable to wheat may become useful as grain producing area. This requires still much work.

But the new Triticale varieties may serve as a catalyst to mobilize more resources.
CIMMYT's work now also include some wide crossing of certain grasses and wheat. This may provide for new genotypes that can conquer other soil difficulties. One grass from an ocean beach has now been crossed with wheat. In the distant future salt tolerance of wheat can be increased. This can make investments in irrigation a more safe proposition. Also certain diseases may become less threatening if we can transfer resistance into wheat.

SUMMARY

We are looking at wheat as one of the major food crops that will be expanded into the Region. As a new crop in this part of Africa, it still requires much understanding. Governments are faced with ever growing import demand for wheat.

World supplies of wheat are provided only by a small number of wheat exporters. As urbanisation increases rapidly in the region, wheat demand may grow from 5 million tons to 20 million tons in 20 years.

This conference is held at a time when some new production methods are being tried. We are faced with very difficult soil conditions, and difficult disease conditions. By communication among people from widely different disciplines and wheat growing conditions we expect to get a better knowledge of how to make the most from the new technology that the International Centres together with national programs have developed.

The situation in this Region is very urgent. Land and water are still available in several countries. Can we formulate the best ways to meet our demands for food on the short term and on a longer term? How can we best use the available resources without destroying our soils that must provide for many more generations to come? We know the current need for growing imports. Let us state clearly what we can achieve. We must present our policy makers with realistic biologically sound information. We must labor during this workshop to gain insight in the many factors both biological and social, that dominate our use of available land, water, genotypes and manpower.
KENYA

Wheat is grown in the Kenyan highlands bordering the Rift Valley, at altitudes of 1800 to 3500m. At Njoro, (2400m) rainfall averages about 950mm. At higher altitudes it is about 100 mm more, and at lower altitude about 100mm less. Planting and harvesting dates, and days to maturity vary because of the effect of altitude on temperatures and precipitation. Only one crop per year is taken from the land.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Planting</th>
<th>Harvesting</th>
<th>Days to maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low and medium altitude (1800 - 2600m)</td>
<td>April - June</td>
<td>September - October</td>
<td>130</td>
</tr>
<tr>
<td>High and very high altitude (2600 - 3500m)</td>
<td>June - August</td>
<td>December - February</td>
<td>150</td>
</tr>
</tbody>
</table>

Land devoted to wheat production has varied considerably since 1955 when 140 000ha were planted. Following a decline in the 1950's the area increased to a maximum of 167 000 ha in 1968 but this was followed by another decline to 83 000 ha in 1974. By 1977 the area, was again up to 138 000 ha but dropped to a low of 67 000 ha in 1979.

Yields have also varied considerably since 1955 but generally show a gradual increase. In 1955 yields averaged 0.81 t/ha but reached 2.5 t/ha in 1979. Wheat production reached a high of 244 000 tons in 1967 but has levelled off in recent years, and in 1979 was about 150 000 metric tonnes.

Wheat research in Kenya is conducted mainly by the Ministry of Agriculture with major emphasis at the National Plant Breeding Station, Njoro. At N.P.B.S. the objectives of research include:

1. the development of disease resistant varieties with high yields and quality potential,
2. determination of nutrient requirements of crops; weed and insect control practices, tillage and moisture conservation practices essential in wheat production, and
3. extension of information to extensions officers and to farmers by conducting fields days. The Govt. of Canada, through the Canadian International Development Agency (CIDA) assist in this program at Njoro. Other government agencies are:
   (a) The National Agricultural Laboratory (NAL) located at Nairobi that provides soil testing and research facilities and,
   (b) National Seed Quality Control Service (N.S.Q.C.S.) at Lanet that conducts yield testing of lines considered for release, and seed certification.

In addition, a regional base is maintained by CIMMYT at the N.P.B.S., Njoro, for the main purposes of: (1) introducing germplasm that may be used in the Kenya national program and (2) pre-screening of germplasm from all areas of wheat research for use in this region.

— A. Ridley
Agronomist, N.P.B.S., Njoro.
TANZANIA

In 1968, following a feasibility study on expanded wheat production in Tanzania by Beamish et al., Tanzania embarked on a Wheat Research Project with technical assistance from Canada. The primary objective of the project was to identify the agronomic practices which were limiting wheat production in the country, secondly to establish a research team and research facilities to monitor the problems of mechanized wheat production under dryland conditions of the northern highlands of Tanzania. This was to be achieved by training Tanzanians through counterpart – on the job training with Canadian experts, backed by professional training in specialized research disciplines.

During the first five years of the project (1970-75), the foundations of the first objective above were pretty well identified. Research work was started in the following main areas:

(a) Breeding, selection, and evaluation of improved wheat varieties,
(b) Soil Survey studies on the Hanang plateau in the northern highlands of Tanzania,
(c) Soil and crop agronomic studies on wheat production including tests of appropriate, farm machinery and implements suitable for these marginal rainfall districts (500-900mm annual rainfall), and
(d) Soil fertility studies.

The highlights of initial research experiences of the project were compiled and published for wheat farmers’ use in the wheat bulletin entitled “Wheat Production in Tanzania 1977.”

The success of the second objective was spectacular but incomplete.

However the achievements of the first phase of the wheat research project prompted the need to continue and expand the research activities and expand financial and technical support to mechanized wheat farms in the area. Under phase two of the Tanzania – Canada Wheat Program (1979-84) Canada has agreed to expand the research facilities by establishing a fully fledged Agricultural Research Institute at Selian (S.A.R.I.) in Arusha which would primarily continue with the research activities in wheat and also extend support in such related crops as barley, durum wheat, triticales as well as crops like beans and oilseeds which can be grown under mechanized operations using basically the same machinery as for wheat production.

The facilities at the S.A.R.I. will also include such facilities as a workshop complex with training facilities for introductory courses for mechanized farm operators. Initially these operators will come from the National Agricultural Food Corporation wheat farms which are also being developed under Canadian assistance. But it is envisaged that such facilities will be ideal for training farm managers and farm machine operators from mechanized cooperative and village farms in the area.

Tanzania Research Staff Development will be intensified during this period. Indeed Canada has deliberately allocated lots of training funds to ensure that over and above project requirements, Tanzania staff are developed and trained at all levels so that they can take over the research programme when the Canadian input is terminated yet allowing for inevitable turnover to other national programs.

Staff retention and promotion are the stumbling blocks in the project. Once trained and having acquired experience project staff are often attracted to other organizations which offer better pay and other fringe benefits. It is hoped that with the establishment of the Tanzania Agricultural Research Organization, this trend will be arrested.
The role and the adoption of wheat research skills and technologies have enabled wheat farms in the Basotu areas to turn from nearly abandoned wheat production in 1973/74 with average yields of 0.5 t/ha to economically viable production of over 1.5 t/ha in 1979/80. The National Agricultural Food Corporation which is responsible for the development expansion in the Hanang district is currently expanding wheat production farms at an ambitious rate of 4,000 ha a year to a total of 28,000 ha by 1984/85.

It is envisaged that there is potential land for mechanized wheat production in the Hanang plateau of over 40,000 ha. When this is fully developed Tanzania will realize about 120,000 tons by the mid 1980's. It is against these projections that continuous research is needed to keep ahead of production problems which will surely be on the increase as the area under wheat production expands.

— A.S. Mosha
Director, S.A.R.I., Arusha.

MALAWI

Wheat has been grown in Malawi since its introduction by the early Missionaries during the last century. Cultivation has been limited to highland areas where it is grown during the cool season, April to August, that gradually merges into a hot dry harvesting period September to October.

Smallholder farmers grow wheat as a cash crop. Farmers until 1979, used to keep their own seed which is mixed and of poor quality for baking. Their varieties are very susceptible to rust diseases and give low yields. As a result production has been low and static. Wheat fields vary from 0.25 ha in size with a mean of 0.5 ha and average yield of 0.7 t/ha. Estimates of the National Rural Development Programme (NRDP) have shown that 1,000 ha of wheat are grown at present and that 2,228 ha could be developed into wheat schemes.

The demand for wheat products is increasing, mostly due to the increasing population and standard of living. More people now consume wheat products such as bread, cakes, biscuits, "chipate," "mandazi" and "samoosa." For example in 1976 20,000 tonnes of wheat were imported at a cost of K1.0m and three years later the wheat imports rose to 26,000 tonnes at a cost of K3.6m.

Since Malawi is self-sufficient in all its food crops except wheat it has been decided by the government to put greater importance on wheat production.

The possibility of increasing wheat production in Malawi was not seriously considered until a Wheat Research Station was established in 1968 at Tsangano in the Kirk Range (main wheat research growing area). The main objectives of the wheat research programme has been to increase wheat production by:

(a) Selecting high yielding varieties that are ecologically suited to Malawi, possessing a high level of resistance to major wheat diseases (stem rust, leaf rust and septoria), and which have grain of suitable quality for baking. Lodging and minor diseases are also taken into consideration,
(b) Determining fertilizer requirements under both irrigated and rainfed conditions,
(c) Determining the best time to plant wheat especially under irrigation,
(d) Developing new production technology,
(e) Introducing wheat growing on tobacco estates and on rice settlement schemes.
As far as breeding is concerned no crossing work is undertaken at present. Efforts are concentrated on introduction and selection from screening and yield nurseries received from CIMMYT, RSA, Zimbabwe, Kenya and other international organizations concerned with wheat improvement.

— P.H. Mnyenyembe
Chitedze Research Station, Lilongwe.

ZIMBABWE

There has been a marked change in wheat production in Zimbabwe since 1965. The current breeding programme was started in 1956, and in 1965 the country produced 4% of its requirements. By 1974 this had increased to 75% and in 1976 self-sufficiency was achieved. This was possible firstly because of the opening of large irrigation schemes in the south-eastern lowveld and secondly because of incentive prices paid for wheat. The crop produced in 1978 was the biggest ever, and since then there has been a slight decline. Coupled with the increase in production, there has been a steady increase in consumption, which in 1980 overtook production.

The increase in national yield has also changed dramatically. In 1952 it was 1 t/ha and this increased to 2.2 t/ha by 1964. It then steadily increased to 3.4 t/ha by 1968, to 4.0 t/ha in 1971 and 4.9 t/ha in 1980.

Big differences in yield levels are found between the highveld and the lowveld. The reason for this is that generally the lowveld is not suitable for wheat production, despite the fact that this was the area where the initial expansion took place. In recent years large scale expansion has taken place in the highveld, as more dams have been built, to the extent that in 1980 about 80% of the national crop was grown at medium to high altitudes. This unsuitability of the lowveld is due mainly to the short winter season with high temperatures during May and August. Generally the highveld has a much cooler climate with a longer period of low temperatures.

The breeding programme has played an important role in wheat production. This has been achieved by the breeding of dwarf varieties and in this regard the development of the variety Mkwasine (S 948 A5 A3) has been a key factor. This variety contains 3 dwarfing genes and has enabled dwarfness to be exploited to the full by the breeding programme. The first triple dwarfs were released for commercial production in 1966, and as such, Zimbabwe was probably the first country in the world to utilize triple dwarfs commercially. This variety is also being used in breeding programmes in many other countries.

The breeding programme is a pedigree line selection one with F2 populations being developed in Salisbury. Use is made of a very high altitude site in the Eastern Highlands to grow a summer generation. In this way 2 generations a year are grown, thus reducing time to produce varieties. Testing of Advanced varieties is done at 13-15 sites a year, and 3 years data is required before a variety is considered for commercial release. Research work on planting date, seed rate, nitrogen application and irrigation studies have been carried out. The result from these are at present being used in making recommendations for commercial production.

(Note — This is an abstract of a paper by C.J.J. Badenhorst, Wheat breeder at the Crop Breeding Inst., Dept of Res. & Specialist Services, P.O. Box 8100, Causeway)

— Paper presented by G.W. Herd
Plant Protection Research Institute, Causeway.
MADAGASCAR

Wheat is an old crop in Madagascar because in 1900 the production was already 200 tonnes on the Volcanic Soils of the highlands (Antsirabe). But because of rust attacks this production decreased very quickly. In 1969 the Agronomic Research Institute (IRAM) started a research programme. A wheat mill was built in Antsirabe at that time (Tombontsoa). But again, the rust attack decreased the yield drastically.

All these crops have been grown under rainfed conditions. Since then, it has been found that disease attacks are very low during the dry season in paddy fields. Therefore we have concentrated our research in these fields. There is a potential of 300 000 ha of paddy fields more or less suitable to wheat in the highlands, of which about 25 000 ha can be used with good results.

The actual wheat consumption is 60 000 tonnes but this is increasing by 4% per year. Total population is about 9.5 millions, increasing by 2.8% per year.

In 1972 a joint cooperative project between Norway and Madagascar (FIFAMANOR) started a research programme and extension on wheat, potatoes and fodder crops.

In 1980, the production of wheat was estimated at 500 tonnes. A wheat mill with a capacity of 60 000 tonnes will be finished in the near future in the area of the project.

So far, two growing seasons are being used:

(1) The rainy season: from mid January to May with high temperatures and a great risk of diseases attacks. The crop is grown on the hills with an altitude higher than 1500m. The actual yields are between 0.5 to 2.0 t/ha.

(2) The dry season in paddy fields from mid May to October. Diseases attacks are very low but the main problem is water management. The yields are higher than during the rainy season: 1.5 to 3.0 t/ha. The suitable areas should be higher than 1250m above sea level; peat soils should be avoided.

We need varieties resistant to diseases (rusts, leaf diseases), to high temperatures and to low pH soils. Three varieties are now grown commercially; all of them are resistant to rusts but not fully resistant to Septoria and Helminthosporium. They are:

- Romany: a tall variety adapted to acid soils, but late maturing. It is grown only under rainfed conditions on the hills.
- Fe: early variety suitable to the paddy fields, but the yield is lower than that of 763.
- 763: This variety can be grown either under rainfed conditions or under irrigation in the paddy fields.

Results of last year trials during the rainy season show that some FIFA crosses and some IBWSN lines performed better than Romany at the station, but in trials in farmers’ fields, they were not better than Romany. Some Brazilian varieties were tested, last year, for the first time on a larger scale. They are adapted to lateritic soils but have certain drawbacks: they are very often taller than Romany, late maturing and susceptible to rusts. None of the tested varieties was outstanding but further work is worthwhile.

The varieties of Triticale always give good results. The yield has been 20-30% higher than that of wheat.
In the paddy fields three new lines seem to have a higher yielding capacity than 763. Each one has its drawback, not fully resistant to rust, or later maturity than 763 but these problems are not too important in the paddy fields.

— Mr. Rakotondramanana
FIFAMANOR, Antsirabe.

ZAMBIA

Zambia has grown wheat since the 1940s and was self sufficient prior to independence; however few ate bread. Like Zimbabwe, this area grew irrigated wheat in the dry winter season. In 1973 and 1974 no wheat was grown. This coincided with a large increase in consumption, highest ever world prices and a reduction in the price of copper, the main source of foreign exchange. Zambia requested assistance from Canada and a feasibility study team recommended the growing of rainfed wheat, as in Tanzania and Kenya for many years.

