REGIONAL WHEAT WPRKSHOP FOR EASTERN, CENTRAL AND SOUTHERN AFRICA

ARUSHA, TANZANIA
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PROCEEDINGS OF THE REGIONAL WHEAT WORKSHOP FOR EAST, CENTRAL AND SOUTHERN AFRICA HELD IN ARUSHA, TANZANIA JUNE 13 - 17, 1983

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OPENING ADDRESS TO THE REGIONAL WHEAT WORKSHOP FOR EAST, CENTRAL AND SOUTHERN AFRICA

Dr. J. N. R. Kasembe

The Director, TARO Research Institute, Arusha,

The Team Leader, Canadian-Tanzanian Wheat Project, Distinguished Guests, Ladies and Gentlemen,

Wheat is one of the major staples in Tanzania and is special in many ways. It is grown on over 240 million hectares in the world, an area larger than that of any other crop. Also wheat contributes more calories and more protein to the world's diet than any other food crop, contributing to world trade which exceeds that in all other grains combined. Thus, Tanzania has rightly put emphasis in wheat production in the areas suitable for that crop.

The Tanzania-Canada Wheat project, has initiated wheat production in this country, although a limited small holder production was practiced before the project. Compared to the yields in the developing countries, (555 - 3885 kg/ha), Tanzania's average yields are above average (2,000 kg/ha), and this has come about as a result of research on production methods which preceded the management practices now in operation. (Calculated theoretical maximum yield is 20,000 kg/ha while world record is 14,100 kg/ha). Environment is the first limiting factor on every step of the yield ladder, and skill of the farmer comes second, and, when these two are not limiting, farm inputs, especially in Tanzania, become very important. Research in wheat production, therefore, must first address itself to identification of constraints in production, which may be related to the following areas,

(a) <u>Types and varieties of the crop</u>-the tendency in the last two decades for breeders is to develop new wheats which are shorter, higher yielding, earlier to mature, resistant to diseases and more responsive to fertilizers.

(b) <u>Management practices</u>-the trend for agronomists is to work out suitable production practices, eg. methods of sowing, irrigation or rainfed, fertilizing, moisture conservation and weed control. This is accompanied by the development of farm machinery for the appropriate farm practices eg. for tilling the soil while conserving moisture.

In both the above cases, CIMMYT, (The International Maize and Wheat Improvement Centre) in Mexico and ICARDA (International Centre for Agricultural Research in Dry Areas) in Syria serve as centres for germ plasm, nurseries, data, training participants, and consulting on production problems. In East, Central and Southern Africa, the region is served by CIMMYT with its regional office in Nairobi. CIMMYT as an International Agricultural Research Centre deals with the major problems mentioned earlier, while the National Agricultural Research Systems in individual countries deal with the detailed applied research. I understand the participants in this Workshop are from Burundi, Ethiopia, Kenya, Lesotho, Malawi, Malagasy, Rwanda, Tanzania and Zambia. From these countries we shall examine and discuss in detail the production constraints, crop management, plant protection, water management and soil management. This workshop, therefore, marks the beginning of National cooperation within the region. The Consultative Group for International Agricultural Research Centres, at its meeting last month in Paris, examined the Quinquennial Review of CIMMYT and commended the work done by the centre. The Group recommended more efforts in strengthening the relationship between CIMMYT and the African Region, whose members are meeting today.

Also the International Federation for Agricultural Research and Development (IFARD) at its recent meeting at the IITA in Ibadan, recommended the strengthening of both IARC and NARC through workshops like this and through exchange of reports, journals, staff and students.

The experience of the very good work done by the Tanzania-Canada Wheat Project team in both production and research has to be shared with our neighbours and also the team will learn from the other countries from the region any experience which may benefit our project here in Tanzania.

I wish the workshop every success especially in your efforts for further cooperation.

Thank you.

SESSION 1, Tuesday Morning, June 14, 1983

WHEAT PRODUCTION AND CONSTRAINTS IN EACH COUNTRY

Chairman: F. M. Shao

CONSTRAINTS IN WHEAT PRODUCTION IN EAST AFRICA AND SOME SUGGESTED SOLUTIONS

E. A. Hurd

INTRODUCTION

Wheat consumption is increasing at a rapid rate in all developing countries. As peasants move to the urban areas, they begin to eat bread, a convenience food. Although wheat production is usually associated with large scale mechanized systems, many parts of the world have successfully demonstrated that wheat, like maize, can be grown for profit with hand tools, or oxen. In either case, high labour inputs are used.

Obviously the constraints differ with scale. The large producers may have problems of shortage of foreign exchange to purchase replacement equipment or spare parts. The small holder often has a shortage of capital, lack of borrowing power and encounters high interest rates if he does borrow. These problems are exagerated when he has to wait for long periods to receive payment for crop sold.

Often such economic constraints are more limiting than the technical ones for both groups of farmers. Of course solving economic problems is not on the agenda of this workshop but we need to realize their importance in relation to those we will discuss.

Some solutions are being found for these constraints in the small holder sector, such as low interest rates, direct subsidies and, in the extreme, food aid programs to combat very high risk production. Even crop insurance; subsidies to small holders can be effective in lessening constraints. Let us discuss the agronomic or technical constraints.

The goals of research into disease and breeding are to develop varieties which are ideally suited to a range of local environments. Research into soils and agronomic practices, on the other hand, is designed to modify the local environment (micro-climate) so that it is more hospitable to plant growth. In the early stages of a new wheat research program, breeders and pathologists screen a wide range of varieties with help from CIMMYT and ICARDA. This identifies varieties that tolerate the hard features of a particular environment. Agronomic research at this stage attempts to remove the most severe constraints. Research is refined gradually. Screening is followed by race identification and select crossing. Agronomists zero in on cultural practices that maximize production. All of us in attendance are at one stage or another of such research developments.

SOME SPECIFIC CONSTRAINTS:

Every researcher believes that his area of work is the most important. My bias is drought research and I am convinced that the one overriding constraint is moisture stress - more loss in yield is due to moisture stress than to any other single cause. Thirty six per cent of land is classed as arid or semiarid (less than 30″ or 750mm rainfall per year) and much of the rest undergoes temporary drought stress. Scarcity of land, food shortages or lack of foreign exchange to buy it, force production into more arid areas. Even where wheat is grown under irrigation, it suffers from shortage of water, or will, if water is not conserved. Southern California, Arizona, and Mexico all have much desert land suitable for irrigation but do not have the water. In the Texas panhandle, farmers have switched to low-water-use crops like wheat and cotton bred for drought resistance even though all crops are grown under irrigation. Their water table is receding. The savannah areas of Kenya, Tanzania and Ethiopia have short, limited rainfall seasons. Wheat is one crop that grows well in these areas because it is drought tolerant and matures quickly, in 90 or 100 days.

Drought is linked with nearly every other constraint e.g. diseases, weeds, low soil fertility, acid soil and primitive cultural practices. Heavy leaf rust may not cause much loss if the weather is cool and the soil is moist. On the other hand, moderate leaf rust infection combined with drought can cause severe grain shrivelling. Acid soils and aluminum toxicity are as much a drought problem as any other. Roots grow poorly, if at all, in acid soil but reasonable crops can be produced as long as moisture is plentiful. What do we do about drought ?

AGRONOMY FOR DROUGHT AVOIDANCE:

The most dramatic solutions to drought are in the agronomic area. Conservation of available moisture is carried out through weed control, shallow cultivation (soil dries out to depth of cultivation), minimum tillage/direct drilling and stubble mulch. The latter increases penetration rate in heavy rains as well as preventing soil erosion. Also the surface trash reflects sunlight keeping the soil cooler. Other papers will elaborate on this important topic.

WEATHER MODIFICATION:

Attempts to increase rain by cloud seeding has had limited success. Weather modification is unlikely to be looked to for a solution to drought in our wheat programs in this area of Africa in the near future.

BREEDING FOR DROUGHT RESISTANCE AND OTHER CONSTRAINTS:

A participant in a drought conference in the Philippines in 1982 suggested that breeding for drought resistance was a 'mirage'. The numerous examples of success present in the literature confirm that breeding for resistance to drought is practical.

Some scientists have said that when breeding for yield, whatever the crop stress, workers should select under as near ideal conditions as possible. However, these are frequent examples of varieties that do well in ideal growing conditions but poorly under drought stress. Breeding for drought resistance on the dry Canadian prairies has resulted in a 15 to 18 per cent increase in yield in durum wheats. The main character involved was extensive rooting at depth; a character that could only be selected for in large segregating population when grown under moisture stress.

Breeding for disease, maturity, lodging, shattering. threshability, and sprouting are all solutions to various constraints. As we select for these simply inherited characters, we are or should be, also selecting for yield under whatever environment constraints are present, such as drought and Al^{+++} toxicity. Most breeding programs are designed to eliminate negative ganes which are simply inherited such as disease susceptibility. Breeding for yield and drought resistance is the accumulation of many small effect plus genes. Many breeders do not use available genetic and statistical knowledge in planning their programs. As an example, if you were selecting for dwarfness and white seed colour you would probably be dealing with 2 recessive genes for each character. There would only be 1 plant of this nature in 256 or 39 short white seeded plants in 10,000. Even if you identified all 39, you have a ridiculously small number of plants from which to select for all other desired characters. We obviously need to select in large populations to give us any chance of making even a slight improvement in yield, drought resistance, quality and other multigenic characters.

If you are to grow large F2s and subsequent populations you need to handle very few crosses. If you are making few crosses you must select parents carefully. Both parents should be well adapted to the intended environment. If an exotic variety is included we should make a double cross where the exotic is only one quarter of the genetic base.

RESEARCH CONSTRAINTS:

We have looked at economic and agronomic constraints and at research solutions to the production constraints. But research itself has constraints. We are all aware of the shortage of money for equipment and even travel to off-station sites.

Aid programs are usually heavily involved in training as professional manpower is a serious constraint in research in most of the countries represented here. Experience is even more limiting because an M.Sc. or even Ph.D, in itself does not make a researcher. Training provides the "tools" but only the experienced worker can walk into a "sick" field, diagnose the problem and provided a cure, or design a research program to solve the problem. To acquire experience takes years. If new graduates are not going to make costly mistakes in making recommendations, or cause long delays in providing solutions, they should work daily for two or more years with experienced researchers. They should be part of the decision making during this time.

This paper is designed to provide some background of a general nature which will help to knit together specific workshop reports.

WHEAT PRODUCTION AND RESEARCH IN ETHIOPIA

Efrem Bechere

INTRODUCTION

Wheat is an important rainfed crop in the highlands of Ethiopia. The Abyssinian centre of Origin occupies first place with regard to the number of botanical varieties of wheat found in Ethiopia. Even today with a high rate of genetic erosion the existence of a wide diversity of genetic material is evidence of this statement (5).

In Ethiopia, durum or macaroni wheat (Triticum durum) and bread wheat (Triticum aestivum) are by far the two most widely grown species although other wheat species of less significance like T. dicoccum, T. turgidum, T. compactum, T. polonicum, T. pyramidale and T. abyssinium are also grown.

Durum wheat occupies about 2/3 of the total wheat area in the country. Nearly all varieties of durum wheat are landraces consisting of a mixture of tetraploid types suitable for unleavened bread (5%), "Injera" (60%) and pasta products (35%). Although some high yielding durum wheat varieties have been multiplied recently and distributed to farmers, the area under improved varieties is very small. In contrast, bread wheat is believed to be a recent introduction to Ethiopia. It has wider adaptation and higher yield potential than durum wheat. Practically all of the bread wheat in the country at the moment is grown on state farms, whereas almost all of the durum wheat is produced by private farmers (2,6).

In Ethiopia, wheat is generally sown from July to August but up to mid-September in some areas, and harvested from late December to February.

WHEAT AREA AND PRODUCTION

Wheat ranks 5th in area of production, 6th in gross output value and 11th in foreign exchange value in Ethiopia (1).

The total production of wheat in 1971 was 839,500 metric tons and in 1974 production decreased to 652,800 metric tons and in 1980 to 469,000 metric tons with average yields of 0.74 ton/ha, 0.80 ton ha and 0.90 ton/ha, respectively. Total cultivated wheat area decreased from 1,092,000 hectares (1971) to 816,000 hectares (1974) and to 516,000 hectares (1980). (Table 1).

Table 1 - Production & Area Under Wheat in Ethiopia (1948/52 - 1979/80)

Year	Production (1000 MT)	Area (1000 HA)
1948-1952		
Average	460.0	840
1952-1956		
Average	508.0	856
1960-61	255.0	364
1961-62	260.0	255
1962-63	266.0	380
1963-64	653.8	921
1964-65	692.9	962
1965-66	721.7	987
1966-67	738.9	1008
1961-1965		
Average	663.0	1612
1967-68	760.6	1029
1968-69	782.0	1049
1969-70	808.0	1070
1970-71	839.5	1092
1971-72	876.0	1113
1969-1971		
Average	643.0	782
1972-73	644.8	806
1973-74	652.8	816
1974-75	698.9	765
1975-76	532.5	537
1976-77	605.2	548
1977-78	429.0	493
1978-79	448.8	511
1979-80	469.0	516

Source - Ethiopian Statistical Abstract 1948/52 - 1978/80.

From the surveys conducted by the Ministry of Agriculture, one can gather that the main areas of production are the Arsi region with a total area of 163,300, the Shoa region with 160,300, Bale with 34,000, Gojam with 27,800, and Begemdir with 26,300 hectares. Wheat is grown also in Wello with 19,900 hectares and to a lesser extent is found in Kefa, Sidamo, Gamo Gofa and the Illubabor regions. The production of this crop has increased steadily in recent years rising from 429,000 metric tons in 1977/78 to 469,000 metric tons in 1979/80 (5). This increase was due to an increase in the area under this crop from 493,000 hectares to 516,000 hectares. The national average yield per hectare is only 8-9 quintals.

Local consumption of wheat is high and has been increasing steadily in recent years. Although production has been rising in recent years, large quantities of wheat were imported to meet the local needs. According to the Agricultural Marketing Agency reports, imports for wheat for the year 1979 were 135,598 tons of grain and 101,218 tons of flour (5).

Wheat has a wide variety of uses in the country. In the production areas it is used as a staple food. The grain is boiled or roasted and mixed with peas or other pulses and eaten directly or ground into flour for the preparation of various types of local breads. Besides, a large portion of the production goes to the milling industry for the preparation of industrial flour for bread making, pasta products and other delicacies. Virtually all parts of the wheat plant are utilized; straw for animal feed and bedding, as well as organic matter for the soil are examples of the crop's versatility (5).

CLIMATE

The topography of the Ethiopian highlands includes high plateaus (average elevation 1700m), severely eroded massifs and spectacular steep valleys. The environmental heterogeneity and geographical isolation of people and crops within the highlands has led to wide crop genetic diversity, shown by the morphological variation observed within all the crops (7).

Wheat areas in the highlands are restricted to between 6° and 15°N and 37° and 42°E and to elevations from 1500-2800 metres. It is wholly grown under rainfed conditions. The total annual rainfall ranges between 400-1000mm. with an average of 750mm. Most of the rainfall occurs between June and September and the peak fall comes in July and August. In most wheat growing areas low rainfall is unlikely to be a limiting factor, particularly at elevations above 1700m.

The maximum and minimum temperatures range from 25°C to 30°C and 3° to 8°C, respectively.

The soils are variable although mostly red ferrisols on the slopes and deeper, black, brown clays in the valleys.

FACTORS LIMITING WHEAT PRODUCTION IN ETHIOPIA

One of the major reasons for the low wheat yield in the country is the low genetic potential of the varieties grown. The majority of the Ethiopian farmers continue to use local cultivars which for the most part are agronomically poor, low yielding, and susceptible to diseases and lodging. Therefore, the major problem is that improved varieties are not readily available (6).

At the higher elevations, sharp night frosts are constraints to wheat production. Moreover, at these elevations the high rainfall has the indirect effect of greater disease incidence, waterlogging, lodging and the difficulty of weeding and cultivating. At lower elevations, lack of enough precipitation is one of the limitations to wheat production.

The main effect of temperature variation is variation in maturation period. Dessicating winds in October and November cause premature drying of ears in some areas (2).

Lack of proper management within the actual peasant farming system is one of the bottlenecks for wheat production. Oxen are used to pull the wooden ploughs, harvesting is generally by hand sickle, threshing is done by the trampling of animals and grain is cleaned by hand winnewing. The use of fertilizers, herbicides and insecticides is very minimal. Little or no attention is paid to such practices as land preparation, plant population, date of sowing or fertilizer type, rate and method of application. The shortage and high price of commercial fertilizers have contributed to this.

Wheat in Ethiopia also suffers greatly from the effects of diseases and insects. The extent of damage depends on climatic conditions. The major wheat diseases that are prevalent in the country are leaf-rust, stem rust, stripe rust and septoria. Other diseases commonly found include Helminthosporium spp;, Fusarium spp., bacterial stripe, bunt or stinking smut and root rot (6).

Another factor which should not be disregarded at this time is the lack of proper dissemination of research results to the farmers. This no doubt has its contribution to the low level of wheat production prevailing in the country currently.

OTHER CONSTRAINTS

Other constraints relating to wheat production are those associated with research. The first and probably the most significant constraint is the shortage of high caliber researchers. At present there are only six agronomists and breeders working on this very important crop in the whole Nation. The pathologists, entomologists, weed scientists and soil scientists working on wheat have still to be shared with other crops because of a critical shortage of personnel in these disciplines. To solve this problem the research on almost all major crops in the country is carried out in a form of team approach.

Facilities such as laboratory equipment, proper seed storage places, field machinery, transportation, etc. are also in short supply and they hamper greatly the development expected from research.

WHEAT IMPROVEMENT WORK IN ETHIOPIA

The durum wheat cultivars traditionally grown in the country are generally tall (125 to 150cms) and weak-strawed. As they grow and manufacture carbohydrates, they deposit a large amount of their dry matter in the stem and leaves in relation to the amount in the grain. They lack satisfactory resistance to lodging and diseases. Their yield potential is low and they do not respond well to fertilizers. Their merits however are good adaptation, drought tolerance and good quality. Moreover, they are more dependable than the improved varieties under poor farming conditions (4,6). On the other hand, since bread wheat is a recent introduction, the varieties in production are improved varieties which must be replaced as the need comes.

Therefore, the first and foremost task of wheat breeding has been and still is the development of widely adapted, high yielding and disease resistant varieties of both bread and durum wheats. However, other characters such as resistance to lodging and insects, drought tolerance, early to medium maturity, good tillering capacity, and good grain quality also receive due consideration in the breeding work (6).

At present, new improved varieties of durum and bread wheat are being developed using the following methods:-

1. Selection from Indigenous Germplasm Collections

Since Ethiopia is the centre of genetic diversity for tetraploid wheat, it possesses an excellent genepool as far as durum wheat is concerned. Therefore better types can be obtained through testing and evaluating indigenous germplasm collections. Selections like DZ-04-118 and DZ-04-688 (Marou) were obtained through this method. The screening work is continuing in cooperation with Plant Genetic Resources (PGRC/E) until all the local germplasm collections are evaluated (6).

2. Selections from Introductions

Every year, hundreds and thousands of varieties and segregating lines of both durum and bread wheats are received from various International Research Organizations (FAO, CIMMYT, ICARDA, etc.,) and National Research Institutes (Kenya, Turkey, Australia, etc.). After being tested, the most promising lines/varieties are then advanced for further testing at more locations so as to obtain more information on yield, disease reaction, grain quality and other genotype by environment interactions of the varieties/lines. The bread and durum wheat varieties which have been released since 1960, were the results of selection from introductions followed by repeated testing of promising varieties at different locations in national yield trials.

3. Hybridization

Durum wheat hybridization work at the Debre Zeit Research Centre was initiated in 1974. Since then quite a number of crosses have been made between locally adapted varieties and high yielding exotic types mainly for improving disease resistance and yield capacity under rainfed conditions. Some of the material from the programme is in the final stage of yield testing.

Bread wheat crossing work was started at Holetta Research Station in 1972 and over 1,000 crosses were made since then. Most of the parents used in the crossing programme were released varieties and promising entries from different nurseries which have good agronomic characteristics with emphasis on disease resistance. Some lines from this programme have been included in national yield trials and the most promising ones will be released as varieties. In general, the pedigree method of breeding with individual plant selection is being followed in the hybridization programme.

Summaries of all the bread and durum wheats released in Ethiopia up to 1980 are given in Tables 2 and 3, respectively.

Table 2 - Summary of Bread Wheat Varieties Released in Ethiopia since 1949. (6)

Variety or Section	Year Released	Ear Type	Chaff Color	Grain Color	Maturity	Height
Kenya 1	1953	Beardless	White	White	Medium	Tall
Kenya 5	1954	Beardless	Red	Red	Early	Tall
Kenya 6	1954	Beardless	Red	White	Early	Tall
Kenya-Supremox Yaqui (102)	1959	Beardless	White	Red	Early	Tall
Anguilera-Kenyax Marroqui-Supremo x Yaqui (105)	1960	Beardless	Red	Red	Early	Tall
Yaktana 54	1967	Bearded	Red	Red	Medium	Tall
Kentana-Frontana x Mayo 48	1967	Beardless	White	Red	Medium	Tall
Suprem-Kenya x Yaqui 48	1967	Beardless	Red	Red	Medium	Tall
Frocor x (Yt x kt) sib	1967	Bearded	White	White	Early	Medium
Enkoy - k 4500	1974	Bearded	Red	Red	Medium	Medium
Romany BC	1974	Bearded	Red	Red	Late	Tail
Mamba	1973	Bearded	White	White	Late	Tall
Kanga (FW/68)	1971	Bearded	Red	Red	Early	Medium
Derreselign-(CI 8154-F2)	1974	Bearded	White	Red	Early	Medium
Laketch-8156 white	1970	Bearded	Red	White	Early	Short
Son 63	1975	Bearded	White	Red	Early	Short
Salmayo	1973	Beardless	White	White	Medium	Tall
K-6106-8	1977	Bearded	White	Red	Early	—
K-6290-Bulk	1977	Bearded	Red	Red	Medium Early	—
Son 64-SKE-AME/CC PMB 1994-1-49-94	1977	Bearded	Red	Red	Medium Early	—
CI 14393	1977	Beardless	White	White	Medium Early	—
Pichihuila "s"	1980	Bearded	White	Red	Early	—
Cno "s"-GalloxKal-Bb cm 7652	1980	Bearded	White	Red	Early	—
K 6661-12	1980	Bearded	White	Red	Early	—
K 6295 - 4 a	1980	Bearded	Red	White	Early	—
Bobito "s"	1980	Bearded	White	White	Early	—
K 6797-6	1980	Bearded	White	Red	Early	—
K 6399-3	1980	Bearded	Red	Red	Late	—
Brochis "s"	1980	Bearded	White	Red	Late	—

Table 3 - List of Durum Wheat Varieties Released in Ethopia (6)

Variety of Selection	Years of Release	Ear type	Chaff Color	Grain Color	Maturity	Height
Gerardo VZ-466/61-Box G11 "s" cm 9605-2G DZ-1GDZ-1GDZ-ODZ	1976	Bearded	Red	Amber	Medium late	Short
Cocorit 71	1976	Bearded	White	Amber	Early	Short
Ld 357/CI 8155	1979	Bearded	Red	Amber	Medium late	Tall
(61-130 x Lds/Gll "s") Cl "s" cm 9615-9GDZ-2GDZ-2DZ-1GDZ	1979	Bearded	White	Amber	Early	Short

N.B. (1) Two durum Wheat Varieties (a) A 10 and (b) B 18 were also released from the Paradiso Experiment Station at Asmara in 1949.

(2) Another Selection of durum wheat, Cr"s" (21563/61-130x Lds) Candeal II, CD 38862-1BS-1BS-OGS is being considered for release this year under the name "Boohai".

FUTURE PLAN FOR INCREASING WHEAT PRODUCTION

New and improved varieties of durum and bread wheat are being developed by various International and National Research Institutes from time to time. The introduction and selection of these materials under Ethiopian conditions will no doubt increase the chance of obtaining better and improved varieties for the Ethiopian farmers. Therefore, the search for new and better varieties through this procedure will continue.

The hybridization programme between locally adapted varieties and high yielding exotic types has shown very promising results up to now and therefore this programme will be strengthened in the future.

The total cultivated land in Ethiopia is only about 8.1% of the total area (i.e. only about 9.5 million hectares) at the moment. So, there is still a tremendous amount of virgin land to be put under production of wheat and this will undoubtedly be exploited in the future.

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WHEAT PRODUCTION AND CONSTRAINTS IN ZAMBIA

Joyce C. P. Namwila

INTRODUCTION

The performance of the agricultural sector for the past three years has shown a steady upward trend with regard to marketed agricultural produce. This has been a result of the poor performance of the mining industry in recent years so that more emphasis has been placed on the need for the country to lessen its dependence on copper. It has also shown the need for diversification of the economy away from copper mining towards other sectors, especially agriculture. This has been found necessary not only to enable the country to have a wider range of export products in the long run, but more importantly to make the country self-sufficient in its food requirements in the immediate future. To this end, concerted efforts have been made to increase agricultural production through various incentives given to farmers which have included high producer prices and favourable conditions for remittances of dividends.

The bulk of Zambia's wheat requirements are still met by imports which are costing the country a substantial amount of foreign exchange, equivalent to about K32 million. Of the 180,000 tonnes needed to meet the demand, only approximately 7 per cent, or 12,000 tonnes are grown locally, mainly by large scale farmers. Although local wheat production has increased, demand is growing at a faster rate of about 3,000 tonnes per year, forcing the country to import a large amount to satisfy domestic needs.

WHEAT GROWING AREAS

Almost all the wheat grown in Zambia is under irrigation and, since this is a capital intensive operation, it is grown mainly by commercial farmers. There have been attempts in the past six years to grow rainfed wheat commercially, but these have so far proved uneconomic. Further research is required to prove its economic feasibility. The main irrigated wheat growing areas are in Central and Southern Provinces, mainly in Mazabuka district, although there are a few growers in Livingstone, Lusaka, Kabwe, Chisamba and also in the Copperbelt Province. Rainfed wheat is still being grown mainly in Mbala by a few farmers with a very small hectarage. Some attempts have also been made in Mporokoso, Isoka and Mkushi areas. Other small-scale growers are found in the Zambezi flood plains mostly in Mongu and Kalabo districts using residual or seepage moisture.

PRODUCTION

Wheat production figures show that there has been an increase over the past eight years (Table 1).

TABLE 1: CULTIVATED WHEAT AREA AND MARKETED PRODUCE

YEAR	1975	1976	1977	1978	1979	1980	1981	1982*
Marketed Produce (tonnes)	934	3459	4741	6400	4322	6670	8536	1210
Cultivated area (hectares)	435	1140	1700	1585	1600	2400	3027	3082
Yield (t/ha)	2.15	3.03	2.79	4.04	2.70	2.78	2.81	4.00

Source: Bank of Zambia Report (1981)
* Beaumont 1983

This has been due in part to new improved varieties and also increased wheat hectarage but the average farm yields have fluctuated considerably from 2.15 to 4.0 tonnes per hectare. Yield trial results show an increase in yields from 4.2 to 6.5 tonnes/ha in varieties released for commercial production between 1976 and 1983.

AGRONOMIC PRACTICES

Planting of the irrigated crop occurs between May and the second week of June. The farther north the location, the later the optimum date if seeding. The cool weather in June to early August encourages tillering during the vegetative phase. The rising temperatures and the exposure to more hours of sunshine in the later half of August and in September, encourages photosynthesis and ripening (Moono, 1979). The prevailing weather conditions between May and September are very favourable and suitable for growing wheat. Rainfed wheat is planted from mid-January to early February. The recommended seed rate is 95kg per hectare for both seasons. Planted seed may quite often be attacked by termites before it germinates. Therefore, all seed has to be dressed with an insecticide and a dressing with either Captan or Thiram plus Malathion is most commonly used.

Fertilizer is recommended at 300-400 kg/ha Compound 'C' (6-18-12-10NPKS) as a basal dressing followed by a top dressing of urea at 220 kg/ha (100N kg/ha) at 3-4 leaf stage.

During the 1982 season, farmers rates ranged from 250 kg/ha to 350 kg/ha of 'C' or 'D' (10-20-10-20NPKS) compound and 150 to 240 kg/ha of urea (Beaumont, 1983).

Weeds are a serious problem during the rainy season especially with poor cultural practices. Herbicides recommended for the rainfed and irrigated seasons are the same. Grasses are controlled in the irrigated season with 'Hoegrass' applied at a rate of 2.5 litres per hectare at the 2-3 leaf stage, but are seldom a problem in the irrigated season.

2, 4-D amine (40%) at 1.3 litres or 2, 4-D ester (50%) at 1.5 litres/ha applied at mid-tillering and at least 10 days after 'Hoegrass' will control most broad-leaf weeds. 'Buctril M' at 1.4 litres/ha is also recommended and can be applied between 2.6 leaf stages.

During and after the grain filling stage, American bollworm, when present in large numbers, may cause damage to the crop and lower yield. 'Sevin' is recommended at 2.0 kg/ha when necessary.

During the 1982 season thirty-eight commercial farmers grew irrigated wheat, including companies and projects such as the Mpongwe Wheat Development Scheme, Nakambala Sugar Eastates, Zambia Consolidated Copper Mines and the Rural Development Corporation. The area of wheat grown ranged from ten hectares to 250 hectares per farm. The total hectarage of wheat grown during the same season was 3082 hectares yielding 12180 tonnes, an average of 4.0 t/ha. The individual yields varied from 1.6 - 6.3 t/ha. There were twelve new growers who began production in 1982, some of whom planted late and used poor irrigation techniques, resulting in low yields, which pulled the average down quite substantially (Beaumont, 1983).

The current estimate for 1983 irrigated wheat is between 2500 and 3000 hectares. This is in contrast to the 4000 hectares that was originally thought to be possible. The reduction is largely due to farmers fears about profitability and preference for other crops such as onions and potatoes. Other farmers are reducing their wheat hectarage due to lack of water because of the poor rainfall during the 1982/83 rainy season in the Southern Province.

CONSTRAINTS FOR IRRIGATED WHEAT PRODUCTION

There are various problems hindering the increase in the national irrigated wheat hectarage. Some of these are outlined below:-

1. The major constraint to increased wheat production remains the very high cost of irrigation equipment which few farmers can afford. The initial costs are very high and the crop needs capital-intensive methods.

2. The high cost of farm inputs like fertilizer and other agricultural chemicals is also a major constraint hindering increase in the cultivated wheat area. Part of the subsidy on fertilizer has recently been removed increasing costs by an average of approximately K180 per tonne.

3. Lack of cheap hydro-electric power in potentially suitable areas such as Mkushi and Mpongwe, is a limiting factor in irrigated wheat production. The Mpongwe Wheat Scheme uses diesel powered engines to pump irrigation water.

   Total costs of producing wheat are estimated to be just under K2000 per hectare. To achieve a profit at present prices it is therefore necessary to obtain a yield approaching 6 t/ha. These calculations are based on the use of electricity. It is virtually impossible to make a profit on irrigated wheat without hydro-electric power.

4. The lack of spare parts particularly for tractors and combines contributes to delay in planting, harvesting and carrying out other farm activities thus leading to loss in yield.

5. Wheat growers faced many frustrations in 1982 marketing their crop. Better organisation is required to improve this situation.

6. Low rainfall in a preceding rainy season may limit the water available for the irrigated wheat crop and result in a reduced hectarage.

7. A number of farmers plant varieties not recommended for Zambia and some use low quality seed. Some va-

rieties marketed by the Zambia Seed Company and grown by farmers e.g. Tanori and Limpopo, are highly susceptible to stem and leaf rust and powdery mildew. These varieties also have a lower yield potential than Emu for example. The proportion of the seed available from the Seed Company for each variety (2% Emu, 10% Limpopo and 75% Tanori) is at variance with the proportion advised by the Research Branch which recommends the greatest area to be planted with Emu and the smallest with Tanori. Closer co-operation and flow of information are obviously required between Zamseed and the Research Branch.

In an effort to encourage production, prices of wheat have been raised from K32. to K35.75 per 90kg bag (K356 to K397 per tonne). Zambian Agricultural Producers of maize, wheat, soyabeans, tobacco and sunflower will be entitled to foreign exchange incentives. For each 90kg bag of wheat sold in excess of 2000 (5000 bags for maize), K0.50 will be paid in foreign exchange. These incentives aim at providing producers with some foreign exchange to meet payments for items such as farm implements, spares and chemicals, which may not be locally available.

Wheat production will increase further in the coming years with the launching, by the Rural Development Corporation, of two new irrigated wheat projects extending over 500 hectares at Minisiri Farm and 5000 hectares at Chisamba. In addition, Britain is to assist Zambia in procuring essential spare parts and equipment worth about K1 million to help irrigated wheat farmers boost production.

CONSTRAINTS FOR RAINFED WHEAT PRODUCTION

Rainfed Wheat production on a commercial scale has so far met with little success. Earlier optimism on the production of rainfed wheat has proved infounded. The Zam-Can Wheat Production Farm at Katito near Mbala has ceased production due to soil and disease problems which led to uneconomic production. The farm has been transferred by the Ministry of Agriculture to Zambia Agricultural Development Limited together with most of the equipment provided by Canada to farm as they (ZADL) see fit. The Zam-Can Wheat Research Project has retained 60 hectares of the land and sufficient equipment to continue trials at the site. Average wheat yields in the 1981/82 season were 800kg per hectare which is below economic levels. The break-even point for rainfed wheat production is about 1.3 tonnes per hectare.

During the same season (1981/82) four other large scale trials between two and three hectares each) were grown. Two of them near Isoka failed completely, one at Mporokosa gave a yield of approximately 500kg per hectare and one near Mbala gave 2250kg per hectare which appeared promising. However, this was the first wheat crop at the farm and Helminthosporium sativum inoculum in the soil was presumably low.