Rainfed Wheat was tried in Southern Province but the temperatures were found to be too high in the early growth stage for wheat. One lesson that seems to have to be re-learned by production oriented people, who are often in a hurry, is that Research must precede production. After failure in Southern Province production was moved to Mbala in the north at higher altitudes. But production continued to go ahead of research. As a result production has been well below its potential. Soils — agronomists, pathologists and breeders are now providing varieties and cultural practices that will allow the crop to show its potential. The Production Farm has about 1000 ha of wheat growing this season and yields of 1.5 to 2.0 t/ha are expected.

The Integrated Rural Development Programme, IRDP, has been encouraging small scale growers to produce wheat on half to 1 hectare fields. The problems and solutions of rainfed wheats will be discussed during the workshop.

Irrigated wheat is highly successful. Some farmers average 6 t/ha and the average for Zambia was just over 4 t/ha in 1980.

The 2600 ha sown last year produced 11 000 tonnes, or 10% of the requirement, as average imports are close to 100 000t.

The price in Zambia is K24 per 90kg bag, nearly double the average world price. This is not enough incentive to encourage commercial farmers to grow a great deal more wheat. Costs are high and irrigated wheat requires a large foreign exchange input. Some increase in area is taking place and a number of schemes that include wheat are in the planning stage.

Quick self sufficiency in wheat is an obvious objective and it seems most likely to come from large scale production projects. One such project is well into the development stage. This, the Mpongwe project, is believed to have the potential to produce perhaps half of Zambia’s requirement. We will hear more about this EEC Project also later in the Workshop.

Rainfed wheat is easier for emerging farmers to manage and is believed to have an important role to play in production. It will contribute more to long term development than to quick self-sufficiency.

Wheat production on the flood plains of the Zambezi and on dambos using residual moisture also has potential and is being promoted.
Research in Zambia for rainfed wheat is carried out by Canadians with strong support from Mr. Raemaekers on a Belgian assistance programme, both centred at Mount Makulu Research Station. The same team do the breeding and pathology research for irrigated wheat. This is supplemented by research on horizontal resistance at the National Irrigation Research Station and breeding at the University. The N.I.R.S. also conducts research on the agronomy of irrigated wheat. The EEC project at Mpongwe is also testing varieties and conducting agronomy trials.

The main variety testing and agronomy research for rainfed wheat is carried out at Mbala in Northern Province where the rainfed wheat is grown.

— E.A. Huré
Wheat Coordinator, M.M.R.S.

COMMON FEATURES OF THE NATIONAL PROGRAMS

In the discussion of the above noted national programs a number of common features were noted:

(1) All reported a research infrastructure, production oriented,
(2) A varietal testing program, emphasizing disease resistance, adaptability and yield,
(3) Training and involvement of local staff,
(4) A recognition of the fact that the potential for wheat production has yet to be realized in most countries,
(5) Problems of developing release mechanisms for new varieties, and
(6) Involvement of international agencies.
AGRICULTURAL SCIENCE ASSOCIATION OF ZAMBIA

Tuesday, March 10, 1981. 1400 hours
ASA: ASSOCIATION PAPERS
CHAIRMAN: Mr. W. Chibasa

14.30 – Chairman’s Introduction

1415 – Wheat root development in acid soils from Mbala.
J.A. Toogood, University of Zambia

1430 – Some physical properties of the Katito Wheat Farm, Mbala soils.
K.S. Gill and J.A. Toogood, University of Zambia

1445 – Radioautographic studies of herbicidal influence on absorption of 32, 35, and 45 in maize (Zea mays L.)
R.K. Rajoo and C.P. Ghonsikar, Mt. Makulu Res. Stn, UNZA

1500 – Ear characteristics in relation to kernel rots in opaque-2 maize (Zea Mays L.)
R.G. Kaporia, University of Zambia

1515 – Control of bean rust (Uromyces phaseoli Arth.) by ULV applications of a copper fungicide.
J.N. Zulu, University of Zambia

1530 – Importance of Septoria leaf blotch and possibilities of breeding for resistance in sunflower (Helianthus annuus L.) in Zambia.
P.A. Lepoint, Mount Makulu Research Station

1545 – A study of interrelationships of seed yield components in flax (Linum usitatissimum L.)
M.S. Mwala, Mount Makulu Research Station

1600 – Appropriate weed control strategies for small farmers.
J. Parker, Mount Makulu Research Station

1615 – Efficiency of traditional methods of pest control in stored grain.
E.M. Sakufiwa, Mount Makulu Research Station.

(Note – Some interruptions and a break for tea delayed completion of the program until 1700 approximately)

ABSTRACTS OF PAPERS

Following are the abstracts for the above listed papers. Readers interested in receiving a copy of the full paper should contact the author. Names and addresses are given in an appendix.
At the September, 1980 meeting of the Rainfed Wheat Research Committee Dr. E.A. Hurd reported that root development was restricted to the top 100mm of soil, with a few roots penetrating to 150mm. The data provided by Dr. K.S. Gill on Db indicated that no hardpan exists to cause this restriction. It appeared that low pH (3.8 in CaCl₂) was the inhibiting factor. To test this hypothesis wheat was grown in pots with soil limed to 0, 15, 30, and 45 cm depths to a pH of 7. Four replicates were used in a latin square design. Pots were boxes made of plywood 65 x 12 x 12 cm, placed in a pit excavated to 50cm depth. The lime, Ca(OH)₂, was added and mixed with each layer of soil as it was placed in the boxes. Fertilizer mixture D was applied at 300kg/ha at a depth of 10cm. Wheat was planted, 6 seeds per pot at a depth of 5cm and later thinned to 5 plants per pot. All pots were then watered and waterings repeated when any signs of wilting appeared. At the start of heading watering was stopped in order to encourage maximum depth of root growth. A week later the dry matter yields of above-ground growth was measured and root growth in the 0-15, 15-30, 30-45, and 45-60cm layers examined and weighed and the data analyzed. Results showed conclusively that root extension in the Mbala soils is inhibited by acidity. Growth of the crop was best in pots limed to 45cm depth and root-growth was good to whatever depth lime was applied.

SOME PHYSICAL PROPERTIES OF THE KATITO WHEAT FARM
MBALA, SOILS
Drs. K.S. Gill and J.A. Toogood

Depthwise changes in physical properties of soils are an important factor influencing plant growth, particularly distribution of roots in various layers. Initial observations at the above farm indicated that wheat roots were confined to the surface 15 cm only. Presence of a compact layer was considered as the possible reason for non-penetration of roots beyond 15 cm. Soil samples for every 15 cm layer down to 90 cm depth were taken with the help of a 10 cm ID and 15 cm high core sampler from 12 spots in the above farm. These samples were used for the determinations of bulk density, particle size distribution, particle density, porosity and amounts of water held under 100 cm suction and 15 bar pressure. Clods were also collected simultaneously for bulk density determination by the clod method. On the basis of the number of years a field was cropped the 12 spots were grouped into three sets.

The bulk density by both core and clod methods as well as % sand in most cases decreased significantly with increase in depth. The differences in bulk density values calculated by two methods were not statistically significant. The similar results by two methods and the significant decrease in % sand with increasing depth indicated that the bulk density changes were possibly due to change in the % sand. There was no compact layer in the soil to prevent the roots from going deeper. The results on the other physical properties were also statistically analysed and are presented.

RADIOAUTOGRAPHIC STUDIES OF HERBICIDAL INFLUENCE ON ABSORPTION
OF ³²p, ³⁵S AND ⁴⁵Ca IN MAIZE (ZEA MAYS L.)
R.K. Rajoo and C.P. Ghonsikar

Influence of atrazine, DPA, EPTC and 2, 4-D on uptake of nutrients like phosphorus, sulphur and calcium was studied radioautographically in maize. The treatment of these her-
bicidaes were kept twice, normal, half and quarter of the recommended dose. The radioauto-
graphic observations reveal that atrazine and 2, 4-D reduced $^{32}P$ uptake gradually with
increasing dose from subnormal to twice normal level. DPA and EPTC also reduced its uptake
but level differences were marginal. However EPTC at 8kg/ha increased $^{32}P$ absorption more
than control probably due to reduced physiological growth. Uptake of $^{35}S$ was also progressively
reduced by all four herbicides except for the difference that level difference in DPA was mar-
ginal. In case of $^{45}Ca$ absorption, atrazine and EPTC lowered radioactive material with normal
dose whereas subnormal dose of DPA increased uptake but higher doses decreased it. 2, 4-D was
not very effective in reducing $^{45}Ca$ uptake at any of the levels. All the three nutrients were
uniformly distributed in the plant body in spite of reduction by herbicides.

EAR CHARACTERISTICS IN RELATION TO KERNEL ROTs IN OPAQUE-2 MAIZE
Dr. R.G. Kapooria

Homozygous Opaque-2 maize from a genetically broad based population was tested for
disease responses and their relationships to husk coverage and ear orientation. studies were
made with kernels pretreated with 10% sodium hypochlorite, 0.135g/liter streptomycin sul-
phate, and 2 ug chlorotetracycline and laid on blotters soaked in 0.67 g botran in 45ml sterile
water. Significant differences existed between ears with loose and tight husk but ear orientation
did not show any effect on kernel infection. Effect of husk coverage was similar for erect and
drooping ears. High % of infected kernels occurred on top than middle or bottom of the ear.

Seven genera and nine species of fungi were isolated from 12000 maize kernels. 
*Fusarium moniliforme* and *Cephalosporium* sp. were the dominant fungi whereas *Alternaria
alternata*, *Aspergillus flavus*, *Fusarium graminearum*, *F. oxysporum*, *Nigrospora* sp., *Penicillium
oxalicum* and *Mucorales* (unidentified) were less abundant.

The relationships between kernel position and the occurrence of fungi was also studied and
showed higher numbers of fungi at the top and progressively less numbers from the middle,
to the bottom of the ear. *Fusarium* and *Cephalosporium* spp. were found distributed all over the
ear. Greater diversity of fungal flora existed in ears with loose then with tight husk. Though ears
with complete husk coverage should provide an effective barrier to certain invading fungi, loose
husk type cultivars are prefered by farmers because such ears ensure rapid drying.

CONTROL OF BEAN RUST (*U. PHASEOLI ARTH.*) BY ULV APPLICATION OF A
COPPER FUNGICIDE
J.N. Zulu

Despite the long held view that copper acts essentially as a protectant fungicide, there
have been suggestions that it may be absorbed into leaves and even translocated when such
formulations are applied in this way. No experimental evidence has been produced to support
this hypothesis nor is there any clear indication why ULV applications of the material are so
effective. The problem was critically examined using an oil based copper fungicide formulation.

Bean plants (*Phaseolus vulgaris L.*) were used when the unifoliate leaves or trifoliate leaves
were fully expanded twelve days or twenty days respectively after sowing. For inoculation of
plants freshly-collected uredospores with about 75% germination capacity, were thoroughly
mixed with talc in a specimen tube or Fissions ‘Whirlmixer’ for five minutes. The plants were
inoculated in a settling tower and the leaves were later moistened with water and kept in an
incubator for 24 hours at 18°C. Infection was assessed as number of pustules per cm$^2$. leaf.
Fungicide application was by a mini ultra low volume applicator (miniulva) with a number 4
constrictor.
The experimental data did not support the hypothesis. The chemicals appeared to act solely as protectants and their ability to control disease appeared to be related to their distribution on sprayed leaves (especially in relation to uredospore deposition), their limited redistribution on leaves and their tenacity.

IMPORTANCE OF SEPTORIA LEAF BLOTCH AND POSSIBILITIES OF BREEDING FOR RESISTANCE IN SUNFLOWER (*HELIANTHUS ANNUUS* L. VAR. *MACROCARPUS*)

P.A. Lepoint

As a result of the popularisation of locally bred cultivars, sunflower has become the major oilseed crop in Zambia. Leaf spot (*Alternaria helianthi*), leaf blotch (*Septoria helianthi*) and stem rot (*Erwinia aroideae*) are the major diseases of sunflower. Exotic varieties of Russian origin have virtually no resistance to *A. helianthi* but they possess good horizontal resistance (sensu J.E. Van der Plank) to *S. helianthi*. Furthermore, exotic hybrids often carry complete resistance to leaf blotch conferred by a single dominant gene which is strongly linked to the restorer fertility gene used in hybrid production.

A paired t-test conducted on lines segregating for Septoria resistance revealed a 26 ± 6% (P=0.05) loss in yield to the disease. A local hybrid variety possessing R gene derived from the cultivar, Australian hysun (Pacific Seed Company, Australia) began to show some leaf blotch symptoms late in the 1980-81 season. Differential interaction was clearly established when the two parent lines were tested against different isolates of the pathogen. It would then seem that until strong genes of resistance are available, vertical resistance (sensu Van der Plank) to *S. helianthi* should always be backed up by horizontal resistance in order to provide reliable varieties.

A STUDY OF INTERRELATIONSHIPS OF SEED YIELD COMPONENTS IN FLAX (*LINUM USITATISSIMUM* L.)

M.S. Mwala

In order to establish selection criteria in a breeding programme aimed at improving seed yield, there is need to identify those morphological and/or physiological plant aspects that are associated with the trait. This study with flax was aimed at finding out:

1. whether there were differences among genotypes of flax with respect to seed yield component,
2. the magnitude of relationships between the components and seed yield,
3. which components were more important in determining seed yield, and
4. magnitudes of their interrelationships and implications.

Fourteen components were obtained (96 days after planting) from 14 seed — and 4 fibre-flax genotypes sown at one location in South Dakota in 1979. Four rows plots, seeded at 63 seeds per 31 cm, arranged in a randomized complete block design with four replications were used. Seven plant attributes (total dry weight, number of plants, total boll dry weight, 100 boll dry weight, 100 boll seed dry weight, number of seed in 100 bolls and residue boll seed dry weight) were obtained directly from a sub-plot of 0.108m² and used to calculate other seed yield components (bolls per plant, boll weight per plant, seed dry weight per plant, seeds per plant, seeds per boll, bolls per sample, 1000-seed dry weight and seed dry weight per boll), harvest index and seed yield from sample.
The analyses led to the following conclusions:

1. All genotypes were different with respect to all studied components.
2. All studied components were significantly ($\alpha=0.05$) associated with seed yield except bolls per plant. Total boll dry weight had the highest correlation, $r = 0.927$, with seed yield whereas bolls per plant had the lowest, $r = 0.197$.
3. A combination of total plant weight, boll dry weight, seed per boll, boll number, seed number, 1000-seed dry weight seeds per boll and seed weight per boll explained 98% of the variation in seed yield (i.e. $R^2 = 0.98$).
4. Seed weight per boll had the highest direct effect on seed yield ($P_{18} = 0.5335$) whereas seeds per boll had the lowest of 0.2488. Indirect effect of boll number on seed yield via seed number was the highest (0.4221). Absence of significant negative indirect effect suggested that improvement of seed yield based on positive selection of the seven components would be effective. Plant weight, seed per boll and 1000 seed weight were found not to be the important factors in determining seed yield compared to boll weight, seed weight per boll and seed number.