Further cropping of the land will probably increase disease levels and thus reduce yield. This year (1983) the same farmer grew 20 hectares of wheat and has obtained a yield of only 1.0 tonne per hectare. Another farmer south of Lusaka grew eight hectares of wheat (in 1982/83) but he planted very late and his crop was badly hit by drought. The yield is expected to be less than 1.0 t/ha.

In the research trials in the 1980/81 and 1981/82 season (Zam-Can Wheat Project Annual Reports) better fertilizer and lime treatments yielded about 1 tonne per hectare. Boron had a tendency to give an increase in yield, but a reduction in 1000 grain weight was recorded in the boron treatments which could have been due to a higher number of kernels per ear. In the deep-liming trial, mean yields of 1.5 and 1.6 t/ha have been obtained (compared with the control at 1.3 t/ha). With deeper liming there is a trend towards higher yield. The very low yield of all the plots with zero fertilizer indicate the inherent low fertility of the highly leached soils on which the trial was conducted. Yields within the production fields in 1980/81 were highly variable ranging from 0.3 to 2.7 t/ha. This variation is highly correlated with several measurable soil factors (i.e. negatively with A1 and positively with Mg). (Penney, Hodgins, Aulakh, 1981). Yields are expected to be higher once aluminium tolerant and Helminthosporium resistant varieties are available and/or when alternative sites with lower rainfall and soils with pH higher than 5.0 are identified. The rainfed breeding programme has now identified some superior lines for future exploitation.

Triticales appear to have a greater tolerance to Aluminium toxicity and their yields double those of wheat in trials at Mbala in years with average or below average rainfall. However, in general they are more susceptible to H. sativum. Screening for resistance to H. sativum may result in fairly rapid development of a variety suitable for rainfed conditions prior to development of more suitable wheat cultivars.

Experiences over the last four seasons at the Mbala site both on a commercial scale and in trials, have identified the main problems as disease (mainly H. sativum), drought and aluminium toxicity (Penney and Little, 1982).

The performance of rainfed wheat in the Southern Province has been much worse than further north. The South is characterised by higher summer temperatures whose effects are detrimental to wheat yields. High night temperatures reduce tillering and hasten development of the reproductive phase. High temperatures tend to lower the harvest index and also encourage heavy H. sativum development.

Weeds (especially grass weeds and sedges) can be a serious problem and further research is required to improve cultural methods and identify suitable herbicides.

Once the above problems have been overcome, rainfed wheat will hold several advantages over irrigated wheat. Although yields will undoubtedly remain lower than irrigated wheat; its advantages are:-

i) low initial capital inputs
ii) lower input costs
iii) lower foreign exchange costs
iv) no irrigation management
v) potentially abundant land available for development

WHEAT IN SEEPAGE/RESIDUAL MOISTURE AREAS

Another method of wheat production that needs further exploitation is the growing of the crop under seepage/residual moisture conditions. During the 1982 season small-scale growers in the Kalabo and Mongu districts of Western Province grew wheat crops each of about 0.25 ha amounting to 22 ha in all. Further promotion of dambo-grown wheat is necessary as it is easier for small-scale farmers to manage and will have a small but important role to play in production. The critical factor in wheat production of this type is the selection of suitable sites. Initial results indicate that fields where the water table is approximately 40-50 cm below the soil surface are the best; water-logging results if it is higher and drought stress if it is lower.

CONCLUSION

The need to increase local wheat production in Zambia cannot be over-emphasised. The Government through various efforts is trying to boost the production. Efforts by the research branch, including the breeding of higher yielding and better adapted varieties, are aimed at finding solutions to the major agronomic constraints. Hopefully the area under wheat cultivation will rise as more companies and individuals invest in irrigated wheat production. Despite all these efforts and in view of the current high domestic demand, imports of wheat will continue to account for a substantial amount of local consumption for many years to come.

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FOCUS ON RESEARCH FOR RAINFED WHEAT PRODUCTION IN TANZANIA

A. S. Mosha and E. N. Munisi

INTRODUCTION

Wheat Production in Tanzania is confined to two highland plateaus, one in the north and one in the southwest. Land area which could be used for mechanized wheat production in northern Tanzania is reckoned at 60 - 70,000 ha in the Hanang Plateau and about 40,000 ha in the Loliondo area. In the southern highlands potential mechanized wheat land is reported in the Sumbawanga plateau to be about 3-5,000 ha and in Njombe district to be 3,000 ha. However, only small portions of these potential wheat lands are devoted to wheat. If the remaining potential land were used for wheat it would be competing with other cereals for per unit area calory production. All this potential wheat land is rainfed. It is at 1,000m to 2,000m of elevation. (Table 1).

Table 1. Summary of Present and Potential Land for Mechanized Wheat Production in Tanzania

Zone	Districts	Hectares under Wheat 1981/82	Potential Hectares for Mechanized wheat Production
Northern Highlands	West Kilimanjaro	7,692	8,000
	Monduli & Arusha	1,619	2050
	Mbulu-Oldeani & Karatu	3,239	3,600
	Hanang Plateau	20,000	60,000
	Loliondo	Nil	40,000
	Sub Totals	32,550	113,650
Southern Highlands	Njombe	1,776	3,000
	Others	1,215	5,500
	Sub-Totals	2,991	8,500
	Grand Totals	35,541	122,150

BREAD WHEAT VARIETY IMPROVEMENT

Research work on wheat variety development is directed to bread wheat, although attention is also paid to the varietal evaluation of durum wheat, malting barley and triticale. The breeding program has successfully developed wheat varieties which are resistant to the major wheat rusts, stem rust (Puccinia graminis), leaf rust (Puccinia recondita) and stripe rust, (Puccinia striiformis). Most of the current commercial wheat varieties are tolerant to the other common diseases such as tan spot (Helminthosporium tritici repentis) and powdery mildew (Erysiphe graminis). Consequently, the grain yield potential of our commercial varieties in Tanzania is about 3,000-4,000 kg/ha under research plot conditions as seen in Table 2, while under farmer's field conditions the average yields are 1,125-1,575 kg/ha.

Table 2. Five-Year Wheat Grain Yield Averages (kg/ha) and 1981/82 Disease Summary of Seven Commercial Wheat Varieties in Northern Tanzania (Research plot condition).

VARIETY	1977-79	1980	1982	Grand Mean	DISEASES West Kilimanjaro		
					S. Rust		Helm. sp.
T. Mbuni	3334(1)	2748(2)	3454(3)	3240(1)	70/50	S	7/0
T. Tai	3154(2)	2552(5)	3751(1)	3153(2)	20	MR	6/0
T. Joli	3094(3)	2626(3)	3257(7)	3033(3)	tr	R	tr/0
T. Trophy	3094(3)	2429(6)	3356(5)	3013(4)	30/20	MS	7/0
T. Kozi	2854(7)	2773(1)	3290(6)	2925(5)	tr	R	7/0
T. Mamba	2885(6)	2086(7)	3685(2)	2885(6)	50/20	MS	7/0
T. Kweche	2944(5)	2626(3)	2632(7)	2818(7)	20	MS	6/0

Number in ( ) indicates the ranking of the variety.

INTEGRATED MANAGEMENT PRACTICES IN WHEAT PRODUCTION

It will be observed from the data above that we have yet to exploit the yield potential of our commercial wheat varieties in Tanzania under the rainfed conditions. We are therefore faced with the question of manipulating the soil and crop environmental conditions and the additive genotype X environment interaction in order to realize this potential.

Wheat as a commercial crop is comparatively highly mechanized. The type of tillage implements to be used is dictated by the soil type and conditions. In West Kilimanjaro with heavier rainfall (900 mm), the disc plough type of implement has been used with some degree of success (1575-2250 kg/ha) in conjunction with strip farming. In the Hanang Wheat Complex with an annual average rainfall of

500-750mm, the blade type of tillage implements has been very successful in terms of seedbed preparation and in reducing the cost of operation for weed control. The timing of tillage with the objective of killing weeds with post harvest-preseeding operations has been effective in so far as soil moisture and nutrient conservation are concerned. This is particularly true when the tillage is initially after harvest when sufficient weed growth warrants. Under tropical conditions where there is substantial weed growth subsequent to each rainfall, as many as eight or more tillage operations may be required for effective weed control.

Nevertheless, repeated tillage operations reduce the initial trash cover on the soil surface which leads to soil erosion. This is very evident on wheat farms in the Hanang district.

Weed Infestation as a limitation to Wheat Yields

Experiences in Tanzania have shown that despite timeliness of tillage and seeding operations, weed infestation is a serious limiting factor to good yields in wheat.

Post emergence broad leaf weed growth in wheat has been effectively controlled by 2,4-D amine, MCPA and 2,4-D Ester, when applied at the right time and at the recommended rates.

Grass weeds in wheat are a major economic factor in wheat production in Tanzania. Herbicide work on specific grasses has demonstrated yield advantages as will be reported. However, serious reservations are posed as to the economics of grass weed control by herbicides. The variable rainfall pattern in Tanzania both at seeding and after seeding, leaves a lot to be desired in terms of time of herbicide application in relation to the stage of the weed and the wheat crop.

Time of Seeding Wheat in Relation to soil Moisture.

In Tanzania the time of planting wheat is directly dependent upon the rainfall distribution. Studies have shown that the primary criterion for determining the date of planting is when sufficient rain has occurred to fill the soil profile to a depth of one metre. On the average in the northern highlands the rainfall distribution is such that the wheat crop will have sufficient growing and maturing periods through to ideal dry harvesting conditions. This is an important consideration when rains come earlier than normal so that adequate soil moisture and weed kill are achieved too early in the season. Research work has yet to refine grain yield components such as the interaction between the time of planting and variation in maturation period of the various. varieties. Understanding such interation will be relevant in years where rains begin early and therefore end earlier than usual. Under such conditions medium to late maturing varieties run into moisture stress at the critical filling stage. Similar studies on the interaction between time of seeding and seeding rates need to be conducted. Perhaps where conditions favour earlier seeding, higher seeding rates could counteract decreased tillering resulting in a weed competitive advantage for the wheat crop.

Soil Nutrient Utilization Under Rainfed Condition.

Extensive research has been done on the major plant nutrients in the wheat growing areas in Tanzania. N.P.K. trials on wheat in northern Tanzania have given widely variable results. Little or no response by way of increased yields in wheat has been obtained for phosphorus or potassium, while responses to nitrogen have varied inconsistently from district to district, and from season to season. In the southern highlands consistent economic responses to phosphorus, potassium and nitrogen have been obtained in wheat in Mbeya and Njombe districts. The greater response to fertilizer N, P and K in the Southern highlands may result at least partially from the higher precipitation distributed over a longer period than in the Hanang region of the Northern highlands. Sumbawanga plateau and Njombe district get 900-1125 mm of rain a year, distributed between November and May, whereas the Hanang region receives about 600 mm most of which falls from December to April.

There could be some interesting research work relating to efficient utilization by the improved wheat cultivars of the available soil nutrients and moisture during the relatively brief growing season in marginal rainfall areas such as the Hanang region. On the other hand, producing wheat economically under 900 - 1125 mm of grain distributed throughout the growing period poses a different set of problems.

FUTURE RESEARCH PRODUCTION PROBLEMS.

Monoculture wheat production in commercial agriculture in Tanzania has met with various management problems. The National Agriculture Food Corporation (NAFCO) wheat farms in the Hanang district are threatened by the ever increasing grass weed infestation, particularly love grass (Setaria verticillata). There is need for research on alternative crops which can be grown in rotation with wheat to break the weed ecology. However, such crops should be able to be handled with the same machinery as for wheat with but minor modifications. There are suggestions that crops such as soyabeans, sunflower, beans, and maize may fit into the wheat production management.

Land management planning in relation to water erosion is another problem area. The soil erosion which is being experienced on the Hanang wheat farms is partly the effect of the torrential tropical rains which may fall at rates as high as 50mm in three to four hours. The long slopes within the large fields characteristic of the Hanang farms accentuate the erosion problems. Therefore, studies which look at the influence of soil type and field size and shape in relation to the slope upon the severity of water erosion need to be conducted.

PROBLEMS AND PROGRESS OF WHEAT PRODUCTION IN NJOMBE, TANZANIA

J. M. Orondo

Tanganyika Wattle Company Limited, a subsidiary of Commonwealth Development Corporation, is situated in Njombe District at the heart of Southern Highlands of Tanzania. TANWAT is the single largest wheat producer in the region. Wheat has been grown in the Southern Highlands of Tanzania since its first introduction to Tanzania by German Missionaries in 1898. TANWAT has been engaged in the crop diversification work since 1966 in which wheat was aimed to be a major crop. The major wheat production area in the country is in the Northern Highlands where a National Agronomic Research Centre is also situated. Because of the isolation of the Southern Highlands from the North and difference in climatic conditions, an agronomic research programme was established in the late sixties to identify the specific major factors limiting wheat grain yields. During the early agronomic trials it became evident that the relationship between variety, planting date, weather and disease incidence were the main factors limiting grain yields of wheat.

VARIETY

The original varieties grown commercially at Njombe originated from the Kenyan and Tanzanian national programmes. These varieties had satisfactory rust resistance but were not satisfactory with regard to their Septoria resistance. Since 1979 F_2 segregating populations, screening nurseries and yield trials were obtained direct from CIMMYT. CIMMYT varieties now account for more than 60% of commercial varieties following a vigorous seed increase parallel with agronomic trials. Especially the progenies of Mexican and Brazilian crossing programme appear very promising. Brazilian lines for screening are also obtained directly from Passo Fundo in Brazil. Major and promising varieties currently grown at TANWAT are given below:

K6290-17 = Nyati 'S' = AFM x Romany	—	NPBS Njoro, Kenya
W3697 = Tai = K4500-2	—	A.R.I. Arusha
Moncho 'S' CM 8288-3M-6Y-5M-1Y-1M-OY	—	Entry 10 in 14th ISWYN
IAS 54	—	Entry 20 in 15th ISWYN
Veery 'S' CM 33027-F-15M- 5OOY-OM	—	Entry 3 in 15th ISWYN
Pvn 'S' - Za75 CM 36681-19Y-1IM-1Y-OM	—	Entry 304 in 12th IBWSN
PF 70354-2Ptz-OY	—	Entry 186 in 9th ISEPTON
B7408	—	Entry 187 in 9th ISEPTON
Ram 'S' (triticale) x 12257-2N-OM	—	reselection from UAC
Veery 'S' CM 33027-F-12M-1Y-9M-OY	—	Entry 204 in 12th IBWSN
SWM 3115-2M-4Y-1M-1Y-OM	—	Entry 439 in 12th IBWSN
CM 41860-A-5M-2Y-2M-1Y-OM	—	Entry 488 in 13th IBWSN.

Commercial wheat yields have declined from the record 2510kg/ha in 1971 to the lowest 1098kg/ha in 1981, but with the introduction of new varieties yields are now increasing steadily. The best varieties of triticale yield 25% more than the best wheat varieties but the exploitation of this potential crop will be frustrated if the buying authorities don't show any interest.

TIME OF PLANTING AND WEATHER CONDITIONS

A potentially large source of yield variation appears to be the time of planting effect. The testing of varieties is therefore carried out at early and late dates to assess performance under maximum disease conditions and late to assess performance when available soil moisture may limit yield. Early plantings are low in yield due to heavy foliar diseases mainly Septoria, Fusarium and Helminthosporium. Varieties such as Moncho 'S' and K6290-17 respond strongly to time of planting as demonstrated in 1982 early and late planted trials.

	Early	Late planted
Moncho "S"	1791 kg/ha	2883 kg/ha
K6290-17	1497 kg/ha	2728 kg/ha

DISEASES

As in many environments, diseases play a big part of the wheat growing problems is Njombe. Rusts are not of major concern in this part of the country, and present commercial varieties offer excellent resistance to rusts. But many other diseases are devastating.

Ophiobolus graminis and **Helminthosporiun Sativum** clobber the roots and crowns. Under the damp and wet highland conditions, **Septoria spp., Xanthomonas translucens** and **Fusarium** sp. are very damaging One variety, Minami Kyushu (Ex FAO Screening Nursery) is not affected by fungal pathogens but only by the bacterium **Xanthomonas translucens**. Minami Kyushu is a tall variety with poor agronomic characteristics, but it is the highest yielder when disease incidence is severe.

WHEAT IN KENYA: CURRENT STATUS

H. H. A. Mulamula

PRODUCTION

TABLE I WHEAT PRODUCTION IN KENYA 1963 - 81

GROSS PRODUCTION		HECTARAGE	NATIONAL MEAN
YEAR	90 kg Bags ($x\ 10^6$)	$x\ 10^4$	YIELD (BAGS/Ha)
1963	1.45	11.75	12.00
1964	1.65	12.25	13.00
1965	1.45	13.00	11.00
1966	1.90	13.75	14.00
1967	2.65	15.00	17.50
1968	2.50	16.75	14.75
1969	2.40	16.00	14.50
1970	2.20	12.75	15.50
1971	1.90	11.50	16.50
1972	1.65	10.50	15.80
1973	1.55	10.75	14.25
1974	1.65	10.50	15.80
1975	1.75	11.00	16.00
1976	1.80	12.00	16.00
1977	1.60	13.75	13.00
1978	1.70	13.80	14.25
1979	1.85	13.80	15.50
1980	2.30	10.0	22.25
1981	2.60	10.5	25.00

Gross production as a function of time (19 yrs)

$Y = 18.2 \times 10^5 + (0.0170 \times 10^5)\ X$

where Y = gross production in 90 kg bags and X = years from 1 to 19.

This represents a rather steady increase in gross output over the last 19 years.

Hectarage as a function of time

$Y = 13.684 \times 10^4 - (0.1208 \times 10^4) X$ Ha

where Y = hectares

and X = years

This represents a loss of 1208 Ha per annum or 22,952 Ha over the last 19 years.

National mean yield (bag per hectare) as a function of time

$Y = 12.305 + 0.367X$ (p 0.01)

where Y = yield in bags/Ha

and X = years

The increase in yield per Ha has more or less compensated for annual reduction in hectarage to sustain a stable national gross production level over the last 19 years.

The following factors have contributed to these increased yields.

the development of widely adapted, high yielding and disease resistant varieties,

efficient agronomic practices with respect to

Seedbed preparation and moisture conservation,

Good quality seed,

adequate crop fertilization for macro and micro-nutrients,

effective weed control, and

Suitable infrastructure, marketing and credit facilities.

Up to date stem rust has more or less been held at bay. Of late, stripe rust has become a major constraint in medium to high altitude areas (2400 - 3000 m asl). There is already a breeding programme in progress to incorporate resistance in our existing and future varieties.

CONSTRAINTS

Scale of production

Over the last 20 years, there has been a major change in land use pattern following the settlement of persons formerly landless, on land formerly owned by a few large scale farmers in parts of the Rift Valley, as well as the central and eastern provinces. As you are aware, the land issue has always been at the hub of Kenyan politics even before independence. You may be wondering what effect all these social economic changes have on current research constraints in Kenya.

Over the last 80 or so years wheat has customarily been considered a high capital enterprise requiring sophisticated machinery such as tractor mounted drills, sprayers and combine harvesters.

Figures (Table II) show that while the majority farm size in 1968 (five years after independence) was between 20 - 400 Ha (82%), in 1982 the majority farm size was < 20 Ha (72%) in some parts of Nakuru District. The farm size distribution of the majority (< 20 Ha) shows that 64% of the farmers have between < 4 to 8 Ha of wheat. If this trend is taken to represent the situation prevailing in the rest of wheat districts of Kenya, then there is an urgent need to re-structure our research particularly in agronomy so that the interests of the majority (small scale farmers) are considered. Much of the research conducted on varieties, disease control can easily be adapted to suit the small farmer.

We are not equipped at the moment to advise a farmer wishing to grow two hectares of wheat on how to sow, control weeds and harvest the crop without sophisticated high capital machinery which are costly and not always available. We have to change the attitude of the farmer into accepting growing wheat without these machinery.

Because small scale wheat growers cannot afford to own these machines, there has been a tendency for private contractor services to step in during the last ten years. They operate at a profit leaving the farmer with a very slim profit margin.

The Kenya Government is studying this problem very critically and unless it is taken up seriously, through advocating for large scale wheat production, we may be addressing farmers who do not exist now, but who existed 20 years ago.

In the preliminary trial which was initiated in 1981, the following treatments were tested (see insert):

PLANTING

1. Commercial large scale drill
2. Oxen seeding. Seed dribbled in furrows opened by oxen draw single mould-board plough
3. Trail seeder powered by a 50cc motocycle engine
4. Seed broadcast and incorporated with oxen.

WEED CONTROL

1. No weeding
2. Knapsack sprayer
3. Hand weeding with a hoe
4. Commercial tractor mounted sprayer.

HARVESTING

1. Cut and thresh
2. Cut by hand and thresh with a stationery thresher.
3. Combine harvester.

TABLE II WHEAT FARM SIZE DISTRIBUTION

NAKURU DISTRICT	1968 - FARM SIZE (Ha) DISTRIBUTION				
	< 20	20-120	121-400	> 400	
A:					
Rongai	2	17	12	3	
Njoro	3	22	24	4	
Solai/Lanet/Dundori	18	42	13	2	
Subukia	2	17	3	0	
Mau Narok	0	6	13	4	
Total	25	104	65	11	205
% of Total Farms	12.2	50.7	31.7	5.4	
		82.4			

B.	1982 - FARM SIZE (Ha) DISTRIBUTION				
Rongai	98	29	5	0	
Njoro	168	36	8	0	
Solai/Lanet/Dundori	36	18	1	3	
Subukia	8	6	0	0	
Mau Narok	2	7	4	2	
Total	312	96	18	5	431
% of Total Farms	72.4	22.3	4.2	1.2	
	94.7				

1982 - ANALYSIS OF FARMS (<20 Ha)

C:	< 4	5-8	9-12	13-16	17-20	
Rongai	19	33	19	10	17	
Njoro	55	63	31	8	11	
Solai/Lanet/Dundori	8	15	7	3	3	
Subukia	6	0	2	0	0	
Mau Narok	0	1	1	0	0	
Total	88	112	60	21	31	312
% of Total Farms	28.2	35.9	19.2	6.7	9.9	
	64.1					

Treatments that were hand weeded, cut by hand and threshed with a stationary thresher consistently yielded well: 1968 kg/ha (for commercial Drill); 2200 kg/ha (for oxen-seeded) 2166 kg/ha (for trail-seeder) and 1890 kg/ha for broadcast treatments. The lowest yield recorded was 405 kg/ha for commercial drill in the absence of weed control and was harvested by combined harvester. This test will be continued.

It should be borne in mind that small scale growers are the major contributors to pyrethrum, tea, coffee, sugarcane and rice in Kenya.

Acid soils

About 30% of our wheat growing area particularly that comprising of plinthic ferrisols are acid (p^H 4.3 - 5.0). Durums and common wheats containing durum germ-plasm are sensitive to acid condition. Clovers and Lucern will hardly take off under such acid conditions. Triticale and maize do not show any appreciable sensitivity to acid conditions. Work is in progress to develop varieties tolerant to acid conditions and to determine the influence of soil amendments on crop performance.

Weeds

Of late, weeds have been recognized as a major constraint in wheat production by both small scale and large scale farmers. Broadleaf weeds and grass weeds, particularly wild oats, setaria, beckeropsis and rye grass have been contained largely through the use of good quality seed, adequate seedbed preparation and good general crop management.

Our attention is now drawn to isolated cases of brome grass and nutsedges whose importance is becoming apparent after successful control of other weeds.

CULTURAL PRACTICES

There has been no major changes in recommended cultural practices since the last meeting two years ago. The current recommendations include:

Seedbed Preparation

Should begin within one to two months after harvesting in order to conserve soil moisture through weed control. Lack of farmer owned equipment tends to nullify this recommendation. As a result of this, crop failure due to drought is most frequent among small scale farmers who rely on contractors to carry out land preparation and other operations.

Seed Quality and Varieties

Out of the 16 or so currently licenced varieties, farmers are advised to plant at least 3 varieties to minimize risks from rust. When possible, farmers are advised to use certified seed. However the seed inspectorate team does assist farmers wishing to produce their own seed. The most commonly used seedrate is 100 kg/ha but ranges from 75 to 125 kg/ha.

Fertilizer Recommendations

Phosphorus.

Up to now fertilizer recommendations have been related to the cropping history of the land. Generally new land from bush or grassley requires more P and less N; and vice versa for continously cropped land. Attempts are now being made to quantify this characteristic in relation to P - sorption properties of new VS continously cropped land. This exercise requires a moderately equipped laboratory with a least an accurate spectrophotometer (with wavelength 400 - 1000 nm) and centrifugation facilities.

Preliminary tests show that Plinthic Ferrisols and Mollic curdosols have a high P - sorption capacity is the range of 2000 micro-g/1g soil over a period of 24 Hrs. A 0.01 m $CaCl_2$ support solution produces a clear filtrate even without centrifugation. Shaking during incubation does not seem to influence sorption rate and P-equilibration time. The ultimate objective of this exercise is to use P-sorption isotherm as a means of quantifying P-fertilizer response.

Lime

Liming material is readily available in Kenya around L. Victoria and along the coast. The current price is around K.Shs. 240 per ton. Preliminary work seems to indicate that one ton of lime influences soil pH by 0.2 units. The pH of our acid soils in around 4.8 to 5.0 Therefore at least 5 tons/ha of lime must be applied to increase soil pH to 6.5. The current work on lime requirement includes: rates, frequency of application, influence on soil reaction, depth of application and differential crop reaction to varying soil pH. Durums and bread wheats with durum germplasm, lucern and clovers are highly sensitive to low pH. While Triticale and maize exhibit no adverse effects due to low pH.

Micro-nutrients

So far the only micro-nutrient known in wheat barley and triticale is copper. Areas affected are known (88,000 Ha) and recommended steps include seed dressing followed by foliar spray at 1.0 kg/ha (50% Cu^{++}) respectively. Soil analytical procedures do not tally well with probable Cu-response but generally 5 ppm is thought to be the threshhold level in the soil.

Weed Control

Over the last seven years (1976 - 1982) the Station has received and evaluated 90 herbicides for the control of a wide range of weeds. The weeds include broadleaf and grass weeds, especially wild oats, setaria, rye grass in wheat and barley. Generally, grass weed control is difficult and costly. Our experience shows that successful weed control must assume a multidisciplinary approach in order to ensure success. This includes efficient land and animal management. Above all, the prevailing farming system must be such that it is conducive to effective weed control. Two factors namely:

(a) telephone farming or absentee farmers

(b) mono-culture similar to what was practised by the Breweries and the Wheat Board initially posed the greatest hindrance to efficient integrated weed control campaign. The systems attracted absentee farmers who relied on hired contractors for all production practices. Contractors as second parties were least interested in long term values of the land. The systems advanced credit for the production of crops of interest only namely wheat or barley. Therefore rotation as a means of weed control was overlooked.

The situation has changed however and steps have been taken to involve true farmers in wheat and barley production. Credit facilities are now available for the production of rapeseed as an alternate crop. This has greatly assisted in the control of noxious weeds such as wild oats and rye grass.

WHEAT PRODUCTION AND CONSTRAINTS IN MALAWI

Parichi Mnyenyembe

INTRODUCTION

Malawi is located south of the equator between latitudes 9°45′ and 17°16′ and between 33° and 36° east. Its total area is 118,500km² of which 94,100 is land area (79%). Out of the total land area 27,420 km² (29%) are mountains and hills; and 66,680 km² (71%) of land is arable - only about 20% arable land is cultivated at present. Lakes and rivers occupy 24,400 km² (21%).

According to 1977 census figures the population of Malawi now is over 6 million if a growth rate of 2.9% per annum is assumed.

Malawi is an agricultural country with 85% of the population living in the rural areas earning their living from agriculture. In general, Malawi has three seasons - a wet season from November to April, May to August is mostly dry and cool with mist and showers occuring in highland areas, and September to October is dry and hot. Annual rainfall varies from 635 to 3048 mm depending on altitude.

Maize is the main food crop which is grown by over 95% of the small holder farmers who occupy well over 75% of the total cultivated area. Other crops grown in Malawi include tobacco, tea, groundnuts, sugar, cotton, rice, coffee, cassava, pulses, sunflower, sorghum, millet, wheat, tung, cashew nuts, macadania, citrus fruits, rubber and guarbeans.

BACKGROUND INFORMATION:

Traditionally Malawi has been self-sufficient in all cereals except wheat and it exports its surplus grain. It is a nation of maize eaters, but is adding wheat to its diet at a very fast pace. This can be seen from the import figures, and during the 1970s wheat imports averaged 29,000 metric tons annually and wheat consumption continues to increase. As a result, large quantities of wheat are imported at high prices to meet the local demand. The potential for increasing wheat area is very great. The areas of potential for wheat include estates with irrigation facilities, irrigated schemes, dimbas and cool highland areas. Just 20,000 ha at an average yield of 2 tons per hectare would produce enough wheat for the country's requirements.

The possibility of increasing wheat production in Malawi was not seriously considered until a small research station manned by a research assistant was established in 1968 in the Kirk Ranges (the main wheat growing area). Since then until the 1980s wheat has been considered a minor crop because the planners and/or economists probably felt that the people's preference to maize was unshakeable or they thought it was cheaper to import than grow locally. This can be seen from the price ADMARC offered the farmers, 11t per kilo while the same raw material was imported at 40t per kilo.

But now several events have raised the government's interest in increasing wheat production to self-sufficient level. First the population growth is very high, second the change of eating habits has increased the demand for wheat flour and third the cost of importing wheat is very high.

Wheat now is considered as of the impotant crops in Malawi. The proposed building of a larger wheat research station by the government shows that wheat now has become as one of the important crops. Also the increase of the producer price from 11t to 22t will act as an incentive to farmers to grow more wheat.

The recent increases of number of farmers growing wheat have only began to moderate wheat imports.

WHEAT PRODUCTION:

Wheat has been grown in Malawi since its introduction by early missionaries in mid-last century. Cultivation has been limited to highland areas where it is grown during the cool season, March to July. that gradually merges into a hot harvesting period, September to October. Almost all the wheat is produced by the small holder farmer.

Small farmers grow wheat mainly as a cash crop but they also use some for their own needs. Until 1979, farmers used to keep their own seed which was mixed and of poor quality for bread making. Their local varieties were very susceptible to rust diseases thus gave very low yields. Their fields varied in size from 0.25 ha to 2.5 ha with average yield of 700kg/ha.

The small holder farmer alone cannot meet Malawi's wheat requirements of over 30,000 tons per annum. As a result the present wheat strategy of being self-sufficient in wheat, as soon as possible is aimed in four directions:-

1 Wheat production on dryland by small farmers in cool highland areas.

2. Wheat production as dimba crop by the small farmers during cool months.

3. Wheat production by small farmers on irrigated schemes during cool months.

4. Wheat production on estates in rotation with tobacco.

   This last direction is fairly new but may prove to be the area where an explosive increase wheat production is possible, since:

   (a) Tobacco is only grown once in four years. Large amounts of commercial fertilizers are used on tobacco so these fertile soils which otherwise lie fallow can be used for the remaining period for other crops e.g. wheat.

   (b) High levels of management are available on the tobacco estates.

FACTORS LIMITING WHEAT PRODUCTION:

Varieties

Many farmers grow wheat using their own seed which is mixed, low yielding and of poor baking quality. The farmers have been keeping their own seed from year to year without selection; as a result the local wheats are very variable and low yielding. Yields of local wheats are less than 1,000 kilos per hectare. These local wheats are a mixture of Kenyan and Australian materials which are believed to have introduced into Malawi by the early missionaries during the last century.

Now one of the main objectives of wheat research in Malawi has been to select high yielding varieties that are ecologically suited to Malawi conditions, possessing a high level of resistance to major wheat diseases and which have grain of suitable quality for baking. Lodging and early maturity (less than 150 days) have also been taken consideration.

The following varieties have been released for production in Malawi:

TORIM: A semi-dwarf variety of early to medium maturity and of high yield potential under irrigation. Resistant to lodging and with a very high test weight. Fairly susceptible to mildew and rust diseases.

LIMPOPO: A dwarf variety of early-medium maturity and very good baking quality. It is resistant to rusts and powdery mildew.

JUPATECO: A semi-dwarf variety of medium maturity. It is resistant to rust and high yield potential.

KENYA NYATI: Tall variety of medium to late maturity. It is fairly susceptible to rusts. It takes 140-150 days to mature.

Other promising varieties which are not yet released are 69/1^{2}A1, T4=**Anza**= SST$_{44}$ SST$_3$ **and Elrina.**

Time of Planting

The main limiting factor in dryland wheat in Malawi is time of planting. Farmers plant wheat in April/May. Main rains in Malawi come between November, April. Rains or showers after the main rains are very unreliable. So if wheat is planted very late the crop stand is very poor due to little and/or lack of top soil moisture to germinate the wheat.

A series of trials were conducted to determine the optimum planting time for wheat in the highland areas. Results illustrated that the best time to plant wheat is between early-March to mid-April. Wheat planted after mid-April suffer from severe moisture stress during the grain filling period while if seeded earlier than March yield reductions result from severe disease outbreaks and weed competition.

Fertilizers

Farmers in the past rarely applied fertilizer to their wheat crop and if they did the rates were low. This was because wheat was considered a very minor crop fetching very little money on the market to pay for fertilizer.

It was not until the late 1970s when credit packages were available to farmers, the price of wheat increased and optimum time of planting wheat was established that farmers realized the benefits of applying fertilizers to wheat. The recommended fertilizer rates are 30-60kgN/ha and 40kg P_2O_5 /ha.

Birds

Birds notably Quelea spp are a notorious pest of wheat. Fortunately for Malawi these birds occur in very small groups and as such they are not responsible for much damage. However, in some years they can cause up to 70% damage. and therefore bird scaring is an important aspect of wheat production especially when the crop is ripening.