**APPROPRIATE WEED CONTROL STRATEGIES FOR SMALL FARMERS**

J. Parker

The aim of this study was to provide information on the prospects of herbicide use on the small farm. Atrazine-based maize herbicides were applied through CDA (Controlled Droplet Application) sprayers by 20 ox-owners, each cultivating 5-20 ha.

Generally, while there were some problems with the sprayers (poor maintenance) and old herbicide (precipitation) acceptable weed control was achieved. Poor land preparation, dry weather following application, spraying post-emergence of weeds and the presence of resistant weed species were factors that led to incomplete control in some cases.

Detailed economic data from one season showed herbicide use to yield a 17% lower net benefit than conventional cultivation, and a 39% lower return to capital. Labour profiles suggested that a maize herbicide has limited scope in reducing labour bottlenecks in this farming system. An additional risk of herbicide use is the increased dependence on unreliable extension, credit and input supply agencies.

Results in a Research Station trial from one season showed that the commonest traditional weeding regime resulted in a yield that was 77% of a clean-weeded control, and that the critical period of weed competition was between 10 and 40 days after emergence of the crop.

The herbicide system tested seems to have little to offer the farmers studied. A totally different picture could well emerge if herbicide was investigated in less competitive and less easily-weeded crops (e.g. cotton, rice) and/or among different farmer categories.

**EFFICIENCY OF TRADITIONAL METHODS OF PEST CONTROL IN STORED GRAIN**

E.M. Sakufiwa

Small farmers in the rural areas of Zambia have evolved their own methods of reducing post-harvest losses in stored grains. It is necessary to assess the effectiveness of these methods before attempting to introduce any new recommendations for storage. The present work was undertaken to determine the efficacy of traditional methods in controlling pests of stored maize (*Zea mays* L.). Maize on the cob, with and without husks, and shelled maize was used. Cobs with and without husks were stored in four separate cribs raised 1.5 m above ground. Under two
of the cribs a fire was lit every morning and afternoon to smoke the stored maize. Shelled grain was mixed with either sand or wood ash and stored in clay pots placed on a wooden platform raised 1.5 m above ground. The control consisted of shelled maize alone stored in a clay pot. There were no replications. The moisture content of the grain, the percent visible insect damage per kg of grain and the numbers of live, adult insects per kg were assessed at the start and on three occasions at four week intervals. Moisture content was determined with a Cera-Tester, type T.C.T. (A/S N. Foss Electric, Denmark).

At the start, the mean moisture content of the grain in all treatments was 10.9%, and after 12 weeks this figure had risen to 14.7%, with the smoked treatments having a mean of 13.5% and the others, 15.1%. At the beginning about 2.5% of the grain was visibly damaged by insects. After 12 weeks almost 50% of the grain was damaged with the control and the de-husked cobs which were not smoked having the highest percentage of damaged grain. Least damage was noted in the smoked treatments. Insect numbers increased from a mean of 13 at the outset to 541 after 12 weeks. The greatest number of insects were recorded on cobs which were not smoked, while the least number occurred on smoked cobs without husks. The main insect pests were *Sitophilus* spp. and *Tribolium castaneum* Herbst. Among the methods tested, smoking promoted drying of the grain and also restrained the increase in insect numbers which also reduced damage.
The Chairman introduced Dr. J.M. Prescott to give the keynote address.

CIMMYT’S APPROACH TO PATHOLOGY RESEARCH

In 1979, over 50 developing countries harvested 100,000 ha or more of maize, while more than 25 developing countries harvested over 100,000 ha or more of wheat. Even so, there are more hectares of wheat than of maize in developing countries, and still, many countries are heavy net importers of wheat. Maize and wheat are major sources of food and nutrition in over 35 developing countries. In a number of these countries, wheat and maize account for well over half of the average per capita caloric intake and a substantial portion of the total protein as well.

CIMMYT’s main roles in the world today are the development of germplasm for use by national variety improvement programmes, assistance in developing better management or cultural practices, and training. CIMMYT does not release varieties, this is up to the various countries with which we cooperate. From the germplasm side, what are our products and what are the main aims of our research effort? The overall goal is the development of broadly adapted high yielding varieties or cultivars.

Bread wheat: Current breeding emphasis is given to spring x winter habit crosses, multiline component development based on cross 8156, greater disease resistance, enhanced aluminium toxicity resistance in certain lines, development of earlier high yielding materials, and wheat for the humid tropics.

Durum wheat: Main emphasis on developing greater disease resistance, improved straw strength, better leaf characteristics, added cold and drought tolerance, greater earliness in high-yielding types, and improved industrial quality.

Triticale: Objectives include selection for improved seed type, higher test weight, widening of the germplasm base while maintaining the effective levels of disease resistance, and exploratory research on the potential of octoploid (bread wheat x rye) Triticale types.

Disease resistance is a major part of all aspects of CIMMYT’s wheat programme. There are about 40 species of fungi, bacteria and viruses that are parasitic to wheat, barley and Triticale. These pathogens are responsible for the diseases which cause major reductions in yield among the small grain cereals. CIMMYT germplasm, through the system of international nurseries is exposed to a large number of these pathogens responsible for small grain diseases. By repeatedly testing the materials contained in these nurseries for disease reaction in a wide number of locations around the world, our breeders and pathologists are able to identify and develop wheat, barley and Triticale genotypes possessing a wide spectrum of resistance.

Among the most serious diseases of wheat and other small grain cereals are the rusts: stem, leaf, and stripe. Since these diseases, the rusts, are considered dynamic diseases, often
changing by mutation, or other means, they provide a continuous threat to wheat varieties, including varieties previously considered resistant.

Our pathology group provides support information to the wheat, barley and Triticale breeders. The pathology group is responsible for artificially inoculating nurseries grown in Mexico and other countries of the world to impart heavy disease pressure for the selection of resistant lines. In turn, these resistant lines are crossed to agronomically desirable types with good yield potential, and the resulting progeny is distributed to variety improvement programs around the world through the international and regional screening nurseries. Screening for diseases that either are not present or not sufficiently severe or virulent in Mexico must take place in “hot spot” areas where they naturally occur. Our regional programs provide this important function. For example, East Africa is a good area to select for stem rust (also stripe and leaf) resistance; the Andean region has good locations to select for stripe rust resistance; North Africa and the Middle East for leaf rust and Septoria leaf blotch resistance; South America for barley yellow dwarf virus resistance; South-Central Africa for resistance to Helminthosporium and powdery mildew diseases; etc.

For these and other important diseases, we seek research collaboration with scientists located in the appropriate geographic areas to provide information on and to improve the resistance levels of the materials distributed worldwide.

Pathologists assigned to regional programs are also actively involved in disease surveillance and disease screening of experimental lines through regional nurseries operated in Asia, Africa (including the Middle East) and Latin America, plus all the international nurseries distributed worldwide from Mexico.

Pathologists conduct greenhouse experiments designed to monitor changes in virulence of the three rusts. In fact, collaborative projects are underway in connection with a number of national programs on this subject. In addition, cooperative, highly specialized research is conducted on stripe rust in the Netherlands and Turkey, on stem rust in Egypt and Kenya, and leaf rust in Yugoslavia and Turkey. Another International Agricultural Research Centre, ICARDA, cooperates with CIMMYT on these diseases also. Specialized screening of material for resistance to Septoria leaf blotch is conducted in Turkey, Israel, Ethiopia, and now Portugal. The same is true for barley yellow dwarf virus (BYDV) in South America.

Wheat pathologists also provide consulting services to national programs. Principally, we assist national programs in disease survey research and by visiting, with national program scientists, the many locations where they have planted disease observation and screening nurseries, working hand-in-hand with these cooperators, to evaluate the disease resistance of the material.

The Disease Surveillance Programme is part of CIMMYT’s regional wheat effort. Initiated in 1973 and funded by the government of the Netherlands, this programme has been operated by only CIMMYT staff until recently, when one of our sister International Agricultural Research Centres (ICARDA), joined the effort. This programme concentrates on monitoring and testing material concerned with the various wheat and barley diseases in the region bounded by Morocco in the West, Thailand in the East, Southern Europe in the North, and Zambia in the South. CIMMYT has two senior pathologists assigned along with two associate pathologists provided by the government of the Netherlands. Also ICARDA has one senior scientist working in this project as well as their research facilities at Aleppo, Syria. Collateral research activities for yellow rust, leaf rust, and stem rust are conducted in the Netherlands, Yugoslavia, and Egypt, respectively.
In addition to normal regional programme activities, the regional pathologists are working on two unique projects: a disease surveillance-early warning system for the region and a series of in-service pathology methods workshops concentrating on practical field and laboratory methods for screening and identification of disease resistant lines. Both of these extra projects are done cooperatively with the Research Institute for Plant Protection (IPO) in Wageningen, and with financial support by the government of the Netherlands.

A computer operation known as “EPIDAT” (Epidemiology data analysis programme) has been developed for analysis of the data from the Regional Disease Trap Nursery (RDTN) and is now operative. In addition, another computer facilitated analysis programme known as “EPISEL” (Epidemic Selection and data analysis programme) has been proposed and hopefully will be developed for the Regional Disease and Insect Screening Nursery (RDISN). These two data analysis programmes will provide the backbone for the Disease Surveillance Programme and help to provide the necessary information on the disease/pathogen situation in the region to the cooperating National Variety Improvement Projects in the region, in a timely manner.

The RDTN consists of 150 varieties and lines of wheat, barley and Triticale and was distributed to 54 countries in 1980. The RDISN consists of 800-1400 wheat, barley and Triticale advanced lines plus several check varieties. It was distributed to approximately 25 countries in 1980.

Currently, CIMMYT has three pathologists stationed in Mexico at our headquarters and three posted to other countries, plus the two associate pathologists provided by the Netherlands government, in Regional positions. In fact, by the end of 1980, of the nine wheat scientists posted to our programmes outside of Mexico, three were senior pathologists. The emphasis on the disease component of variety improvement continues to be a very strong item at CIMMYT. The following table indicates our present staffing position for our regional activities and our intentions for 1986.

### REGIONS & STAFFING FOR CIMMYT PATHOLOGY PROGRAMMES

(For wheat, barley, and Triticale)

<table>
<thead>
<tr>
<th>Region</th>
<th>Disease surveillance (Eastern hemisphere)</th>
<th>Tropical East Africa</th>
<th>Andean</th>
<th>Southern Cone</th>
<th>South Asia</th>
<th>North and West Africa</th>
<th>ICARDA (Middle-East)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of countries</td>
<td>54</td>
<td>14</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Base of Operations</td>
<td>Turkey</td>
<td>Kenya</td>
<td>Ecuador</td>
<td>Chile</td>
<td>Thailand</td>
<td>Portugal</td>
<td>Syria</td>
</tr>
<tr>
<td>Staff Target (1980)</td>
<td>1(+1)*</td>
<td>1(+1)*</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Staffing Target (1986)</td>
<td>2(+1)*</td>
<td>3(+1)*</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3(+1)*</td>
<td>1</td>
</tr>
<tr>
<td>Special Breeding priority problems</td>
<td>Septoria</td>
<td>Stem rust</td>
<td>Stripe rust</td>
<td>BYDV</td>
<td>Acid soils</td>
<td>Helminthosporium, root rots</td>
<td>Helminthosporium, root rots</td>
</tr>
<tr>
<td>Special Breeding priority problems</td>
<td>Septoria</td>
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<td>Helminthosporium</td>
<td>Helminthosporium, root rots</td>
</tr>
</tbody>
</table>

*Associate pathologists provided by the government of the Netherlands.
CIMMYT utilizes its' regional programmes in the capacity of providing the linkage between our resident or Mexico based research activities and those of collaborating national programmes. We attempt to serve all small-grain producing areas, with the primary emphasis on the developing world and endeavour to maintain the widest possible variation in our germplasm so that material is available for all important production areas.

While on this topic of the future, what direction does CIMMYT’s disease resistance/pathology programme intend to follow in the 1980’s? As one would expect, we will continue to concentrate our efforts on the rusts-stripe, leaf and stem. At the same time, we will be extending and enlarging our efforts in developing better or more functional levels of resistance to *Septoria tritici*, *Helminthosporium* spp., *Fusarium* spp. and *Rhyncosporium secalis* in barley. The disease surveillance programme in the Eastern and Western Hemisphere will be combined and operated as one programme for analysis purposes. This will include the RDTN, RDISN, ELAR, and VEOLA Nursery Networks and possibly others.

The collaborative research projects such as determining on a more scientific basis the nature of disease resistance in plants, expanded spring and winter variety improvement programme, wide crosses, heat tolerance, enlarged testing of all our material for resistance to a specific disease (*Helminthosporium*, *Septoria*, etc) at “Hot spot” locations, etc. will continue.

We will continue the multiline programme development, work on varietal mixtures, and strategic geographic placement of specific varietal genotypes. The specialized nursery programme will be reorganized and expanded. Training at the practical or applied level will certainly continue and hopefully expand, funds permitting. This is how we are looking ahead at the present time and the direction we will be going in the next few years.

—Dr. J. Michael Prescott
CIMMYT/Ankara.

**DISCUSSION**

A lively discussion followed Dr. Prescott’s presentation. The following paraphrased questions and answers covers the main points raised:

Q Is there an interaction between resistance to disease and stations where tests are made?
A Yes, this does appear to be a fact.

Q Are there different races of *Helminthosporium*?
A No, this has not been established.

Q Is there a place for horizontal resistance in wheat breeding?
A This is being studied with the object of determining the best procedure to follow. Computer techniques and multilocation testing may help.

Q Workers in Zambia are studying horizontal resistance. What is CIMMYT’s opinion on this?
A They are accumulating information on methods that may be useful. Testing only in Zambia may be too restrictive to evaluate the material coming from the work. CIMMYT uses the multiline varieties as another approach to the possibility of breakdown of gene-for-gene resistance.

Q To what extent is CIMMYT helping to solve problems in specific countries?
A CIMMYT has good communication with countries like Canada and there is an exchange of material. Canada, like most wheat growing countries, is quite satisfied with the conventional breeding methods for rust resistance. There has been no breakdown of resistance in Canada in over twenty-five years.
PROBLEMS AND PROGRESS IN DISEASE RESISTANCE AND BREEDING

ZAMBIA:

A. Disease Resistance:

Zambia will have to grow 50-55000 ha of wheat if she is to become self-sufficient in this crop. Successful production on such a scale will depend on disease resistant cultivars. Wheat will likely be produced in the dry season under irrigation as well as in the rainy season.

The seasons are quite different from each other in terms of temperature and humidity and consequently in disease occurrence. Most foliar pathogens need an optimum temperature of between 20 and 30°C, free water and high relative humidity in order to germinate and sporulate. These conditions are common in the rainy season in Zambia.

The maximum and minimum temperature at Mt. Makulu during the rains are 26 and 17 respectively. They are approximately 2 degrees lower at Mbala. Wheat foliage, during the same period is wet for long periods, either by dew or by frequent rains. The relative humidity is around 85%.

Dry season temperature and relative humidity are much lower and rainfall is nil. Except for rusts and powdery mildews no other foliar pathogens can grow under such conditions. Leaf and stem rust are usually more important in the dry season than during the rains, when epidemics only develop towards the end of the season. Although disease-free irrigated crops have been grown the possibility of an epidemic is always present and resistant cultivars are a necessity. Powdery mildew is a dry season disease only and most cultivars are susceptible. Chemical control of leaf rust and mildew is possible but the utilization of resistance provides better protection.

Pathogens causing leaf spots and head blights only occur during the rains. Helminthosporium sativum which infects all plant parts, is the major obstacle to successful rainfed wheat production. In 1973 this fungus reduced the yield of the cv. Jupateco 73, a cultivar which yields 4.6 t/ha in the dry season, to 0.5 t/ha. Many other cultivars were killed prematurely and did not produce grain at all. Scab (Fusarium spp.) resistance is also required as a measure against losses, as well as possible mycotoxins. Bacterial infections are also part of the rainy season disease complex and most wheat lines are susceptible to these diseases.

The commercial irrigated wheat varieties Emu 'S', Tai and Ram are resistant to rusts and mildews. Some new sources for resistance are Veery 'S', Banu, KZ/Kal-Bb, Jungfrau 'S', and Au-Up301/Gallo, — all originating from CIMMYT. High levels of general resistance to the rainfed wheat disease complex, especially to H. sativum, are not yet available. A few sources of resistance have been detected through intensive screening and they are now being recombined: Predgonnaja — Nacozani, IAS 64— Aldan 'S', KZ/Kal-Bb, Jup-Pavon, and Tai x Kal-Aid.

—R. Raemaekers
Belgian Development Cooperation.

B. Plant Breeding

The problems associated with the production of wheat are, of course, universal; differing only in minor details and relative importance. Mr. Raemaekers has very ably outlined for us the over-riding importance of diseases in the production of wheat in Zambia, particularly the production of rainfed wheat. I would like to present a list of other problems — by no means complete:
Obviously, any one of these subjects could occupy the time available. Hopefully the discussion period will provide an opportunity to elaborate on those items of common interest.

The breeding program in Zambia is in its infancy. Varieties grown in the early seventies did not have sufficient disease resistance to be productive in the rainy season. Original crosses between local varieties and material selected from CIMMYT nurseries failed to survive the stem rust epidemic of 1979. Mr. Raemaekers was able to identify additional lines that were rust resistant and had some resistance to *Helminthosporium sativum*. Two of these lines, "RAM" and "TAI," were released in Zambia for commercial use, as well as parental material in a further series of crosses. This material is in F₄ lines and you will see them this afternoon on the field tour.

To add to the task, the season of 1980 saw the presence of bacterial infections which sometimes are quite severe on otherwise desirable material. Again Mr. Raemaekers came up with suggestions for additional crosses to meet this new threat, and we are encouraged by the appearance of some of these F₂ plants now growing in the nurseries.

We are employing a traditional pedigree method of breeding. Crosses are made during the winter; the F₁ is grown under partial irrigation Sept.—Dec. providing an F₂ for the rainy season Jan. — April; F₃ selections are screened for agronomic characteristics and rust in the winter irrigated crop; F₄ plant lines are again screened in the rainy season. It is possible to raise large F₂ populations which can then be grown under two different environments.

Mr. Raemaekers has already indicated some of the more promising selections we are using as parental material.

The following tables of data indicate the yields we are obtaining under both irrigated and rainfed conditions.

### TABLE 1: COMPARATIVE WHEAT YIELDS – 1980 (t/ha)

<table>
<thead>
<tr>
<th>RAINED</th>
<th>MT MAKULU</th>
<th>MBALA</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST</td>
<td>EMU</td>
<td>RAM</td>
</tr>
<tr>
<td>A</td>
<td>2.2</td>
<td>1.6</td>
</tr>
<tr>
<td>B</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>C</td>
<td>2.6</td>
<td>2.4</td>
</tr>
<tr>
<td>D</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>E</td>
<td>2.1</td>
<td>2.1</td>
</tr>
</tbody>
</table>
IRRIGATED:

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>EMU</th>
<th>RAM</th>
<th>TAI</th>
<th>LSD</th>
<th>EMU</th>
<th>JUPE</th>
<th>LIMPO</th>
<th>LSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nirs</td>
<td>4.9</td>
<td>4.5</td>
<td>4.3</td>
<td>NS</td>
<td>5.7</td>
<td>5.9</td>
<td>4.7</td>
<td>0.7</td>
</tr>
<tr>
<td>G. Valley</td>
<td>4.2</td>
<td>—</td>
<td>3.8</td>
<td>NS</td>
<td>5.7</td>
<td>5.5</td>
<td>4.7</td>
<td>0.7</td>
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<tr>
<td>UNZA</td>
<td>4.6</td>
<td>4.3</td>
<td>4.3</td>
<td>NS</td>
<td>4.5</td>
<td>4.6</td>
<td>4.7</td>
<td>NS</td>
</tr>
<tr>
<td>Mpongwé</td>
<td>7.8</td>
<td>6.4</td>
<td>6.4</td>
<td>?</td>
<td>7.0</td>
<td>8.3</td>
<td>7.7</td>
<td>?</td>
</tr>
</tbody>
</table>

TABLE 2: COMPARATIVE WHEAT YIELD - 1980

<table>
<thead>
<tr>
<th></th>
<th>RAINFED</th>
<th>IRRIGATED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MT. MAKULU</td>
<td>MBALA</td>
</tr>
<tr>
<td>EMU</td>
<td>1.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Kvz/Pak 20</td>
<td>3.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Banu</td>
<td>2.8</td>
<td>1.4</td>
</tr>
<tr>
<td>LSD</td>
<td>0.5</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Lines named in the above tables were as follows:
Ram = Romany 2/Africa Mayo = K 6290–17
Tai = K 4500-2 = W3697 = ENKOY
Kvz/Pak20 = KAVKAZ/PAKISTAN 20
Banu = Kvz/3/Correcaminos – Inia/Ciago/El Guaché – Sonora 64

The relatively low yields of material grown at Mbala is an indirect effect of the acid soils at that location. Root growth is restricted to the limed topsoil. If the rains cease at a critical stage the wheat suffers from drought even though there is moisture available below this shallow root zone. Later maturing varieties generally suffer most under these conditions. Tai is a late maturing variety and out yielded Emu at Mbala because of its superior disease resistance, and in spite of its later maturity.

Table 2, indicates the yielding ability of two promising lines under rainfed and irrigated conditions. Both lines indicate some progress in obtaining more desirable material for rainfed production of wheat. The lower yield of Kvz/Pak20 at Golden Valley under irrigation was due to American Bollworm attack and an irregular irrigation pattern.

I hope this has given the workshop participants a “bird’s-eye” view of Zambia’s problems and progress in the production of wheat. Like all researchers we have even “more promising”, material coming along.

—D.S. McBean
Plant Breeder, M.M.R.S.,

ZIMBABWE

Wheat is grown under irrigation in the winter in Zimbabwe and this largely determines the spectrum of diseases which affects the crop. Diseases which are favoured by warm humid conditions, such as Helminthosporium sativum and Septoria spp., are not a problem during the dry winter and in fact are rarely seen. The more important diseases are stem rust, Puccinia graminis tritici, leaf, rust, P. recondita, maize streak virus and mildew, Erysiphe graminis. During the past two years loose smut, Ustilago tritici has occurred in commercial crops whereas previously this disease was only detected in crops, such as international nurseries, grown from imported seed.

Resistance to both of the rusts is a primary consideration in the breeding programme and all the breeding material is screened, in rust nurseries. Selection for resistance to stem rust is
carried out in nurseries planted during the summer months when conditions are suitable for the rapid and heavy development of infection following inoculation with mixtures of stem rust isolates. Susceptible spreader rows are planted at regular intervals throughout the nursery and inoculated with a suspension of uredospores in a light mineral oil applied through a ULV spinning disc sprayer. About two litres of the suspension is required per hectare. Selection for resistance to leaf rust is carried out in the winter months in the south eastern lowveld where leaf rust is likely to occur each year. The leaf rust nursery is not inoculated because it is planted in a commercial production area.

Breeding for resistance to stem rust in the Zimbabwe programme has essentially been concerned with the use of major genes for resistance. Because of climatic conditions during the winter when the main commercial crop is grown, rust, either leaf or stem, does not normally appear until relatively late in the development of the crop, i.e. in September or later. As a consequence, rust infections have been generally light, causing little damage, and the selection pressure on the rust for increased virulence has been low. Under these circumstances, major genes have remained effective for a considerable time. This has not always been the case in Zimbabwe.

In the fifties and sixties attempts were made to grow wheat commercially during the summer rains and rust attacks in the winter grown crop occurred very early in July due probably to the carry over of rust from infected summer crops. Summer wheat production is no longer practised and this source of inoculum has been removed. However, with the probability of increased wheat production in neighbouring countries there is a distinct possibility that rust in Zimbabwe could appear earlier in the crop due to aerial dispersal of spores from crops in neighbouring territories — particularly if these crops are grown out of phase with ours in the summer or autumn. It is important therefore that there should be cooperation between the territories in the region in studies on the epidemiology of wheat rusts and their dispersal in the region and on virulence patterns and effective sources of resistance.

At the present time in Zimbabwe the standard races of stem rust are 34 and 222. Previously recorded standard races were 17, 21 and 174, but these have not been detected in recent years. Within the standard races there is a fairly wide range of virulence to the known Sr genes and the genes which appear to be effective at the present time are Sr 9e, Sr 13, Sr 21, Sr 22, Sr 24, Sr 25, Sr 26 and Sr Tt-1 Backcross programmes have been initiated to incorporate these genes into some of the commercial cultivars such as Tokwe and Nuanetsi. At the present time most of our commercial varieties are not adequately protected and could be damaged if conditions suitable for rust development occurred.

Leaf rust is more of a problem in the south eastern lowveld at an altitude of c.500m. Wheat has generally been rotated with cotton in that area and because of the lateness of the cotton crop some difficulty in seeding wheat at the optimum time is encountered. Consequently plantings have spread over a period of time from May until late June and this tends to worsen the severity of leaf rust, and also stem rust, on the later plantings. However, it is unlikely that wheat production will continue in this area because of the increased production of sugar cane.

With the development of winter wheat production maize streak virus has become more prevalent in both summer maize and winter wheat and an investigation is commencing into the resistance of wheat cultivars to the virus with the object of controlling the disease by plant breeding. Apart from the damage to the wheat crop itself wheat serves as a reservoir of infection for maize and hence both crops would benefit from a reduction in the amount of virus infection which develops during the winter.
The only other disease of consequence at present in the wheat is mildew but whilst several of the currently grown cultivars are susceptible, the disease is of spasmodic occurrence and appears more frequently on sandy soils than on the heavier soils. There has been no real attempt to breed for resistance to this disease except to discard material which is obviously susceptible in the breeding nurseries.

—G.W. Herd

TANZANIA

(a) ARUSHA

Wheat breeding in Tanzania is concentrated on the Selian Research Station in Arusha formerly at Lyamungu. The main effort is in wheat but some work is also being done on Durum wheat, malting barley, and triticale. The barley breeding work is being phased out and this work will be taken over by the Uyole Agriculture College at Mbeya. Some thought is being given to expanding the program to include oilseed crops to provide an alternative to wheat.

The wheat breeding program is of the selection type since no cross breeding work is done. Material is brought in from all over the world, principally through CIMMYT, Kenya and icarda. These introductions range from early generation material (F2) up to advanced test material. Thus new lines of superior merit selected in the area where they will be used are being made available.

The main selection pressures in the program are for yield and disease resistance. All introductions will continue to be screened at Lyamungu since this site has the most reliable levels of disease.

A large number of diseases attack wheat in Tanzania, causing yearly losses in yield, grade, and quality. The important diseases are caused by Fungi, and as yet no viral or bacterial diseases of wheat have been identified.

The two diseases of major importance are stem rust and stripe rust both of which can cause losses of up to 100% under the right conditions. An acceptable wheat variety must have a high degree of resistance to both of these rusts.

*Helminthosporium* has become important in recent years since this disease can cause severe losses in yield, grade, and quality. No good source of resistance has yet been identified, however varieties differ in their tolerance to this disease. Some measure of control can be gained by using tolerant varieties and manipulating the time of planting to avoid the time of peak infection.

The yield losses caused by other diseases are not so high but they occur yearly and reduce yield, grade, and quality. With many of these diseases it has been difficult to breed for resistance coupled with good yield. Some of these diseases include, Leaf rust, Black Point, Glume Blotch, Bunt, Smut, Root Rot and seedling Blight. These diseases with the exception of leaf rust can be controlled using fungicide or systemic fungicide seed dressings.

There are many insects which attack wheat but most of them do not cause sufficient economic losses to warrant control. Insects feed on a wide range of plant species and in Tanzania none feed solely on wheat. There are two insects which when conditions are right can increase in population to the point of causing serious losses if not controlled by spraying. These two insects are the Armyworm and the American Bollworm.
The wheat breeding program has been successful in meeting the above challenges. There are nine recommended varieties, Mbuni, Kororo, Kwechi, Tai, Mambo, Trophy, Kozi, Nyati and Joli. These varieties have a maturity range from 100 to 130 days. While Mbuni is the main variety no one variety is the answer to all the hazards and most farmers grow a number of varieties to minimize the risks. All varieties have acceptable bread making quality.

—E. Dave Mallough  
Plant Breeder.  

(b) Njombe*

Climate conditions are quite different in Njombe to the main wheat producing areas in the north of the country. At Njombe the incidence of Septoria tritici and Septoria nodorum is usually heavy in the wheat crop, Fusarium is a problem in some seasons, but the incidence of stem and leaf rusts and Helminthosporium is relatively light.

Most of the varieties currently grown at Njombe have originated from the Tanzania or Kenya national wheat programmes. While these varieties have afforded excellent stem rust resistance, they are not very satisfactory with regard to their tolerance of Septoria.

A local screening programme is in progress to identify material more suited to local conditions and screening nurseries are now obtained direct from CIMMYT. Generally the introductions from Mexico are showing better Septoria resistance than the material obtained after initial selection in the East African programmes. In particular the progeny of the South American Mexican variety crossing programme is appearing particularly promising.

The incidence of Septoria in the crop can be reduced by delayed planting but this often results in yield reduction from the effects of soil moisture deficit in the later stages of growth in seasons when the rains finish early. The testing of varieties is therefore carried out in trials at two planting dates to assess performance under conditions of maximum disease incidence and for conditions when available soil moisture may be a yield limiting factor.

—R.A. Haggarty  
Research Agronomist  
Tanganyika Wattle Co. Ltd., — Njombe, Tanzania.  
*(Author unable to attend and paper arrived too late to be read).