IMPROVEMENT OF WHEAT AND TRITICALE IN BURUNDI

Reverien Ntukamazina

FOREWORD

The improvement of wheat and triticale is carried out at the Agronomic Research Station of Kisosi, located at an altitude of 2175 m. in the Mugamba, a region of the high summits on the Zaire-Nile ridge (Lat. 3°33" South; Long 29°41" East) Three centres of the Institute des Sciences Agronomiques du Burundi (ISABU) participate regularly in running multi-local tests under the supervision of Kisozi Station. They are the Zotechnical Centre of Ruvyirinza (1850m) and the Agricultural Centres of Muuanira (2200m) and Nyakararo (2250m).

Growing of wheat and triticale is restricted to regions with an altitude of over 1900 m. and covers approximately 13999 ha. Yields are generally between 500 to 800 kg/ha.

HISTORICAL ACCOUNT OF WHEAT SELECTION IN BURUNDI

The first introductions at the Kisozi Station date back to 1931 and were from France (Bon Moulin, reversible early). from Canada (Marquis) and from Kenya (K. Governor and K. Standard). All these varieties were very susceptible to black stem rust (Puccinia graminis). As of 1935, we resorted to introducing new varieties. However, a true selection programme began only in 1937. The selection programme made some varieties more diffuse during the years 1937-1942. However, the poor baking value of those varieties directed research to a cross-breeding program that would last 26 years (1942-1968). Its goal was to maintain qualities previously fixed from selection (early maturily high yield and resistance to rust) and to improve baking quality. At the end of that period of time, 2 varieties were distributed to rural areas, 130-1-77 and 10-180-54-29. The flour from variety 130-1-77 needed to be mixed with flour of foreign wheat. This was discontinued to favour variety 10. 180-54-29 which had acceptable baking value. Lines developed from this variety were unfortunately very susceptible to yellow rust (Puccinia striiformis).

With the establishment of CIMMYT (International Centre for Improvement of Maize and Wheat), we switched to studying foreign selections. The regional programme of CIMMYT in East Africa allowed us to acquire selections which were tested to prove their adoption to ecological conditions in Burundi. After about twenty multi-local tests conducted in 1977, it was confirmed that variety Romany, bred in Kenya, was of a quality superior to all others. It was then distributed as of 1978. These tests were to prove externally the production potentiality of variety Romany in areas at altitudes higher than 1900m. A second variety, K. Nyangumi was proposed for areas with lower altitudes. A programme similar to that for wheat was initiated to test triticale, a cereal that was introduced in Burundi in 1975. Two varieties were selected: T 74 for regions at altitudes over 1900 m, and RACUM "S" for regions at lower altitudes.

Encouraging results that were reached with triticale on relatively infertile acidic soils led us to devote the same amount of effort for this new cereal as we were for wheat. This is why the tests in 1980 included not only 192 varieties of wheat and but also 197 varieties of triticale.

MAIN CRITERIA FOR SELECTION

Yield

So that commonly used cereal varieties offer optimal production potentials they are selected only when they are sufficiently resistant to drought and when their yields are satisfactory enough, given the less favourable conditions of most land. This is essential considering that the majority of wheat fields which are seeded in April receive only 250 to 400 mm of precipitation and that no fertilizers are used.

Resistance to diseases

Rust in the most important disease of the wheat in Burundi. All selections are tested for their resistance to Puccinia striiformis (yellow rust), P. recondita tritici (brown rust) and P. graminis (black rust). Of these three kinds of rust, the most damaging seems to be the yellow rust, wreaking havoc throughout regions with altitudes ove 2100 m. Disease severity is estimated using Cobb's scale.

Baking quality

Baking quality is determined for those varieties of wheat and triticale which are agronomically interesting. An ad hoc laboratory has been established and equipped with the assistance of Belgian Aid in Burundi. It can determine the quality of flour by employing an alveograph and a farinoghraph and by using the Zelary test as well as the Hagberg falling number index.

SELECTION PROGRAMME

Sorting nursery

The objective of sorting nurseries is to study the resistance to rust of the latest selections. These tests are conducted on fertile soil with the help of fertilizers and on poor and highly acid soils without the addition of mineral fertilizer. Good soil conditions promote a better vegetative development which facilitates study of disease resistance and appraisal of other varietal characteristics such as days to maturity, straw height and resistance to lodging caused by sudden showers. Tests without fertilizers allow us to evaluate how varieties react to unfavourable soil conditions. Two types of nurseries are normally developed each year: that with experimental standard established by ISABU which groups varieties of various origins. and that developed in cooperation with CIMMTY, screening Nursery for African coordinated wheat yield Trial (SNACWYT) and International Bread wheat Screening Nursery (IBWSN).

Precise Comparative tests at Kisozi

Two series of such tests are also run each year at the Kisozi Station, one with the experimental standard established by ISABU and one with that developed in cooperation with CIMMYT, such as ACWYT (African Cooperative Wheat Yield Trial). The ISABU tests evaluate the best varieties from the previous year from sorting nurseries and from ACWYT. In general, these tests are repeated two to six times during the same season and under varying soil conditions.

Multilocal tests

The multilocal tests determine the reaction of varieties to several environmental conditions. They are conducted at six sites: Rutegama (1700m), Ruvyironza (1850m), Muravya (1800m) Kisozi (2150m), Munanira (2200m). and Nyakaro (2250). At each site, the test is repeated with and without addition of fertilizers.

The Wheat-Triticale program was compelled to give up hybridation experiments, due to the fact that such breeding is spaced over prohibitively long period of time prior to the distribution of a variety. In cooperation with CIMMYT, ISABU is concentrating its efforts towards the selection of varieties for further evaluation based upon data sent from countries with climatic conditions similar to those of Burundi.

WHEAT PRODUCTION AND CONSTRAINTS IN MADAGASCAR

Rakotondramanana and Randriantsalama Rodin A.

Wheat has been grown in the highlands of Madagascar (900 - 1800 m. a.s.l.) for many years but it remains a minor crop. Wheat consumption is around 60,000 tons/ year. To save foreign currency, the Government has decided to increase local production and to build a 60,000T mill which will be used initially to process imported wheat.

GROWING SEASONS AND AREAS

FOR WHEAT PRODUCTION.

At the moment, two growing seasons are being used.

— **Rainfed crop:** from January to May; wheat is grown in the hills, mainly in the volcanic soils around the Antsirabe region. High temperatures and low pH soils are among the limiting factors.

Irrigated crop: from May to September: Wheat is grown on rice fields under irrigation or residual moisture. Temperatures are lower and soils are better than for the rainfed crop. Water management is one of the problems to be solved. There is a potential of 300,000 ha of rice fields in the high plateau of Madagascar which can be used more or less for wheat growing depending on the availability of irrigation.

INSTITUTIONS DEALING WITH WHEAT.

— **The FIFAMANOR project** is a bilate ral cooperative project between Madagascar and Norway. The objective is to deal with research, seed production and extension for wheat, potatoes and fodder crops and to introduce a new breed of cattle in the Antsirabe region.

— The extension service of the Ministry of Agriculture should deal with wheat extension as part of their program.

— **The KOBAMA**. it is the newly built mill in the Antsirabe region. It began production in 1982 with imported wheat. This institution is actually the coordinator of wheat production in the Country. Starting this year (1983) KOBAMA is organising wheat production by contract with farmers in close association with the extension service of the Ministry of Agriculture.

The FOFIFA is the national research institute for all crops in the Country. As part of their program they are to do research in wheat.

CONSTRAINTS FOR WHEAT PRODUCTION IN THE COUNTRY.

In 1982, total production was estimated at 500 tons. Many constraints explain this low level of production:

Price policy.

The price of wheat was kept at FMG 70/kg from 1974 to 1982 (US $ 1 = FMG 422). It was only in 1982 that the price was increased to FMG 120/kg. There is hope that with this new price, production will increase steadily but still wheat doesn't compete with other more profitable crops like potatoes and vegetables (1 kg of potatoes costs FMG 100/kg).

— **Marketing.**

Wheat is grown by small farmers scattered over the Country. So far, the total production has not been collected properly due to the lack of infrastructure, but the mill is going to deal with the marketing of wheat in the Country.

— **Lack of inputs.**

Fertilizers and pesticides are not always available and when available, farmers normally use them firstly for rice. Anew fertilizer plant will be finished in the near future which is intended for production of urea.

OUTLOOK IN THE FUTURE.

There is a potential for wheat production in the country especially in rice fields. High yielding varieties of wheat and triticale have been developed at FIFAMANOR after 10 years of research. There is a need to emphasize extension and to make available the inputs for wheat production (fertilizer NPK, boron and lime).

DISCUSSION DURING THE SESSION CONCERNING WHEAT PRODUCTION AND CONSTRAINTS IN EACH COUNTRY

J. Kasembe, chairman.

The delegate from Kenya (H. Mulamula) has elaborated on the question of training and the difficulties involved in this exercise. In this regard I would like to mention that in our discussions at the International Federation of Agricultural Research and Development (IFARD) meeting we made specific recommendations in relation to CIMMYT involvement in training. We suggested that CIMMYT involves itself in the training program in a manner that facilitates training that is is suited to each of the agroecological zones for the two crops it is dealing with, mainly wheat and maize. In so doing CIMMYT should collaborate with the regional governments in designing local training programs and/or provide consultants as advisors for on-the-job training. Secondly, CIMMYT could also give absentee supervision i.e., provide second supervisors to Master and Ph.D. programs at local universities in order to enhance proper training of both students and staff at higher levels.

My second comment relates to the question of water management. The International Institute for Tropical Agriculture is trying to develop a technique whereby a no tillage practice is used to conserve soil moisture. I would like to get clarification on the complications involved in applying this method. I would also like to know if this method might be a viable alternative to breeding for drought resistance.

E. TORRES: CIMMYT, E.A.

I would like to indicate that action on the recommendations, made by IFARD in regard to training will follow but I can not say to what extent the recommendations will be adopted. At the present time, CIMMTY provides upgrading courses for wheat in the fields of agronomy, breeding and pathology in Mexico. In the future, major emphasis will be placed on regional training as well as training across borders. In respect to Mr. Mulamula's concern over people leaving areas of work for which they were trained in order to look for better paying jobs, I would like to suggest that the only solution is to keep training more people until the market is saturated.

E.A. HURD: KENYA.

I would like to suggest that all alternatives that help conserve soil moisture should be encouraged. However, the best method will of course depend on the circumstances. Minimum tillage, for example, has been very successful in the semi-arid wheat growing areas of Northern Tanzania due to the introduction of the chiesel plough to replace the disc plough. So far very little work has been done on breeding for drought resistance but there is a very good potential for it.

E. STOBBE: KENYA.

One of the major problems encountered in zero tillage practices is lack of foreign exchange required to buy chemicals for weed control.

K. G. BRIGGS: KENYA.

Sometimes minimum or zero tillage practices can promote diseases such as **Helminthosporium** and **Septoria.**

A. S. MOSHA: TANZANIA

Breeding for drought resistance is very relevant to our situation particularly in the semi-arid areas of Northern Tanzania. How can such a program be coordinated so as to be more effective in identifying varieties suitable for these areas ?

E. A. HURD: KENYA

Breeding for drought resistance requires a good understanding of the mechanism for drought resistance in resistance varieties. Current breeding programs in CIMMYT are done under irrigated conditions. Unless the work is done under drought conditions, very little can be achieved. In addition, basic research is required under drought conditions in order to select the parents. Root studies done in Western Canada, for example, showed that drought resistant varieties had extensive root systems. Many of the varieties grown in Mexico under irrigated conditions are shallow rooted.

S. K. SAMKI: TANZANIA

I am concerned about the problems involved in procuring liming materials as well as the high costs involved in purchasing them. I would like to know what alternative soil and crop management practices are being used to contain the problem of acid soils.

ANSWERS Most countries indicated that resistant varieties were used to contain the acid soil problem. Varieties originating from Brazil as well as crosses between Mexican and Brazilian varieties were found to be most resistant to acid soils.

R. BUTTON: TANZANIA

How effective are the various extension services in transferring research findings to farmers actually growing the wheat ?

H. H. MULAMULA: KENYA

Farmers in Kenya respond very positively to technical advice if they happen to own the land which is under production. But, if the owner of the land is somebody else, it very difficult to get maximum response to such advice and these are the farms with the most problems.

E. BECHERE: ETHIOPIA

Lack of proper management practices due to poor extension services is a major problem in Ethiopia. Initially, for example. farmers may respond quite favourably to newly released varieties, but due to lack of frequent follow up, the farmers may go back to their old varieties. Lack of enough extension personnel is the cause of the poor extension services.

E. BEKELE: ETHIOPIA

When screening work is done for disease resistance, is there usually more than one location so as to cover different ecological zones ?

A. S. MOSHA: TANZANIA.

Yes, screening work is done in different ecological zones since resistance varies from one location to another.

K. S. GILL: ZAMBIA

In order to reduce the costs involved in chemical weed control when practicing minimum or zero tillage in developing countries, the readily available human labour in these countries should be used as an alternative or in combination with herbicides.

E. STOBBE: KENYA.

Research on minimum or zero tillage should be conducted to establish whether it is actually practical, even though the chemicals may not be available at the time or may be prohibitively expensive. Under minimum tillage a combination of weed control practices can be applied but where zero tillage is involved herbicides are the only alternative

J. M. ORONDO: TANZANIA.

Triticale in Njombe yields about 25% more than the best varieties of wheat. What is the experience in other countries ?

ANSWERS:

Experience in other countries (Malagasy, Ethiopia, Zambia and Kenya) has shown that triticale yields better than wheat even under irrigated conditions. The major problem with triticale is that farmers are reluctant to grow it. In Kenya, for example the marketing system is the major constraint in increasing triticale acreage. The pricing system is not very encouraging.

E. TORRES: CIMMYT, E.A.

My experience with triticale is that it outyields wheat whenever the conditions are slightly marginal for wheat. In Mexico triticale is being slowly adopted by farmers, particularly on the acid soils of the Central Plateau. Farmers and extension officers noticed the superiority of triticale, and multiplied the seed provided to them very fast. Farmers use triticale as food either alone or in combination with wheat and also use the straw to feed oxen. In the northern area where mechanized farming is practiced, triticale has been officially released by the government. Improvement of triticale varieties in terms of kernel type and flour yield is currently being done so that in future varieties which resemble wheat more closely can be released and will be competitive. In addition, governments can encourage triticale production by introducing more favourable pricing policies.

R. LITTLE: ZAMBIA

Experience in Zambia has shown that where **Helminthosporium sativum** is a problem, generally triticale is much more susceptible than wheat. In wet years yield differences between wheat and triticale are quite small, but in dry years triticale greatly outyields wheat.

D. G. TANNER: TANZANIA.

Why were figures given as break-even points for irrigated wheat in Zambia so high ?

G. NAMWILA: ZAMBIA.

The high cost of inputs involved in irrigated wheat e.g. equipment cost, fuel costs, labour cost etc account for the high break-even figures.

SESSION 2, Tuesday Afternoon, June 14, 1983
WHEAT CROP MANAGEMENT (AGRONOMY)

Chairman: R. Button

MAIZE - WHEAT RELAY CROPPING
Parichi Mnyenyembe

INTRODUCTION:

Relay intercropping is the practice of growing two or more crops simultaneously during part of the life cycle of each. A second crop is planted after the first crop has reached its reproductive stage of growth but before it is ready for harvest.

In Malawi, maize - wheat relay cropping is very popular in highland areas where wheat is grown. However. very little research has been done in highland areas to know the best time to plant wheat in maize fields. Some farmers undersow wheat when maize is dry (April/May). This is very late for wheat since most precipitation falls during the period January through April.

Due to lack of research information an experiment was designed to find out the best time for farmers to undersow wheat in the maize. The trial was initiated during the 1981/82 season at Tsangano Experimental Station.

MATERIALS AND METHODS:

The maize variety used was UCA and the wheat variety was 69/12A1. Fertilizer applied was 80 kilos of nitrogen and 40 kilos of P_2O_5 per hectare for maize, and 60 kilos of nitrogen and 40 kilos of P_2O_5 for wheat. The maize received 20:20:0 as basal dressing (four bags per hectare) and CAN (26%N) as top dressing (same rate), while wheat received all its fertilizer as a broadcast at planting. The wheat received only CAN and single superphosphate.

For income calculations the 1981/82 fertilizer and seed costs were used:-

K12.60 per 50 kilo bag of 20:20:0
K13.00 per 50 kilo bag of CAN
K 3.75 per 10 kilo bag of UCA
K 0.22 per kilo of wheat seed from ADMARC

Although single superphosphate was used for the wheat, the anticipated application would have been four bags of 20:20:0 and two bags of CAN per hectare for wheat compared with four of each of maize. The fertilizer cost per hectare of maize and wheat would then be: K102.40 and K76.40, respectively or K178.80 for both. Seed costs per hectare for maize and wheat would be K9.38 (2.5 bags of UCA) and K17.60 (80 kilos wheat seed/ha recommended), respectivelly or K26.98 for both.

COSTS PER HECTARE:

	Fertilizer	Seed	Total
MAIZE	K102.40	K9.38	K111.78
WHEAT	76.40	17.60	94.00
	K178.80	K26.98	K205.78

RESULTS AND COMMENTS

Results are shown in Table 1. Yield figures in Table 1 are averages from the four replications. From one year's data it is difficult to make very meaningful conclusions. Yields of maize look very low because of a stalk borer infestation and because yields were not adjusted to the correct moisture content. The moisture meter broke down and it was not possible to take grain samples to a laboratory for moisture determination. The yields of wheat are low because the wheat was not planted until the maize began to tassel in mid-April. However, these results show an advantage in intercropping wheat and maize in terms of yield and income. When yields of the two crops are combined there is more grain per unit land.

The income results are also in favour of intercropping, when 1982 prices are used and assuming that wheat was sold to ADMARC for 22 tambala per kilo and maize for 11 tambala. Table 2 shows that monocropped maize gave the lowest total cash income, monocropped wheat next lowest, and all intercropping gave more income, sometimes double that of monocropping.

Income only compared the sales of the two crops. A more insightful comparison is that of profits, when costs are subtracted from crop income. For these calculations the 1981/82 fertilizer and seed costs were used. Table 3 shows comparative profits. These were obtained by subtracting K111.78 from the income of monocropped maize, K94.00 from the income of monocropped wheat, and K205.78 from the intercopped income. Again the lowest profit was from monocropped maize, and intercropping was more profitable than monocropped wheat except for the latest planting.

Some flattening of these differences in income and profits would occur if we equalized the yield differences in maize. (The initially low yield of monocropped maize may have been accidential). Even if the same yield were used for mono and intercropped maize, however, the total yield of grain, total income and profits would still favour intercropping. Maize yields were not lowered and may have been raised (by broadcast fertilizer of by flattening ridges as check for weeds?), and wheat yields were not lowered by intercropping, but only by delayed planting.

Table 1. Harvest Results

TREATMENTS	MAIZE P/ntsat harvest	MAIZE Cobsat harvest	MAIZE Grain yield kg/ha	WHEAT P/nt Hgt (cm)	WHEAT Ears per M-row	WHEAT Shelling %	WHEAT Grain yield kg/ha	Total grain yield
1. Maize Pure Stand	22	20	1646	—	—	—	—	1646
2. Wheat Pure Stand	—	—	—	66	39	61	1183	1183
3. Maize + Wheat at tasselling of maize	24	22	1862	63	46	71	1142	3004
4. Maize + Wheat 1 week after 3	23	21	1934	67	45	62	1399	3333
5. Maize + Wheat 2 week	22	19	1677	58	51	66	1307	2984
6. Maize + Wheat 3 week	24	23	1996	65	49	64	1100	3096
7. Maize + Wheat 4 week	23	21	1749	64	46	67	998	2747
8 Maize + Wheat 5 week	24	22	1954	63	57	33	658	2612
Mean	23	21	1831	64	48	60	1111	2942

Maize planting 30/11/82

Wheat - first planting 14/4/82 (treatment 2 and 3)

2nd " 21/4/82

3rd " 28/4/82

4th " 5/5/82

5th " 12/5/82

6th " 19/5/82

Wheat Variety : 69/12A1 Maize Variety : UCA

Table 2: Cash Income Per Hectare (Kwacha/ha)

Treatments	From Maize	From Wheat	Total
1. Maize Pure stand	181.06	—	181.06
2. Wheat Pure stand	—	260.26	260.26
3. Maize + Wheat at tasselling of maize	204.82	251.24	456.06
4. Maize + Wheat 1 week after 3	212.74	307.78	520.52
5. Maize + Wheat 2 week after 3	184.47	287.54	472.01
6 Maize + Wheat 3 week after 3	219.56	242.00	461.56
7. Maize + Wheat 4 week after 3	192.39	219.56	411.95
8. Maize + Wheat 5 week after 3	214.94	144.76	359.70

Table 3 : Profits per hectare (Kwacha/ha)

Treatments	From Maize	From Wheat	Total
1. Maize Pure stand	69.28	—	69.28
2. Wheat Pure stand	—	166.26	166.26
3. Maize + Wheat at Tasselling of maize	93.04	157.24	250.28
4. Maize + Wheat 1 week after 3	100.96	213.78	314.74
5. Maize + Wheat 2 week after 3	72.69	193.54	266.23
6. Maize + Wheat 3 week after 3	107.78	148.00	255.78
7. Maize + Wheat 4 week after 3	80.61	125.56	206.17
8. Maize + Wheat 5 week after 3	103.16	50.76	153.92

EFFECT OF NITROGEN FERTILIZER APPLICATIONS ON YIELDS AND PROTEIN CONTENT OF WHEAT AND TRITICALE AT VARIOUS LOCATIONS IN KENYA.

B. Toews, A. Ridley and J. Wamwongo.

Triticale was introduced to Kenya in 1967. Thousands of lines have since been screened. Top lines have been evaluated against common wheats in Kenya National Performance Trials. Results from these trials have shown a large yield advantage (78%) of triticale over wheat (Table 1).

Trials were subsequently conducted in 1981 and 1982 to evaluate recommended varieties of what and triticale at representative locations in the wheat growing area in Kenya. Nitrogen fertilizers were applied at 0 to 160kg/ha at planting time to determine the effect of nitrogen applications on yields and protein content of grain. The sites ranged in altitude from 2077 metres at Ngorengore to 2835 metres at Mau Narok. The climate class ranged from semi humid, semi arid at Ngorengore to sub humid at Mau Narok. Soil P^H ranged from 4.8 at Eldoret in 1981 to 5.8 in Mau Narok.

Good grain yield responses (0.5 to 1 tonne/ha) to nitrogen application occurred at four of the eight locations. However, there was no consistent effect of nitrogen application on protein content of the grain, irrespective of yield response (Table 2).

Yields at Eldoret in 1981 (strongly acid soils) were considered low, particularly for wheat which yielded half of triticale. In 1982 at Eldoret on a similar soil type with higher P^H, triticale outyielded wheat only by 7% confirming that the advantage in yield potential of triticale is enhanced by strongly acid soils. Triticale consistently outyielded common wheat on all the other sites as well and averaged 34% higher than wheat. Yields of Mwewe Durum Wheat (not shown) were consistently lower than common wheat at all sites.

Protein content of common wheat was higher than triticale at all sites except Mau Narok-1982 (Table 2). Attempting to increase protein content of triticale and wheat through high nitrogen fertilizer application was not effective.

Straw to grain ratios for triticale were consistently lower than those for wheat and even at 34% higher grain yields, straw yields of the two were similar. Many farmers consider straw a serious problem in seed bed preparation, but triticale should not generally increase the need to burn, a practise commonly carried out in Kenya wheat growing areas.

Triticale flour can be blended with wheat flour up to 20% without losses in bread making quality. It can also be used by itself for various baked products. Considering the yield advantage of triticale over common wheats some effort must be made to increase triticale hectarage in Kenya. At the moment, pricing and marketing policy have been such that there is little incentive for farmers to grow triticale in significant hectarages.

Table 1: Average yields of selected triticale and wheat varieties in Kenya National Performance Trials 1976-80.

Triticate		Wheat	
Variety	Yield kg/ha	Variety	Yield kg/ha
T 14	3830	K. Fahari	2400
T 48	3830	K. Tembo	2390
T 50	3870	Bounty	1960
T 65	4140	A. Mayo	2050

Source: M. W. Oggema, B. N. Wabwoto and H. H. A. Mulamula. "State of Triticale Research and Production Potential in Kenya", Triticale Workshop, Egerton College-1981.

Table 2: Summary of results in 1981 and 1982.

Site	Year	Altitude (Metres)	Climate Class	Soil PH	Nitrogen Response	Ave. Yield T/ha		Ave. Protein %		Straw/Grain	
						Wheat	Trit.	Wheat	Trit.	Wheat	Trit.
Njoro	81	2165	Semi-humid	5.3	Poor	3.61	4.46	13.7	12.1	1.7	1.5
Eldoret	81	2150	Semi-humid	4.8	Trit. only	0.90	2.07	14.5	12.8	2.8	1.9
Mau Narok	81	2835	Sub-humid	5.8	None	1.58	3.32	12.2	11.3	4.6	2.9
Njoro	82	2165	Semi-humid	5.6	None	5.15	5.97	12.5	11.5	—	—
Eldoret	82	2150	Semi-humid	5.3	Good	3.27	3.49	11.1	8.9	1.8	1.7
Mau Narok	82	2835	Semi-humid	4.9	Good	3.86	5.28	11.2	11.8	3.1	2.3
Ngorengore	82	2077	Semi-humid to Semi Arid	5.4	None	2.96	3.75	14.0	11.4	1.6	1.4
Maralal	82	2580	Semi-humid to Semi Arid	5.4	Good	3.80	4.45	11.4	10.5	1.5	1.4

REVIEW OF CROP MANAGEMENT RESEARCH IN TANZANIA

S. D. Lyimo and R. Button

Crop management studies have been carried out at Basotu Plantations Ltd. in the Hanang Wheat growing complex which is under the National Agricultural and Food Company (NAFCO) since 1972 and at Arusha Research Institute farm since 1980.

Experiments conducted at Basotu Plantations Ltd and Arusha Research Institute farm by the section in 1982 are shown below:

1. CROP ROTATION

Arusha Research Institute farm.

Main objective: To determine the effect of preceding crops of wheat, maize, beans, soya beans and sunflower on the yield of a succeeding crop of wheat.

Materials and design: Randomized complete block design replicated four times with plot size of 4.4m x 16.0m. Plots were seeded with a double disc press drill and broadleaf weeds were controlled with 2, 4-D. All plots were previously seeded to wheat continuously for more than ten years.

Results: No meaningful data available until 1983 crop season. The experiment is planned to be continued for 8 years or more. (Table 1.1).

Basotu Plantations Ltd

Main Objective: To determine the effects of preceding crops of wheat, maize, beans and fallow on the yield of succeeding crops of wheat.

Materials and design: Non-randomized, non-replicated strip plot technique was adopted with plot size of 14m x 150m. Plots were seeded with the double disc press drill and 2, 4-D was used for broadleaf weeds control.

Results

Table 1.1: Field plan for crop rotation at Basotu for 1979 - 1984 period.

ROTATION	PLOT NO.	1979	1980	1981	1982	1983	1984
MAIZE/WHEAT	1	wheat	maize	wheat	wheat	maize	wheat
	2	wheat	wheat	maize	wheat	wheat	maize
	3	maize	wheat	wheat	maize	wheat	wheat
BEANS/WHEAT	4	wheat	beans	wheat	wheat	beans	wheat
	5	wheat	wheat	beans	wheat	wheat	beans
	6	beans	wheat	wheat	beans	wheat	wheat
FALLOW/WHEAT	7	wheat	fallow	wheat	wheat	fallow	wheat
	8	wheat	wheat	fallow	wheat	wheat	fallow
	9	fallow	wheat	wheat	fallow	wheat	wheat
WHEAT CONTINUOUS	10	wheat	wheat	wheat	wheat	wheat	wheat

Table 1.2: Yield of wheat, maize and beans in kg/ha from the crop rotation trial at Basotu for the period 1979 - 82.

Crop Rotation	Yield in kg/ha				Mean
	1979	1980	1981	1982	1979-82
What continuous	2280	2700	2530	1590	2280
Wheat after maize	2270	3090	3580	2030	2740
Wheat after beans	2870	3450	3240	2350	2980
Wheat after fallow	2970	3200	3850	2090	3030
Maize after wheat	3910	11250	2690	2380	5060
Beans after wheat	520	850	310	0	420
Wheat after Maize-Wheat	2250	3120	3110	2430	2730
Wheat after Beans-Wheat	2490	3310	3050	1860	2680
Wheat after Fallow-wheat	2190	2890	3050	2240	2590
Average second wheat crop [1]	2320	3110	3070	2180	2670
LSD 0.05					371
CV					8.8%

[1] The average second wheat crop is the average of the second wheat crop after maize, beans and Fallow.

Results in Table 1.2.

The "wheat continuous" treatment was the lowest and yielded significantly less than all other wheat treatments. Wheat yielded highest when seeded on bean and fallow stubble.

High yields of wheat on fallow likely resulted from improved weed control, nutrient status and moisture conservation. High yields on bean stubble may have caused by poor bean growth resulting in improved moisture conservation and nutrient status.

The low bean yields probably were caused by 2, 4-D drift damage, improper seeding equipment or inappropriate time of planting.

2. PLANTING TIME

Arusha Research Institute Farm:

Main Objective: To determine the optimum range of time for seeding wheat in Northern part of Tanzania in relation to the highly variable seasonal rainfall.

Materials & design: The experiment was conducted in a randomized complete block design replicated four times. Each plot was 4.4 x 16.0m in size. Seeding was done using the double disc press drill and broadleaf weeds were controlled by using 2,4-D

Table 2.1: Wheat yield in kg/ha for different time of planting at Arusha for 1980-82 crop seasons.

Treatment	1980	1981	1982
Mid - February	2700	—	0
March 1st	4300	—	0
Mid March	3400	—	2500 ab
April 1st	3160	—	2790 a
Mid April	2620	3340	3160 a
May 1st	2490	2760	2610 ab
Mid May	1840	*	2070 b
L.S.D. 0,05			650
C.V.			16.3%

— Plantings not carried out.

* Not harvested because of bird damage.

Results are in Table 2.1.

Lowest yield values were obtained from the 7th time of planting. The 1980 yield data indicate that the best time of planting was between mid February and April 1st whereas for 1982 it was between the end of March and May 1st.

Basotu plantations Ltd

Materials & design: The experiment was carried out in a strip plot technique with size of 150m x 5m. Due to untimely operations especially with spraying no data was taken from any of the treatments in the 1982 crop season.

Results & discussion;

Table 2.2: Yields of wheat in kg/ha, at Basotu for various times of planting from 1975 to 1981.

TIME OF PLANTING	NYATI VARIETY								MBUNI VARIETY	
	1975	1976	1977	1978	1979	1980	1981	MEAN 75-81	1980	1981
MID DEC	0	2100	990	—	—	—	—	1030	—	—
1ST JAN	0	2140	670	0	3490	960	*	1210	970	*
MID JAN	380	2340	1960	1690	2110	1580	*	1677	2730	*
1ST FEB	850	1480	1770	2130	—	2370	390	1498	2300	980
MID FEB	670	1690	1710	2010	—	2350	1830	1710	2930	—
1ST MAR	580	—	2380	980	2290	420	2600	1542	700	2250
MID MAR	690	1070	2150	1210	1720	2430	1060	1476	*	900
1ST APRIL	600	1090	1760	—	1350	1110	1520	1238	1640	1310
MID APRIL	—	—	—	—	—	1560	2140	1850	2010	1890

— Plantings not carried out.

* Data not available.

The data shows that the preferred period of seeding is mid January to mid-March, with mid February being the optimum time. It's recommended to commence seeding in late January or early February if the soil is moist to a depth of 60 cm in order to reduce the risk of delayed and late seeding due to rains in February.

To commence seeding in late January or early February should allow adequate tillage operations for weed control and seedbed preparations, reduce the risk of late seeding and allow dry conditions for harvesting.

Further research work is required to obtain a more accurate estimate of soil conditions, weather conditions etc to determine the optimum time and conditions to seed wheat at both sites.

3. PLANTING RATES

Arusha Research Institute Farm

Main objective: To determine the optimum rate of seeding wheat.

Materials & design: Randomized complete block design replicated four times with plots 4.4m x 16.0m in size. All plots were seeded with Mbuni variety using the double disc press drill. Broadleaf weeds were controlled by the application of 2, 4-D.

Results:

Table 3.1: Wheat yield of Mbuni variety in kg/ha, for different rates of seeding at Arusha for 1980-82.

Seeding rates in kg/ha	Yield in kg/ha			1980 - 82 Means
	1980	1981	1982	
50	2580	2650	3020	2750 b
67	2700	2750	2980	2810 ab
84	3000	2930	3390	3110 a
100	2760	3410	3220	3130 a
118	2850	2860	3000	2900 ab
134	2620	3180	3410	3070 a
170	2710	2850	3350	2980 ab
200	3060	3220	3110	3130 a
LSD 0,05				294
CV			12.8%	6.6%

The two lowest rates, i.e. 50kg/ha and 67kg/ha gave the lowest yields, probably due to wider spaces left between plants that became infested with weeds. Variable but good yields were obtained from some rates above 84kg/ha but the practical convenience and economics of using rates higher than 100 kg/ha make the practice questionable.

Basotu Plantations Ltd.

Material & design: The experiment was carried out in a strip plot technique with plot size 150m x 5m. Nyati and Mbuni varieties were seeded using the double disc press drill.

Results

Table 3.2: wheat yields in kg/ha, for Nyati and Mbuni varieties, at various rates of seeding at Basotu for 1976 - 82 crop seasons.