MADAGASCAR

As in many countries, diseases and pests are part of the problems of wheat growing in Madagascar.

1. Rusts:

We have both stem rust (P. graminis) and leaf rust (P. recondita). So far, stem rust is the most important. The three varieties grown commercially are, for the moment, resistant to these rusts, therefore as long as there is no change in races we can use them safely.
It should be mentioned again that these diseases are mainly occurring during the rainy season but not too much during the dry season in the rice fields.

2. **Leaf diseases:**

The most important of the leaf diseases is *Septoria nodorum* but we have also sometimes *Helminthosporium* sp. and *Fusarium* sp. Also these diseases are mostly occurring during the rainy season and to a lesser extent during the dry season.

Trials last year showed that repeated applications of fungicides (captafol and triadimephone) during the season increased the yield of wheat up to 40% compared to non-treated plots. There was no rust at all in this trial which indicate that leaf diseases may cause a large reduction of the yield.

3. **Pests:**

Larvae of *Noctuidae* (*Heliothis* sp. etc.) attack wheat and Triticale at the heading stage. The attack is more severe in Triticale than in wheat. In one of last year trials, repeated application of an efficient insecticide increased the yield of Triticale by 25%. With wheat, the yield increase was lower. A soil living insect (*Heteronychus Plebejus*) attacks the wheat crop at the seeding stage. The application of aldrin in the rows at sowing time decreases the attacks. This insect attacks only during the rainy season.

A lot of aphids are sometimes found on the leaves but the effect on yield is not yet known.

During storage *Sitophilus granarius* attacks wheat. Application of malathion or dichlorvos has been efficient for a period of one to two months but it has to be repeated in the storing period is longer than that.

—Mr. Rakotondramanana  
FIFAMANOR, Antsirabe.

**DISCUSSION ON DISEASE RESISTANCE & BREEDING**

Dr. R.J. Baker, of the Crop Development Centre, University of Saskatchewan, Canada, lead the discussion with the presentation of the following summary:

**Disease Resistance and Breeding Discussion:**

The ultimate goal of wheat research in any country must be to discover or develop varieties which are suitably adapted to local environmental conditions. Research in soils and agronomy is designed to modify the environment so that it is more hospitable to the wheat plant. On the other hand, research in wheat breeding is aimed at developing varieties that are more tolerant of the local environment.

There are two distinct aspects of plant breeding and we see both in the countries represented at this workshop. For relatively new programs, the main activity is one of testing introductions from international organisations such as CIMMYT and ICARDA, from neighbouring countries and from other countries that have similar environmental conditions in order to select those that are best adapted to local conditions. Co-operation and communication is critical to the success of this early phase of wheat breeding research.
Once the best adapted cultivars have been identified, one may proceed to more formal wheat breeding involving hybridization, inbreeding and selection. There are three important principles in this type of breeding that should be kept in mind.

1. In order for a group of desirable characteristics to be incorporated into a new variety, those characteristics must exist in some combination in the parents used in the breeding programs. One must first find sources of resistance to disease or resistance to acid conditions before these desirable characteristics can be incorporated into a new variety.

2. For any characteristic, it will be easier to select lines that exceed the better of the parents when the parents are similar in performance than when the parents are quite dissimilar. This general observation has significance in choosing the types of segregating populations in which to practise selection. Superior varieties are more apt to be found in crosses of "good" by "good" rather than in crosses of "good" by "poor".

3. Inbreeding is an essential part of wheat breeding. This requirement adds several years to the time from initializing a breeding program to release of a new variety. We should not expect a breeding program based solely on hybridization to yield a new variety in less than eight or ten years.

Plant diseases, while being merely one aspect of the environment, deserve special consideration for two reasons. First, if resistance has not been incorporated, fungal and bacterial diseases can often lead to catastrophic crop failures. Second, many plant diseases differ from other environmental factors in that they change in response to changes in the resistance spectrum of the wheat varieties in use. These changes are invariably to the disadvantage of the wheat breeder and the wheat producer. It is likely that breeding for disease resistance will be a never-ending task.

It has been suggested that horizontal resistance, in contrast to vertical resistance, might reduce the need for continuous effort in breeding, for disease resistance. I was pleased to hear of the research on horizontal resistance being carried out by de Milliano and his group in Zambia.

From the talks given in this session it appears that the main diseases of wheat in south, central and east African are the three rusts (stem, leaf, and stripe), the leaf spots and head blights and mildew. Various contributors have shown that one disease is most severe in one country while another may be so in another country. It is also quite clear that the spectrum of diseases on rainfed wheat is different from that on irrigated wheat. Leaf spots and head blights tend to be worse on the former, rusts on the latter.

Other objectives of wheat breeding programs in the area include yield and tolerance to acid conditions. Some discussion suggests that breeders and agronomists should watch for possible varietal differences in responses to micro deficiencies and to fertilizers. If such differences are found selection for suitable types might prove useful.

Summary of Discussion:

To summarize the discussion following Dr. Baker's remarks, and also comments made after previous speakers, some paraphrased questions and answers are presented:

Q Are resistance mechanisms common?
A It is difficult to discover. Evidence is inconclusive.
Q Has any attention been given to Hosford's work in North Dakota?
A Yes, but levels of resistance in his materials are not high enough for tropical, high humidity conditions.
Q Should research be done on toxins in Fusarium?
A Some research is already being done. Rainy season wheat is usually infected while dry season wheat often escapes.

Q Is Helminthosporium found on many different grasses?
A Yes, it has been isolated and used to inoculate wheat. Usually the virulence is initially low.

Q Is this disease found in roots?
A Yes, Helminthosporium and Fusarium are both found there but not considered a serious problem.

Q Does Helminthosporium attack florets?
A Yes. Infection of flowering causes sterility; infection later may not affect grain formation.

Q Is CIMMYT expanding its work in tropical areas?
A Yes, especially in the last few years.

Q In terms of effectiveness when does one turn from international to national hybridisation programs?
A Final selection for high yield under specific local conditions is essential, hence each country must eventually develop its own programs, and most are doing so.

Q Does CIMMYT have a good supply of germplasm?
A For dry season wheat, yes; for tropical rainy season, no.

Q What unusual difficulties have been encountered by workers in this part of Africa?
A Some have problems in importing seed for trials; farmers using unadapted varieties; deficiencies in soils of Cu, B or Zn; cross infection of streak virus in maize to wheat; inability of wheat to do well in hot soils at early stages of growth, problems with birds, especially Quelea.

Q Is there a variety interaction with boron sterility?
A Yes. It seems to affect only Blue-bird type varieties.

EXPERIMENTAL PLOT TOUR – MT. MAKULU RESEARCH STATION

On the afternoon of March 11 the workshop participants toured demonstration plots, nurseries and F2 populations. All plots were sown early in January and weeded chemically. The main diseases were H. Sativum, bacteria and some stem rust. The demonstration plots showed a comparison between susceptible and resistant cvs. Limpopo, Emu and Yecora were examples of very susceptible varieties, with flag leaves necrotic and heads infected soon after flowering. Jupateco was less severely infected but had not yet headed. Tai and Ram were included as rainy season varieties. Tai is more promising than Ram but neither show suitable resistance. Other entries in the demonstration plots were selections from CIMMYT material Kal/Ald, Bany Au-up 301/Gallo-SX, Klvz/Kal-Bb, Klvz – Pak 20, Hort-Maya ‘S’, Kal-Bb/Ald, Jup-Ald, Alondra, Veery are mostly selections from spring – winter crosses based on resistant wheats from Russia.

PF7748 and Toropi are examples of Brazilian lines with some disease resistance but not adapted agronomically. Tern’s’ and C1 1495ND were examples of durum wheat and Beagle ‘R’ and CEP 76287M1A were Triticale cvs. The demonstration plots were exposed to high disease pressure.

The disease observation nurseries contained many local selections from F2 introductions and from local crosses between resistant selections made earlier. Also included were new nurseries from CIMMYT and ICARDA of durum and bread wheats and Triticale. Varying levels of adaptation and of resistance were observed.

A large nursery of F2 populations was toured. The 150 CIMMYT F25 each contained 200 plants while 17 locally produced F20 each contained 16 000 plants. The visitors also toured a split plot experiment with two cvs, Emu and Banu, designed to assess crop losses due to H. Sativum. Dramatic differences were evident between sprayed plots and checks.
Wednesday evening Banquet:

The workshop held a dinner at the Ridgeway Hotel sponsored by the National Milling Co. and Supa Baking Co., both of Indeco Ltd. The Chairman was Dr. D.M. Naik, guest speakers were: Mr. F.J. Mkwanazi, General Manager of the National Milling Co., and Dr. J.M. Prescott, CIMMYT Regional Pathologist, Turkey
The morning session on Thursday, March 12, began at 0900 hrs. Ms. R.K. Chungu, Chief Agricultural Research Officer at the Mt. Makulu Res. Station acted as Chairlady. In the absence of an invited guest speaker the various countries were called on in turn and gave reports as follows:

TANZANIA

Since the wheat crop requires cool growing conditions with relatively high moisture, wheat production in Tanzania is restricted to areas where rainfall is between 500 and 700mm, and the altitude is 1300m or more. During the past decade, research has identified and developed wheat production techniques which have increased wheat production in regionally adapted areas.

It is essential that there be a careful and timely application of a year-long sequence of well-integrated management practices. Some key soil and crop management practices are outlined below.

Soil Tillage:

Tillage prepares the soil for the planting and growing of crops, and the success with which such preparation is carried out, largely determines the yield of the crop, and the long-term productivity of the soil. In addition to preparing the soil for planting, tillage must also provide for control of weeds, and reducing rainfall run-off by allowing maximum infiltration of water. Conservation tillage (conservation of soil and water) becomes of utmost importance. Maintenance of plant residue on the soil surface not only protects the soil against wind and water erosion, but improves water infiltration as well. Wheat straw should never be burned.

In general, recommended tillage practices for wheat production in Tanzania have been identified as follows:

1. The first tillage should be immediately after harvest, using a chisel plough with wide shovels, where crop residue, soil and moisture conditions are favourable. Chisel points should be used where conditions do not allow operation of wide shovels. Depth of tillage should be 7.5 to 10 cm (3 to 4 in).

2. All subsequent tillage operations should be carried out only when necessary to prevent weed growth. The chisel plough with wide shovels should be used to maintain maximum cover of plant residue on the soil surface. Each operation should be at an angle of approximately 15 degrees to the previous one. Tillage should be deep enough to control weeds and leave a cloddy soil surface.

3. When excess plant residue prevents the operation of the chisel plough it may be necessary to use a disc type implement for the first operation. This will bury about 50% of the plant residue. The chisel plough should be used for all subsequent operations. It must be strongly emphasized that excessive use of a disc type implement will result in very little plant residue on the surface, a pulverized soil, and a high potential for wind and water erosion.
(iv) In all tillage operations careful attention must be given to direction of travel relative to the slope of the land. Operation of equipment in the same direction as the sloping land will initiate severe gully erosion under the very intense rainfall which is experienced in Tanzania. Always till across the slope.

Tillage accounts for most of the costs of wheat production and should be looked at very critically. Costs can be affected appreciably by choice of implements and number of operations. The chisel plough appears to be the most versatile tillage implement, and when used by a careful operator, can produce the most effective and economical tillage for commercial wheat production.

What about alternatives to tillage? It has been demonstrated in several countries that field crops can be grown successfully with a very minimum amount of tillage, or no tillage at all from the time a crop is harvested until the subsequent crop is planted.

This management technique is accomplished through very precise selection and application of herbicides. It is a challenge to all attending this workshop, to determine in our respective areas whether it is agronomically and economically feasible to produce wheat under a system of minimum tillage or, in fact, no tillage at all. Such a cropping system could substantially reduce the inevitable destruction of our soil resource through wind and water erosion.

Seeding:

A critical decision must be made by the wheat grower regarding time of seeding, in order to utilize to advantage, the rainfall pattern, and the prevailing temperature and soil moisture conditions. Wheat must be planted when conditions are most favourable to rapid germination. These conditions are generally found when the rainy season has been definitely established; when moisture is uniformly present in the soil, at least at depths of less than 75 cm (30 in.); when moisture is available at the seeding depth of 5 cm (2 in.) from the surface; and when the estimated time to maturity will assure harvesting during a dry period. Wheat should not be planted in dry soil.

The most satisfactory situation has been to plant in to a weed-free seed bed which is somewhat cloddy and has some protective plant residue on the surface. The double disc, press drill gives the best germination and emergence under most conditions. Satisfactory results may be obtained from discer seeding but it requires more skill and attention on the part of the operator. The soil should be packed immediately after seeding with the discer. Broadcast seeding of wheat is not recommended. Wheat should be planted at a depth of 4 to 5 cm (1.5 to 2.0 in) or into moist soil well firmed around the seed. The recommended rate of seeding is 100 to 110 kg/ha (90 to 100 lb/ac). A higher seeding rate is suggested where heavy weed growth is expected.

Fertilizer Application:

Most of the nutrients required for good wheat production are available in the soils where wheat is grown in Tanzania. Availability and effectiveness depend on good soils conditions which are obtained by timely operations after harvest and followed through to the seeding of the next crop. When these conditions do not provide sufficient nutrients, supplemental fertilizer should be considered. It has been shown that there is usually a sufficient nitrogen supply released during the period from harvest to seeding. Testing over a number of years has indicated only small and variable responses to the application of nitrogen fertilizers. Good management practices which control weed growth, provide for crop residues on the soil surface, and promote infiltration on rain, help to maintain high levels of nutrients in the soil.
Most soils in the wheat growing areas of Tanzania have been shown to supply adequate amounts of Phosphorus and Potassium for satisfactory wheat yields and no response to phosphorus or potassium fertilizers have been observed to date. Trace element investigations reveal that manganese and copper deficiencies may limit wheat production in isolated areas of Tanzania. In the event that fertilizer nutrients are required, the fertilizer should be applied in the soil close to the seed rather than broadcast on the surface.

Weed Control:

A good crop of wheat cannot be grown simultaneously with a heavy infection of weeds. In fact, even a light infestation of certain weed species can cause severe yield reduction. Control measures may be cultural, chemical or a combination of these methods. Wheat producers in Tanzania should continually assess, with an open mind, the available weed control alternatives. Presently, thorough tillage during the harvest to seeding period, together with careful choice of seeding date, rate of seeding and depth of seeding, and the use of high quality weed-free seed, are the recommended practices to give the wheat a competitive advantage over the weeds. The application of 2, 4-D has successfully controlled annual broadleaf weeds in the commercial wheat crop. Annual grasses, such as Setaria verticillata (Lovegrass) are becoming very serious weeds in many wheat fields. There have been a number of herbicides developed for control of grassy weeds in wheat. Some of these are being tested in Tanzania.

Tillage and all that goes with it (large tractors, fuel, implements, spare parts) is extremely costly, while it can also open the door to severe soil erosion. It could therefore be very appropriate to consider substituting certain tillage operations for herbicide application as we continue to improve the wheat production package.