Rate of seeding kg/ha	NYATI 1976	NYATI 1977	NYATI 1978	NYATI 1979	MBUNI 1980	NYATI 1980	MBUNI 1981	NYATI 1981	MBUNI 1982	MEANS 76-82
67	1970	1440	2020	1930	2710	1710	2040	2410	1490	1940
100	1730	1400	2300	2000	3240	1670	2520	2390	1530	2090
135	1790	1280	2130	2030	2890	1790	2900	2430	1850	2120
170	2010	1120	2160	2080	3390	1920	2740	2170	1200	2090
C.V.										10.0%

General recommendations/conclusions:

There was no significant difference between different rates for the period 1976 - 82 at Basotu.

At Arusha seeding rates of 84, 100, 134 and 200 kg/ha were significantly greater than the 50 kg/ha rate.

The presently recommended rate of 84 to 100 kg/ha appears to be a practical and economical rate of seeding wheat. The experiment has been terminated at both sites effective this year.

4. PLANTING METHODS

(Arusha Research Institute Farm)

Main Objective: To evaluate some methods of seeding wheat in terms of yield and weed control.

Materials and design: The trial was conducted in a randomized complete block design replicated four times with six seeding treatments. Each plot was 4.4m x 16.0m in size.

Results and discussion:

Table 4: Yield of wheat in kg/ha, for the different methods of seeding for 1980 - 82 period at Arusha.

Treatment	Yield in kg/ha			1980 - 82
	1980	1981	982	Means
Double disc press drill-PD	2700	4440	3250b	3460
Hoe press drill - HD	2350	4400	4060a	3600
Discer - D	2560	4640	3830a	3680
Discer with press drill packing - DSP	2280	3940	3170b	3130
Discer with harrow packing - DHP	2310	4520	3610ab	3480
Broadcast followed by harrowing - BH	2400	3930	3190b	3170
LSD 0,05			590	
C.V.			11.1%	

The 1982 yield data shows that the Hoe press drill was the highest yielding treatment and had significantly higher yield than the PD, DSP and BH. The lowest yielding treatments were the DSP and BH.

The 1980 - 82 results indicate that there were no significant yield differences for all the methods of seeding. The discer and Hoe press drill were however, the highest yielding treatments. Discer seeding with no packing yielded better than discer seeding with packing. Packing at Arusha may not be beneficial or critical probably due to heavy rains after seeding.

DISCUSSION DURING THE SESSION CONCERNING WHEAT CROP MANAGEMENT (AGRONOMY)

J. C. PATEL : ZAMBIA (Question to W. Toews).

In some of the stations where there were no responses to N, do you have any information about the fertility levels of the soils upon which you were working ?

W. TOEWS: KENYA

Unfortunately we don't have good tests for soil fertility. However, I think the major limiting factor in these soils was low soil pH. Usually other factors were not limiting, except in one area called Mau Narok where the soils were copper deficient. In this area copper was applied as a seed dressing and also as a foliar application to correct the deficiency.

J. C. PATEL : ZAMBIA (Question to W. Toews).

General trends have shown that triticales are somewhat higher in protein content than wheats. However, in your case the opposite seemed to be true. Can you tell us something about that ?

K. G. BRIGGS: KENYA

Kenya wheats have been selected for very high quality and their protein contents tend to be higher. So, our expectation in Kenya should be that most triticales will be lower in protein content than most wheats.

A. S. MOSHA: TANZANIA

Are there problems with kernel shrivelling in Kenya triticale varieties ?

K. G. BRIGGS: KENYA

Kernel shrivelling is still a limiting factor in Kenyan triticales. The best variety we have so far is T65. I think it is possible for Kenya to breed varieties better than T65 but our biggest concern at the present time is stem rust in triticales.

LITTLE: ZAMBIA

My experience is that the more Al tolerant wheats take up P much more easily in the presence of Al than the more sensitive varieties. Is it possible that this may be what is going on with Al tolerant triticale varieties i.e. they are able to take up more P than the more sensitive varieties ?

W. TOEWS: KENYA

I think that is true. It has been suggested that wheat varieties that are much more Al tolerant can alter the rhizosphere pH decreasing the effect of Al so that the crop can take up P more easily. It is possible that uptake may be one of the primary factors in Al toxicity.

E. BEKELE: ETHIOPIA

I wonder which is more appropriate, making recommendations on the basic of seed rate or using plant population instead? Since plant population for the same seed rate varies from one variety to another depending on the size of the seed, I am inclined to think that plant population is a better method of determining how much seed should be used, rather than seed rate.

S. D. LYIMO: TANZANIA

To some extent we have been practicing your idea. In the case of Nyati variety for example, which is relatively small seeded, we have been using a smaller seed rate compared to Mbuni which is a bigger seeded variety.

J. C. PATEL: ZAMBIA

I am of the opinion that for each variety we should establish the 1000 grain weight and base the seed rate for each variety upon that, assuming that the seed size is fairly uniform within each variety.

N. S. SISODIA: ZAMBIA

Besides seed size, I think we should also consider such factors as the tillering ability of each variety which ultimately also contributes to the number of productive heads per unit area. Compensatory mechanisms is another factor which should also be considered because where the seed size is larger, normally the plant population is lower but the plants usually tiller more to compensate for the smaller plant population. Therefore, for commercial varieties there are many factors other than seed size that determine the ultimate seed rate to use.

K. S. GILL: ZAMBIA

I am wondering whether it is not possile to establish a better criteria of planting time than the mere planting date. Such factors as rainfall received in a particular period, available soil moisture at seeding time in combination with particular soil types etc. might be more useful determining the planting time.

R. BUTTON: TANZANIA

In all of the time of planting experiments we have recorded such variables as available soil moisture at seeding time, NO_3 - N at seeding time, growing season rainfall, accummulated rainfall to planting time etc. but when these parameters were correlated with wheat yields the correlation coefficient was extremely low. In the case of rainfall, for example, in some years a good amount of rain might be obtained but most of it may be lost through runoff. A study is being initiated to determine how much moisture is lost this way. This might help to explain why the correlation between moisture parameters and wheat yields are so low.

A. S. MOSHA: TANZANIA

What factors determine the tillering ability of wheat ?

E. A. HURD: ZAMBIA

My experience in Zambia is that when planting is done in early May to the late May when cooler temperatures begin and when the nights are quite cool we obtain good tillering. When planting is done in April when the temperatures are normally quite high tillering is very poor and there is no potential for high yields. However, in my opinion a drought resistant variety should not tiller very much otherwise the crop will experience moisture stress bceause too many tillers use up the soil moisture too fast. So, if drought is the main stress perhaps one should use a low tillering variety and control head population with seeding rate.

K. G. BRIGGS: KENYA

Most of the Mexican lines that come through the CIMMYT program have a high tillering ability as one of their common characteristics. However, when they are grown under dryland conditions you get an array of tillers many of which do not fill. I think this whole business of maximum ability to produce effective tillers is going to be an important one if the breeders are to find varieties that do especially well under dryland conditions.

J. C. PATEL: ZAMBIA

It is generally well documented that cool temperatures encourage tillering. Warm temperatures on the other hand usually decrease the number of effective tillers. It has also been reported that warm temperatures initiate early heading and this effect is usually associated with degree days. Because of the warmer temperatures the plant meets its degree day requirement within a short period and that reduces the number of effective tillers.

SESSION 3, Wednesday Morning, June 15, 1983

WHEAT BREEDING, PATHOLOGY AND SEED PRODUCTION

Chairman: E. A. Hurd

WHAT DOES CIMMYT HAVE TO OFFER EAST AND CENTRAL AFRICA VIS-A-VIS INCREASED WHEAT PRODUCTION

E. Torres

Wheat is a minor crop in Africa, Latin America and S.E. Asia. It has not replaced maize as the main grain crop in Latin America as a whole; estimates for 1977 - 79 give maize 49 per cent and wheat 16 per cent of the total cereal production.

Turning to non-saharan African countries wheat is even a less significant crop, with a share of only 3 percent of total cereal production between 1977 and 1979.

People in the Andean countries and in non-Saharan African countries consume about 2,200 calories per person per day. Wheat contributes 200 of these calories in America and 100 in Africa. To appreciate the meaning of these values, let us remember that wheat contributes approximately 1000 calories per day to the average person in North Africa, Turkey, the Middle East, the Soviet Union and Eastern Europe.

A question may appear, still imprecisely stated, but roughly asking :

> "if wheat is not an important crop in East Africa (or elsewhere), why worry about it ?"

To further define the issue, and to formulate the question with proper wording, let us look at some recent wheat statistics.

The 1982-83 wheat harvest is being estimated at 478 million mt. As in most years, developed market economies contribute about 35 percent, the Soviet Union and Eastern Europe 25 percent, China, India and Argentina 25 percent, and the remaining developing countries 15 per cent. The latter group is a chronic wheat importer, and the World has already allocated 100 million mt to satisfy its needs.

Non-Saharan Africa will import about 3.5 million mt of wheat in 1983. Production is expected to reach 1.5 million mt, which represents 30 per cent of the demand. In 1965 local production was only 1 million mt and was enough to satisfy half the needs. It is a paradox that the more wheat is produced, the less self sufficient this region is. In fact, demand for wheat in Africa has grown at an annual rate of about 6 percent, second only to S.E. Asia where it has grown at 7 percent per year. Population growth accounts for half of the demand growth in Africa. The other half is due to increased consumption per person.

Although wheat prices are in a slight decline from last year, wheat imports aggravate the critical shortage of hard currency. A recent purchase by Kenya of 67,000 mt of wheat at prices ranging from 153 to to 156 US$ per tonne, represent a drain of over 10 million dollars.

The **Wheat Issue** in maize-consuming Africa has many facets, and raises more than one concern. Policy makers may validly wonder whether the trend of increased wheat consumption is healthy for the economy of the nation; if it is found to be harmful, they should see that the trend is slowed down or even reversed.

Given that national food policies expressly encourage or tolerate greater and greater wheat consumption, that wheat is a feasible crop, and assuming that financial policies should aim at curtailing imports. the time of crisis will come, when a crash wheat production program may have to be set upon short notice. Objective conditions leading to this point include social pressure for food, economic pressures on currency available for wheat import, and actual or politically-induced stock shortages. Subjective conditions that may trigger the launching of a crash production scheme include positive motivation and sound advice in the circles of policy makers. This sequence of events has happened repeatedly in recent wheat history.

Past CIMMYT Director General, Haldore Hanson, and Wheat Program Directors N. E. Borlaug and R. G. Anderson reviewed recently (3) the greatest modern breakthroughs in wheat production in developing countries, such as Mexico, India, Pakistan, Bangladesh, Turkey and China. The needs of these countries were greatly different (dryland winter wheat in Turkey, irrigated spring wheat in Mexico, India and Pakistan, early dwarfs in Bangladesh to fit during the dry winter in between two rice crops), However, when these success stories are seen together, a unifying feature is apparent. Those successes were preceded by a long standing, strong commitment of Agricultural Research to -
training staff in wheat breeding, pathology and production, identifying or breeding varieties best suited for their unique needs, and developing cropping practices to best utilize these varieties.

Additionally, on-farm experimentation and demonstration plots excelled, whenever used, other means to enthuse farmers and also kept researchers on the track of farmer's problems and constraints.

Wheat research in Africa must look after the crop and its problems at the current modest scale of cultivation. Also learning from history, it should look ahead and prepare a supply of adapted, superior germplasm, appropriate agronomic practices and trained manpower to assist in the success of accelerated wheat production projects, whenever they materialize. Failing to fulfill the technical input may result in a further delay for the take-off of agricultural development.

Carl Eicher, an expert in African Rural Economy at Michigan State University has pinpointed (2) five recurrent issues, each with an underlying dilemma, in the search by African States for a significant role of agriculture in their overall development. These dilemmas are

(1) High vs low priorities to agriculture.

(2) Western vs political economy models for development.

(3) Expansion vs exploitation of agriculture by pricing and taxation policies.

(4) Capitalism vs socialism, and

(5) Imported "Green Revolution" varieties vs locally bred ones.

The last dilemma addresses to the issue of low yields, and will be the only one to be discussed, given the expertise of this group, but we must remember that it is only an aspect of the complex problem of agricultural development.

Wheat yields in non-Saharan Africa as a whole, are indeed stagnant relative to the substantial increases obtained in Mexico, Turkey, India and Pakistan. The genetic progress achieved by CIMMTY wheats is clearly expressed in those countries. In Africa, however, yields remain low, unresponsive to this intrinsic progress. Such a phenomenon demands an explanation.

I propose that this explanation comprises two elements, both pertaining to the constraints for wheat production which are specific for the region. First, these constraints have been addressed by CIMMYT too recently to have a finalized product. Second these constraints call for a greater local breeding effort than the general needs of the major wheat growing areas of the world.

In support of the first concept, I refer to our Wheat Program Director, Dr. B. C. Curtis (1) who distinguishes three phases in the evolution of this program. In the first phase, up to 1970, efforts were concentrated on wheats for irrigated cropland. In the second phase during the 1970's, the former approach was maintained but extra attention was given to genetic and agronomic research for rainfed wheat production. In the third phase, which began just a few years ago, a whole new thrust is being channelled "toward improving the level and stability of yields, particularly in the more marginal production environments". These environments are described as those plagued with pathogens (**Septoria, Helminthosporium**), problem soils (acidity, salt and aluminum toxicity) and climatic extremes (drought, cold, heat). Evidently we must wait to reap the fruits of this new endeavour.

The second concept has been included by Eicher (2) in the dilemma to provide a technical solution to low yields. He asks whether Africa can use directly high yielding varieties developed at International Centers, "or whether improved cereal varieties could be more efficiently developed through investments in research programs in national and regional research stations in Africa".

This dilemma is solved by blending the two apparently conflicting options, and establishing a partnership between the region and CIMMYT. In fact, this team approach is what Regional Projects are all about. Their aim is to facilitate that biological and social scientists from CIMMYT, posted in a region, may join local researchers in addressing location-specific production constraints.

To this partnership CIMMYT contributes its outstandingly diverse wheat germplasm featuring wide adaptability and high yield potential — probably the most diverse, active gene pool of spring wheat in the world. The region contributes the backbone of locally adapted germplasm. The combination of these gene pools should result only in advantages for the region.

Regional Projects are complemented by International Nurseries. In the context of solving site-specific constraints, CIMMYT Wheat International Nurseries include now small F2 nurseries from constraint-oriented crosses. In this regard, CIMMYT will offer in 1983 F2 populations aimed at providing solutions to scab, Helminthosporium, aluminium toxicity, cold stress (durums) and stem rust (durums).

Turning specifically to the East Africa Project, it is not casual it had been established in Kenya. The National Wheat program located at the National Plant Breeding Station (NPBS), is a reputable institution credited with the release of varieties that have faithfully supported wheat production in Kenya. Furthermore, many of these varieties have gone beyond national borders. In times of stem rust epidemics in N. America, Kenyan varieties contributed reliable resistance. Two straight Kenyan varieties were released and grown in Mexico in the late 1940's as a stop gap against rust.

As important as Kenya is within the East African Project, all other countries in the region must regard the project as theirs. The region needs the resistance to **Helminthosporium** and the tolerance to acid soils from wheats bred and selected in Zambia, as much as rust resistant wheats selected in Kenya. Thorough assessment of **Septoria** resistance requires the contribution of Holetta and Njombe as much as Eldoret's. We all need the research on irrigated wheat that may be carried by our colleagues in Zimbabwe and Malawi, and the evaluation of the best germplasm under the diverse and somewhat extreme environmental conditions of Rwanda, Burundi, Mozambique, and everywhere in the region. I believe there is ground for expanded participation of locally bred wheat varieties in the regional nurseries assembled at NPBS. With your concurence we may exchange early segregating populations, from crosses made by national programs between local cultivars and CIMMYT's best advanced lines. There are Veery "S", Bluejay "S", Chova "S" and Chat "S" considered for release in several countries in the region. They should also enrich your array of progenitors.

Let me iterate that the very essence of this or any other Regional Project of CIMMYT is to facilitate the free flow of germplasm among countries in the region. And not just of germplasm, but of ideas, and approaches to solve common or similar problems.

Forums like this workshop provide formal occasion for the exchange of intellectual inputs, and their periodicity should be fostered.

More informal avenues of communication should be explored. Visits by breeders to to national programs in neighbouring countries or in ecologically-related regions at the time of selection, may lead to a better understanding of the common problems and of their likely common solutions, and should encourage team work and solidarity.

Training within this region should be done on larger scale than before. Financial resources may be more efficiently used to cover visits of scientists from the smaller national programs to well established research stations in the region. These visits would target on specific activities such as crossing, inoculations, disease assessment, selection, harvest, etc. By their short duration they should not burden unduly the host researchers.

Naturally, training opportunities in Mexico will be maintained. With Dr. G. Kingma as training officer for Breeding and Pathology, trainees from the region are assured an experienced guide.

In this paper, I have expressed my belief that National Wheat Programs should continue working on current constraints for wheat production, and also prepare themselves for possible large scale production plans.

I also believe that if the East Africa Project of CIMMYT is going to interact effectively with National Wheat Programs in this venture, it must **Intensify** the incorporation of products from local breeding in regional nurseries ,the exchange of national scientists within the Region, the encouragement for crosses between locally adapted cultivars and superior advanced CIMMYT lines, and local training opportunities.

I can very clearly see that the accomplishment of these goals will require from all of us an **intensification** of our personal involvement in field work.

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A REVIEW OF WHEAT AND TRITICALE IMPROVEMENT RESEARCH AT THE UNIVERSITY OF ZAMBIA

N. S. Sisodia

The climate in Zambia is ideal for wheat production, particularly irrigated wheat in the dry season. Despite this, in 1982 the country produced only about 12,000 m.t. which is only about 8% of the nation's requirement. For self sufficiency, Zambia needs to grow about 35-40,000 hectare of irrigated wheat. At the 1983 import price of Kwacha 247.0/m m.t., ex Dar-es-Salaam, the country will spend approx. K35 million in foreign exchange plus about K25 million in transportation from Dar. and local handling charges. Both irrigated and possibly rainfed wheat production, therefore need to be increased rapidly. Of the various inputs for increasing/sustaining wheat production, a regular supply of high yielding and disease resistant varieties is needed. Realising this, the School of Agric. UNZA initiated irrigated wheat improvement research as early as in 1972-73. This report summaries work done over the years.

The program was initiated by Dr. M. Taha and later joined Dr. M. Ashraf in 1973, who left in September 1978. Mr. D. Lungu took over the work until August 1979, when he left for his Ph.D. The author took charge of the program in September 1979. Others associated with the program at various stages were Drs. I. Mukherjee, C. Nissly and Mr. I. Javaid. It would be appropriate to mention that what is being done and achieved since 1979, is with much limited manpower, physical and financial resources. Since January 1981, the Technician associated with the work is away for training and technical assistance is only available at planting and harvest time. The work, therefore, is being carried out mainly by casual workers, some of whom had been long with the project, and specifically trained during last 2-3 years. The project is receiving only approx. K5,000.00 annual support from the University.

SCOPE OF WORK

Initially the main objective of the program was to identify/develop improved varieties of wheat well adapted to Zambian climate for production during the dry season under irrigated conditions. Later work on triticale and **durums** (macaroni wheat) was also included in the program. Although main emphasis continues on irrigated wheat research. work on rainfed wheat was started in 1975. However, since 1981, work on rainfed wheat has been nearly stopped. In 1980 work on screening/ selection for Aluminum tolerance in wheat was initiated. The first F_2 - Al Nursery from CIMMYT was planted at Golden Valley Farm in 1979 in normal pH soils. Subsequently arrangements were made with the then Wheat Coordinator Dr. E. A. Hurd, to plant the Al Nurseries at Mbala in unlimed, low pH soils and alternate plantings of selections between Lusaka and Mbala. Thus 122 F_3 single plant selections from Golden Valley Nursery and another set of F_2 - Al Nursery were planted in Mbala in 1980. This work was later taken over by the Zam-Can Wheat project and therefore, discontinued in 1981. Three selections from the UNZA Al Nursery 1981 are currently in the second year of rainfed wheat trials. The scope of work therefore, had been and/or is as follows:

a) To identify/develop high yielding, disease resistant varieties for irrigated conditions. Among diseases, stem and leaf rusts, and powdery mildew are important ones.

b) To explore the potential of triticale and **T. durum** under irrigated conditions in Zambia.

c) To identify wheat and triticale varieties suitable for growing under rainfed conditions.

d) To identify acid soil tolerant wheat and triticale varieties.

EXPERIMENTAL APPROACH

The source material for our program is mainly Screening Nurseries from CIMMYT (Mexico and Kenya) and ICARDA. In addition, the Regional Wheat Yield Trial from ICARDA and the African Cooperative Wheat Yield Trial from CIMMYT Kenya, are being conducted and provide some useful material. In 1975, crosses were made by Dr. Taha in all combinations between vars. Umniati Zambezi I, Super x, Turpin 7, Pakistan II, Chenab 70 and Son 64/C271/Pk to develop local breeding material but the progenies were found susceptible to stem and/or leaf rusts and by F_5 all material had to be discarded. No hybridisation work was undertaken since 1979 because it is believed that at this stage, there is no special breeding problem of irrigated wheat in Zambia that can't be solved through material introduced in Screening Nurseries supplied by CIMMYT and ICARDA. This approach is considered to be quicker and economical in the present context of irrigated wheat crop in Zambia. The following selection and testing procedure is currently in use.

First step

Preliminary evaluation of introductions in Screening Nurseries. Single 5m long row plots are used. Infector rows are planted in between ranges and all round the nurseries. These are artificially inoculated for leaf and stem rusts. Selection is based on disease resistance, visual assessment and yield.

Second step

Preliminary Yield Trials (PYT). Selections from Preliminary Evaluations are tested in 6.5m x 0.8m (4 rows) replicated plots at the UNZA Farm.

Third step

Micro Varietal Trial (Mic. VT). Selections from PYT are tested in 5m x 1.6m (8 rows) replicated plots at two sites UNZA Farm and Golden Valley. Promising entries are entered in the Cooperative Trials. Some outstanding selections from PYT are directly entered in the Cooperative Trials.

Fourth step

Cooperative Trials. Includes entries from all programs. **Irrigated Advance Wheat Trial** (IAWT). Conducted at 4 locations.

Irrigated National Wheat Trial (INWT). Conducted at 6 locations and includes promising entries from the IAWT.

On-Farm trials. Most promising entries from INWT are planted in ½ ha plots at 4-6 commercial farms. Those entries are also retained in the INWT for a second year data. Seed of all entries in yield trials is separately multiplied for further use. Since 1980, selection for rusts has been based on artificial rust epiphytotics. Rust inoculum is kindly supplied by R. Raemaeker, Pathologist, Belgium Development Project, Mt. Makulu. The syringe injection method is used for inoculation. All entries in Yield Trials are planted separately in a Disease Screening Nursery with infector in such a way that very high disease pressure is built up. Two to three plants in each entry are inoculated. During the past three seasons, disease development had been quite good at the UNZA Farm enabling proper screening of the material.

EXPERIMENTAL RESULTS

Irrigated Wheat Improvement

During the period 1972-78, 2723 wheat genotypes were evaluated. In 1975, Umniati, Turpin 7, Chenab 70, and Zambezi I were accepted by the Ministry for production (Progress report 1975, Dept. of Plant Science). In 1978 Cooperative tests, a number of varieties such as M'Christu B, KAI-FAO215, Kapochi etc. performed well. However, these were susceptible to rusts and were discarded. Thus during this period, although a few high yielding varieties were identified, these were not tested for rust resistance under artificial inoculated conditions and ultimately were discarded.

During 1979-83, 434 wheat varieties were evaluated in stations trials; of these 65 were entered in the Cooperative tests. 2831 genotypes were evaluated in Screening Nurseries. Over the years, the number of UNZA entries in these trials increased from 6 in 1980 to 26 in 1982 and 20 in 1983. Overall UNZA's contribution was 30% of the total varieties tested in these trials; of these, 42% were retained for further testing. This indicates good performance of UNZA selections in the Cooperative trials.

In table 1, performance of top 50% varieties in various station trials over the years is summarised. Two facts emerge from these data. First, there was an increase in mean trial yields over the years from 3287 kg/ha in 1979 to 6242 kg/ha in 1982. This increase in mean trial yields resulted mainly from improved management, which was desirable for the proper evaluation of genotypes. Secondly, although the results were not consistent from year to year, the overall mean yield of vars. in the Micro V.T. was higher (111% of controls) in comparison to those in the PYT's (equal to controls). This was expected since Micro V. T. was an advance trial and included better performing entries from the PYT's. Summarising, these results indicate reliability of the selection criteria and evaluation procedure being followed.

Tables 2 summarises the varieties in most advance tests. For comparison, data on the existing commercial vars. Emu and Jupateco are also given. One of these vars. UNZA-W-2 = (My54/N10B-Y50XK. line-CD) Buho was released this year and named 'Canary' after a common Zambian bird. It is a tip-awned variety, has strong straw and does not lodge even when higher than recommended dose of fertilizer is applied. It has shown a slight edge in yield over Emu and Jupateco and is resistant to stem/leaf rusts and to powdery mildew. The remaining four varieties listed in this table are in the final year trial INWT and of these three (UNZA-W-11, UNZA-W-13 and UNZA-W-17) are being also tested in On-Farm trial this year. Mention should be made of the variety UNZA-W-17, a Veery selection. A line of the same pedigree originating from the Belgium Development Project was released this year in Zambia and named 'Loerie'. Both these lines (viz UNZA-W17 and Loerie) were tested in the 1982 INWT and over six locations yielded 117% and 107% of the controls respectively. Phenotypically they look alike including in seed type.

Both are being tested again this year in the INWT and it would be interesting to know if they are really different in yield potential. It will be noted from table 2 that of the six vars., four are Veery selections (Kvz-Buho's' x Kal-Bb). This substantiates the high yield potential, rust resistance and wide adaptation of Veery selections observed by CIMMYT in many countries through its International Testing Program.

Performance of triticale under irrigated conditions

Although triticale has shown promise over wheat under rainfed conditions in Zambia (Zam-Can Wheat Project Reports), it's potential under irrigated conditions had not been tested. Therefore in 1980 five triticale lines were tested with 12 wheat vars. + 3 controls in a PYT at the UNZA Farm. Three of the five triticales UNZA-T-1, UNZA-T-2 and UNZA-T-3 (Table 3) ranged in yield from 112 to 122% of the wheat check Emu. In 1981, these three lines were tested in a Cooperative Triticale Trial (17 triticale + 3 wheat check) and ranked top three yielding 119 to 145% of wheat check Emu. These results initiated interest in exploring the potential of triticale under irrigated conditions.

Beside yield and other agronomic attributes, plumpness of kernels has been an important selection criteria in triticale. In table 4, an attempt has been made to summarise the comparative performance of wheat and triticale over the years. Overall, triticale and wheat yield averaged 124% and 108% of the controls respectively and indicates higher yield potential of triticale over wheat at the same management level. Data of some promising UNZA triticale lines in advance tests are summarised in table 3. One of these lines UNZA-T-1 (IA-M_2AxPi62/Bgl) has given consistently 116-118% yield of controls over the three year period. This line is in the final year trials INWT and INTD as well as in the On-Farm trial this year. It has also performed well in the Rainfed trials during the past two years, and has shown good tolerance to acid soils. In 1982 season at Mbala it was scored 1 for acid soil tolerance in comparison to a score of 3 for PF 7748, a Brazilian wheat used as a check. It's kernels are also fairly plump and bold (test weight 73, for wheat about 80).

Thus, on the basis of experience so far, triticale does appear to have potential for irrigated production in Zambia and work on triticale needs to be continued. Beside yield and possibly quality (nutritional - higher protein of better quality) advantage, its higher level of tolerance to acid soils, which are common in Zambia, makes it an attractive crop for Zambia. On the utilisation aspect, no special problem is anticipated as it can be used for blending with wheat flour for making bread. The Government is considering price fixation for triticale, which is expected to be the same as for wheat.

Performance of durum wheat under irrigated conditions

Durum wheat is not grown at present in Zambia. Durum products - semolina, macaroni, etc are made from bread wheat and/or imported. In future, it may be desirable to grow durum wheat locally. Therefore, work on durum was undertaken on an exploratory nature to explore the potential of the crop in Zambia. Promising durum selections were included in wheat trials in 1981 and 1982. Although data is limited, and is based on selection and testing of a few varieties only, durums appear to have equal yield potential to wheat under irrigated conditions in Zambia. In table 5, performance of three durum varieties, which have been in trials since 1980 has been summarised. In yield, these vars. have given equal/better performance to the wheat checks but all have shown susceptibility to powdery mildew. Powdery mildew, therefore, may be a more serious problem on durum wheat in Zambia requiring special efforts to select for powdery mildew resistance when durum wheat production becomes of interest to Zambia.

Rainfed wheat/triticale selection

During 1975 - 78 period, 542 wheat genotypes were screened during the rainfed season (Jan. to May) but all sufferred a heavy infection of **Helminthosporium** and were discarded. In 1980, 645 wheat/triticale genotypes were planted for screening on Dec. 29 and Jan. 17. Again **Helminthosporium** infection was severe particularly on the first planting. In the same season, 23 triticale vars. were evaluated in a yield trial planted on Dec. 31. **Helminthosporium** infection was less but there was a serious incidence of **Fusarium** on heads after anthesis resulting in sudden drying of the heads to the extent that the trial had to be abandoned.

It was observed that **Helminthosporium** infection in a variety flared up suddenly after anthesis. Thus, later flowering vars. appeared tolerant as for these, the environmental conditions for **Helminthosporium** development become less favourable. Experimental evidence of relationship between anthesis and **Helminthosporium** development had been reported on rye (**Secale cereale**) from the Netherlands. The implications of this observation in **Helminthosporium** management are important as genotypes requiring maximum period for anthesis and minimum period for grain filling would be more appropriate. Such genotypes may avoid the congenial environment for **Helminthosporium** development around the period of anthesis in a particular environment. For example, under Mbala conditions, genotypes flowering in 85 - 90 days around April end and maturing by mid-June (40-45 days) may be more appropriate. However, it has to be ensured that such genotypes do not suffer from drought during the ripening period.

As mentioned before, the program is concentrated on irrigated wheat, the rainfed season is utilised for further screening the selections made in the dry season against rusts. From these, apparently better performing entries are entered in the Rainfed trials conducted by the Zam-Can wheat project. Thus in 1981, five wheat and two triticale vars. and in 1982, three wheat and seven triticale vars. were entered in these tests. In addition, six wheat and nine triticale lines selected by D. Tanner from the UNZA's Al Screening Nursery 1981 at Mbala, were also evaluated in these trials. Four wheat and six triticale lines have been retained from 1982 trials and are currently in the advance trials. Among these, of most interest is the triticale variety UNZA-T-1, which had been in trials for three years and has a high level of acid soil tolerance as mentioned before. Limited seed of this variety was given to 4-5 farmers in 1983 for field level assessment. The results are still awaited.

CONCLUSION

Irrigated wheat varietal development research is well underway in Zambia at UNZA and at Mount Makulu. This year, two vars. named Canary and Loerie were released. At present the major emphasis in research is on high yield and yield stability. However, as the wheat production expands in Zambia, the research program should include development of acid soil tolerant vars., development of vars. adapted to specific ecological conditions and development of better quality - first nutritional and then industrial quality varieties. Triticale has given approx. 16% higher yield than wheat and work needs to be continued on this crop on account of its better acid soil tolerance, better disease resistance and possibly better nutritional qualities.

At present, irrigated wheat area in Zambia is only approx. 3000 ha. There is an urgent need to expand the wheat acreage for attaining rapid self sufficiency. One major constraint to expanding wheat acreage is irrigation - both source and application. With the existing method of irrigation using sprinklers even when irrigation source is available, the initial cost of applying water from the source to the field is approx. K4000 /ha. Most of this cost is in foreign exchange. This is quite high and prohibitive to irrigation expansion. The total cost of developing additional 30,000 ha irrigated wheat area would amount to approx. 120 million; of this, 70-80% would be in foreign exchange. Therefore, in order to rapidly expand the irrigated area, research on surface irrigation methods is urgently needed on aspects such as best method, suitability of diferent soils, water - use efficiency, economics etc. It needs to be mentioned that in many third world countries including India, nearly all area is surface irrigated. Why not then in Zambia ?

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Table 1. Mean yields in relation to controls[1] of top 50% wheat varieties in Station trials

Trial	1982		1981		1980		1979		Mean	
	Kg/ha	% Control	Kg/ha	% Control	Kg/ha	% Control	Kg/ha	% Jupoteco	Kg/ha	% Control
Micro V.T.	6019 (10)	105 (2)	4596 (16)	107 (4)	4520 (20)	113 (6)	-	-	4872 (46)	111 (12)
PYT-A	6229 (9)	101 (2)	5570 (7)	110 (2)	4835 (6)	101 (3)	3522 (10)	114 (1)	4977 (32)	100 (8)
PYT-B	6503 (9)	105 (2)	5138 (7)	107 (2)	4875 (11)	102 (3)	3407 (10)	101 (1)	4924 (37)	99 (8)
PYT-C	———	———	4243 (6)	119 (2)	4656 (7)	104 (3)	2932 (10)	118 (1)	3799 (23)	99 (6)
Mean	6242 (28)	103 (6)	4832 (36)	110 (10)	4673 (44	106 (15)	3287 (30)	110 (3)		

( ) indicates number of varieties.

[1]Control varieties were Emu, Jupateco in 1981, 1982 and Tanori in 1980.

Table 2. Yield and other attributes of UNZA Wheat varieties presently in most advance tests (1979-82)

S. No.	Variety/cross	Av. Yield Kg/ha	* % Cont.	Disease reaction			Ht. cms	Days to		1000K wt. gms	1983 Use
				S. Rust	L. Rust	P. Mildew		Head	Mature		
1	UNZA-W-2 (My54/N10B-Y-50xK.line-CD) Buho	5799	103 (15)	40MR-10MS	0-20MR	0	92	79	131	46	RELEASED
2	UNZA-W-11 Vicam71-Ciano's'xCalidad/Nad67-7C) Ti71'R'	5633	107 (12)	0-20MS	0-20MS	0	92	86	132	43	INWT + On-Farm
3	UNZA-W-13; Veery's' CM33027-F-12m-1y-4m-2y	6173	106 (10)	40MR-25MS	0-10MR	0/2	95	87	133	36	INWT + On-Farm
4	UNZA-W-17; Veery's' CM33027-F-15m-500y-Om	6296	116 (9)	50MR-20MS	0-5MR	0	98	81	131	45	INWT + On-Farm
5	UNZA-W-25; Veery's' CM33027-F-12m-1y-6m-Oy	6402	109 (5)	20MS	0-20MR	0	96	87	132	42	INWT
6	UNZA-W26; Veery's' CM33027-F-8m-1y-8m-1y -2m-0y	6358	108 (5)	20MS	0-10MR	0	100	87	132	44	INWT
7	Emu	—		10S-100S	40S	0	93	78	131	45	—
8	Jupatero	—		60S-100S	80S	1	99	77	129	41	—

( ) indicates number of trials

* controls were Jupateco in 1979, Emu and Jupateco in 1980/1981 and Limpopo in 1982.

Table 3. Yield and agronomic characteristics of UNZA triticale selections in advance tests (1980-82)

S. No.	Variety/Cross	Av. Yield Kg/ha	* % Cont.	Diseases Rust	Diseases Midew	Ht. (Cms)	Maturity (Days)	1000K Wt. (grs)	Test wt. Kg/hl	1983 Use
1	UNZA-T-1 IA-M_2 xPi 62/Bgl	6194	118 (9)	0	0	127	139	47	73	INWT, INTT + On-Farm + Rainfed
2	UNZA-T-2 M_1 A (Bison)	6189	109 (6)	5MS	0	116	134	46	69	Rainfed
3	UNZA-T-3 $(M_2\ A)^2$	6360	112 (6)	tR	0	118	136	53	68	INTT
4	UNZA-T-4 Panda 'R'-Abn	6047	115 (5)	tMR	0	105	134	49	76	INWT, INTT
5	UNZA-T-9 Cml's'-Ska	5665	109 (5)	tMR	0	121	139	48	71	Rainfed
6	UNZA-T-10 Tj-Bgl's'	6322	118 (5)	0	0	134	142	59	69	INTT

( ) indicates number of trials

* wheat vars. Emu and Jupateco as controls.

Table 4. Average yields of wheat, durums and triticale based on top 50% varieties

	1982		1981		1980		Mean	
	Kg/ha	% Controls	Kg/ha	% Controls	Kg/ha	% Controls	Kg/ha	% Controls
Wheat	6241[3] (28)	103 (6)	4832[5] (36)	110 (10)	4673[5] (44)	106 (15)	5133[13] (108)	108 (31)
Durums	5609[2] (5)	101 (4)	4429[2] (3)	108 (4)	—	—	5166[4] (8)	107 (8)
Triticale	6026[2] (19)	109 (4)	6100[4] (14)	135 (8)	5249[1] (3)	109 (3)	5990[7] (36)	124 (15)

( ) indicates number of varieties and superscripts indicate number of trials.

Table 5 Performance of some durum wheat varieties

S. NO.	Variety/Cross	1982 Yield Kg/ha	1982 % Cont.	1981 Yield Kg/ha	1981 % Cont.	1980 Yield Kg/ha	1980 % Emu	Mean Yield Kg/ha	Mean % Cont.	Disease S. Rust	Disease P. Mild	Ht. (cms)	Maturity (days)	1000 K.wt. (gms)
1	UNZA-D-1 Fg's'xMagh-Gta's'	5753	100 (5)	4573	107 (2)	5291	126 (1)	5400	104 (8)	tR	9	94	136	56
2	UNZA-D-2 Redhead's'	5757	98 (4)	4558	106 (2)	4447	107 (1)	5227	101 (7)	0	6	96	140	51
3	UNZA-D-3 Bit's'	6808	115 (4)	4142	116 (1)	—		6275	115 (5)	tS	6	91	133	57

( ) indicates number of trials.

WHEAT AND TRITICALE BREEDING IN ZAMBIA

G. L. C. Musa (Reading by R. Little)

Wheat and Triticale research is being carried out by five projects in Zambia; two based at the Mt Kakulu Central Research Station (the Zambia - Canada Wheat Research Project and the Belgian Development Project), one at the National Irrigation Research Station (Horizontal Resistance Breeding Programme), one at the University of Zambia (Plant Science Department), and one at the Mpongwe Development Project in the Copperbelt Province. All have some interest in breeding or selection and all take part in a co-operative variety testing programme co-ordinated by the Wheat Research Co-ordinator.

This paper gives details of the Zambia-Canada Wheat Project breeding programme which is developing wheats for the irrigated and rainfed seasons and triticales for the rainfed season. The testing of advanced lines in co-operative trials is also discussed.

OBJECTIVES

The most important criterion used by breeders and farmers for the eventual acceptance or rejection of any new variety is yield per unit area or yield potential. Thus, the breeding programme has the following objectives:

to develop high yielding varieties which are suitable for rainfed and irrigated conditions, and to identify genotypes with desirable attributes for use as parents in the breeding programme.

The major characteristics required for the two seasons - roughly in order of priority -are:-

Irrigated

High yield
Resistance to stem rust
Resistance to leaf rust
Resistance to powdery mildew
Maturity about 130 days
Straw strength
Good seed type

Rainfed

High yield
Resistance to **H. sativum**
Tolerance to Al-toxicity
Resistance to stem rust
Resistance to leaf rust
Resistance to **Xanthomonas campestris**
Resistance to Scab
Maturity 130 - 160 days
Straw strength
Good seed type

EVALUATION OF GENETIC STOCKS

To identify new and useful genetic stocks for various characters the material is first evaluated at up to three sites i.e. Mt. Makulu, Golden Valley and Mbala. Material is assessed for disease resistance, aluminium tolerance, maturity, height, grain characteristics etc.

Disease Resistance

Rust epidemics in Zambia are rare and usually light. However, in 1981 a serious epidemic of leaf rust was reported at the Mpongwe Wheat Scheme. In 1982 powdery mildew was widespread but occasionally severe on varieties known to be susceptible. A very large percentage of the 1983 irrigated wheat acreage is expected to be under varieties susceptible to both the rusts and also powdery mildew. The potential for a rust and/or powdery mildew epidemic is therefore high. The breeders are therefore exercising selection pressure for rust and powdery mildew resistance. Two new varieties (Loerie and Canary) with good overall disease resistance have been released for the 1983 season but will not have a major impact on the acreage until 1984.

To facilitate rigorous selection, a field collection of rust spores stored under vacuum at 2-5°C is used to inoculate spreader rows within the breeders' nurseries, usually at two locations (Mt. Makulu and the University Farm). Powdery mildew infection occcurs naturally if susceptible spreaders closely planted are included in the nurseries.

Disease pressure can be extremely high in the rainfed season. Resistance to **H. sativum** and scab is screened principally at Mbala which is a natural "hot spot". Segregating populations from new crosses, introduced populations and advanced lines are tested. Only genotypes exhibiting improved disease resistance are retained for further testing.

Aluminium Tolerance

Yield trials and observations indicate that Al-tolerant lines are substantially higher yielding than present (sensitive) strains, although they will not completely overcome the Al-toxicity problem. Reports from Brazil indicate that Al-tolerant varieties of wheat produce satisfactory yields in soils of up to about 20% Al-saturation.

All entries in yield trials for the rainfed season, local breeding material and introduced lines claiming Al-tolerance are screened in an aluminium tolerance screening nursery.

Screening is conducted in an unlimed field in Mbala with a soil pH of 4.2; Al-saturation in the subsoil at Mbala ranges from 25 to 50%. Experimental materials are compared on a 0-9 scale with two controls, PF 7748, an Al-tolerant line from Brazil (set at 3) and Jupateco, an intolerant line from Mexico (set at 7). In future a laboratory screening technique will also be used to complement field tests and facilitate the handling of large numbers of lines.

Maturity

The optimum planting time for the rainfed season is mid to late January, which is some three months after the usual onset of the rains. Earlier plantings have resulted in a high development of **H. sativum** due to prevalence of warm, wet conditions during the period mid-November to mid-January, and therefore in low yields. Plantings in February although less infected by **H. sativum** frequently suffer from drought especially if the rains finish early in, say, early March, and yields are low. There is therefore a very short planting period when the probabilities of both low disease pressure and adequate moisture during the season are increased. If rainfed wheat is to be a commercial success it would be desirable to increase this planting period.

The varieties used in the time of planting trial were susceptible to **H. sativum** (resistant varieties were not at that time available). It may be possible to plant more resistant material earlier to obtain higher yields but it would be desirable if this material was of longer maturity so that harvesting would take place after the end of the rains. Fortunately the later maturing lines generally appear to be more resistant to **H. sativum.**

Earlier planting would also have advantages in soil management as the present optimum dates mean planting when soils are usually at field capacity resulting in difficult land preparation and planting conditions, and the danger of soil compaction and erosion.

Quality

This is restricted to materials in advanced stages of yield testing. At the present moment, quality is not rated very highly as a selection criterion in the breeding programme. Present local production is only approximately 10% of the consumption and the necessary quantity of high quality wheat can be easily imported. However, the situation is being kept under review and genotypes with a good seed type are selected preferentially.

BREEDING STRATEGY

In the development of varieties for the irrigated season, lines are selected from material introduced from all over the world but principally from CIMMYT (Mexico and Kenya), ICARDA and Brazil. However, for the rainfed season where introduced lines have so far not provided material with all the desired attributes, single, double or triple crosses have been made. In order to develop a superior variety for rainfed conditions, the programme puts most emphasis on combining high yields, Al-tolerance and resistance to **H. sativum**, and where possible also to bacterial blight, **Xanthomonas campestris**, and scab.

Following a careful examination of lines screened for desirable attributes, a decision is made as to which lines are to be crossed to combine the desired agronomic characteristics. The resulting hybrid populations undergo rigorous screening for disease resistance, Al-tolerance, plant type, maturity, and also height, and good kernel characteristics, etc. when variation is available. Table 1 gives a list of parents currently used in the programme as sources of resistance to **H. sativum**, stem rust, leaf rust and powdery mildew and tolerance to Al-toxicity. The movement of the hybrid populations in the generations following the cross is presented in Table 2.

By using the alternate sites at Mt. Makulu or Golden Valley (irrigated) and Mbala (rainfed) two generations are realised in a year. Yield testing of advanced lines can start at F_5.

EVALUATION

Lines derived from the local breeding programmes and promising lines from screening nuseries are evaluated for field performance - yield and other characters.

A similar programme of testing is used for both the irrigated and rainfed seasons. Initial yield testing in Preliminary Yield Trials is carried out by the plant breeder concerned. Selected genotypes are tested against standard varieties. The more promising lines are entered by the breeder into a Co-operative Advanced Yield Trial at three or four locations. If found promising, the lines are retained for testing in the National Yield Trial at up to six sites over two years. The tests are designed in such a way as to give reliable comparative details on new and existing varieties. The main selection pressures in the programme are for yield and disease resistance.

Varieties which have shown promise in yield potential after two years in co-operative yield trials and are likely candidates for release are grown in approximately 0.5 hectare plots at up to six locations is the farmer's field during their second year in National Trials. These "on farm tests" give the breeder the opportunity to:-

i) evaluate the varieties in large plots

ii) gain farmer's reaction

iii) obtain some indication of yield under commercial conditions, and

iv) increase seed prior to possible release. (The plots are contracted as pre-basic seed with the Zambia Seed Company).

Varieties which perform well in three years of co-operative trials and exhibit no weaknesses in "on farm trials" are submitted to the Variety Release Committee by the breeder with a request for release.

RESULTS

Prior to 1976, the best varieties under irrigation had a yield potential of 4 tonnes per hectare (t/ha). With improved germplasm, mainly from CIMMYT, new varieties with yield potentials of over 6 t/ha have been identified and released.

Table 3 shows a summary of yields of the best wheats and triticale in the irrigated co-operative yield trials with yields between approximately 6 and 7 t/ha. This is well above the national average of 4 t/ha in 1982.

Under irrigation the yield potential of triticale is roughly equal to that of wheat, but under rainfed conditions it is superior to wheat especially in a dry season where the rains finish early (Table 4). Under such conditions triticale varieties have yielded up to almost three times those of wheat e.g. 1980-81 season - rainfed). This is probably due the deep rooting in the soil profile where Al levels are too high for wheat, enabling them to withstand drought conditions better when the rains cease in early or mid-March.

However, during the 1981-82 rainfed season with extended rainfall, triticales performed similarly to wheat (Table 4). This was due mainly to the high development of **H. sativum** to which triticales in general appear to have lower levels of resistance than wheat especially when disease pressure is high. In the absence of drought stress the deeper rooting of the triticales did not show to any advantage.

It is evident from the data presented in Table 4 that under rainfed conditions yield potential is low due mainly to diseases and Al-toxicity problems in acid soils. However some lines have given yields of over 1.5 t/ha and one wheat line PF7748 (from Brazil) yielded 2.4 t/ha in 1981/82.

FUTURE PRIORITIES

The genetic potential for yield of the currently developed and cultivated varieties under irrigation is high (up to 7 t/ha).

Yield levels of over 6 tonnes per hectare have been achieved with intensive agricultural practices under irrigation, while yields of about 2 tonnes per hectare can be obtained in trials under rainfed conditions. However, the national average of irrigated wheat in 1982 was low (4 t/ha). This indicates a large gap between the potential and what achieved by many farmers. Several causes for this wide gap are known, the major ones being date of planting and irrigation management which are largely beyond the scope of varietal improvement. For the irrigated season the breeders will attempt to continue to maintain a supply of high yielding disease resistant varieties, while for the rainfed season commercial production will be possible only if varieties with improved disease resistance (especially **H. sativum**) and tolerance to aluminium are available. This effort by the breeders should be in conjunction with attempts to ameliorate soil acidity and locate alternative sites where disease pressure and/or aluminium toxicity are less severe.

TABLE 1 Sources of disease resistance, aluminium tolerance and yield potential used in the wheat and triticale breeding programmes in Zambia.
+ Line exhibits character indicated

Parentage/Pedigree	Resistance to				Al-tolerance	Yield
	H. sat.	Leaf Rust	Stem Rust	Powdery Mildew		
WHEAT						
Abura-Ald'S',CM50513-ly-5f-70ly-4f-0y	+					
Amazonas					+	
Banu 'S', SE381-4s-1s-Os-Mb-MM-OMM		+	+	+		
Emu 'S'				+		+
IAS58-Mad'S', CM50472-1y-4f-70ly-2f-0y	+		+		+	
IAS63-Ald'S' xGto-Lv,F11915-A-500m-2y-8f-702-5f-0y	+	+			+	
IAS64-Aldan, CM47207-16m-2y-3f-702y-12y-0y		+	+		+	
Jupateco 73				+		+
Kvz-Kal-Bb SWM1698-3L-0ke-3Mb-1MM 1MM-0MM	+		+		+	
Limpopo						+
Maringa					+	
PF7668 = Toropi/Bb-Inia/3/PF70338	+					
PF7748 = ND81/IAS59/ /IAS58	+	+	+		+	(+)
PF70402-Ald'S' x PAT72160-Ald'S', B19789-H-504m-4y-5f-2y-0y	+				+	
PF72640 = Toropi/IAS54	+				+	(+)
Pe173280-Atr (TzPPxIRN46-Cno67/Protor),CM50321-5MM-1MM-2MM-1MM-0MM	+	+	+		+	
Veery 'S', CM33027-F-15m-500y-0m		+	+	+		+
TRITICALE						
Beaguelita 'S',X22427-100y-1y-7m-1y-0y	+				+	
Bgl 'S'/Bgl 'S' x ITA-Les				+	+	
Bgl x IRA-Bgl, X22548-2Ke-2Ke-0Ke					+	
Bison			+	+	+	
Bvr-Arm, 74cT301-6			+	+	+	
FS1534	+			+		
Giraf 'S', X32636-2y-3b-4y-3b-6y-0y	+				+	
IA-M_2 A x Pi62/Bgl 'S', X16304-110y-3m-3m-0y		+	+	+	+	+
IA-Spy	+	+	+	+	+	
IRA-Bgl, X15570	+	+	+	+	+	
IRA-Drira, B507, PC217	+			+	+	
Lince			+		+	+
M_2 A, X2802-9n-1m-2n-1m-3y-0y			+	+		+
M_2 A-Bgl, X15490					+	
M_2 A-Ktz12 x Bgl, B175 PC855	+		+		+	
M_2 A-Rm	+		+	+		
PFT7717 = M_2 A^2	+	+	+	+	+	
PFT7725 = IA-M_2 A				+		+
PFT78104 = Tejom-IRA				+		+
Panda 'R' - Abn	+				+	
Panda 'R' - Rahum			+	+		+
Ram 'S' = IA-IRA x Bui, X12257-1n-0m	+		+	+		
				+		

TABLE 2 Movement of Hybrid Populations in the Generations following the cross for the development of varieties for rainfed conditions.

Year	Generation	Location	Plot Type
	Cross	Mt. Makulu	In winter-irrigated season
1	F_1	Mt. Makulu	Space planted with supplemental irrigation
	F_2	Mbala	Space planted
2	F_3	Golden Valley	Plant rows
	F_4	Mbala	Plant rows
3	F_5	Golden Valley	Plant rows Increase plot Plant rows
	F_6	Mbala	Preliminary Trial
4	F_7	Golden Valley	Increase plot
	F_8	3 locations	Advanced trials
5	F_9	Golden Valley	Increase plots
	F_{10}	6 locations	National Trials
6	F_{11}	Golden Valley	Increase plots
	F_{12}	6 locations	National Trial On farm Tests

Table 3 Summary of Yield Data of Superior Wheat and Triticale Varieties compared with the Checks under Irrigated Conditions 1982 (kg/ha)*

Yield Trial	No. Sites	Breadwheat Check	Breadwheat Average	Breadwheat Top Strain	Triticale Check	Triticale Average	Triticale Top Strain
Prelim.	1	6089	6624	7657	A	—	—
Advanced	4	6020	6028	.6992	5925	6147	6978[B]
	4	6066	5984	6619	—	—	—
National	6	5922	5920	7046[C]	—	—	—
Av. of all Trials		6024	6139	7079	5925	6147	6978

* Average of all entries in each trial

A (-) Indicates No Yield Trial, Irrigated Triticale research in its infancy

B Tejon - Bgl 'S' X-16134-35Y-1Y-1M-1Y-1B-0y

C Veery 'S' Newly released as Loerie, April 1983.

Table 4 Summary of Yield data of the Highest Yielding Wheat and Triticale Varieties compared with the checks under Rainfed Conditions at Mbala 1981 and 1982 (kg/ha)*.

Yield Trial	Breadwheat						Triticale					
	Check+		Average		Top Strain		Check		Average		Top Strain	
	81	82	81	82	81	82	81	82	81	82	81	82
Prelim A.	677	752	583	1120	843	1843	687	549	1522	1062	2161[A]	1855
B.	1022	605	642	1164	1040	2401[B]	1082[C]	-	1645	-	2121	1664
Advanced A.	677	849	557	682	802	910	858	633	1408	999	1903	1447
B.	-	705	-	913	-	2020	-	624	-	897	-	-
National	519	528	445	677	693	1093		-	-	-	-	-
Average of all trials	724	687	557	911	845	1653	875	602	1525	986	2062	1655

* Average of all entries in Trials

\+ Wheat Check Jupateco

A PFT 7727, Triticale Variety from Brazil

B PF 7748, Wheat Variety from Brazil

C Triticale Check, Beagle 'R'

WHEAT BREEDING AND PATHOLOGY IN TANZANIA

A. M. Sariah and D. G. Tanner

INTRODUCTION:

It is believed that wheat was first introduced in Tanzania by German Missionaries in the Southern Highlands in the late 1880's. Ever since that time peasants in the Southern Highlands have grown the crop for personal consumption. A lesser but still considerable volume has been produced by commercial operations such as the Tanganyika Wattle company in recent years and this represents a significant part of the commercial crop in Tanzania.

By contrast, the bulk of the wheat crop in the Northern Highlands is produced on a commercial scale and accounts for over 60% of the wheat produced in Tanzania.

Since the establishment of the Agronomic Research Project at Lyamungu in 1971, considerable progress has been made by the breeding and variety development program. Large numbers of varieties were tested and many of them dropped; the new and more promising cultivars originated as selections from the advanced lines obtained from the National Plant Breeding Station in Njoro, Kenya and were released beginning in 1973. Due to lack of continuity in the staff of the section, there have been no variety releases for several years, although testing of promising lines has continued so that we currently have several promising candidates for release.

Since no crosses have been made at the station, the breeding program has been based on selections made from materials introduced from Njoro, CIMMYT, (Mexico and Kenya) and Icarda (Syria). The introductions originate from early generation materials (F_2 populations), screening nurseries and yield trials containing advanced lines. Thus, all of the wheat varieties selected under the prevailing Tanzania climatic conditions have been screened previously in Mexico and Kenya for yield, broad adaptability and disease resistance.

The Tanzanian selection program is concerned mainly with the common spring type of bread wheat and in recent years it has included a variety development program on durum, triticale and barley, the latter crops being co-ordinated by U.A.C. Mbeya. To date, there have been no varieties released for commercial production for the latter group of crops.

BROAD OBJECTIVES OF THE SELECTION PROGRAM:

Varietal resistance to a large number of diseases; rusts (3 species), tan spot, spot blotch, leaf and glume blotches, black point, scab, powdery mildew and root rots.
Varieties with high yield potentials
Early maturity.

Resistance to lodging

Freedom from shattering combined with good threshability

A high return of good quality flour per unit of wheat.

METHODS:

New wheat cultivars are developed by the wheat research program in the following ways;

(a) Selections of lines from space-planted segregating early generation (F_2 F_3) material introduced into Tanzania. This F_3 and F_4 seed is again space planted and the desirable plants are again selected. The F_4 or F_5 seed from the selected plants is planted into single wide spaced non-replicated rows and the yield and general performance compared to a check cultivar planted every 5th or 6th row in an observation test. Seed from rows selected for superior performance over the check are planted in the initial yield trial (TVT III) in 4 to 6 rowed plots replicated 4 times.

(b) Selections of varieties from cooperative international trials enter the first set of trials TVT III planted in the same manner as described above. Wherever possible, this first set of trials is planted at least at two locations and this depends on seed availability.

(c) Varieties proven in the TVT III are advanced to the next stage of testing TVT II using the same design with testing at up to 5 locations if possible. Any line or cultivar proving superior in the TVT II tests is promoted to enter the most advanced trial TVT I which is conducted at 7 or more locations. Each year from the observation trials to final testing, multiplication plots are planted and rogued out for uniformity and purity. These plots provide the seed for the ongoing testing and ensure that all the seed entering into the various tests is grown in the same year and at the same location.

Up to 500 heads of promising lines are taken and planted in head rows. The materials bulked from head rows forms the basis for production of Breeder's seed of a new variety.

DISEASES:

Rusts

Rusts are major diseases of wheat and the small grains in Tanzania. The three rust species of major concern are stem rust **(Puccinia graminis tritici)**, stripe or yellow rust **(Puccinia striformis)**, and leaf rust **(Puccinia recondita)**. A severe epidemic of leaf rust **(Puccinia hordei)** occurred on barley 'fields on the farms at the Hannang complex in the 1982 season. The disease epidemic was favoured by an abundance of rust inoculum, adequate moisture plus warm temperatures and it progressed rapidly from late April to mid-May. This outbreak caused considerable loss in yield. Several barley lines under test possessed resistance as did a number of cultivars at West Kilimanjaro.

At Lyamungu, (Kilimanjaro region) where most of the screening work is carried out, both stem and leaf rusts of wheat were apparent on a few lines in the observation nursery in the same season. Stem rust with 24 strains identified in East Africa (Davis, 1976) presents the greatest hazard to the wheat crop since under favourable conditions it can and does cause up to 100% losses for susceptible cultivars. On the other hand, reports mention that leaf rusts occur nearly every year and although they often have little effects on yield, under conducive weather conditions for infection they can cause drastic reductions in yield on susceptible types of wheat.

Stripe rust in East Africa has normally been confined to the cooler and wetter higher elevation regions, but probably due to a mutation which has generated new stripe rust strains, now it occurs at elevations as low as 1240m. Low levels of stripe rust have been observed on the Hannang complex over the last two years on specific varieties. Many of the wheat cultivars recommended for Tanzania are susceptible to currently prevalent strains of the disease. This poses a potentially greeat hazard to the wheat industry. The two sites with high levels of this disease are Lyamungu and Kilimanjaro, and, for this reason, they will remain the main screening sites for disease resistance. The present material being tested contains promising lines resistant to the three rust species.

Foliar Diseases

In 1982 season, a pathologist visited the wheat farms on the Hannang Plateau to assess diseases of wheat in this region. According to his report, several foliar diseases were present on the wheat farms. These diseases included; tan spot caused by **Pyrenophora trichostoma F (=Helminthosporium tritici-repentis** Died); spot blotch caused by **Cochliobolus sativus (=Helminthosporium sativum** P.K.); and leaf and glume blotch caused by **Septoria tritici** and S. **nodorum** respectively. The three pathogens were identified from material sampled at each of the farms. **Phoma** spp. **Alternaria** spp. and **Fusarium** spp. were noted occasionally on the incubated samples. Black chaff caused by the bacterium **xanthomonas translucens** occurred on the glumes of some plants in a few fields.

Both field diagnosis and laboratory isolations of pathogens from the plant parts revealed that spot blotch and tan spot and to a lesser extent leaf and glume blotches were major foliar diseases of wheat in the Northern zone. These diseases were more prevalent in the early seeded than the late seeded fields. Often the leaf lesions could not be readily assigned to specific pathogens in the field as there was an inter-gradation of symptoms of spot blotch, tan spot and leaf blotch. At times, two and sometimes all three diseases occurred on the same leaves. However, Septoria diseases appear to cause greater losses in the Southern Highlands than in the Northern zone.

Black point occurs in all wheat regions in Tanzania but is more pronounced in the more humid areas. At Lyamungu, in some years, the infection on the head of both **Helminthosporium** spp. reaches severe proportions and detrimentally affects the viability of the seed from infected heads. These diseases are important constraints to the wheat industry as they diminish yield and quality of the crop. The identification of good sources of tolerance to these diseases is important as well as utilizing escape from disease pressure through time of planting manipulations. To date, a few of the commercial cultivars show moderate tolerance to these pathogens.

Powdery mildew, **(Erysiphe graminis).** is usually epidemic at Lyamungu and it periodically occurs at higher elevations at West Kilimanjaro. Selecting for high resistance to mildew is possible and all the released varieties under commercial production are resistant.

Scab caused by **Fusarium** spp. is common in the same areas where **Helminthosporium** spp. are found. Earlier it was pointed out that infections by fusarium were apparent on plant samples collected on the farms in the 1982 season. The present program discards any material which is susceptible to the scab-causing fungi, resulting in good levels of resistance in in commercially grown cultivars.

Root Rots

In 1982, common root rot was identified in all the wheat fields and isolations from the samples revealed that the **Cochliobolus sativus** fungus occurred on 30% of the sampled plants, possibly resulting in a crop loss of about 8% (Tinline, 1982).

YIELD

High yields are related to a complex of factors so that it is usually unproductive to attempt to improve any one yield component in the development of new varieties. We feel that it is very important to test the yield potential of new varieties at as many locations as possible under optimum conditions for the expression of genetic yield potential. Table 1 shows yield of a few promising lines in advanced testing as compared to standard cultivars, while on table 2 yield averages of the currently grown commercial cultivars are summarized over 5 years.

MATURITY

Early maturity is usually a desirable characteristic. Early maturity offers an escape mechanism whereby, cultivars mature before the onset of certain diseases, particularly rusts. In times of low precipitation, early maturity permits the crop to ripen before the soil moisture is depleted, or where frosts are common, early maturity increases the chances or having a successful crop. Under favourable conditions, late maturing varieties outyield early maturing ones, but probabilities of unfavourable climatic conditions on the Hannang plateau and in the southern highlands are high. Therefore, selection for early maturity is desirable.

Table 1

Comparison of yield of promising lines in advanced trials to commercial cultivars (t/ha) and stripe rust ratings at West Kili manjaro in 1982.

	AR	WK	BS	KA	NJ	MB	GRAND MEAN	STRIPE RUST %
W 8000 Bluejay 'S'	3.5	4.1	2.7	2.1	2.8	2.0	102	0
W 8009 Tzpp - Anexlnia.....	5.1	4.1	2.6	2.7	2.5	1.8	112	0
W 9075 Veery 's'	4.6	4.7	1.8	2.3	3.3	1.6	109	0
W 9280 Veery 's'	3.5	5.6	2.6	2.6	2.8	1.6	111	20MR
T 6024 Rahum	4.5	4.8	—	3.0	3.2	—	117	0
T 6027 M_2 A_2 - Cinx7272	5.4	4.5	—	2.5	3.4	—	120	0
Location mean	4.3	4.0	2.0	2.0	2.7	1.6		
Check mean	4.3	3.4	2.2	2.1	3.3	1.7		

Grand mean is expressed as percentage of the check mean.
W = bread wheat
T = triticale

AR = Arusha; WK = West Kilimanjaro; BS = Basotu (Hanang); KA = Karatu; NJ = Njombe; MB = Mbeya.

Table 2

Five years yield Averages of the Commercial Cultivars (tons/ha) and stripe rust ratings at West Kilimanjaro.

	1982	1980	1979	1978	1977	Grand Mean	Stripe rust %
MBUNI	3.1	2.7	3.4	3.1	2.7	3.0	70/50s
TROPHY	3.0	2.4	2.6	2.9	2.8	2.7	30/20MS
KWECHE	2.4	2.1	3.1	2.9	2.9	2.7	20 MS
TAI	3.3	2.6	3.0	3.3	2.8	3.0	20 MR
MAMBA	3.2	2.5	2.9	2.9	2.5	2.8	50/20MS
KOZI	3.0	2.1	2.7	2.8	2.7	2.7	tr R
JOLI	2.9	2.1	2.8	3.1	2.7	2.7	tr R

Test Sites:

The trial sites for this program vary in number from year to year depending on needs, workload, availability of seed and accessibility during the season.
In the Northern Highlands these sites are as follows:

Lyamungu situated in a high rainfall (1800mm) coffee region on the slopes of Mt. Kilimanjaro at an elevation of 1283 meters. This site exhibits a high disease incidence and all 3 rusts, foliar diseases plus fusarium occur every season. Therefore, has been retained as the main screening site. All the early generation material (F_2 populations), & International screening nurseries are planted there. No variety trials are conducted there.

West Kilimanjaro NAFCO Upper Farms (Unit 3A) Situated at 1950m, has an annual rainfall of about 1100mm. Another site with high stripe rust pressure every year, but also high yield potential. Some of the screening work is carried out here depending on amount of seed available. The advanced cultivar trials are also carried out at this location.

Karatu situated in the Karatu-Oldean area at approximately 1829 meters with an annual precipitation of about 800mm. It used to produce a large volume of wheat in the past but over the last few years has suffered from the drought occurring over areas of Tanzania.

Arusha Research Station 1380mm elevation and 834 mm annual precipitation. This is the main testing site for all cultivar trials. It is situated in a dry sport or rain shadow of Mt. Meru and the rainfall pattern which is not very reliable causes uncertainties to farmers and researchers. We hope in the future when irrigation facilities eventually become available it will be used to advance early generation material during the short rains.

Hannang Complex 1768 m elevation and 600mm of precipitation annually. The Hannang complex consists of 6 wheat farms owned by NAFCO comprising of 20,000 ha of production. Trials are planted at up to 3 locations within the complex, to represent the wide range of soil types and rainfall regimes. Early maturing cultivars with high yield capacity will be important for the complex, enabling the minimization of drought stress. By necessity, the farms plant over a time period of up to 2 months.

In the Southern Highlands, there are two main sites;

Njombe Approximately 1950m elevation and receives an annual precipitation of 1200mm. The testing at this site is conducted in cooperation with the Tanganyika Wattle company. They plant and maintain National Cooperative Trials (Tanzania Variety Trials) in wheat, triticale and barley. Njombe has extremely high disease pressure (**Septoria spp.**). In the past, all the cultivars grown at Njombe originated from the Agronomic Wheat Program at Lyamungu but many of these cultivars have been phased out because more promising and disease tolerant cultivars have been identified from other sources.

Mbeya 1770m elevation and 870mm rainfall. Testing in this region is conducted in cooperation with the personnel at Uyole Agricultural Centre. Trial lines performing well are promoted to testing in regional sub stations and extension (farmers' fields). Early maturity is a must for the small scale farmers in the southern highlands because of frost risk.

SUMMARY

Experience has shown that wheat can be grown successfully between altitudes of 1280m to 2450m in Tanzania, although the disease situation is often critical as discussed in the report. Therefore intensive wheat production calls for a continuous breeding effort to monitor the currently prevailing strains of rust endemic to this region and other foliar diseases and to release new lines with better all around performance. In this pursuit, the breeding program utilizes all available international germplasm sources and test material over a comprehensive range of locations within Tanzania.

As for the drought experienced frequently at the Hannang wheat complex and Karatu, efforts are geared towards selecting early maturing lines. Also, it is possible that Triticales may have a place in certain areas with marginal rainfall for they often appear more vigorous and more resistant to drought than wheat. The only limitation are the pricing policy and the end use of triticale which have not yet been defined by the nation. The biscuit company here in Arusha expressed an interest in using triticales for manufacture of their products and this could help solve the dilemma of growing triticale on field scale. The same applies to the durum; its future depends on the demand for the pasta products.