—R.A. Bradley
Agronomist, Tanzania-Canada Wheat Research & Production Project, Arusha, Tanzania.

KENYA

Wheat has been grown in Kenya since the early 1900's, but was immediately affected by rusts which thrive in the Kenyan environment. In 1906 a plant breeder began research in Nairobi to develop resistant varieties. The plant breeding program was moved to its present site at Njoro in 1927. Since then, a continuing expansion of the research program at W.P.B.S. Njoro, has contributed to the establishment of recommendations for growing wheat. These include:

1. Seedbed preparation:

Seedbed preparation should begin immediately after the previous crop has been removed. Delay results in weed growth, loss of soil moisture, and reduced yields (Table 1).

<table>
<thead>
<tr>
<th>Time</th>
<th>Delay after harvest (months)</th>
<th>Yield t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct. 1</td>
<td>0</td>
<td>3.44</td>
</tr>
<tr>
<td>Dec. 1</td>
<td>2</td>
<td>3.01</td>
</tr>
<tr>
<td>Feb. 1</td>
<td>4</td>
<td>2.55</td>
</tr>
<tr>
<td>Apr. 1</td>
<td>6</td>
<td>2.39</td>
</tr>
</tbody>
</table>

(data from N.P.B.S. Njoro).
The type of equipment used in seedbed preparation was found to have no significant effect on yield. There was, however, a difference in cost of preparation due to the method used. In general, one disc harrowing followed by two or three light tine cultivations on stubble land was found to be least expensive.

2. Seed and variety:

Sixteen varieties are recommended without hectarage restrictions, but for specific altitudes. Eight other varieties are recommended but should not be grown on more than 10% of the farmers land because they may have reduced resistance to disease. Farmers are advised to plant at least 3 different varieties to guard against complete crop loss. In 1981, two new varieties i.e. Kenya Kongoni, and Paa were released.

Recommended seeding rates vary with tillering capacity and size of seed, and range from 75 to 125 kg/ha. In general, good tillering varieties and small seed varieties are planted at the lower rates.

3. Fertilizer recommendations:

Most soils in the wheat growing regions are deficient in phosphorus. Nitrogen is generally not required unless (1) land is cropped steadily to wheat (2) above normal precipitation occurs, prior to planting, causing leaching. Recommendations are based largely on cropping history of the land (Table 2).

<table>
<thead>
<tr>
<th>Land Category</th>
<th>Recommendation N (Kg/ha)</th>
<th>Recommendation P$<em>{2}$O$</em>{5}$ (Kg/ha)</th>
<th>Ratio N/P$<em>{2}$O$</em>{5}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>I on new land</td>
<td>14</td>
<td>70</td>
<td>1:5</td>
</tr>
<tr>
<td>II second crop</td>
<td>15</td>
<td>60</td>
<td>1:4</td>
</tr>
<tr>
<td>III third crop</td>
<td>17</td>
<td>50</td>
<td>1:3</td>
</tr>
<tr>
<td>IV continous wheat</td>
<td>25</td>
<td>50</td>
<td>1:2</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>40</td>
<td>1:1</td>
</tr>
</tbody>
</table>

These recommendations may be modified if soils were tested.

Copper is deficient in soils of volcanic ash origin, mainly in the Nakulu — Njoro — Narok area. Copper should be applied as copper oxychloride (50% Cu) at the rate of one kg/ha with the seed, plus one kg/ha foliar sprayed.

Liming of acid soils has not consistently resulted in yield increase, thus no general recommendations is made for adding lime. Lack of crop responses to additions of lime may be due to the effect of increased pH on micronutrient availability (e.g. boron).

4. Weed control recommendations:

Grassy weeds are the most difficult to control in wheat in Kenya. These include:

(1) Wild oats. Herbicides found to give control in decreasing order of effectiveness are: super suffix, iloxan, suffix, avenge, TO-2, dosanex.
(2) Setaria. Herbicides giving best control are: stomp, igran, dosanex.
(3) Ryegrass. Can be controlled with iloxan.
(4) Bromegrass. No herbicide has been found to be effective in controlling this weed in wheat.
5. Disease control recommendations:

No recommendations are made for the use of fungicides to control rusts. Some farmers have reported good results using Balaton at 1 kg/ha for leaf and stripe rust control. This is a systemic type chemical and is effective for only 3-5 weeks. It is costly to use. Farmers estimate cost at approximately 160 sh. K. per acre per treatment applied by aircraft.

—A. Ridley
N.P.B.S., Njoro.

MADAGASCAR

1. Growing seasons:

The two main seasons are the rainy season from January to June and the dry season from May to October. The wheat during the dry season is cultivated under irrigation in the rice fields. As the rainy season starts, already in October the farmers begin with a potato or bean crop which can be harvested in January before sowing the wheat. Naturally the rice fields are occupied by the rice during the rainy season. The rice is normally planted in November and harvested in April.

2. Soil conditions:

The pH is highest on the volcanic soils, normally between 5.0-6.0 (in water). Also on alluvial soils (loamy, clay) you can have a pH over 5.0 but on peat and lateritic soils it is between 4.0-4.5. If the pH is higher than 5.5 the wheat grows quite well. If the pH is lower than that, two tons of dolomite/ha is recommended. The acid soils are quite a problem and you often see symptoms of aluminium toxicity.

Ten to fifteen tons of organic manure will also be recommended as it normally gives a better yield. The organic manure gives a better physical condition to the soil and it can as well add some necessary microelements to the soil. The only microelement we have found to be a threat to the wheat crop is boron. We recommend 20 kg/ha of boracin every second year on soils which we know have this problem. Some trials have shown a complete failure for the wheat crop without adding boron.

3. Fertilizers:

As most of the soils in the highlands of Madagascar have a deficiency of phosphorus it always make a profit to add 200 kg of hyper Reno/ha. The amount of NPK 15-15-15 recommended is 250-500 kg/ha. Our trials have shown that the average yield with the above fertilizations are as follows:

<table>
<thead>
<tr>
<th>Without fertilizer</th>
<th>0.3—0.5 t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 tons organic manure</td>
<td>0.6—1.0 t/ha</td>
</tr>
<tr>
<td>NPK 15-15-15 300 kg/ha</td>
<td>1.0—1.5 t/ha</td>
</tr>
<tr>
<td>NPK + manure</td>
<td>1.5—2.0 t/ha</td>
</tr>
</tbody>
</table>

4. Soil preparations:

Between different crops the farmers always plow or turn the soil by hand. If there is time for the soils to rest one month after plowing it will give a higher yield probably because the soil compacts during this rest. On our research station we have found that a soil compaction after sowing also gives a good result.
5. **Seed rate and seed bed preparation:**

The recommended seed rate is 150 kg/ha but there is not any great differences between 100 kg and 200 kg/ha. If you will get an insect attack at the seedling stage it will however be preferred to have a surplus of seedlings. The insects are also controlled by using Aldrin 5-10 kg/ha in the rows. During the rainy season the temperatures are normally too high and the plants do not tiller enough, therefore the higher seed rates are to be preferred.

6. **Weed control:**

Because the area of wheat cultivated by each farmer is very small (0.05-0.30ha) the weed control is done by hoeing and doesn't give any big problems. In the paddy fields there is not any big problem as the weeds don’t germinate on the dry surface of the soil. The worst weed species are grasses like Digitaria and Eleusine and Cyperaceae like Cyperus.

7. **Water management:**

With the rainfed wheat there is too much water in the beginning just after sowing and too little when the crop is going to maturity. The amount of rain during January and February, which are the most rainy months, is about 500mms. The rains can stop falling as early as April.

In the rice fields during the dry season there are two systems for water management. On loamy soils the water rises by capillary forces and the problem is to drain the soil enough before sowing because the wheat is very sensitive to a poorly drained soil. The water level should be below 30cm from the soil surface before sowing. On other soil types the rice fields are irrigated by flooding, using canals and furrows. Also here one must be careful with the irrigation, giving just enough water every time one is irrigating. The farmers normally drench the rice fields when the rice is growing and are not very careful when irrigating the wheat.

8. **Harvest:**

Threshing of the wheat is done by hand, in the same way as with the rice, beating the wheat on a big stone. Because of this the hard – threshed varieties are not very popular.

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_H. Larsson_

FIFAMANOR, Antsirabe.

**ZIMBABWE**

Wheat is grown in Zimbabwe during the winter or dry months under irrigation, normally during the months of May to October. For it to be economically viable, it is normally grown in rotation with one or two of the summer crops. This double cropping programme often introduces certain production problems, notably degradation of the soil structure and management problems associated with growing two crops in one year. The selection of rotations are thus very important so as to overcome these problems. The most commonly used rotations are, maize – wheat – soyabean, soyabean – wheat – maize, soyabean – wheat – soyabean and cotton – wheat – cotton.

Land preparation is normally by plough followed by disc-harrow, ensuring that the land is level without any depressions and that a suitable fine seedbed is obtained. Seeding is done by either seed drill, or by broadcasting and then incorporating into the soil. Broadcasting is either by fertilizer distributor or by aircraft. The recommended seed rate for drilling is 100 kg/ha with
a 25% increase for broadcasting. Seeding date varies from region to region, with the lowveld as soon after 1 May as possible and the highveld from 15-25 May.

Good irrigation management is one of the most important factors in wheat production. About 85% of the irrigation is using sprinkler systems, with the remaining being flood. Irrigation is normally done according to a schedule based on open pan evaporation data, or predetermined systems based on past mean evaporation data or on actual growth stages of the crop.

The major nutrients required for wheat production are nitrogen, phosphorus and potassium. These are applied as a basal dressing of compound fertilizers. Further nitrogen is applied as a top dressing in the form of ammonium nitrate. This is applied by broadcasting or put on through the sprinkler systems. The recommended levels are nitrogen 150-180 kg N/ha, with 80-90 kg at planting, 50 kg as a top dressing at 4-6 weeks and a further 30-40 kg at 8-10 weeks. Phosphate is applied at the rate of 60-100 kg P₂O₅/ha and potassium at 30-50 kg K₂O/ha. Trace elements, like sulphur, zinc and copper, are also sometimes applied.

Trials have shown that there is a marked response to high levels of nitrogen and phosphorus, but only when both nutrients are applied together.

Weeds are normally not a very big problem, as these are in most cases summer weeds that may be controlled by frost. Nevertheless herbicides are used, with the most common ones being M.C.P.A. and Faneron.

Harvesting is done by combines in September - October, under normally favourable conditions, and the grain is delivered to the grain marketing Board in bags. Grading is done there on moisture content, test density, % extraneous matter and % broken and sprouted kernels.

—C.J. Badenhorst
Crop Breeding Institute, Causeway
(Report presented by G.W. Herd).

MALAWI

Wheat production in Malawi under dryland conditions has been studied by the Department of Agricultural Research since 1969. The crop is successfully grown in high altitude areas during the cool season, March to August, that gradually merges into a hot dry harvesting period, September to November. The main wheat growing area is in the Kirk Range Mountains of central and Southern Malawi bordering Mozambique, in Ntcheu and Mwanza districts and in Mwera Hill, Nchena-chena and Viphya plateau.

In addition to soil and crop management experiments, soil moisture conservation field trials have been conducted at Tsangano, Ntcheu where the soils are silt and clay loams with a slightly acid to neutral reaction and medium organic matter content. The area received an average annual rainfall of 1000-1400 mm (86% falling between November to April) and temperatures vary between 8.7 to 15.1°C (minimum) and 16.9 to 22.6°C (maximum).

As the crop grows on the residual moisture, accounting for the 14% of the annual rainfall and the amount which depends on the intensity of the yearly rainfall, investigations were needed, for wheat, triticale and barley, to find a suitable planting time and means of moisture conservation for the crops to mature during dry weather while at the same time ensuring that there is ample moisture throughout the crops life.
Since water, nutrients and weather in general affect the yield and protein content of wheat, an experiment was set up to study the effect of mulching on available water in early and later ploughed; early and late planted wheat (Kenyanyati) and triticale (Bacum).

On the basis of observations from these experiments, it would appear that in a dry year, early planting (mid-March) with mulching, good variety and properly fertilized, wheat or triticale should do well with a yield of 1500 kg/ha. Mulching with wheat straw at a rate of 3.0 cm thickness or 90 kg/ha and higher when the seedlings are at least 3.0 cm high was done. Fertilization is done at the rates of 50 kg N/ha, 40 kg P₂O₅/ha and 20 kg K₂O/ha, broadcast and worked in 8 days before planting. In a wet year, planting in April with or without mulching, fertilized good variety such as Kenyanyati gives a reasonable yield of at least 2100 kg/ha.

In a rather wet season (1978/79), disease incidence was observed. They were leaf rust with 2.20% crop attack and Septoria nodorum with 2.5% crop attack. This was not the case during the dry season of 1979/80 when the disease incidence was very negligible.

The soils dealt with are ferrallitic and weakly ferrallitic, medium to fine texture, moderately structured and generally acidic pH 5.8 (in H₂O) with an average CEC of 7 me/100g. The organic matter content is about 5.8% with a nitrogen content of about 0.30%. The available water in a profile of one meter depth is about 95mm with an average bulk density of 1.2 gm/cc.

In addition to research conducted in high altitude areas where the small-holders grow their wheat, the Department of Agricultural Research conducts irrigation experiments on wheat in lowland areas where yields averaging 3000 kg/ha are obtained. Work of screening and testing new suitable varieties in these lowland areas still continues.

—C.J. Matabwa
Chitedze Agricultural Research Station, Lilongwe.

ZAMBIA

(a) Zambia-Canada Project

The Zambia-Canada Wheat Development Project is situated in the Mbala district of the Northern Province, at latitude 9°02' south and longitude 31°22' east. The climate consists of a wet season from November to April and a dry season from May to October, with a cool period in June and July. Average rainfall is approximately 1200mm.

Soil survey work was done in 1977-78 and 360 ha of land was cleared. An additional 360 ha was cleared in 1979 and some in 1980. The first crop of rainfed wheat was planted in January /February 1979. At the present time the total area under cultivation is 1080 ha.

During the 1980 season chisel ploughing and disc harrowing were tried immediately after the wheat harvest. Land was found to be very dry and hard to work. A heavy duty chisel plough is used after the first good rain to open up the land. Subsequent cultivations depend on the amount of weed growth. Chisel ploughing with 18-Inch shovels and harrows behind is used ahead of seeding. A trial to study the effects of tillage methods is being carried out.

Soil pH (CaCl₂) at the project is about 4.1. These very acid soils are quite a problem in the area and symptoms of aluminium toxicity have been observed. In trials carried out during the past two years dramatic visual differences in crop growth were observed in the limed plots.
compared to the unlimed plots. Limed plots gave significantly higher yields. Lime movement in the soil was found to be slow and the change in pH at various depths varied with the quantity of lime used.

A five year rotation trial is under way. Crops of maize, beans, potatoes, soyabean, groundnuts, sunhemp and alfalfa are included.