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WHEAT DISEASES IN ETHIOPIA
Eshetu Bekele

INTRODUCTION

Ethiopia consists of several ecological regions with a great variety of climates and soils, and many types of agriculture. Thus, the plant pathological problems in the country are numerous. The indigenous varieties of the Ethiopian wheats are mostly mixtures of various biotypes and they have gone through centuries of natural selections. These biotypes have withstood climatical conditions of the country, whereas the European varieties introduced since 1930's have succumbed to diseases and other factors.

The importance of the three rusts, namely leaf, stem and yellow rusts, was recognized early in the wheat improvement work in the country. Preliminary studies on the physiologic races of stem rust began as early as 1940's. When the wheat improvement programme started in 1949 at the Paradiso Experiment Station near Asmara, a large number of indigenous and exotic varieties were tested for disease resistance along with other agronomic characters. The Kenyan varieties (e.g. Kenya 1 and 5) selected and released to farmers during that time were very popular varieties in northern Ethiopia. With the establishment of the Debre Zeit Experiment station in 1955, the wheat research programme was strengthened. Here also. a large number of indigenous and exotic varieties were screened for the central highlands of Ethiopia. Disease resistance was one of the selection objectives in the programme. A large number of diseases on economically important crops, including wheat, were collected, identified and published during that time.

With the establishment of the Institute of Agricultural Research (IAR) in 1966, a more coordinate research programme was initiated at Holetta Research Station. Emphasis was placed upon such activities as survey, identification and documentation of wheat diseases. Some loss assessment studies were also made for economically important wheat diseases in order to work out priorities in the research programme. The establishment of the Scientific Phytopathological Laboratory (SPL) at Ambo strengthened the research work on the rust diseases of wheat.

MAJOR WHEAT DISEASES IN ETHIOPIA

More than 40 fungal, bacterial and nematode diseases of wheat have been identified in the country. However, only a few of these cause economical damage to the crop in the major wheat growing areas. These are treated below in their order of importance.

Rusts

All the three rusts are the most important wheat diseases in Ethiopia. **Puccinia graminis** f. sp. **tritici** Eriks. & E. Henn. generally causes damage at altitudes below 2200m. **Puccinia striiformis** West. is usually a problem at altitudes above 2500m. **Puccinia recondita** Rob. ex Desm. is endemic to most intermediate altitudes. Yield losses due to these rusts at the production level are variable mainly due to variable weather conditions. Some preliminary loss assessment studies made in the early 1970's showed losses up to 32, 35 and 66% due to stem, stripe and leaf rusts, respectively, on susceptible varieties. The stripe rust epidemic of the 1981/82 crop season knocked out the commercial variety Mamba and limited production of other commercial varieties, K6290 and Romany back cross.

Septoria Leaf and Glume Blotches

Both **Septoria nodorum** (Berk.) Berk and **Septoria tritici** Rob ex Desm. occur in most wheat growing areas. However, **S. tritici** is the most prevalent. Yield loss on a susceptible variety was reported as high as 55%. Leaf and glume blotches are more severe at agricultural research stations such as Holetta Station (2400m) than on farmers' fields probably due to other agricultural practices and the survival of the pathogen on crop residue.

Eyespot

Eyespot disease of wheat caused by **Pseudocercosporella herpotrichoides (Fron)** Dei was first reported by Waller (1974) on wheat at Holetta Research Station. Since then it has become increasingly important in the highland cereal production areas. Yield reduction in infected plants which had not lodged was in the range of 11-16% and it was as high as 34-49% when lodging occurred.

Bunt

Both species of bunt, **Tilletia foetida** (Wall.) Liro and **Tilletia caries** (DC.) Tul. were recorded in the country. **T. foetida** being the most prevalent, causes considerable damage in cool areas at altitudes above 2400m. The annual crop loss due to bunt is estimated at about 5% in farmers' fields and very rarely occurs in State Farms and Research Stations.

Head Blight or Scab

Read blight caused by **Fusarium** sp. is damaging the crop in most wheat production areas where the humidity after heading is high. Crop loss due to this disease has not been determined.

Others

Loose smut (caused by **Ustilago tritici** (Pers.) Rostr.) Helminthosporium blotch (caused by **H. tritici repentis**) and bacterial stripe (caused by **Xanthomonsa translucens**) do commonly occur in most wheat growing areas, but are of less importance.

RESEARCH ON WHEAT PATHOLOGY

Diseases are now becoming the major constraints in wheat production in the country. Pathologists and wheat breeders at Holetta and Debre Zeit Research Stations and the Scientific Phytopathological Laboratory (SPL) at Ambo work together towards the development of resistant varieties to the above mentioned major diseases. International and national nurseries are being screened every year for disease resistance and other characteristics at various ecological zones in the country. Most of the semi-dwarf wheat varieties from CIMMYT are susceptible to foliar diseases and rusts. The materials originating from the Near East have similar weaknesses. The Kenyan varieties, on the other hand have shown some resistance to rusts and Seproria. Consequently, most of the commercial Ethiopian bread wheat cultivars have originated from the Kenya material.

Currently, the breeding programme focuses on the development of rust and Septoria nurseries which are the major source of resistant germplasm for the breeding programme. Rust spore trap nurseries and race identifications have been designed to give some epidemiological information to the breeding programme.

The Ethiopian tradition is to grow mixture of genotypes in every wheat field. Modern research shows the wisdom of this tradition. Thus, wheat variety mixtures are evaluated for their performance and disease developments.

As the above research activities indicate, the development of resistant varieties to the three rusts and Septoria for the existing high potential production areas is the strategy adopted as a general policy to alleviate the problems. Presently, there are a few candidate varieties from the breeding programme.

NATIONAL AND INTERNATIONAL COOPERATION

The National wheat improvement programme has been organized in such a way that breeders, pathologists, agronomists, soil scientists etc. from different institutions work together in a team. This team approach has created more close collaboration and more planned and organized research activities. The Ethiopian Phytopathological Committee (EPC) which brings together all pathologists working in the country, has become a forum for discussion and exchange of ideas concerning crop diseases in general.

At the regional levels, we have established excellent cooperation with wheat improvement programmes in East Africa and the Middle East. Exchange of trap and screening nurseries, information and expertise are some of the areas we are dealing with.

CIMMYT is one of our major international cooperators in terms of material exchange, training, visits and information exchange. We also have created contacts with other international and national programmes.

We look forward to more cooperation. We have special interest in fostering more regional cooperation, preferably through international organizations such as CIMMYT. Rusts, for example, are the major wheat diseases in our region and East Africa could be just one epidemiological unit for the rust. In such a case, it would be to our common advantage in the region to exchange information concerning the prevalence and movement of rust races, plan deployment of varieties to be planted in the region etc.

STEM RUST RESISTANCE BREEDING AND INTER-RELATIONSHIPS IN KENYAN WHEATS

K. G. Briggs

HISTORICAL ASPECTS.

Incorporation of lasting stem rust resistance into Kenyan wheats has been an essential part of breeding since wheat production started in Kenya. Until the early 1950's the main approach was to "add in" specific resistances to new rust races as they occurred. The consequence of this was that by 1953 stem rust race evolution was far ahead of the breeders, all the wheats grown were closely related to one another, and the life expectancy of a variety was only 1 to 2 years. A more scientific approach was established in the 1950's involving a major widening of the germplasm base through introductions, and a major expansion of seedling testing of physiologic races on known differentials. The emphasis changed from selection of race specific resistance sources to selection of sources with a 'good level of resistance to a useful range of races'. Some excellent resistance sources were found, many of which are still important today, including Mida-McMurachy-Exchange, Africa x Mayo 48, Wisconsin 245 x Supremo 51, S. Africa No. 43, and various Triticum timopheevi derivatives (e.g. WIS245, WIS249).

From 1960 till the mid 1970's the racework was further extended, using a more useful set of Kenyan differentials, and up to 23 East African races were isolated. An array of 38 different resistance sources was tested for seedling resistance to EA races and several of these are still in use (eg. C18154/FROCOR, SRPC527). Breeding efforts were aimed at combining complementary sources of resistance to 'block out' the entire array of EA races identified in annual race surveys. Adult plant resistance was also shown to be of value in Kenya, notably the sources Hope, Africa Mayo, Kenya Page and Conley, and to be of supplementary value to seedling resistances. Due to prevailing circumstances, the ability to carry on stem rust race work was lost in the mid 1970's, but the benefit of the earlier breeding work has continued to protect the Kenyan acreage completely against stem rust. Resistance sources identified pre 1974 continue to be effective, and good new sources are still being found, mainly from CIMMYT germplasm. The latter are still uncharacterised with respect to East African races. Racework and characterisation of new resistance sources was, however, started again in 1980 with re-establishment of the CIDA funded Kenya/Canada Wheat and Oilseed Research Project.

VARIETIES RELEASED SINCE 1960 AND THE CURRENT SITUATION:

During the period 1960-1971 new varieties released continued to be mainly adapted material plus a new backcrossed resistance source, with each variety fairly unrelated to previous ones. After 1971 and till the present time this pattern changed drastically so that all new varieties are very much inter-related. Breeding has continued into the 1980's amongst these interrelated varieties, with very little introgression of new germplasm, and most of the stem rust resistance in current commercial varieties is therefore based on relatively few resistance sources, mainly those identified in the late 1960's. The likely resistance sources, based on pedigrees, and the deployment of these sources in the 1981 crop, are given in Tables 1 and 2. The high dependence the CI8154/FROCOR and WISC245 combination is apparent, as well as the relative unimportance in acreage of adult plant resistance sources. Pyramiding of resistance sources is protecting Kenyan acreage well, as it is known to do well in Canada, USA and Australia.

There is some evidence that prevailing field races in nurseries in Kenya are virulent on the CI8154/FROCOR source when used alone (i.e: K. Nyoka scoring 30 MR/MS and K. Kiboko scoring 50S in Njoro 1982/83 increases, non-inoculated), while the WISC/SUPR source appears to remain field resistant. There is concern that K. Kongoni, a widely adapted, high yielding variety becoming popular in 1983, may lack the WISC/SUPR resistance and could serve as a widely grown host for some stem rust races. This possibility should be closly monitored, and a breeding program should be established to put the WISC/SUPR source back into K. Kongoni.

There is an urgent need to re-establish the race and differential testing system proven so successful in the late 1960's, as well as to re-establish the annual race surveys. The new field resistant sources obtained in recent years (such as Paa, Veery and other CIMMYT sources) should be used in breeding to back up the existing resistance sources. One cannot expect the resistance of CI8154/FROCOR, WISC245 and others identified in the late 1960's to last forever.

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Table 1 1981 Kenyan variety distribution (% of 104,323 hectares) and probable stem rust resistance sources.

Variety	% 1981 Hectares	Probable stem rust resistance sources	1983 Field Rating
Bounty	3.0	BTY	P
K. Leopard	1.3	CI12632 (T.timopheevi type)	G
Africa Mayo	1.4	AFM	F
K. Nyati	1.2	AFM	F
K. Fahari	22.2	SRPC527, CI8154/FROCOR, TOB66	F
K. Paka	10.8	CI8154/FROCOR, WISC245, TOB66	G
K. Tembo	21.7	CI8154/FROCOR, WISC245, TOB66	G
K. Nungu	13.0	CI8154/FROCOR, WISC245, TOB66	G
K. Kifaru	7.4	CI8154/FROCOR, WISC245, TOB66	G
K. Nyangumi	5.0	AFM, CI8154/FROCOR, WISC/SUPR, TOB66	G
K. Ngiri	5.6	WRT-TC, CI8154/FROCOR, TOB66	G
K. Nyoka	2.9	CI8154/FROCOR	G
Paa	2.4	KVZ, CHRIS, CIANO	G
Others	2.1		

K. Kongoni	—	CI8154/FROCOR, (WISC245 ? ?)	P
K. Nyumbu	—	CI8154/FROCOR,WISC245,TOB66,	
K. Kulungu	—	CIANO	G
K. Popo	—	KL.ATL.,SRPC527,CI8154/FROCOR, TOB66	G

(P=Poor, F=Fair and G=Good resistance)

Table 2 Deployment of stem rust resistance sources, % coverage of 1981 Kenyan acreage.

	% 1981 HECTAREAGE
CI12632 (T. t. type)	1.3
AFRICA MAYO	7.6
BOUNTY	3.0
SRPC527 (Aeg.spelt.,Aeg.ovata)	22.2
CI8154/FROCOR	88.6
TOBARI 66	79.7
WISC 245 (T. t. 1 type)	52.9
WRT-TC	5.6
'PAA' TYPE	2.4

DISEASES OF WHEAT IN KENYA
W. C. McDonald

Yellow or stripe rust is the major disease problem at present because of a shift in wheat growing into higher altitudes where a cooler environment favours the disease. Most farmers with large farms routinely spray with one or two sprays of Bayleton or Tilt to minimize losses. The aim of the N.P.B.S. to develop resistant varieties suffered a set back in 1982 when a new race of stripe rust attacked two newly released resistant varieties, Paa and K. Kongoni. The new race also decimated the yellow rust parental collection which is used as a source of parental material in the breeding program. From a total of 235 entries, 104 were susceptible and were discarded. These included promising entries such as some Veery lines and those containing Kavkaz in their pedigree.

Seedling tests in growth chambers, where optimum temperatures of 9C for spore germination and 15C for disease development can be obtained, identified 14 more entries that are susceptible. Of the remaining 117, 30 have good agronomic characteristics and should be useful parents.

The stem rust situation has changed dramatically in the past 10 years. At that time a major activity of the Plant Pathology Section was the identification of stem rust races from over 500 collections made in all parts of Kenya and Tanzania. Today we cannot find stem rust in farm fields. Only 7 spore collections of identified races survived the variable storage conditions at the station over the past 8 years. Four of the old races and possibly two new races were established by single pustule isolations from infected plants in plots at Njoro The six races combine virulence on the resistance genes Sr9e, Srll, Sr17, SrTtl and the unknown genes in the varieties Kota, Giza 144, CI8154xFrocor², lumillo and Bonny. A mixture of the six is used to screen seedlings of breeders lines where only a few seeds are available. The single gene lines with Sr24, Sr26 and Sr27 are resistant to all races.

Loose smut, generally considered unimportant in the past, appeared at rates of 10 to 15% in fields of K. Tembo, K. Paka and K. Nungu. Seed treatment trials indicated that Vitavax and Baytan provide satisfactory control.

Leaf spot diseases, mainly Septoria leaf blotch and tan spot caused by Pyrenophora trichostoma are normally present but little work has been done with breeding or the use of fungicides for control.

Take-all and common root rot are important and will continue to cause losses until wheat-grass rotations are changed to include non-susceptible crops, possibly rapeseed.

SPROUTING RESISTANCE OF KENYAN WHEATS

P. M. Kireru

Due to the many problems a breeder is faced with, he often ignores the seeking of resistance to pre-harvest sprouting as a breeding strategy. Another reason for avoiding study of pre-harvest sprouting is its erratic and non-predictable nature. The problem arises during periods of wet weather at harvest but dies off when weather conditions improve. However, when the problem does arise, it adversely affects the grain yield, quality, marketability, grade, storage and net return to the producer.

Breeding for sprouting resistance in Kenya is in its infancy. Commercial varieties have been screened for their sprouting resistance and crosses between local and exotic varieties of proven resistance have been made.

This paper highlights the problems of sprouting, factors governing sprouting resistance of Kenya cultivars and available selection procedures in early generations. The overall subject of resistance to sprouting is complex and cannot be covered in this short presentation. Those requiring more information can find it in the proceedings of three international sprouting symposia of 1976, 1979 and 1982 which were held in Sweden, Britain and Canada respectively.

THE PROBLEM OF SPROUTED WHEAT:

Pre-harvest sprouting is a serious problem in wheat farming in Kenya. Sprouted wheat is unsuitable for seed and is susceptible to weevils and storage fungus.

Yield losses occur mainly by reduction of test weight. Constant wetting and drying results in brittle grains which break during harvesting. The broken pieces of grains, plumules and radicles of the germinated seed together with the light starch-depleted grains are winnowed out at harvest and all this accounts for the observed yield loss.

In Kenya if the germinated wheat exceeds five percent but does not exceed 30 percent, the consignment is assigned one grade lower than the grade appropriate to its weight in pounds per bushel. If the germinated wheat exceeds 30 percent the consignment is classed as undergrade and rejected.

Bread made from pre-harvest sprouted wheat has an increased diastatic activity and high molecular weight dextrins which result in gummy crumb, pale crust and inferior loaf volume. Loaves with sticky crumb can cause trouble to bread slicers during the slicing operation. A deposit of gummy crumb adheres to the blades and accumulates during the slicing operation. The slicing quality gradually deteriorates as the sticky blades tear the delicate crumb until the loaves disintergrate or the slicer blades just stop.

FACTORS GOVERNING SPROUTING RESISTANCE:

Sprouting is a quantitative characteristic which is governed by several factors and each factor is controlled by several genes. The factors which have been found to confer resistance to sprouting under Kenyan conditions are seed dormancy, alpha-amylase level, germination inhibitors in the bracts and rate of wheat absorption by germinating seeds.

Seed dormancy has been found to be one of the chief factors that govern sprouting resistance in Kenyan wheats. The Kenyan cultivars which have shown stable seed dormancies are Kenya Kifaru, Kenya Kudu, Kenya Kanga, Kenya Kongoni, Kenya Page and Kenya Zabadi. Seed dormancy is closely associated with red seed coat but it is not known whether the association is due to linkage or pleiotropism.

The rate of production of alpha-amylase during periods of wet weather is another factor that contributes to sprouting resistance. Cultivars like Kenya Kongoni, Kenya Nyangumi, Kenya Ngiri, Kenya Zabadi and Kenya Page produce high levels of alpha-amylase only after prolonged wet weather and hence are able to resist sprouting as compared to Paa, Bounty, Kenya Mamba and Kenya Popo that readily produce the enzyme.

The chaff can have a germination inhibiting effect which also contributes to sprouting resistance. The Kenyan commercial varieties that exhibit this character are Fanfare, Kenya Kifaru, Kenya Kongoni, Kenya Nyoka and Kenya Ngiri.

Most Kenyan commercial varieties take up water at a relatively slow rate during germitation but a few like Kenya Mamba, Kenya Fahari, Kenya Nyati, Kenya Popo and Kenya Swara take up water more readily acccounting in most cases for their sprouting susceptibility in farmers fields. Table 1 shows some Kenyan commercial varieties and their resistance to pre-harvest sprouting.

Seed dormancy and rate of alpha-amylase production best correlates with observed field sprouting. Any procedure that can be used to demonstrate existence of these characteristics can be used as a selection device for sprouting resistance. Seed dormancy tests in the laboratory and the falling number procedure for alpha-amylase determination are useful tools for selecting against sprouting in F5 and F6 generations.

PRE-HARVEST SPROUTING RESISTANCE OF SOME KENYA VARIETIES:

Variety	Level of Sprouting resistance
Africa Mayo	Moderate
Bounty	Moderate
Fanfare	Good
Kenya Fahari	Low
Kenya Kiboko	Moderate
Kenya Kudu	Moderate
Kenya Kanga	Moderate
Kenya Kongoni	Good
Kenya Kuro	Low
Kenya Leopard	Moderate
Kenya Mamba	Nil
Kenya Nungu	Moderate
Kenya Nyoka	Good
Kenya Nyangumi	Good
Kenya Ngiri	Good
Kenya Nyati	Moderate
Kenya Page	Good
Kenya Popo	Low
Kenya Paka	Moderate
Kenya Swara	Low
Kenya Tembo	Modrate
Kenya Zabadi	Good
Paa	Nil
Kenya Kifaru	Good

In the very early generations, mass selection is a useful tool applied at harvest ripeness. If wet pre-harvest conditions are anticipated the material can be left in the field to be rained on for a period of two to three weeks after which it can be harvested, threshed and sown the following season. The germinated seed would not germinate when sown and the seeds that would germinate are those that can resist sprouting. This procedure was found to work very well in the NPBS 1982/83 off season nursery following plant selection made under extremely wet conditions at Njoro late in 1982.

If wet pre-harvest conditions are not foreseen at harvest ripeness, heads should be harvested and immersed in water for 12 hours after which they are put in a germinator for not more than six days. The heads are then dried, threshed and sown in the next season.

The best Kenyan varieties which have been found to have a promising resistance to sprouting and can be used in a sprouting resistance breeding programme are Kenya Kifaru, Kenya Kongoni, Kenya Nyangumi, Kenya Ngiri, Kenya Page and Kenya Zabadi.

Best techniques for selections given limited resources are mass selection in early generations, observed ear sprouting in the field or in the laboratory, dormancy tests, and level of alpha-amylase in the ear.

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SCREENING AND EVALUATION OF WHEAT AND TRITICALE VARIETIES IN THE ANTSIRABE REGION OF MADAGASCAR

Rakotondramanana and
Randriantsalama Rodin A.

INTRODUCTION

Wheat has been grown in the highlands of Madagascar for many years by small farmers. The quantity produced, so far, has been very low compared to the actual consumption which in around 60,000 tons. The Government has built a new mill which is actually run with imported wheat. The objective is to be self sufficient in wheat in the long run. The FIFAMANOR project is a cooperative program between Norway and Madagacar. It is doing research, seed production and extension on wheat, potato and fodder crops. Besides FIFAMANOR the mill itself is also taking part in the extension. Therefore, there is a hope that the production will increase steadily in the near future.

ENVIRONMENT FOR WHEAT PRODUCTION

Temperatures and rainfall:

Wheat is grown between 900 and 1800m a.s.l. in the highlands. Two growing seasons are being used:

the rainy season : from January to May: wheat is grown in the hills under rainfall conditions.

the dry season : from May to October : wheat is grown in the paddy fields after rice under irrigation or residual moisture.

Table 1. Temperatures and Rainfall
Average of records at FIFAMANOR from 1974 - 1982

	J	F	M	A	M	J	Jly	A	S	O	N	D
Max. temp. °C	28.0	27.9	27.2	26.0	24.3	22.4	21.6	23.9	26.3	28.9	27.8	28.0
Min. temp. °C	12.6	12.5	12.1	9.3	6.3	4.1	3.7	4.4	5.7	7.7	10.3	11.5
Rainfall mm	287.0	239.6	182.4	72.5	11.2	8.9	18.4	4.6	26.9	51.0	184.2	193.9

During the rainy season, high temperature is one of the limiting factor for tillering During dry season (May) temperatures are lower and wheat stand is better.

Soils

Two types of soils are prevailing in the area where wheat is presently grown:

— the volcanic soils which are loamy soils which rather high CEC, high content of Ca and Mg, higher pH, but most of the times boron deficiency occurs. Usually liming is not necessary but boron application is a common practice.

— the ferrallitic soils which are clay soils with low pH, low humus content, low CEC. specially low content of Ca and Mg. The exchangeable aluminium is very high due to low pH. Liming is a must in any case, although wheat yield remains low in those soils.

Table 2. pH and exchangeable aluminium

	Volcanic soils	Ferrallitic soils
pH (H_2O)	6.2	4.8
pH ($CaCl_2$)	5.5	4.4
Exch. al. me/100g	0.03	0.85

Table 3. Soil analysis from the area of wheat growing

	Volcanic soils	Ferrallitic soils
Exchangeable cations:		
Ca me/100g	7.8	1.3
Mg -"-	2.8	0.4
K -"-	0.3	0.3
Al -"-	<0.03	0.85
Na -"-	0.096	0.085
Exchangeable acidity -"-	0.17	1.16
CEC -"-	11.11	3.61
N (%)	0.6	0.3
Humus (%)	13.6	6.9
C/N	13.3	13.1
P - AL me/100g	0.2	0.3
K - AL -"-	9.4	11.1
Ca-AL -"-	127.0	21.0
Mg-AL -"-	31.0	5.3
Micronutrients		
Mn p.p.m.	68	75
Cu -"-	5.8	1.3
Zn -"-	2.2	0.7
B -"-	0.087	0.45

WHEAT BREEDING PROGRAMME

The wheat breeding programme is mainly of the selection type starting with introductions of early generations (F2) or advanced lines (F4 - F5). Although some cross breeding work was done in 1974, it has been dropped because it was realised that introduction is cheaper and quicker. Varieties come mainly from CIMMYT (Mexico or Nairobi). Screenings are done on ferrallitic soils, on volcanic soils and under rainfed and irrigated conditions. The screening programme tries to identify varieties with high yield and resistance to diseases (P. graminis, P. recondita, H. sativum, S. nodorum) as well as tolerance to acid soils and high temperatures.

it was found that two groups of varieties are doing well under rainfed conditions either on ferrallitic soils or on volcanic soil : these are : (i) the Brazilian varieties and (ii) the MASA varieties which in this case, are the results of crosses between Brazilian and Mexican varieties.

Table 4. Yields of the best Brazilian varieties (kg/ha)

Varieties/lines	Number of trials						Index
	13	10	8	7	4	4	
CNT 7	3320						122
PF 71 131		3150					122
IAS 63			2930				115
PF 70 354				4140			121
PAT 7392					3530		146
IAS 54						3140	123
Romany (check)	2720	2560	2540	3420	2420	2540	100

Brazillian varieties are known to be tolerant to low pH soils, but they are too tall and therefore lodging occurs very often.

Table 5. Yields of the best MASA varieties (aluminium tolerant lines) kg/ha)

Varieties/lines	Number of trials			Index
	6	5	3	
PAT 7219 x Kal-Bb (1)		4490		136
PF 7339 - Ald"S"	4310			133
IAS 63 - Ald"S"		3840		116
PF 70354/Kal-BbxAld"S"		3580		108
PF 7339-Ald"S" (2)			4490	125
PAT 7219 x Kal-Bb (2)			4260	119
IAS 64 - Ald "S"			3890	109
PF 7339 - Ald "S"			3650	102
PF 70354 - Ald "S" (1)			3610	101
CZHO - Rom x Ald "S"			3610	101
*PAT 73111 .... etc...			3440	96
Romany (check)	3230	3320	3580	100

*PAT 73111 [CLLFN "S" (4777/REI x Y - KT)]

These MASA lines have screened at FIFAMANOR from the F2 generation As it can be seen from these figures the yield increase over the check (Romany) is much higher than which the Brazilian varieties. The MASA varieties combine the advantage of the Brazilian and the Mexican varieties, i.e : high yield, high resistance to disease, tolerane to the aluminium toxicity and shorter straw. Production of seed has started already for PAT 7219 x Kal-Bb for commercial wheat.

Most of these lines are tested also for the irrigated conditions on paddy fields. The earlier ones may be suited to this environment where the cycle is a factor of selection.

The following table shows the results obtained with the best Mexican varieties. This group of varieties is performing well only on volcanic soils. Some of these varieties (the FIFA crosses) result from crosses made at FIFAMANOR with Mexican lines, the others have been imported from CIMMYT (International Bread Wheat Screening Nursery).

Table 6. Yield of the best Mexican varieties on all types of soils (kg/ha)

Varieties/lines	Number of trials				index
	11	9	9	8	
FIFA 89.5.3	3090				108
IBWS.N 108.1		3210			115
IBWSN 108.3			3070		112
FIFA 74.2				3100	112
Romany	2850	2780	2730	2780	100

FIFA 89.5.3 = 764 x Romany
IBWSN 108.1 = We-Glo x Kal-Bb sel 1
IBWSN 108.3 = -"- sel 3
FIFA 74.2 = PC 15-292 x 764

The yield increase over Romany is very small. Tests made on baking quality show that this group of varieties have good quality.

On valcanic soils these varieties give good results. It was found that these varieties are susceptible to aluminium toxicity and high temperatures.

Table 7. Yield of the best Mexican varieties on volcanic soils : average of 3 trials.

Varieties lines	Kg/ha	index
FIFA 74.2	3200	124
FIFA 89.5.3	3160	122
IBWSN 108.1	2960	114
IBWSN 108.3	3230	125
Romany	2590	100

Irrigated wheat

Irrigated wheat is grown on paddy fields after rice. Transplantation of rice is done on November and harvest in April. The land is drained soon after harvest and ploughing and land preparation is done immediately. The best seeding date is found to be during the month of May. Soil moisture is maintained by irrigation or occasionally by residual moisture. Weed and diseases problems are negligible. Early varieties are preferred in order to fit the rather short available growing period.

The following table shows the result obtained with the best varieties so far. All of them are Mexican varieties.

Table 8. Yields of the best varieties on paddy fields (kg/ha)

Varieties/lines	Number of trials				index
	22	10	8	5	
BW 19	3480				120
BWSN 104		3570			113
BW 8		3230			102
Myna "S"			3420		116
Tzpp - Son 64 A x N po 63			3180		108
Bunting "S"			3200		108
Bluetit "S"				3920	128
* Kl Toledo, etc...				3720	121
763 (check)	2910	3150	2960	3060	100

* Kl Toledo-Pat 19 x Mochis 73-Jup 73
BW 19 = Kal - Bb
BW 8 = Pichihuila "S"
IBWSN 104 = Npo-Tob "S" x 8156/Kal-Bb
763 = Tobari-8156 x Ciano "S"

The best variety BW 19 is already in the seed increase programme. Some farmers have been growing it already the last two years. We are going to use it as a check in the future instead of 763. Another variety (Bluetit "S") is appearing as well; although it has been tested only on 5 trials it seems to be promising. Kl Toledo-Pat 19 x Mochis 73 - Jup 73 shows also some promises. This season (1983) we start testing the MASA varieties in rice fields. There is no reason why they should not perform very well in this environment; the only limiting factor is that we need early varieties to avoid hampering the rice cycle.

TRITICALE SCREENING PROGRAMME

During the last 6 years we have had screening lines from the International Triticale Yield Nursery (ITYN) and the International Triticale Screening Nursery (ITSN) from CIMMYT. Comparison between triticale and wheat has been carried out as well. Most the trials have been done under rainfed conditions but during the last two years screening has been done in the paddy fields as well.

It was found that Triticale performed relatively well on the acid soils compared to wheat. Besides that, disease problems were negligible (some leaf rust attack are recorded).

Table 9. Yields of the best Triticale (kg/ha):

Varieties/lines	Number of trials									index	Test weight Kg/hl	Sedimentation
	9	7	7	6	5	4	4	3	3			
Ram "S"	4620									100	63	24
Beagle		4420								98	61	24
IRA - Bgl			5020							105	71	18
Drira Fas 204				4850						104	63	24
Tcl Bulk 50 MA				4400						94	65	32
Tcl 65					4370					86	63	22
Bongo "S"						4650				96	60	25
Topo 122							4590			112	65	22
Bgl Deriv Sel Bulk							4530			110	71	15
Bgl - M_2 A							4750			116	65	21
Puppy - Beagle							5290			129	69	20
Tejon - Bgl								4590		110	68	16
Drira - Cinuem									5090	117	64	24
Tcl 10 (check)	4640	4530	4760	4670	5070	4850	4100	4180	4340	100	62	18

From those yields it is possible to conclude that many lines are performing well under the conditions prevailing in this area. The check Tcl 10 is an old variety of the Beagle type with poor breadmaking quality. Two important data to predict flour yield and breadmaking quality are reported here (i.e. test weight in kg/hl and the Zeleny Sedimentation index in ml). Varieties like Tcl Bulk 50 MA, Topo 122, Puppy-Bgl have good breadmaking quality.

Seed multiplication started last year with Tcl Bulk 50 MA, Puppy-Beagle and Tcl 65; this last variety has been chosen for the rice fields due to its short cycle.

The following tables show a comparison between Triticale and wheat varieties.

Table 10. Comparison between Triticales and wheat varieties Rainfed crop : Average of 2 trials, 1982

Varieties/lines		Yield kg/ha	index	Test weight kg/hl	Sedimentation	Days to Maturity
Tcl 10	(Tcl)	4670	150	63	16	+ 11
Tcl Bulk 50 MA	(Tcl)	4500	145	67	32	— 4
PAT 7219 x Kal-Bb	(Wh)	4360	140	76	26	+ 2
PF 7339 - Ald "S"	(Wh)	4040	130	72	47	+ 10
FIFA 74.2	(Wh)	3670	118	78	48	— 5
CNT 7.2	(Wh)	3660	118	69	28	+ 2
CNT 7.1	(Wh)	3600	116	74	21	+ 1
IAS 63 - Ald "S"	(Wh)	3510	113	73	41	+ 6
IBWSN 108.3	(Wh)	3160	102	78	43	— 7
PF 71131	(Wh)	3140	101	73	31	+ 8
PF 70354/Kal-Bb x Ald	(Wh)	3130	101	67	27	+ 13
Veery	(Wh)	3120	101	74	32	+ 10
Romany	(Wh)	3110	100	79	34	131
FIFA 89.5.3	(Wh)	3100	100	78	32	— 6
IBWSN 108.1	(Wh)	2760	89	77	47	— 7

CV 13.9%
LSD 0.05 1058
Tcl = Triticale
Wh = Wheat

The Triticale lines are leading all the best wheat varieties. It is good to mention here the differences between wheat and triticale in the breadmaking quality.

Table 11. Comparison between Triticale varieties and Wheat varieties Irrigated crops (rice fields) : Average of 3 trials 1982.

Varieties/lines		Yield kg/ha	index	Test weight kg/hl	Sedimentation	Days to Maturity
Tcl 10	(Tcl)	3890	213	60	15	+ 9
Ram "S"	(Tcl)	3870	212	61	13	+ 7
Beagle	(Tcl)	3570	195	61	13	+ 9
Tcl 65	(Tcl)	3460	189	64	15	— 1
Bongo "S"	(Tcl)	3240	177	63	14	+ 1
Mapache	(Tcl)	3100	170	62	16	— 1
Tcl Bulk 50 MA	(Tcl)	2940	161	62	21	— 1
Bura	(Tcl)	2710	149	64	23	+ 1
IA x Spy x Cin	(Tcl)	2660	146	62	20	— 1
Welsh	(Tcl)	2340	128	61	20	+ 5
Fawn	(Tcl)	2050	112	68	21	+ 2
BW 19	(Wh)	1830	100	77	31	137

CV 10.1%
LSD 0.05 933
Tcl = Triticale
Wh = Wheat

Again, all the Triticale lines outyield the wheat variety. There was hail damage on those trials, and wheat was much more destroyed than Triticale. That was one reason for the low yield of wheat.

CONCLUSION :

For rainfed crop the MASA varieties which are tolerant to aluminium toxicity give good results in the Antsirabe region. Many lines have been identified. For the volcanic soils and the rice fields the Mexican varieties are doing well. The MASA varieties have to be tried in the rice fields as well; there is no reason for them not to show good performance in this environment.

Triticale always outyielded wheat in all environments. Many good lines with reasonable breadmaking quality have been identified.

Seed multiplication has started also for triticale.

HORIZONTAL RESISTANCE WHEAT BREEDING PROGRAMME IN ZAMBIA

P. Groot

INTRODUCTION

The horizontal resistance wheat breeding programme in Zambia was initiated in 1976 by Raoul Robinson of FAO, as part of an international applied research programme which was to encourage selection of more durable forms of disease resistance in annual field crops. The most common source of resistance resulting from conventional selection programmes provides almost complete protection against a certain disease strain but often seems to be only temporararily effective. Often, when a new race or viable mutation of pathogen arises, the selected resistance gene no longer functions, leaving the plant susceptible and subject to considerable losses.

The primary objective of the horizontal resistance breeding programme is to increase the rate of appearance of horizontal or general resistance against the more important diseases so as to provide the farmer with varieties whose non-specific resistance will show its benefits after a breakdown or in absence of vertical or race specific resistance. In theory, such varieties should not suffer considerable losses in yield as in most cases of failing vertical resistance.

A practical definition of horizontal resistance might be "a general but incomplete resistance of the host plant, independent of the races of the pathogen, showing up after vertical resistance has been eliminated and decreasing the race of infection, colonization and parasite reproduction."

The purpose of this presentation is not to discuss the various scientific theories concerning the mechanism of horizontal resistance but rather to consider how to select for it in a breeding programme, accepting it as an existing phenomenon.

BREEDING METHODS

Parent selection

The parent cultivars were selected on the basis of the following criteria which were developed in Egypt, Kenya, Pakistan and Zimbabwe:

The cultivar had to be susceptible to the infection. For rust, this meant that a pustule could develop but there was no reaction in the host tissue.

The disease severity had to be between low and medium.

There had to be variability in agronomic features, such as plant height, ripening time and ear type.

The minimum acceptable yield under irrigation was set at 4000 kg/ha.

Crossing

A selection pool of recombining genes was developed by making polycrosses among 22 cultivars using Ethrel as the pollen sterilizing chemical. Twelve cultivars normally grown during the rainfed season were added in a second polycross to increase the initial variability and to expand the pool with material better adapted to rainfed conditions.

The recurrent selection programme on this pool consisted of a polycross followed by at least two generations of selfing before the next polycross. Accumulation of general resistance genes was expected under the positive selection pressure after each polycross. The frequency of making new polycrosses was decreased because efficient selection on polygenically inherited properties could not be done before the F_3 or F_4 generation. After the F_4, line selection was the main breeding method for developing new lines to be tested in yield trials.

Selection

Selection of general resistance in segregating lines was carried out under artificial infection using spreader plants, because natural infection levels were generally too low.

STATUS OF THE PROGRAMME

Six to eight pure lines during the rainy season and four to six lines during the dry (or irrigated) season were selected on the basis of yield and disease performance after one to four polycrosses. A fifth polycross, involving some promising rainfed lines, was made during the 1982 season in order to initiate new selection cycles for rainfed lines. It should be appearent that breeding for horizontal resistance is rather tedious. Accumulation of genes for this type of resistance requires a long-term commitment.

METHODOLOGICAL PROBLEMS

Demonstration of improved horizontal resistance was hindered by inter-plot interference. The normal field trial layout with adjacent plots of different varieties resulted in considerable underestimation of the selected general resistance.

Information in the literature suggests that such interplot interference can be minimized through the use of isolated plots. Therefore, this season a field trial having isolated plots was initiated so that horizontal resistance can be evaluated more accurately.

Horizontal resistance was estimated by comparing yield and disease development after flowering (at least 3 scores) in the selected lines and some reference cultivars susceptible to the main diseases such as stem rust, leaf rust and powdery mildew. The sesceptible reference cultivars also served as spreaders of the inoculum. It was assumed that (1) the natural or artificial inoculum was a representative sample of the natural pathotypes of the prevailing disease, and (2) that no vertical resistance genes were operating in the lines which could have confounded the entire situation by masking the general resistance. Some results during the first three years of the programme are shown in Table 1.

To obtain more evidence for horizontal resistance in some of the promising lines a field experiment was established in 1982. An attempt was made to determine whether the development rate of stem rust, the most important disease in the dry season, was retarded and yield increased on the promising selected lines as compared to two very susceptible reference cultivars. A split plot design replicated six times was employed with each plot split into an inoculated half and a disease - free half.

The differences in epidemic severity among the promising lines and cultivars were insignificant because development of disease was late and disease levels were very low. Nevertheless, parameters of epidemic growth rate such as pustule size and spore production per pustule suggested that some lines were less susceptible to rust since they exhibited improved resistance to colonization (pustule size) and parasite reproduction (number of spores per pustule) as compared to the susceptible check cultivars Umniati and TZPP (Table 2).

PROBLEMS IN BREEDING FOR HORIZONTAL RESISTANCE

It is quite difficult under the current methodology in Zambia co-operative tests for promising horizontal resistance lines to gain acceptance since such lines often exhibit what is considered as incomplete and therefore inadequate resistance. The current cooperative tests in Zambia screen mainly on the basis of yield and complete disease resistance. To give horizontally resistant lines a fair chance, the acceptable levels of disease infection must be reviewed. Also, the test for horizontally resistant lines should always include a very resistant and a very susceptible check so that horizontally resistant lines can be ranked according to a sliding scale.

Table 1. Yield and stem rust infection during 3 years (1980-1982) in some promising lines of the horizontal resistance breeding programme.

	Lines or Cultivar	Yield (% of Emu)[1]			% Stem rust (terminal Score)		
		80 (5648)[2]	81 (5794)[2]	82 (5922)[2]	80	81	82[3]
1	MIL09-14	91	111	111	4S	3S	—
2	MIL09-46	103	103	96	O.1S	0.5S	—
3	Condor-177	100	99	97	6S	2S	—
4	MILO4 - 5	99	95	95	5S	3S	—
5	CN 27. 4	87	104	98	15S	10S	—
6	CNO 7.20	75	116	115	15S	4S	—
7	MILO8P2-26	117	93	112	O.1S	10S	—
8	MILO4-23	117	94	96	15S	6S	—
9	Emu	100	100	100	1OMS	1MS	—
10	TZPP	91	93	100	4OS	30S	5S

1. Emu (Commercial Variety)
   TZPP (susceptible check)

2. Yield of Emu in kg/ha

3 In 1982 there was a very low and delayed stem rust infection after artificial inoculation

Table 2: Comparison of parameters of stem rust epidemic in 2 susceptible cultivars with those in 3 promising selections from horizontal breeding programme (one year of results, 1982).

Line or cultivar	Pustule size in mm^2	No. of spores[1] per pustule	No. of Pustules[2] per cm stem
MILO 4-b	0.26	0.56	0.4
MILO10-9	0.30	0.47	0.6
MILO9-17	0.30	0.59	0.6
UMNIATI	0.48	0.87	1.0
TZPP	0.45	1.00	0.8

1. relative to the highest scoring entry (230,000 spores/pustule) which was set at 1.00.

2. Relative to the highest scoring entry (13.5 pustules per cm) which was set at 1.0.

DISCUSSION DURING THE SESSION CONCERNING WHEAT BREEDING PATHOLOGY AND SEED PRODUCTION

R. LITTLE: ZAMBIA

Is it true that vertical resistance is easier to handle by plant breeders than the poly-cross approach where the selection of lines is very difficult ?

P.C. GROOT: ZAMBIA.

Although it is very easy to select for, vertical resistance breaks down easily and if this happens you end up with a variety which is very susceptible to diseases. This is very undesirable to a farmer particularly in developing countries where alternative sources of food are very limited. To diminish his risk it is better to combine a vertical resistance gene in a variety that has gained some general resistance, so that if vertical resistance breaks down you have some yield to expect.

RAKOTONDRAMANANA: MADAGASCAR

Is sprouting also a problem in the triticale varieties grown in Kenya ?

P. KIRERU: KENYA.

The sprouting problem in Kenya in triticale is just as serious as sprouting in wheat. However, we have had some success in screening work for sprout resistant triticale varieties.

A. S. MOSHA: TANZANIA.

At one time it was believed that stripe rust was confined to high altitudes. However, in the last few years stripe rust has spread to lower altitudes. What is the explanation for this effect ?

W. C. McDONALD: KENYA.

It is true that stripe rust is no longer confined to particular altitudes. Even in the United States it has been reported that stripe rust spread to areas where it has never been before. Germination tests were done on some of these stripe rust spores and it was found that some of them could germinate under higher temperatures. Even in Kenya the incidence of stripe rust has increased at lower altitudes.

B. KINFE: ETHIOPIA.

In developing countries where foreign exchange is very difficult to obtain, is it advisable to use fungicides to control rusts on large acreages ? Is it not wiser to depend more on resistant varieties particularly in Kenya where you have enough of such varieties ?

W. C. McDONALD: KENYA.

We have done very little fungicide testing in Kenya. Moreover up to now we have also not been able to supply enough resistant varieties as an alternative. Some of the varieties that were identified two years ago are no longer resistant due to a new race of rust. As a result farmers have to use fungicides to control rusts.

E. TORRES: CIMMYT E. A.

As a pathologist I believe that research on the use of fungicides is an integral part of pathological research as a tool for disease control. However, I do not think we should encourage use of fungicides year after year particularly in developing countries because we understand the problems and the costs involved. Therefore, my suggestion is that the use of fungicides should only be encouraged under emergency situations where no other alternatives are available.

A. S. MOSHA: TANZANIA.

We have found that emergence of durum wheat in Tanzania is always very poor We think that it has something to do with dormancy. What is the reaction from other countries, particularly Ethiopia where more acreage is under durum.

E. BECHERE: ETHIOPIA.

In Ethipiopia we don't seem to have this problem. However, we have found that durums are not as widely adapted as bread wheats.

E. A. HURD: KENYA.

Durum wheats tend to sprout very easily. It is also my experience that when durum wheats are harvested a bit on the green side good germination becomes a real problem.

It is possible that durum wheats may have different dormancy patterns than bread wheats.

SESSION 4, Wednesday Afternoon, June 15, 1983

SOIL AND WATER MANAGEMENT FOR WHEAT PRODUCTION

Chairman: R. Little

RESPONSE OF ONE TRITICALE AND TWO WHEAT CULTIVARS TO LINE SOURCE IRRIGATION

K. S. Gill, J. C. Patel and N. S. Sisodia

INTRODUCTION

There are numerous report in the literature indicating that water deficits limit yield and/or that irrigation increases yield. The degree of yield reduction by a water deficit or enhancement through irrigation have been shown to depend on the degree, duration and timing of the deficit and on the proportion of the total yield that comprises the economic yield of the crop. However, there is limited information on response of different wheat varieties to irrigation under Zambian conditions. In addition, the cereal crop triticale has shown promise under Zambian condition, for commercial production. A project was therefore, undertaken to study the comparative response of two commercial wheat cultivars and one promising triticale cultivar to different levels of irrigation. The different levels of irrigation were imposed with line source sprinkler system (Hanks et al, 1976) which has the advantage of minimizing the amount of land needed for the experimental area as well as allowing for a continuous variation of irrigation.

MATERIALS AND METHODS

This study was conducted at the University of Zambia Farm situated between 15° 21′-15°-24′S and 20°′ 27′-20°28′E and about 1140m above the sea level. Mean monthly temperatures for the area varies from 13°C in July to 24°C in Oct. The soil was Kankola sandy clay loam (Typic Haplustox). Two wheat (Emu and Tai) and one triticale (UNZA-T-1) cultivars were compared during 1981 and 1982 dry winter seasons at three nitrogen (60, 110 and 160 kg/ha) and six irrigation levels. A split plot design with main plots (nitrogen) arranged in a randomised complete block design and cultivars randomly assigned to subplots was used. The irrigation treatments were not randomised. There were four replications.

Fourteen rows (with 20 cm row spacing) of each variety were planted in 16 m long strips. Planting was done on 10th June in both the years. The basal dose of fertilizer was 30, 60, 30 and 30 kg/ha in 1981 and 36, 78, 42 and 40 kg/ha in 1982 of N, P_2O_5, K_2O and S, repectively. These basal doses of fertilizer were followed by top dressing with urea to attain totals of 60, 110 and 160 kg/ha of N in both the years. For crop establishment, 120 mm and 90mm water was applied using sprinklers, respectively, during 1981 and 1982 seasons. The differential irrigation levels were applied using line source system laid at right angle to the strip length as described by Hanks et. al. 1976. The arrangement provided uniform water application along the width of the strips, which decreased continuosly along the length of the strips with increasing distance from the line of sprinklers. The central 15m length of the 16m strip was divided into six equal sections (each 2.5m long) and the amount of water received by each of these sections was measured for each irrigation.

Harvesting was done on 23rd Oct. and 5th Nov., respectively in 1981 and 1982 seasons. Two meter length of 5 rows was harvested to obtain the total dry metter and grain yields. Harvest index as a percentage of grain yield to the total dry matter yield, was calculated. Ten heads were randomly picked to obtain the number of grains per ear and thousand grain weight. The results reported refer to air dry weight for total dry matter and oven dry weights for grain yields. The data reported are means of the three nitrogen levels. The grain yield and harvest index data were statistically analysed according to the procedure of Hanks et al (1980).

RESULTS AND DISCUSSION

Irrigation:

The amounts of seasonal irrigation varied from 45.8 to 18.3 cm in 1981 and 50.5 to 15.8 cm in 1982 (Table 1). In both years as expected, the amounts of water applied decreased and indicated a linear relationship with distance from the line source. This was in agreement with the results of Hanks et al (1976).

Grain yield and harvest index.

In both seasons, grain yield of all the cultivars was highly influenced by the irrigation levels (P=0.1%, Table 2). In 1981, the grain yield at I_1 was significantly higher than at I_2 which was not true in 1982. The grain yields I_1 is 1981 and of I_2 in 1982 were almost similar. These results indicated that the irrigation of 45.8 cm during 1981 and 47.5 cm during 1982 were optimum for the crop.

Comparing the three cultivars, differences in grain yield were statistically significant (P 0.01). During both the seasons, Tai had significantly lower grain yields than the other two cultivars, which were at par with each other. The cultivar X irrigation interaction was significant only during 1981. In this season, Tai yielded significantly lower than the other two cultivars only at three higher irrigation levels (I_1 to I_3), whereas in 1982, Tai yielded significantly lower than the other two cultivars at all the irrigation levels.

In case of all the three cultivars, grain yield averaged over the two seasons (data can be calculated from Table 2) changed almost linearly with the amount of irrigation and showed a highly significant linear correlation. The regression coefficient was highest in case of UNZA-T-1 followed by Emu and Tai in a decreasing order. It means that UNZA - T -1 was most responsive and Tai least responsive to changes in irrigation. Thus UNZA-T-1 appear to be better cultivar for optimum irrigation conditions. Photosynthesis of ears, stems and leaves during the grain filling period is generally recognised as the major contributor to grain yield in cereals (Thorne, 1966, Allison and Watson, 1966 and Evans et al, 1975). Fisher and Kohn (1966c) reported that the yield of field-grown wheat was negatively correlated with the rate of senescence of photosynthetic leaves after anthesis when soil moisture deficits induced senescence. In the present study also, it appears that the photosynthetic capacity of all the cultivars was reduced by increasing water stress at lower irrigation levels.

The harvest indices (H.I's) for the three cultivars at different irrigation levels are presented in Table 3. The effects of cultivars, irrigation levels and their interactions, all were statistically significant. Averaged over the irrigation levels, Tai and significantly lower harvest indices than both Emu and UNZA-T-1 in 1981 and than only Emu alone in 1982. The differences between Emu and UNZA-T-1 were not significant in both the year.

In both the seasons, cultivar x irrigation interactions were significant. Is 1981, all cultivars had almost similar H. I's at lower levels of irrigation (I_4 to I_6) whereas at higher levels, Tai had significantly lower HI's than Emu and UNZA-T-1. In 1982, at lower levels of irrigation (I_4 to I_6) Emu had higher HI's than Tai and UNZA -T-1, but at higher levels both Emu and UNZA-T-1 had higher H.I's than Tai. Averaged over two seasons, the change in H.I. due to irrigation was highest in case of UNZA-T-1 followed by Emu and Tai (data can be calculated from Table 3). It can also be seen that H.I. for all the cultivars had a very high positive correlation with irrigation. Earlier, Poostchi et al (1972) also observed a decline in H.I. of wheat at lower levels of irrigation. Turner (1966) reported a 70% decrease in grain yield but only 52% decrease in total dry matter yield of wheat from a water deficit imposed five weeks prior to ear emergence Aspinall et al (1967) have emphasized, "the organ which is growing rapidly at the time of stress is the one most affected". Lower H.I.'s at lower levels or irrigation indicated that in the present study, irrigation influenced the grain yield more severely than the total dry matter yield. This appears to be due to the late start of differential irrigation, whereby only part of the vegetative growth period but whole of the grain filling period was exposed to water stress under lower irrigation levels.

Yield components:

Generally, both Emu and UNZA-T1 had higher grain number/ear than Tai, irrespective of irrigation level (data not shown here). For all the cultivars, grain number/ear like grain yield and harvest indices also showed a very high positive correlation with irrigation. Earlier Fischer (1973) reported a reduction in grain number/ear due to water stress. The change in grain number/ear as a function of irrigation was maximum for UNZA-T-1 (regression coefficient 0.31) closely followed by Emu, whereas it was much lower for Tai (reg. coefficient 0.22). Consequently the differences between Tai and the other two culvars were more marked at higher than at lower levels of irrigation. This trend of response in case of Tai to irrigation was almost similar to the ones for grain yield and harvest index.

The thousand kernel weight (not shown here) indicated that Tai had smaller grain than both Emu and Triticale. Similar to other parameters, the thousand grain weight also had very high positive correlation with irrigation. But, unlike the other parameters, the change in thousand grain weight as a function of irrigation was minimum in UNZA-T-1 and maximum in Tai with Emu being inbetween the two.

Grain weight/ear was calculated by combining the data of grain number/ear and thousand kernel weight, using the two year regressed values of the two components. When irrigation level was changed from I_1 to I_6, the grain weight/ear was reduced by 29.5, 31.9 and 28.7 percent, respectively, in case of Emu, Tai and UNZA-T-1. The corresponding figures for grain yield were 51.0, 55.2 and 54.3%. These results indicated that the combined effect of fewer grains/ear and reduced grain size accounted for major portion of the reduction in grain yield, of the two, grain number/ear decreased much more (18.1 to 22.8) than grain weight (7.7 to 16.9%) in different cultivars from I_1 to I_6

GENERAL DISCUSSION AND CONCLUSIONS:

Total irrigation of about 45 cm was found to be optimum for wheat crop in Central Zambia and lowering it below this level adversly influenced the grain yield, harvest index, grain number/ear and grain size of all the cultivars. However, the influence of irrigation was found to be different for various parameters of the three cultivars. Due to unit change in irrigation, the grain yield, harvest index and grain number per ear change maximum for UNZA-T-1, followed by Emu and Tai in a decreasing order. But the change in thousand kernel weight with a unit change in irrigation was maximum in Tai followed by Emu and UNZA-T-1 in a decreasing order.

The lower harvest indices at lower levels of irrigation suggested that water stress starting some weeks after planting and continuing up to the crop maturity influenced the grain yield more than the total dry matter yield. The results of yield components indicated that major part of the reduction in grain yield due to irrigation, resulted from the change in grain weight/ear (approx. 56%). Of the two components of grain weight/ear viz. grain number/ear and grain size, the reduction was much greater (20.7%) in the former than in the later (11.7%). This is in agreement with earlier reports that grain size is a more stable character than grain number.

In general, the values of grain yield and other characters were similar for Emu and UNZA-T-1 which were higher than Tai. This indicated a good prospect of UNZA-T-1, a triticale cultivar for commercial production in Zambia. The interaction between cultivars and irrigation suggested that in future there may be scope for breeding cultivars separately for optimum and water stress conditions.

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Table 1 Amounts of seasonal irrigation received at different irrigation levels (I_1 to I_6) in 1981 and 1982 seasons.

	Amount of seasonal irrigation (cm) received					
Year	I_1	I_2	I_3	I_4	I_5	I_6
*	(1.75)	(4.25)	(6.75)	(9.25)	(11.75)	(14.25)
1981	45.88	39.0	32.8	30.5	24.0	18.3
1982	50.5	47.5	40.6	33.2	25.2	15.8

* Represent the distance (m) of rain gauges from the line of sprinklers.

Table 2. Grain yields (Kg/ha) of the three cultivars at different irrigation levels. The probability level of significance is mentioned in bracket.

Grain yield (kg/ha) at different irrigation levels							
Cultivar	I_1	I_2	I_3	I_4	I_5	I_6	Mean
				1981			
Emu	3783	3095	2626	2207	1943	1906	2593
Tai	3247	2867	2452	2217	1874	1790	2408
UNZA-T-1	3780	3188	2798	2226	1997	1889	2646
Mean	3603	3050	2625	2217	1938	1862	2549

LSD's and probabilities — Cultivar (c) = 154 (1%); Irrigation = 242 (0.1%) C X I = 216 (5%)

				1982			
Emu	4008	3895	3321	2951	2583	2089	3142
Tai	3501	3202	2571	2447	1988	1383	2515
UNZA-T-1	4101	3784	3256	2867	2506	1814	3055
Mean	3870	3627	3049	2757	2359	1762	

LSD's and Probabilities — Cultivar (c) = 375 (1%); Irrigation (I) = 323 (0.1%) C X I = NS.

Table 3. Harvest indices (%) of the three cultivars at different irrigation levels. The probability level of signinficance is mentioned in bracket.

Cultivar	Harvest indices (%) at different irrigation levels.						
	I_1	I_2	I_3	I_4	I_5	I_6	Mean
				1981			
Emu	34.9	32.7	31.5	29.6	28.4	28.2	30.9
Tai	32.0	31.8	30.2	28.8	28.6	27.6	29.8
UNZA-T-1	35.0	34.5	33.1	30.0	28.4	27.3	31.4
Mean	34.0	33.0	31.6	29.5	28.4	27.7	

LSD's and probabilities — Cultivar (c) = 0.89 (1%); Irrigation (I) = 1.42 (0.1%) C X I = 1.15 (1%)

				1982			
Emu	38.0	37.4	35.3	33.7	32.9	30.7	34.6
Tai	33.4	32.9	31.7	30.5	29.2	27.9	30.9
UNZA-T-1	36.9	36.4	34.1	30.9	29.5	26.9	32.4
Mean	36.1	35.6	33.7	31.7	30.6	28.5	

LSD's and probabilities — Cultivar (c) = 2.28 (5%), Irrigation (I) = 1.54 (0.1%) C X I = 1.73 (5%)

PHYSIOLOGICAL STUDIES ON WHEAT AND TRITICALE

J. C. Patel, K. S. Gill and N. S. Sisodia

INTRODUCTION

Perfomance of any cultivar based on yield alone provides incomplete information about that cultivar. Grain yield is related to total dry matter accumulated by the crop. Dry matter production varies with cultivar and moisture availability (Begg and Turner 1976). Number of ears per unit area, one of the component of yield, depends upon tiller production and survival, both of which differ with cultivar and moisture availability (Bingham 1966, Begg & Turner 1976). Water stress has both direct and indirect effects upon the survival of tillers. The direct effect is that water is utilized in photosynthesis. Therefore, its deficiency would reduce the photosynthate produced by the plant. The indirect effects are that under water stress, the leaves close the stomates to conserve water loss but this also restricts the entry of carbon dioxide and the exit of oxygen both of which adversely affect photosynthesis. Water deficiency also limits mineral nutrients uptake in solution which are essential for the numerous motabolic processes occurring in the plant.

It is now well documented that some of the dry matter accumulated in the shoots is translocated to the grains. In barley, shoot translocation was found to range from 0% to 66% depending on cultivar and season (Patel 1979). Evans and Wardlaw (1976) suggested that stem reserves contribute to grain filling to an extent that varies according to conditions for current photosynthesis which is determined by many factors including variety and moisture availability.

Dry matter accumulation, tiller production and survival and contribution from shoot to the filling of grains are three of the many aspects which provide a better understanding of the differences between varieties in grain yield. In many parts of Zambia, water is often a limiting resource and therefore, cultivars which can do well under water stress have to be identified It was with these objectives that this project was carried out to study the time sequence of dry matter accumulation (by whole plant, shoot and ear) and tillering for two recommended wheat and one promising triticale cultivars under three moisture regimes.

MATERIAL AND METHODS

The details of site and layout of experiments have been outlined in the previous paper appearing in these proceedings (Gill et al 1983). Briefly, the response of two high yielding wheat cultivars (Emu and Tai) and one triticale cultivar (UNZA-T-1), planted on June 10 during 1981 and 1982 dry winter seasons at three irrigation levels was studied. Although the experiment was carried out at three nitrogen levels, only the results of medium level of nitrogen (110 kg/ha) are reported in this presentation. For crop establishment 90 and 120 mm of water was applied before the start of differential irrigation, during 1981 and 1982 seasons, respectively. Total amount of water applied at the three irrigation levels, viz I_1,I_3 and I_5 was 458, 330 and 238 mm in 1981 and 505, 406 and 252 mm in 1982, respectively.

A 50-cm length of row was randomly sampled for growth analyses at approximately fortnightly intervals. To determine the dry matter, the samples were dried in an oven at 90°C and then weighed. After ear emergence, the ears were separated from the shoots. As the sampling dates for both seasons were not exactly the same, average time trend for the two seasons in total and shoot dry weights was achieved as follows. The data (averaged over the three irrigation levels and over the three cultivars for each of the two seasons were plotted on the same gragh and subsequently the best fitting lines (visually) were drawn. Tiller count was carried out only in 1981 at approximately fortnightly intervals.

RESULTS AND DISCUSSION

Tiller production and survival:

Initial tiller production upto 35 days after planting was highest in UNZA-T-1 and lowest in Tai. (Table 1) However, during the 35 to 58 days after plantig the trend of tiller production was reversed, i.e. Tai had the highest and UNZA-T-1 had the lowest rates of tiller production during this period. All three cultivars attained maximum number of shoots 58 days after planting. The maximum number of shoots were 925, 967 and 670/m^2 for Emu, Tai and UNZA-T-1, respectively (Table 1). Therefore, both the wheat cultivars showed a higher potential for tiller production as compared to the triticale cultivar. After reaching a maximum the number of shoots in all the cultivars decreased rapidly over the next fortnight which coincided with the rapid phase of stem elongation. Subsequently the rate of tiller mortality declined until a constant number of shoots/m^2 were recorded. Similar observations were recorded by Thorne 1962) and Quinlan and Sagar (1962) in wheat. Averaged over the three irrigation levels Tai had 46%effeciency of shoot retention while both Emu and UNZA-T-1 had 52% shoot retention efficiency. Despite the higher tiller retention efficiency in UNZA-T-1, the final number of shoots/m^2 in UNZA-T-1 was only 345 shoots/m^2 while Tai and Emu, respectively had 448 and 478 shoot/m^2. However, the differences of 297 shoots/m^2 between Tai and UNZA-T-1 and 255 shoots /m^2 between Emu and UNZA-T-1 at the maximum stage were narrowed down to 103 and 133 shoots/m^2, respectively at the final count. Thus, whilst tiller production is essential to fill gaps and ensure complete ground cover, a high retention percentage is required in order to avoid wastage and maximize yield. Although there is translocation of material from the dying tillers to those that survive it is not complete (Donald 1968, Rawson & Donald 1969). The tiller retention percentage determines the final ear bearing or productive tillers. As grain yield is a product of number of productive tillers/m^2, number of grains/ear and grain size, a higher number of productive tiller/m^2 should result in a higher grain yield. But, in this study although Tai had a higher number of shoots/m^2 than UNZA-T-1, its grain yield was lower and this was attributable to lower number of grains/ear and smaller grain size. This suggested that the effect of number of productive tillers/m^2 can be modified by the other two yield components.

The data on the effect of moisture stress on final number of shoots/m^2 (Table 1) showed that averaged over all cultivars, the final number of shoots declined as moisture stress increased. Reduction of 220 mm in water application from I_1 to I_5 level of irrigation, led to 14.6% reduction in final number of shoots. That water deficiency increases tiller mortality has also been reported by Jones and Kirby (1977).

There was also some interaction between cultivars and moisture level in tiller survival as the cultivars differed in their response to increasing moisture stress. In general, moisture stress reduced the final number of shoots in all cultivars, however, the reduction was maximum in UNZA-T-1 (Table 1). In comparison to I_1 the final number of shoots in I_5 were reduced by 6.1%, 7.8% and 31.9% in Emu, Tai and UNZA-T-1, respectively. This suggested that the wheat cultivars were better able to withstand water stress than the triticale with regard to retention of tillers.

Dry matter accumulation:

Periodic sampling for dry matter accumulation allows the study of growth rates and the duration of growth, the product of which gives the total dry matter produced over a given period of time. Averaged over all three irrigation levels, UNZA-T-1 produced the highest final total dry mater than both Emu and Tai. This was attributable to its higher growth rate and also slightly longer duration of growth. Both Emu and Tai produced nearly equal final total dry matter.

As mentioned earlier, grain yield is related to total dry matter production and this was reflected accordingly in the results presented in the previous paper (Gill et al 1983) where averaged over I_1, I_3 and I_5 levels of irrigation, UNZA-T-1, Emu and Tai produced grain yields of 3073, 3044 and 2639 kg/ha, respectively.

Averaged over the three cultivars, final dry matter declined with increasing moisture stress and this was attributable mainly to declining growth rates with increasing water deficits. Again this was reflected in grain yields which were 3770, 2838 and 2149 kg/ha respectively for I_1, I_3 and I_5 levels of irrigation.

Dry matter partitioning:

There was an increase in shoot dry weight up to a few days after ear emergence, which suggested that total net photosynthesis during that period was in excess of that required for the growth of the ears. However, subsequently shoot dry weight declined, which meant that after that period the net photosynthesis was inadequate to fill the grains and the plants resorted to using the reserves in the shoots.

The contribution of shoot reserves to grain filling was calculated by extrapolating the highest and final shoot dry weights and expresing the change in dry weight as a percentage of the highest shoot dry weight for each treatment. Averaged over all three irrigation levels, contribution of shoot reserves to grain filling was similar and higher in UNZA-T-1 and Emu (viz. 24% and 25% respectively) compared to Tai (viz. 18%). This suggested that contribution from shoot reserves to grain filling varied with variety. Considering the mean grain size presented in the earlier paper Gill et al (1983), UNZA-T-1 and Emu had similar and higher mean grain size (viz. 43.1 and 42.7 mg respectively) compared to Tai (viz. 36.3 mg). This further suggested that the cultivar with smaller mean grain size drew upon the shoot reserves less that the cultivars with larger mean grain size.

Averaged over all three cultivars per cent contribution of shoot reserves to grain filling was 20%, 23% and 26% for I_1, I_3 and I_5 levels of irrigation respectively.Greater mobilization with increasing water stress was also reported by Evans and Wardlaw (1976).

CONCLUSION

Averaged over all irrigation levels Emu and UNZA-T-1 had the higher efficiency of tiller retention than Tai and UNZA-T-1 also produced the highest final total dry matter. Therefore, triticale showed the same or better potential than the two wheat cultivars which was also reflected in the grain yields. In view of above results continuation of breeding work on triticale is highly recommended. Averaged over all cultivars there was consistent reduction in final total dry matter with increasing water deficit which was also reflected in grain yield. Although no statistical analyses was carried out, the differences were so large, that only the I_1 level of total water application would be recommended if a reduction in yield was be avoided.

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Table 1 Number of shoots/m² for the three cultivars at different stages and different irrigation levels, 1981.

CULTIVAR	NUMBER OF SHOOTS PER M²					
	DAYS AFTER PLANTING					
	35*	58*	127			
			I_1	I_2	I_5	MEAN
Emu	255	925	490	483	460	478
Tai	185	967	472	438	435	448
UNZA-T-1	295	670	430	313	293	345
MEAN	245	854	464	411	396	

*Differential irrigation was not available at these stages.

NUTRIENT STATUS OF WHEAT IN NORTHERN TANZANIA.

A. S. Nyaki and L. A. Loewen-Rudgers

INTRODUCTION

Fertilizer studies in wheat in Northern Tanzania up until the early 1970's were conducted primarily in the Mbulu and West Kilimanjaro areas. These studies emphasized N since these soils were found to supply adequate amounts of P and K to wheat. Fertilizer recommendations, particularly for N were based mainly on the previous cropping history and/or weather conditions that prevailed before and after seeding. Anderson et al (1965).

Mechanized wheat farming has been extended in recent years to the semi-arid areas of the Hanang District where todate the area under wheat is approximately 20,000 hectares. In addition to the relatively low amounts of precipitation (600mm) received in this area, major changes in agronomic practices were also introduced most of which likely influenced the potential of the soil to release nutrients to the wheat crop. Such changes included new tillage practices, weed control techniques, times of seeding etc.

These new developments in wheat production necessitated additional fertility research to assess the actual nutrient requirement of wheat in the major wheat growing areas of Northern Tanzania.