The fertility of the soil at the project is very low and fertilizer recommendations for irrigated wheat are being followed: N @ 120, P₂O₅ @ 60, K₂O @ 30 and S @ 30 kg/ha. Experimental trials to determine rates and placement of P, time of N application, and rates of K and S are being carried out. A need for minor elements B, Zn, Cu, and Mn is being studied.

The recommended seed rate is 90 kg/ha. Adjustment in seed rate is made according to seed size. Seeding is mainly done with a double-disc press drill. Four methods of seeding are being tested at the Project site. Varieties grown are Jupateco, Tai, and Ram.

The rain patterns in the area are unpredictable and it is difficult to pinpoint the best seeding time. From the trials carried out so far it is recommended that wheat be planted between January 20 and February 20.

In newly broken land neither broad-leaf or grassy weeds are a problem. Spot spraying of 2, 4-D Shell amine (7.2) at 2 litres/ha has been used to control broad-leaf weeds. Weed population is building up and weed control trials will be carried out to test various herbicides.

Crop damage from birds has not yet been serious. An army worm outbreak was experienced in 1979, and American bollworms damaged the crop extensively during the 1980 season. The chemical "Sevin" was used to control bollworms.

Soil erosion is a potential problem even though the land is flat.

—B.S. Aulakh
Zam-Can Wheat Project, Mbala.

(b) Mpongwe Project:

The Mpongwe Pilot Project was initiated in 1978 to assess the potential of the Mpongwe soils and water reserves for irrigated wheat and rainfed soyabean production. The soil is a deep red clay overlying a limestone aquifer; pH between 5.0-5.5. Two distinct seasons occur, a rainy summer from November to April and a dry winter.

In 1978, 29.5 ha of wheat yielded 4.5 t/ha, in 1979, 160 ha yielded only 2.3 t/ha and in 1980, 234 ha yielded 4.3 t/ha. The 1979 crop grew well and vigorously with final ear populations of up to 600/㎡. The low yield was due to a large portion of the crop having sterile ears (i.e. ears with no or few grains). The most common cause of ear sterility in Zambia is frost. This was quickly eliminated because no frost was recorded at Mpongwe and none of the more frost sensitive vegetable crops were frost damaged. Water stress and disease were also eliminated. Circumstantial evidence pointed to the cause being due to a boron deficiency because:

a) all previous crops grown on the Mpongwe soil had no sterility, but all had boron applied
b) the sterile ears were dark and erect; similar to those described in other boron-deficient-crops literature.

c) there was a good correlation between soil boron levels and the severity of ear sterility.

d) the only portion of the 1980 crop which contained sterile ears was that which had received no boron.

In each season comparisons were made between sprinkler irrigated and flood irrigated crops. In general the flood area yielded less and was found particularly damaging to the farm machinery. However, once the system was established, flood irrigation was easier to manage and less sensitive to pump failures.

Agronomic practices for wheat production at Mpongwe are based on trials and current Zambian recommendations. Trials have demonstrated that late May to early June is the optimum planting date with Cajeme and Jupateco being the highest yielding varieties. The seed rate used is 80-90 kg/ha. Fertiliser application is designed to give 100 kg/ha phosphate and 130 kg/ha of nitrogen and 0.7 kg/ha Boron. Weeds are adequately controlled using 2,4-D. Experience has shown that a ten day irrigation cycle is necessary to optimise yields applying up to 75mm in late August/early September when the weather is the hottest. Following the above guidelines, encouraging yields of more than 7.0 t/ha were obtained in 1980.

The most interesting mechanical development has been the introduction of direct drilling. This technique was primarily introduced to hasten soya planting which takes place during the rains. Direct drilling reduced the number of field passes and ensured that the maximum use could be made of the limited working days; besides greatly reducing fuel bills. This technique was used in the 1980 wheat crop with very satisfactory results. In replicated trials there has been no yield differences between direct drilling and conventional tillage.

—Dr. A.T.H. Sergeant
Mpongwe Project.

Discussion on agronomy:

Mr. A. Ridley led the discussion on the papers presented. Tillage and land preparation were discussed first. Experience at the EEC Project at Mpongwe with direct drilling has shown advantages: timeliness, reduced cost of tillage, simpler management, and improved soil structure. One disadvantage is the increased cost of herbicides. While more years of experience are needed to reach sound conclusion on the general use of direct drilling, the Mpongwe scheme has found it useful for both crops in a two-crop-a-year rotation of wheat and soyabean. The problems of tillage faced by the small scale farmer were discussed.

Seed and seeding rates then received attention. While low rates of seeding have often given comparable yields in research trials, medium and high rates give lower risk of losses due to weeds, poor seed-bed preparation and low tillering because of warm spells after emergence. In Kenya commercial farmers use 100 kg/ha.

In discussion of fertilizers the place of soil testing and fertilizer response was covered. The importance of measuring pH was stressed, either in water or CaCl₂ solution. Potassium appears to be a necessary fertilizer ingredient to maximize N and P uptake in some areas. The problem of deep incorporation of lime, especially for the small farmer, was discussed.

A few comments on control of weeds terminated the morning’s program.
WHEAT IN SETTLEMENT

The final afternoon of the workshop was devoted to settlement schemes for wheat-growing areas. The chairman was Mr. P. Commissaris, who introduced Mr. Lee Holland to present the lead-off address on a philosophy of settlement, followed by reports on wheat schemes in countries represented at the workshop.

A Philosophy of Settlement

An ideal rural settlement could be one in which the indigenous people are in control of the social and productive concerns of the community, and one which allows for the residence of persons of all ages and both sexes. It is one which is able to undertake a variety of productive rural enterprises and thereby maintain its well being and/or increase its prosperity and contribution to the society as a whole.

This, as an ideal cannot be developed in a short period of time. It certainly cannot be imposed upon a collection of people and it cannot be undertaken on the basis of external management. However, many of our ideals often succumb to the practicalities of the real world and we have to strive to do our best but to achieve less.

In contrast to the ideal of a well planned and implemented rural settlement I wish to present a useful quotation from a professor who has made a thorough study of the subject.* One of his conclusions is that “Settlement should be a last resort of rural development.”

Does that seem unfair? After all a settlement often represents a new beginning: new land, new infrastructure, scope to plan all physical needs properly from the beginning and to introduce a product and/or a means of productivity which should ensure success. In presenting these possibilities however, I have glossed over the key factor, — the human factor, the importance of which can be more fully appreciated by the alternative to the statement that settlement should be a last resort. The alternative in contrast to a development program which can be sketched out on a draughting board and tabulated in so many appendices is: work with the people where they are, i.e. where they are socially secure, where leadership can be identified and where failure of a new idea may not mean total disaster for any particular family or group of families.

This too, is often an ideal, especially in a part of the world where those with a hope for a better life migrate to towns or where rural resources are already controlled or monopolized by an existing population. But, I believe the theme of starting from the vantage point of the people, who may have to live with the ideas and changes being introduced, is far more valid than the strict approach from a physical planning perspective. It will take more time, but, proper developments which necessitate human changes with respect to attitude, new relationships and new technology cannot be brought about quickly.

*Dr. Thayer Scudder – personal communication.

In either case any decision to embark on a settlement plan which in turn depends on the people to be settled and calls for considerable change in the pattern of their lives must be taken with care, with the knowledge that the plan can be implemented thoroughly and that there is
reasonable scope for follow-up of a technical and/or leadership nature when unpredicted
difficulties emerge.

My own experience, which has been very gratifying, has been based on a step by step
approach in which direction was established and decisions made very much in conjunction with
the people involved. Gradually a pattern and considerable popularity emerged. When this
approach is not possible, which is certainly more often the case, I would suggest the application
of a check-list ranging from means of community representation and leadership to the capacity
of community’s resources to sustain the envisaged development.

There are two aspects of settlement formation which are often necessary but which work
against the realization of a community in control as suggested earlier. The first involves the
attractions which have to be offered to lure people to, or interest people in, the new setting.
When this is necessary you have a non-win situation; those who would prove to be the best
participants in the programme will only come when they can be offered more than they
presently possess. Those whose potential is limited may have nothing to lose and will come for
the attractions, e.g. land, house, water; rather than for the opportunity of self improvement. If
the latter type of people predominate then much more time and effort will be required to
ensure the success of the program.

This leads to the second conflicting aspect of settlement, the need for management. If the
participants do not understand their responsibilities, if they are unable to cope with the demands
of their particular operation, if there are too many factors upon which their success or survival
depends but which are beyond their means to control, i.e. the supply of requisites, then an
element of overall management cannot be avoided. This can be undertaken by an external agent
or collectively by the participants of the program. In my experience the former has almost
always been the means of meeting the need. Experts or volunteers are brought in and for a
period of time it would appear that all is well. However, I would stress that the attitudinal
reliance of the people who must continue to live, as the new settlement allows, is not in the
best interests of a collective approach to meeting problems and self reliance in general when it is
known that someone else is in charge. The encouragement of local leadership is obviously more
realistic but takes more time and perhaps calls for a less sophisticated package of changes, e.g.
oxen draft power vs tractors or individual wells and hand pumps vs a centralised (reticulated)
water supply. Will the experts and the planners, will the impatient politicians, accept the need to
implement a realistic development program with a greater element of participation from the
people involved and over a longer period of time? If the answer is no, then the plans must call
for continuing management and the program would better be called a production scheme which
allows for a turnover of participants and/or employees rather than a settlement which implies
independence and societal security.

One more point worthy of note is that the productivity of a rural community or a settle­
ment is best ensured by the inclusion of a variety of enterprises. From the agricultural point of
view each farming family should be engaged in the production of a reasonable number of crops
and/or crops plus livestock. Reliance on one enterprise is unrealistic. From the community
point of view there should be residents with skills beyond the realm of farming, e.g. builders,
carpenters and those capable of repairing implements. Our experience is that a competent farmer
often prefers to hire another person to build a house or an ox cart for him.

I hope I have succeeded in presenting the task of planning and formation of a rural settle­
ment as a very difficult undertaking, because it is. Those who become involved in such
activities are influencing the well being of many individuals and families. The planners very
rarely have to live with their mistakes but new rural dwellers dependent upon those plans may
be adversely affected for the rest of their lives.
Since I was asked to speak on the philosophy of settlement, I will offer this final personal view. The establishment of a viable, productive rural settlement and community would be best approached by attempting to ensure and encourage the dignity and the security of all the individuals who are to become the permanent residents of such a community.

—L. R. Holland
Family Farms Ltd., Magoye.

WHEAT SCHEMES IN TANZANIA

Tanzania as you undoubtedly know lies on the east coast of the African continent with a total area of about 365,000 sq. miles.

The altitude ranges from 0 — over 19,000 ft. above sea level. Wheat grows well between 4000 ft — 7000 ft above sea, mostly in the Northern Highlands of the country although some is also produced in the Southern Highlands. Kilimanjaro and Arusha regions produce about 90% of total domestic production: the rest is produced in Iringa, Tabora, Rukwa and Mbeya Regions. Total domestic production reached a peak of 56,700 tons in 1971/72 and touched all time low of 14,400 tons in 1974/75.

In the mid 60’s the Government of Tanzania decided to expand wheat production with the objective of establishing self-sufficiency in this crop. Pursuant to this a programme was developed in wheat research with the assistance of CIDA (The Canadian International Development Agency) with the objective of adapting and developing technology for dryland wheat production in the Northern Highlands of Tanzania.

At about the same time Tanzania commenced the development of a large tract of land in the Hanang District (Arusha Region) for mechanised dryland wheat production. Up to 1975 yields were low — around 4 bags of 90 kg per acre (0.9 t/ha).

A break-through in technology adaptation and development saw these yields shoot up to 7 bags per acre in 1976. It was realised that sustained wheat production was possible; consequently Tanzania decided to expand production in the Northern Highlands of the country under the auspices of NAFCO (The National Agricultural and Food Corporation) a quasi government institution charged with large scale commercial food grain production. A CIDA financed planning mission came to Tanzania in April of 1978 and after further discussions in December, 1978 with Tanzanian officials a package was agreed for a Tanzania Canada Wheat Development Programme Phase II with components intended to do away with identified constraints for the rapid expansion of wheat production in Northern Tanzania. The components of Phase II include inter alia:

(i) Construction and equipping of a wheat research station in Arusha,
(ii) Training Tanzanian Research/Production staff in Tanzania and Canada or third country,
(iii) Provision of research staff from Canada,
(iv) Survey and mapping of soils suitable for wheat production,
(v) Provision of one machinery advisor and one field operations advisor for each farm of 4000 ha (10,000 acres),
(vi) Supply of farm machinery and equipment enough for five 4000 ha (10,000 acres) new farms,
(vii) Communication within farms and between the farms and Arusha/Dar es Salaam,
(viii) Development of water infrastructure for domestic and industrial use on the farms,

(ix) (a) Construction and equipment of a Central Service Maintenance Centre to handle specialized repairs and maintenance work for the farming complex. This centre will also house a road maintenance and bush clearing unit as well as a forward building unit to assist the farms in the construction of staff housing,

(b) Advisory personnel for the Central Service Maintenance Centre,

(i) — (ix) are financed by the Canadian Government.

The responsibility of the Tanzanian Government in this endeavour is among other things to:

(a) Make the necessary parcels of suitable land available for the programme,
(b) Provide suitably qualified Tanzanian staff for the programme,
(c) Finance farm development including housing, for both Tanzanians and Canadian cooperants,
(d) Finance farm operations costs,
(e) Finance on farm roads as well as construct a 47km access road to the farms (through counterpart funds),
(f) Meet cooperants travelling costs while on duty, and
(g) Meet running and maintenance costs for cooperants’ vehicles.

The Farms:

The Development of New Farms was envisaged to go as follows:

<table>
<thead>
<tr>
<th>Land Area (Acres)</th>
<th>78/79</th>
<th>79/80</th>
<th>80/81</th>
<th>81/82</th>
<th>82/83</th>
<th>83/84</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulbadaw</td>
<td>5,000</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Farm II</td>
<td>—</td>
<td>5,000</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Farm III</td>
<td>—</td>
<td>—</td>
<td>5,000</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Farm IV</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>5,000</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Farm V</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>5,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Total acreage</td>
<td>5,000</td>
<td>15,000</td>
<td>25,000</td>
<td>35,000</td>
<td>45,000</td>
<td>50,000</td>
</tr>
</tbody>
</table>

In addition we have Basotu Farms Ltd (the oldest) and Setchet Wheat Company Ltd. with 10,000 and 12,000 acres respectively.

At the time of writing this, equipment and machinery for Mulbadaw and Farm II (christened Murjanda) have been received on site and orders for Farm III as well as the Central Workshop have been placed.

Seeding has also started and this season we expect to seed a total of 40,000 acres in Hanang District, Arusha.
NAFCO contribution to wheat production since 1978/79 is as below:

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>HA</td>
<td>M.T.</td>
<td>HA</td>
</tr>
<tr>
<td>CIDA assist.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basotu</td>
<td>3,191</td>
<td>7,683</td>
<td>4,240</td>
</tr>
<tr>
<td>Setchét</td>
<td>3,545</td>
<td>4,950</td>
<td>4,570</td>
</tr>
<tr>
<td>Mulbadaw</td>
<td>2,000</td>
<td>4,350</td>
<td>2,192</td>
</tr>
<tr>
<td>Murjanda</td>
<td>—</td>
<td>520</td>
<td>387</td>
</tr>
<tr>
<td>Sub-total</td>
<td>16,983</td>
<td>18,356</td>
<td></td>
</tr>
<tr>
<td>Other NAFCO</td>
<td>3,506</td>
<td>4,420</td>
<td></td>
</tr>
<tr>
<td>Farms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total NAFCO</td>
<td>20,489</td>
<td>22,776</td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

NAFCO currently contributes about 77% of total domestic wheat production.

At the end of the day the objective of the Tanzania Canada Wheat Programme is to enable Tanzania to eventually become self-sufficient in wheat production as well as manpower and research capability which is essential to sustained production.

—Eric N.A. Munisi

ZAMBIA-CANADA RAINFED WHEAT SCHEMES

(a) The Unit Farm Extension Project:

The Unit farm approach is designed to give us information used in development of settlement schemes. The objective is to determine the management skills required and to determine the economics of wheat growing.

Zam-Can provides a contract and a complete line of equipment, according to farm size, as follows:

(i) 20 ha Unit — oxen powered
   - wheeled tool carrier and accessories
(ii) 50 ha Unit — small tractor
    - 24 hp Escher ac diesel, 1 cyl.
    - 36 hp Agrala ac diesel, 2 cyl.
    - full line of equipment
(iii) 90 ha Unit — medium size tractor, 50-60 hp
    - full line of equipment
    - a production farm

Problems have been:
- procurement of equipment
- tied and untied funds
- time lapse from identifying equipment needs until delivery
- difficulty in getting information on equipment

Other services include:

1) Providing seed and fertilizer
2) Management advice in cropping and economics
3) Mechanical services — repairs and guarantee of available equipment
4) Custom service in harvesting and marketing of crop; immediate delivery and crop sold at gazetted price
5) Monthly wage provided and share of profit — first K2000 and 50% of balance
6) Housing and adequate land to suit size of equipment
7) No loss guarantee

The farmer agrees to the following:
1) Farm the land provided to the best of his ability
2) Follow the advice of Canadian advisor
3) Provide labour for farm operations
4) Maintain records of labour used, machine usage, feed, seed, diesel, etc.

The project began in 1979 and is gradually becoming fully operational.

—D. England
Zam-Can, Mbala

(b) Adaptive Research for Small Farmers:

Research for the small farmer involves identifying innovations that are relevant technically, economically and socially. It was hoped that this could be achieved in the development of an improved maize management package for ox-farmers by empirical testing at three levels:

(i) Research Station trials
(ii) On-farm trials (current practice vs. new technology)
(iii) Pilot farm scale testing (evaluation of adoption potential)

The idea being that relevant socio-economic data would emerge spontaneously at levels (ii) and (iii).

By the third season an apparently sound technical package had been developed; however detailed economic data, collected for the first time that season, identified important limitations to the package that had been missed when only farmer’s attitudes and reactions were noted.

It became obvious that to increase the efficiency of farmer-orientated research an interdisciplinary approach should be adopted. Economists and Agronomists should cooperate prior to (identifying priority areas for research), and during the three levels of empirical research.

The biggest problems likely to be experienced in such an approach are with the on-farm trials, where the close control necessary for accurate data collection conflicts with the desire for realistic treatments.

Technological packages (cf. single innovations) should only be tested if all components appear to be appropriate and to overcome constraints within the existing farmer practice. They are likely to be most relevant with the introduction of new crops.

—J. Parker
Mt. Makulu Res.
SPECIAL REPORTS ON ZAIRE AND PROJECTS IN SOUTH, CENTRAL & EAST AFRICA

ZAIRE

In eastern Zaire, in Kivu Province, wheat has been grown by small holders for several decades. Over the years the varieties have become mixed and are generally susceptible to diseases.

Four years ago the Ministry of Agriculture requested seeds of new varieties to be tested at Ndihira Station. It is located in a remote hilly and forested area with only footpaths to the small fields and at an altitude of 2100m. Cooperation of the milling company MIDEMA and the Ministry resulted in good tests of varieties selected in Kenya. Diseases such as stripe rust and stem rust are serious. Besides wheat Triticale proved very good.

A small mill bought the locally produced wheat and milled it after drying. The flour was used directly or in mixture with imported wheat flour to make biscuits. These are readily sold in the region.

Seed multiplication is starting, and distribution of the new varieties will follow. A key factor will be the buying back of the new wheat from the farmers. Triticale is not yet distributed as its quality for the local product still needs to be tested.

Changing over the seed is expected to double the yield and will practically not influence the other farm practices.

In a second area in Zaire in Shaba Province, in highlands near Lake Tanganyika (Marungu Mountains) wheat is also grown by small holders. Land is generally less fertile and the main activity is ranching. People have left villages in the high elevations as conditions are difficult. To stabilize the population in the hills wheat is expected to play a role. With better wheat and merchants to come and collect it farmers can sell enough to make their life more agreeable.

How can the change over from diseased mixtures to higher yielding resistant varieties be achieved?

The local population knows wheat as a possible cash crop, that it can be sold to merchants coming up from the lake. How can the situation be improved, if there appears to be very little infrastructure? During a visit made in January, 1981, soil samples proved to be quite acid in a rapid coloration test, between pH 5 and 6. In ten villages seeds were handed out of wheat and Triticale of more than 150 lines that were identified in Kenya. A key factor will be followed up by the scarce available manpower at zone or subregional level. These men receive some training in the research station near Lubumbashi.

—G. Kingma,
CIMMYT.
INTRODUCTION

Wheat consumption in Africa is increasing with urbanisation and the demand for bread as a convenience food. Whether or not this increasing consumption is desirable is certainly debatable but the trend has become so much a symbol of development that it seems inevitable that it will continue. Although wheat is associated with large capital intensive arable development, clearly it is possible to produce the crop using simple hand tools and a high labour input. In Europe and North America, these labour intensive production methods were in use into the present century. However it is certainly true that wheat as a crop has been extremely successfully mechanised, and the very efficiency of land preparation, planting and harvesting equipment, has led to the development of large capital intensive units to take advantage of economies of scale. In Central Africa where most of the production is irrigated, the effect of irrigation is to emphasise further the economies of scale of large capital intensive production units. The various types of production systems can be classified broadly into 5 groups:

Wheat production systems:

(a) SMALL HOLDER SYSTEMS:

(1) Unassisted Production:

In its simplest form an unassisted smallholder production system involves family labour and occasionally oxen to produce a crop of wheat for consumption or sale. Threshing is very laborious by hand or using a flail and harvesting often by cutting individual ears rather than cutting sheaves. This type of system is found in South West Tanzania in both the Kipenjere and Matengo highlands and in the Kirk Range on the Western borders of Malawi. Although the crop is grown in autumn and winter, it is rarely irrigated, being grown on stored soil moisture. Plots are normally small and frequently terraced to cope with the steep slopes. The main constraints to production in these areas are dense settlement with little available spare land, lack of appropriate tools especially in land preparation and harvesting and threshing, and poor crop prices and or marketing facilities.

(2) Assisted Production:

Both Tanzania and Malawi have made an attempt to increase smallholder wheat production by providing some assistance to smallholder producers. In Tanzania this has mainly taken the form of mechanised land preparation and combine harvesting, while in Malawi it has involved improved extension and the introduction of new varieties. Unfortunately mechanisation is not suitable for many of the high potential rainfed wheat areas because of steeply sloping sites. Also small plots often separated by large distances makes for inefficient and therefore expensive machinery usage. Combine harvesters are very complex pieces of machinery and do not function at their best in remote areas with poor support services. Experience has also shown that buying centres for wheat in remote areas are costly to operate resulting in poor and unattractive prices to growers in those areas, despite the fact that the same remote highland areas are agronomically best suited to the crop.
(3) **Irrigated Settlement:**

Irrigated Wheat conveniently fits into a double cropping system in Central Africa with cotton or soya for instance. Where settlement schemes have been based on a labour intensive crop like cotton, and irrigation facilities are available, wheat has been used as a winter double crop to reduce overhead costs of management and irrigation. Unfortunately, with most irrigation systems, the settlement areas are often technically well suited to fully mechanised production leaving very little for the settler to do. At Chisumbanje for instance, in the Zimbabwe lowveld smallholder settlers growing cotton with irrigated wheat as a winter crop, only contribute 5½ man days/ha to the production of the crop, almost entirely on the furrow irrigation system. Planting, Weeding and Combining are fully mechanised. For the expenditure of 5½ man days/ha/annum a settler can earn between Z£100 and Z£150/ha net profit. Obviously he is heavily dependent on the management/mechanisation unit to provide him with a wide range of services.

(b) **COMMERCIAL SYSTEMS**

(1) **Rainfed**

By far the bulk of wheat grain produced, and certainly marketed, in South, Central and East Africa comes from commercial large scale farming production. From the equatorial zone to 10°S, this is almost entirely rainfed production in highland areas above 1500m above sea level while S of 10°S almost the entire production is as an irrigated winter crop. In the Kenya highland area the wheat crop has been grown on mixed farms up to 3,000m above sea level in rotation with leys, while in Northern Tanzania many of the wheat farms were highly specialised, mono-cropping with crops growing in both rainy seasons on adjacent fields. In drier areas and in the South of Tanzania rainfed wheat is grown in rotation with maize, often seed maize. Two very large farms have been developed, one of up to 40,000 ha at Basotu in Hanang district in N. Tanzania by Tanzanian Government with CIDA aid, and one at Njombe in Southern Tanzania of approximately 2,000 ha with an association with a CDC Wattle Plantation. A characteristic of all the rainfed commercial farms is that they are very capital intensive, i.e. fully mechanised, and have to achieve consistent high yields to operate profitably. Too little rain resulting in a droughted crop, or too much rain resulting in heavy disease infection are very real problems.

(2) **Irrigated**

South of 10°S virtually the entire commercial wheat crop is produced under irrigation resulting in a very high degree of control over yields. Areas such as the Zimbabwe lowveld at an altitude of only a few hundred m above sea level are capable of producing consistent satisfactory yields. Higher areas between 1000m and 1500m above sea level where the basically temperate wheat crop is subjected to far less stress, are capable of consistent high yields more than compensating for the high cost of installation and operating irrigation. For the capital intensive high mechanised commercial producer, economies of scale apply with most efficient crops in blocks of more than 50 ha. In Zimbabwe in particular, irrigated winter wheat is a useful high value rotation crop on intensive arable farms.

(3) **Yields and constraints:**

The Table below summarises the yield range and constraints of the various production systems outlined in the foregoing.
The Table below summarises the yield range and constraints of the various production systems outlined in the foregoing.

<table>
<thead>
<tr>
<th>Production System</th>
<th>Yield Range Kg/ha Grain @ 14% m.c.</th>
<th>Production Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Smallholder Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Unassisted Production</td>
<td>± 500 Kg/ha</td>
<td>Suitable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appropriate tools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poor markets/prices</td>
</tr>
<tr>
<td>(2) Assisted Production</td>
<td>± 1000 Kg/ha</td>
<td>Unsuitable varieties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High cost of extension/support services</td>
</tr>
<tr>
<td>(3) Irrigation Settlement</td>
<td>2500 - 5000 Kg/ha</td>
<td>High development cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low smallholder contribution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High mechanisation requirement</td>
</tr>
<tr>
<td>B. COMMERCIAL PRODUCTION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Rainfed</td>
<td>1500 - 5000 Kg/ha</td>
<td>Unreliable weather conditions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diseases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unsuitable varieties</td>
</tr>
<tr>
<td>(2) Irrigated</td>
<td>3000 - 7000 Kg/ha</td>
<td>High development cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sophisticated management skills required</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lack of suitable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>combination of soils and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>irrigation water.</td>
</tr>
</tbody>
</table>

DISCUSSION ON WHEAT SCHEMES

Workshop discussion brought out the problems that are being encountered and tackled, with varying degrees of success, as follows:

(a) Problems with small scale farms, producing for local consumption or on a small commercial scale:

1) The tendency for landholders to sit back and wait for instructions,
2) The lack of incentive on cooperative farms,
3) The need for diversity of crops to ensure year round use of labour, spreading of resources, and increased income,
4) The need for mechanisation centres and custom services,
5) The difficulties of mechanising small scale operations, as in using row seeders and small scale threshers,

6) Improving technology among the many and varied operators and in the marketing of farm products (cash on delivery being a major problem for some).

(b) Problems with large commercial farms:
1) Need for large scale farm equipment — problems in acquiring and servicing
2) Large labour force needed, with extra needs in busy seasons
3) Areas of potentially productive land not readily accessible in some countries,
4) Where irrigation is used it is sometimes difficult to get one crop ripened and removed in time for a second crop in one year — shorter maturing varieties needed.

CONCLUDING SESSION:

The possibility of arranging further Workshops in the future was discussed. Types of programs suggested ranged from meetings featuring a specific problem to be examined in depth to a more general type of program. One suggestion was to have a plenary session on general topics or themes of interest to all, with sub-groups then examining special topics in depth. It was noted that not all countries would have experts in all topics that might be named and a more general type of program might therefore be of interest to the greater number. It was suggested that CIMMYT personnel might take the lead in planning any future meeting.

Dr. E.A. Hurd told the Workshop that a spore collection program would be spearheaded by CYMMIT and that details would be discussed by Dr. Kingma and other involved before their departure.

Dr. Hurd then brought the Workshop to a close by announcing plans for the Farm Tour the next day and by thanking all who had helped in planning and participating in the Workshop.

FARM TOUR:

On Friday, March 13, Workshop participants went on a bus tour to farms east and northeast of Lusaka. The tour was sponsored by the Commercial Farmers' Bureau and organized by Mr. J. Woods.

The Walkover farms at Chelston and Waterfall showed the soybean-wheat (irrigated) enterprise at the former, and at the latter: vegetable production (both rain-fed and irrigated), cold storage facilities, wheat, maize, sunhemp and strawberries.

At the Kasisi Agricultural Training School Mr. P. Desmarais outlined the program for training selected farmers from adjacent villages in maize, soyabean, vegetable and broiler production.

The tour next included Mr. Galaun's dairy, where a 16-stall milking parlor was inspected.

At the Bonanza Farm hosts were Messrs. Irwin and Hummel, and their wives provided a delightful lunch. Afterwards the hosts conducted a tour of their fields of cotton, maize (both commercial and seed), soyabean for seed, their beef herd, and tobacco drying barns and handling facilities.

Return to Lusaka concluded the tour and the Workshop.
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In addition to the above participants several guests and interested observers also attended.

Additional copies of this report may be obtained from the Librarian, Mt. Makulu Central Research Station, P. Bag 7, Chilanga, Zambia.