Soil analysis at seeding time has been used successfully in many parts of the world to predict N, P, and K deficiencies in wheat. This is particularly true for N which is more often deficient than P and K. Young et al (1967) and Soper et al (1971), for example, reported that if the level of NO_3-N/60cm at seeding time was known, the amount of fertilizer N required for a particular yield of wheat could be predicted.

Therefore, the major objective of this study was to determine if soil analysis could be used to assess the nutrient status of soils on the major wheat farms in Northern Tanzania so that nutrient deficiencies could be detected and appropriate fertilizer recommendations formulated.

The specific objectives of the study were:

(1) To determine if soil analysis can be used to predict N, P and K deficiencies in wheat;

(2) to determine the critical levels of N P and K in the soil beyond which no response to fertilizer occurred;

(3) to determine the most economic rate of fertilizer to apply whenever it was needed and

(4) to determine the relative efficiencies of various times and methods of N fertilizer application.

MATERIALS AND METHODS.

A total of 30 experiments were conducted between 1976 and 1982 on soils of varying physical and chemical characteristics. A completely randomized block design replicated four times was used for most of the experiments. The treatments constituted different rates of N as ammonium Sulphate or (21-0-0), either drilled, broadcast at planting or broadcast four weeks after seeding. Both P and K fertilizers were drilled with the seed. Phosphorus was applied as triple superphosphate (T.S.P.) (21% P) and K as Muriate of Potash (60% K_2O).

Plots were seeded with the wheat variety Trophy (3503) or Mbuni T26-73 using either a four-row small plot cone seeder with double disc openers at 22.8 cm spacing or a six-row small plot belt seeder with double disc openers at 17.8 cm spacing. The plots were kept weed free during the growing season by hand weeding.

From the centre two rows, 3.05m length of sample was harvested from each plot by cutting the straw and grain at ground level. The samples were threshed, cleaned and straw as well as grain weights determined.

Soil samples were taken at seeding time and analysed for pH, conductivity organic matter, nitrate-N, available moisture as well as extractable P and K.

RESULTS AND DISCUSSION.

The sites covered in this study and their respective soil types classified according to the U.S.D.A. classification system are shown in table 1. Generally, all sites were occupied by relatively fine textured soils ranging from clay to clay loam and had pH values ranging from slightly acid to slightly alkaline.

Table 1.

Soil Classification for the Various Experimental sites:

Location	Soil Order	Soil Subgroup
West Kilimanjaro	Ultisol	Ustic Tropohumults
Arusha Seed Farm	Inceptisol	Typic Utrandept
Karatu	Inceptisol	Aridic Humitropept
Basotu Upland	Mollisol	Typic Argiustoll
Basotu Mbuga	Vertisol	Petrocalcic Pellustert

Influence of Soil NO_3 -N at Seeding Time on Wheat Yields and Response to Fertilizer N.

The mean grain yields of wheat receiving no fertilizer N and the respective level of NO_3 -N/60 cm are shown in tables 2 and 3. It is evident from the results that the yields as well as the NO_3-N levels were highly variable from one site to another as well as within sites. It is also interesting to note that the variation in yield obtained was not related to the level of NO_3-N in the soil

Table 2

Mean Grain Yield (t/ha) for the various Experimental Sites

SEASON	BASOTU MBUGA	BASOTU UPLAND	BASOTU CALCIM	ARUSHA SEED FARM	KARATU	W/KILI	ARUSHA BLOCK C	ARUSHA BLOCK D	RUSHA BLOCK B	SETCHET BLOCK 16E	SETCHET BLOCK 19E
1	3.38	1.40	1.35	1.39	2.14	2.01	2.37	3.02	3.82	1.71	1.67
2	1.88	1.55	1.80	4.25	1.93	2.84	3.19	—	—	—	—
3	2.83	2.04	—	4.75	2.19	2.70	—	—	—	—	
4	3.72	1.76	—	2.26	1.24	3.76	—	—	—	—	
5	1.33	—	—	2.80	—	—	—	—	—		

Table 3.

Levels of NO_3-N (kg/ha) to 60cm at Seeding Time.

SEASON	BASOTU MBUGA	BASOTU UPLAND	BASOTU CALCIM	ARUSHA SEED FARM	KARATU	W/KILI	ARUSHA BLOCK C	ARUSHA BLOCK D	ARUSHA BLOCK B	SETCHET BLOCK 16E	SETCHET Block 19E
1	56.2	65.7	100.7	221.4	33.5*	37.6	43.4*	58.1	67.2	86.5	142.7
2	142.0	10.1*	18.9*	112.4	23.1*	31.2	75.4	—	—	—	—
3	36.8	31.7*	—	44.8	42.9	76.3	—	—	—	—	—
4	142	72.2	—	62.0*	38.5*	53.4	—	—	—	—	—
5	100.0	—	—	64.3	—	—	—	—	—	—	—

* Response to Fertilizer N obtained.

at seeding time. A very low linear correlation coefficient (r=0.05) was obtained between the two variables, suggesting that only 0.26% of the variability in wheat yields was attributed to the initial level of NO_3-N/60 cm. It is likely that other factors such as disease and moisture distribution throughout the growing season were more important in influencing the wheat yields. Yield reductions of up to 40% were obtained in the 1978 cropping season at Basotu due to the disease **helminthosporium** Another reason for the relatively low correlation could have been that only a few sites had low NO_3 -N levels.

Responses to fertilizer N were also variable among years as well as among sites. Generally responses to fertilizer N were far more frequent when the level of NO_3-N/60 cm at seeding time was below 60 kg/ha. (Table 3). Therefore, the results obtained thus far suggest that soil analysis at seeding time may be useful in determining whether fertilizer N is needed to maximize yields

Influence of Soil NO_3-N on Time, Rate and Method of N Application.

Although some responses to fertilizer N were obtained at several locations it is important to note that no satisfactory relationship was established between Soil NO_3 -N plus fertilizer N and grain yield or N uptake. Consequently, it was not possible to develop precise recommendations as to the most economic rate of fertilizer N based upon the level of NO_3-N nor was it possible to determine the relative efficiencies of various times and methods of N fertilizer application.

Response to Fertilizer P and K.

Results todate have indicated that with the exception of certain soils on the Setchet Wheat Farm which have been shown to be P-deficient, soils of the wheat growing areas in Northern Tanzania supply adequate amounts of P and K to wheat. If the Setchet Farm is excluded, the lowest level of 0.5M $NaHCo_3$ extractable P recorded in Northern Tanzania was 10.7 ppm in the top 15 cm. while the highest was 276 ppm. The lowest levels of available P were consistently recorded on the Mbuga site where the soil was classified as Petrocalcic Pellustert.

Results from one of several phosphorus studies on red soils (Alfisols, Ultisols and Entisols) which occupy about 1000 ha on the Setchet Wheat Farm are shown in Table 4. These soils contained available P levels ranging from 0-7 ppm and responded to fertilizer P.

Table 4.

Influence of Fertilizer N and P Upon Grain Yield on a Red Soil on the Setchet Farm.

P Rate Kg/ha	N Rate Kg/ha		Sub-plot-Effect (P-Effect)
	0	50	
0	1.71	1.66	1.69
20	2.39	2.40	2.40
40	2.41	2.38	2.40
60	2.28	2.24	2.26
80	2.54	2.62	2.58
	2.27	2.26	LSD (0.05) =0.59 m.t./ha

CONCLUSION,

Results obtained todate suggest that soil analysis at seeding time can be a useful tool in predicting N deficiencies in wheat Generally when the level of NO_3-N/60 cm was below 6/ kg/ha response to fertilizer N was likely. However, due to lack of satisfactory relationship between soil NO_3-N and grain yield precise N recommendations based on soil analysis was not possible. This is not alarming, since few wheat soils in Norther Tanzania contain less than 60 kg NO_3 -N/ha to 60 cm.

The results also indicated that factors other than or in combination with soil NO_3-N were more important in influencing wheat yields.

With the exception of certain soils on the Setchet Farm, all sites considered appeared to supply adequate amounts of P and K to wheat.

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SOIL SUITABILITY MAPPING FOR WHEAT FARMING AT BASOTU

S. Chatwin

INTRODUCTION:

Semi-detailed soil suitability maps (1:50,000 scale) are now being produced for the wheat farming complex at Basotu, Tanzania. This mapping project is uniquely single purpose in its objectives: to delineate what land is suitable for mechanized dry-land wheat farming, what land is unsuitable, and to identify exactly what the different limitations are for each land unit. This paper discusses the mechanics of designing a suitable soil legend to meet the objectives and illustrates the use of soil suitability map for farm planning.

DESIGN OF THE SOIL LEGEND.

Two map sheets are produced for each area under consideration. The first map shows the distribution of the soil types while the second is a derivative map, showing the agricultural suitability of each of the soil types.

In designing a soil legend it is important to first decide which soil properties will affect production and secondly to select only those properties that are mappable attributes or correlative **mappable** attributes For example, soil pH is important but cannot be mapped; however bedrock type, which is correlated with soil pH, can be mapped.

At Basotu, the main limiting soil factors are outlined below:

Limiting Factor	Soil Characteristic
1. Moisture holding capacity	Soil texture Soil depth Stone content
2. Topography	Slope morphology
3. Fertility	Soil texture Surface organic horizon Bedrock
4. Management	Texture (tillage) Texture, slope (erosion)

Therefore the important soil characteristics for the Basotu farms are: texture, depth, bedrock geology, topography, and stone content. It was subsequently decided that a LAND SYSTEMS Legend would best separate variations in these soil characteristics. Primary class breaks were made for land form and geology and subdivisions for soil depth, type of surface horizon and textural variation. Soil classification is not emphasized, but is only appended to the subclasses. These "landform" classes do translate into distinct classes of physical and chemical properties where good separation is shown for average clay contents, C.E.C., and exchangable ions.

SOIL SUITABILITY MAP

The soil suitability map is derived entirely from the soil map. The map follows the FAO 5 class system, indicating what land units are HIGHLY, MODERATELY, or MARGINALLY suitable as well as what land is CURRENTLY or PERMANENTLY UNSUITABLE. Map colors indicate the degree of limitation while symbols describe the limitation. The guidelines used to determine suitability classes for each potential limitation are in Table 1.

An example of the symbolling for each map polygon is

6	4
3F	NN
S	R

where 60% of this unit is marginally suitable because of fertility and shallow depth limitations while 40% is unsuitable because of severe salinity and numerous rock outcrops.

In the Basotu area, approximately 300,000 hectares have been mapped. Highly suitable soils make up 9% of the area, moderately suitable soils comprise 31%, while 20% of the land is marginally suitable. Shallow soil depth and coarse texture, both affecting the water holding capacity, are the main soil limitations.

SUMMARY

The purpose of this paper has been to show how a soils legend is designed for a single purpose objective of designating individual land areas as to their suitability and specific limitations for dryland mechanized wheat farming. To date the maps have been used to locate areas for potential farms as well as to layout farm boundaries. Future planned uses are the layout of fields so that single soil types are incorporated to form homogenous management units.

Table 1: Degree of limitation for various soil properties

Subclass Limitation	LIMITATION DESCRIPTION	SUITABLE			NOT SUITABLE	
		1 HIGHLY	2 MODERATELY	3 MARGINALLY	N1 CURRENTLY	N2 PERMANENTLY
D	blocklike surface structure and very hard, or very sticky. (Vertisols)		mainly montmorillionite clay soils	not applicable	not applicable	not applicable
E	Wind or water erosion damage	NO Limitations	erosion on significant portion of area.	erosion on dominant portion of area.	area dominated by erosion features	erosion has permanently removed soil.
F	low natural fertility		moderate fertilizer response expected; CEC25-15 meg. P10-25ppm;KO. 2-0.4 meg.	significant fertilizer response expected CEC 5-15 meg. P< 10ppm; K<O. 2meg.	not applicable	not applicable
G	excess soil moisture		moderately well to imperfectly drained soils. (mottling)	imperfectly to poorly drained mottling and gleying)	permanently poorly drained within the rooting zone. (gleying)	not applicable
I	inundation-flooding by lakes and streams.		occasional flooding of short duration.	frequent flooding of short duration or occasional flooding of long duration.	annual flooding of long duration	not applicable

(Table 1 continued)

Subclass Limitation Symbol	LIMITATION DESCRIPTION	SUITABLE			NOT SUITABLE	
		1 HIGHLY.	2 MODERATELY	3 MARGINALLY	N 1 CURRENTLY	N2 PERMANENTLY
M	low moisture holding capacity from coarse texture or used with "S"	NO LIMITATIONS.	loam to fine sandy loam	sandy loam	loamy sand	sand, gravelly sand.
N	alkalinity or salinity		significant area with conductivity of 4-8 ms within 75 cm.	dominant area with conductivity of 4-8 ms within 75 cm.	dominant area with conductivity of 8-16 ms throughout profile.	conductivily > 16 ms throughout profile.
P	surface stones larger than 25cm, in diameter		stones 16-30m apart or 0.01-3% surface covered	stones 0.75-16m apart or 3-15% surface covered	stones<0.75 m apart or 15-90% surface covered	90% surface covered
R	bedrock out-crops		bedrock 35-100m apart or 2-10% surface covered	bedrock 10-35m apart or 10-25% surface covered	bedrock 3.5-10m a part or 25-50% covered	bedrock less than 3.5m apart or greater than 50% covered.
S	shallow to bedrock or the petrocalcic horizon		dominantly more than 1m. in depth with significant portion 0.5-1m.	dominantly 0.5m with significant portion less than 0.5m	dominatly less than 0.5m.	not applicable
T	adverse topography		5-12% slopes-can include strongly rolling short slopes<5%	12-20% slopes-can include very strongly rolling short slopes <12%	20-40% slopes	greater than 40% slope.
W	rainfall flooding in depressional areas		occasional flooding of brief duration.	frequent flooding of brief duration	frequent flooding of significant duration.	not applicable

DISCUSSION DURING THE SESSION CONCERNING SOIL AND WATER MANAGEMENT FOR WHEAT PRODUCTION

LITTLE: ZAMBIA.

Did I understand you (Nyaki) correctly that, you can not predict responses to fertilizer nitrogen from the pre-planting nitrate nitrogen levels ?

A. S. NYAKI : TANZANIA

The work done so far has established that responses to fertilizer nitrogen can be predicted on the basis of soil analysis prior to seeding. However, precise nitrogen fertilizer recommendations based on soil analysis at seeding time could not be established.

K. S. GILL: ZAMBIA.

Do you consider pH as being one of the most important factors in characterizing soils in Zambia, Dr. Little ?

D. LITTLE: ZAMBIA.

It is a very important factor as far as wheat production is concerned. Particularly if you are moving to a completely new area, soil pH might be a very good guideline as to whether the area is suitable or not.

W. H. TOEWS: KENYA.

Do you have the history of the experimental sites ? How long have they been under production ? Did you consider the N supplying power of these soils taking into account that newly broken areas are expected to have a better N supplying powers compared to areas that have been under production for a long time , All these factors normally influence responses to fertiliser N.

A. S. NYAKI: TANZANIA

The cropping history of the experimental sites was taken into consideration. Some of the sites such as West Kilimanjaro and Karatu have been under wheat production quite some time compared to the newly broken areas of the Hanang District. However, there was no consistent relationship between the level of NO_3-N in the soil at seeding time and the length of time that the site had been under cultivation. The levels varied from site to site as well as from one year at the same site. However, at most of the sites the levels of NO_3 -N at seeding time were quite high at seeding time (<60 kg/ha). Responses to fertilizer N were not expected when the level of NO_3-N was greater than 60kg/ha/60cm.

SESSION 5, Thursday Morning, June 16, 1983

WHEAT CROP PROTECTION

Chairman: N. S. Sisodia

(In this session discussion followed each paper rather than a general discussion at the end of the session as had been the case for Session 1 to 4.)

THE QUELEA BIRD AS A PEST OF WHEAT IN EASTERN AND SOUTHERN AFRICA

C. C. H. Elliott

INTRODUCTION:

Many superlatives can be attached to a small 20 g. African weaver-bird, the Red-billed **Quelea quelea**. It is probably the most numerous bird in the world with its population having been estimated at between one billion and one hundred billion (Crook and Ward 1968). It occupies a vast track of semi-arid savannah in Africa stretching from Senegal to Sudan, south to Botswana. The natural food of the quelea, as it is commonly known, is almost entirely made up of wild grasses such as Panicum, Echinocloa, Digitaria and Pennisetum. Wild rice **Oryza barthii** and wild Sorghum **Sorghum purpureo-castaneum** are also commonly consumed (Ward 1965). It is therefore easy to understand why the quelea readily eats cultivated cereals which have been developed from their natural food. The quelea is probably the most serious vertebrate pest of standing cereal crops in Africa (excluding maize), and can sometimes cause severe losses to sorghum, millet, rice and wheat. Forturnately it has not learnt how to unpeel the covering leaves of maize cobs and therefore never attacks that crop. Because of its pest status, the quelea is also probably the most studied bird species in Africa. If official but unpublished reports are included with those published, the bibliography on quelea runs to over 400 titles.

The main feature of the quelea's biology is its extreme gregariousness with all its activities being performed in flocks of from a few tens of birds to several tens of thousands of birds. From the control point of view, this has the advantage that each night the birds collect together in large concentrations (sleeping roosts or breeding colonies) which can present a mass target for control operations. The quelea is also migratory and parts of the population are often on the move seeking out where rain has produced a lush production of fresh grass seed. These migrations are thought to connect up the populations of Sudan, Ethiopia, Kenya, Somalia and Tanzania in Eastern Africa and, separately, those of Mozambique, Swaziland, Zimbabwe, South Africa, Botswana and Angola in southern Africa (Ward 1971, Jaeger et al. 1981). When conditions are favourable, rapid breeding takes place usually in dense thornbush and about 40 days later, the local population can be expected to more than double. The adult generation then moves on seeking new breeding grounds and it is the juvenile generation which is left behind and which often turns to cultivated crops. Quelea are efficient gatherers of grain being able to cling to grass heads and remove all the grain quickly. Using a sack-like expansion in its oesophagus, a bird can store a large number of grains in a few minutes, and then digest it slowly later. If necessary, feeding can be compressed into the first hour after dawn and the last before sunset, or it can be completed by a series of raids into cultivated fields, each lasting only a few minutes. As a result, scaring quelea out of cultivation becomes a difficult task, requiring vigilance from dawn to dusk. Studies have shown that one man only effectively protect a maximum of one ha. of crop and will only succeed in doing so, if he has a personal interest (Pepper 1973).

CROP DAMAGE BY QUELEA - GENERAL

It is not difficult to estimate how much individual quelea consume per day and estimates vary from 2-2.5 g/day (Ward 1971) to 4.6 g/day (Elliott 1979). The problem comes in estimating the total damage that a bird can do by half-eating some grain and knocking others to the ground. For this, estimates vary from my own of about 10 g/day to 17-18 g/day (Moseman 1966) to the maximum conceived possible of 100 g/day (Jaeger & Erickson 1980). A flock of 100,000 quelea, which is not uncommon in cultivation given the right ecological conditions, could therefore damage between 1 t. and 100 t./day. The extent of the damage would depend on the state of a particular crop. If qualea attack a cereal at the milky stage, they tend to nip and destroy large numbers of grains in obtaining sufficient food. If the crop is very dry and prone to shattering, then each time a flock lands on the crop, large numbers of grain will be dislodged.

Of more interest to the farmer than the losses he suffers per bird, is the losses which each of this fields suffer. Quelea damage is typically uneven. The birds tend to attack the edges of fields first and to pick thier feeding areas near convenient bushes to which they can return after each foray. They also tend to feed heavily in the fields near to where they roost at night, stopping off to fill themselves completely full.

Damage estimates on farms can be made by attempting to select fields randomly and then following a zigzag path through the fields to collect data on the percentage loss of grain on randomly-selected grain heads examined every few paces. This can be done either visually or, as is the case of wheat, by clipping samples from the crop, sorting them in to damaged and undamaged heads and counting and weighing the difference.

Damage can vary tremendously even within one farm of a few tens of hectares and from year to year. The reasons for yearly variations are not entirely clear. In principle it has been proposed that quelea prefer wild grass seed and only turn to cultivated grain when their natural food is short (Ward 1973). While this may in general be true, in practice the situation is probably more complex. Bird pressure on cereals can vary over a few kilometres in spite of the uniform apparent availability of wild grass seed in a given area.

Under official pressure, attempts have been made to extend the estimates of losses to farms due to birds, to national estimates. This presents difficult statistical problems to the investigator since the limited number of staff available for such assessments means that only widely scattered samples can be taken. Basic information on the total hectarage of crops, especially those grown mainly by smallholders, may be lacking. Where most of a crop is grown mainly on managed state or private farms, as in the case of wheat in Tanzania, estimates can be more reliable. But the investigator also has the problem that many farm managers tend to exaggerate their losses due to birds. Bird damage is much more visible than that due to insects, disease or perhaps due to the manager's own poor management. The investigator also needs to collect his assessments over a number of years given such great annual fluctuations in the levels of bird damage.

Despite these difficulties, estimates of national damage levels have been made in Eastern Africa. The annual potential loss in Somalia, Ethiopia, Sudan, Kenya and Tanzania has been assessed at $15 million if bird control is ineffective (Anon 1981). Of this total, $2.4 million was ascribed to Tanzania. The equivalent figure for the only West African countries, Senegal, for which reliable data are available is $4-5 million (Bruggers and Ruelle 1981). These figures were based on prices, hectarage and conditions in 1975-1979, so they certainly need to be revised upwards. In bad bird years, they are probably underestimates and in drought years when bird breeding is reduced or limited, they are probably over-estimates.

CROP DAMAGE TO WHEAT

In Eastern and Southern Africa, quelea damage is known to affect rainfed wheat in Tanzania and Kenya, and irrigated winter wheat in Zimbabwe. Damage to wheat is also reported from Swaziland and Lesotho.

Only a few damage estimates have been made in Kenya. In 1978, it was estimated at 15.2% over 1200 ha. (Anon 1981). At that time, this was equivalent to a loss of $180,000. In Tanzania in the same year, losses were higher than ever previously recorded. Farm managers at NAFCO Basotu reported a 30% loss over about 8000 ha., and at West Kilimanjaro losses were catastrophic, being estimated at 80-90% and harvesting being scarcely worth-while. In 1979 the same managers estimated their losses at Basotu as 5.5% (4200 ha.), 7.8% at Setchet (3700 ha) and 11.0% at Mulbadow (2100 ha) giving a mean loss 7.5% for the 10,000 ha total, valued at $385,000.

The information provided in 1978 and 1979 was not backed up by precise measurements. It may therefore have been to some degree exaggerated, but it does show that the birds can in some years make a serious impact on wheat farms of substantial size.

In 1980, damage at NAFCO Burka was negligible. Attempts were made to take precise measurements at West Kilimanjaro and the damage was estimated at a maximum of 6%. At the Burka wheat research farm, the individual strips at the farm were assessed for damage and two late-planted fields of about 5 ha. were found on 23.8.80 to have lost 1% and 0%. The same two fields as harvest began on 16.9.80 had lost 55% and 22% respectively. A correlation was found between damage and the presence of lovegrass **Setaria verticillatum.** Quelea appeared to be attracted to the love grass and having eaten that, to move on to the surrounding wheat. Clean fields were less damaged than weed-infested fields. This suggests that the use of herbicides might give a double benefit both in reducing weed effects and in reducing the attractiveness of wheat fields to birds (Elliott and Beesley 1980).

In 1981, damage at NAFCO Basotu was again negligible, but losses at Burka were substantial with the maximum recorded in one strip being 20% and the mean for the whole farm working out at 6% (Beesley 1981). In 1982, damage at NAFCO Basotu was again negligible and the overall losses at Burka were put at 2.8% Elliott et al. 1983).

CROP DAMAGE PREVENTION

Many different methods have been tried to prevent Quelea damage in Africa. These can be broadly classified into lethal control methods by which the quelea are destroyed and non-lethal methods which can be divided into agronomic and physico/chemical methods.

The most commonly used lethal control method is to spray the birds from the air at dusk with either a fixed-wing aircraft or a helicopter, and the target being either breeding colonies nearby cereal-growing areas or night-roosts actually involved in in damage. Of the two types of targets, colony spraying is the most effective since the target remains **in situ** for about 40 days, two generations are killed at one time and after the aircraft puts a cloud of spray over the target, the birds are quick to return to their nets and therefore more readily come in to contact with the spray. Night-roosts are more unstable and can shift site from one day to the next and the birds may even leave the area in front of the aircraft and not come back in to the spray. Lethal control can be extremely effective and can cause such a reduction in the local population of quelea, that the wheat harvest can be taken in with losses to birds kept to negligible levels. The use of ground sprayers is currently being investigated with a view to providing large farms with the means to protect their crops themselves, and to reducing the cost involved in aerial spraying.

Agronomic means of preventing bird damage include the alteration of planting dates bring the vulnerable period of the crop to the time when bird pressure is naturally at its lowest. This has been shown to be possible for irrigated rice in Cameroun (Elliott 1979) but does not apply to rainfed crops where planting dates are dictated by rainfall. Even for irrigated crops, there are often other constraints which are considered more important in determining planting dates than birds, especially if serious bird damage only occurs once every few years.

One particular agronomic technique has been put forward as a method of avoiding bird damage in Tanzania. This involves swathing the wheat soon after it reaches physiological maturity. This has been claimed to solve the quelea problem at NAFCO Basotu and to have been the main reason for the negligible bird damage noted above since 1980. Unfortunately the technique has not been evaluated in detail by a bird pest specialist. In theory it is surprising if it works because quelea feed a great deal on the ground and there would seem to be no reason why they should not feed on the swath lines. It may be that the birds can only readily eat the grain on the surface of the swath line and cannot reach what is underneath. Substantial damage could still occur if the top layers of the swath were eaten. It has also been suggested that the birds do not eat the swath because they prefer eating the standard crop. This again may be true but if so, damage would increase on the standing crop and it would no longer apply when the whole crop was swathed. It is also possible that with the increasing hectarage of the NAFCO Basotu complex, the numbers of quelea are no longer sufficient to make a real impact on the farm's total yield. It has been suggested that with a yield of about 60,000 t. in 1982 (Mosha and Munisi 1983), the NAFCO Basotu farms can now afford to lose a few hundred tonnes of wheat to the birds with only a small percentage loss being recorded

It is felt that there is some likelihood that the apparent success of the swathing technique has been due more to a low bird pressure since 1980 rather than to the technique itself. In 1978 when a heavy loss was recorded in the area, there were at least three breeding colonies nearby. Again in 1979, at least one colony occurred. Since 1979, regular helicopter surveys have been made of the area surrounding the farms and conditions have been unfavourable for breeding. In 1982, extensive breeding occurred about 100 km. to the south of the farm, with 366 ha. of colonies containing an estimated 14 million birds having a reproductive potential to produce 16 million juveniles. These areas were successfully sprayed by aircraft and this may have stopped the expected northward movement of the birds which would have taken them on to the wheat.

The fact that the bird control service provided by the Ministry of Agriculture has been slowly improving since 1979 (assisted by a FAO/UNDP Project) may have had an important influence in keeping bird damage to a low level at NAFCO Basotu. It should also be noted that at Burka, despite the swathing technique having been used, damage levels have been substantial. In the Burka area, bird control operations, being directed against unstable roosts rather than colonies, have generally been less effective.

The physical and chemical methods which have been used to prevent bird damage include bird-scaring, the use of fibres and nets and the use of chemical repellents. The only one of these which is 100% efficient is the use of nets whereby the whole crop is netted in. The costs of such an exercise are prohibitive except for protecting small areas of very high value seed variety trials. Bird-scaring devices are seldom effective for more than a few days and human scarers are usually only effective over small areas and when the farm owner is watching them. Chemical repellents are expensive and have only been shown to be effective when used at high dosages which makes them useful only to protect high value crops on small hectarages.

CONCLUSION

It is hoped that the above has succeeded in describing in broad terms how and why the quelea attacks cereal crops and in establishing that it can be serious pest of wheat. It appears at present that the best method available for preventing damage to wheat is by the earial spraying of breeding colonies of the species which happen to be near wheat-growing areas. Investigation needs to be carried out in methods of dealing with roosting birds actually involved in damage, particularly the use of relatively cost-effective groundsprayers. The introduction of such a technique in eastern Africa (it is already used on a limited scale in Zimbabwe in southern Africa) would allow much greater participation of the wheat farmer in the control process.

It is also felt that the efficacy of the swathing technique needs serious detailed investigations. If it is proven to be effective even in years of heavy bird pressure, it could be presented to wheat farmers as a standard technique for use in all parts of Africa where quelea cause a problem to wheat crops.

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DISCUSSION CONCERNING THE PAPER ENTITLED

"THE QUELEA BIRD PROBLEM"

by C. C. H. ELLIOTT.

E. BECHERE: ETHIOPIA.

Is there any possibility of breeding varieties that are resistant to the Quelea bird ?

C. C ELIOTT, TANZANIA:

All of the resistant cereal varieties that have been produced thus far (and most of these varieties have been sorghums) have all been varieties which have been eaten by Quelea birds in the absence of more palatable varieties. In other words, if every one grew a less palatable variety and the birds were obliged to eat cultivated grain because their wild food were short they would eat the less palatable variety. There has been no variety developed, particularly in sorghum, which will not be eaten by starving birds.

A. S. MOSHA: TANZANIA.

At what stage of growth are Quelea birds most likely to feed on wheat ?

C. C. H. ELLIOTT: TANZANIA.

The quelea bird can attack wheat from the milk stage right on through until the wheat is fully ripe. It is actually difficult to say which stage is most susceptible but I believe they prefer wheat in the dough stage. However, if they have no choice of wheat stage they will eat at any stage.

R. BUTTON: TANZANIA.

Do the Quelea birds have any natural predators or diseases to keep the population in check ?

C. C. ELLIOTT: TANZANIA.

A consultant investigated diseases in Quelea birds over a period of one year and concluded that they were extremely healthy birds. However, Quelea birds do have natural predators but they never seem to have an effect on bird numbers. It is possible that the amount of food available is the most important factor influencing Quelea bird populations since in wet years when there is adequate food supply the Quelea bird population increases drastically.

N. S. SISODIA: ZAMBIA.

It is my understanding that the Quelea bird is not as problematic in Zambia as it is in Tanzania. It this true ?

C. C.H. ELLIOTT, TANZANIA:

Yes Quelea bird damage is not a serious problem in Zambia. Why birds do not attack Zambia's irrigated wheat as they do in Zimbabwe, I do not know. Very little work has been done in Zambia although there is a move now to develop some sort of bird control project in Southern Africa which would also involve Zambia. Perhaps this project might be able to determine why Quelea birds are not a problem in Zambia.

J. M. ORONDO, TANZANIA.

Why is there no Quelea bird problem at Njombe, Tanzania ?

C. C. H ELLIOTT: TANZANIA.

I am very much aware there is no bird problem at Njombe. There are perhaps two reasons for this. First, wheat in the Njombe region is grown at a higher altitude than any other region in Tanzania, with the possible exception of West Kilimanjaro. Also the Njombe region is quite far from the closest breeding grounds.

WHEAT CROP PROTECTION IN ETHIOPIA

Birhanu Kinfe

INTRODUCTION

It is a well known fact that weeds are a universal problem in wheat production. Wheat is very sensitive to weed competition. Despite the fact that weeds are so common and widespread, people seldom fully appreciate their significance in terms of cost of control and subsequent yield losses. Weeds are more expensive to control and the highest yield reducing factors compared to insect pests and diseases in wheat.

Although the struggle with weeds is as old as agriculture, in retrospect, weed science, has been a somewhat isolated and often neglected field of agriculture not only in Ethiopia but even agriculturally developed countries. It has gradually developed and has benefitted from the important modern technology of selective and non selective chemical weed control.

Weed control research work was started in Ethiopia in 1967 by the Swedish Ethiopian joint project in Arsi region which is the wheat belt area. Within the Institute of Agricultural Research (IAR) research on weed control started in 1969. Initially the program was supervised by the agronomy section as a part time activity. Starting from 1970 a weed science section was established in the institute. From 1976 onwards weed control research activities started to be carried out by other research organizations such as Debre Zeit Research Centre, Addis Ababa University (AAU) and Soviet Phytopathological Research Station in the Country. Todate, several weed control research projects on wheat have been carried out with the coordination of the above mentioned research organizations.

The entomology section was established earlier and had more experts than weed science. However, less research work was carried regarding insect pests problem in wheat. This could be attributed to the lower importance of insect pests compared to weeds in wheat in the country.

IMPORTANCE OF WEEDS AND INSECT PESTS

Weeds:

The infestation of weeds in wheat both at peasant and state farm levels is indeed serious. About 60% of the farmers regard weeds as the limiting factors in wheat production. In a study around this wheat belt area it was found that on the average the number of weed plants per m^2 reach 743 compared to the number of wheat plants which is 149/m^2. At times crop losses due to weed infestation in wheat was found to be 50 to 60 percent. This is attributed mainly to inadequate cultivation, use of impure seed and primitive weed control methods.

The major broad leaved weeds in wheat comprise Polygonum nepalense, Guizotia spp, Amaranthus spp. Scorpirus muricatus, Galinsoga spp., Commelina spp., Plantago spp., Chenopodium spp., Launea spp., Galium spurium, Datura stramonium, Oxalis spp., Rumex spp., Argimane mexicana and grassy weeds such as Snowdenis spp. Avena spp., Phalaris spp., Setaria spp., Digtaria scalarum, Lolium spp., Bromus spp, Eragrostis spp. and Cynodon dactylon. Of the above mentioned weed species Avena spp. and Snowdenia spp. are the most troublesome.

Control Methods:

In spite of the enormous challenge weeds pose both at peasant and state farm levels, hand weeding is the major control method used. In peasant agriculture, every member of a family is directly involved in fighting weeds by hand. In many instances farms remain unweeded or weeding is done late after weeds have inflicted serious damage to the crop. This is partly due to shortage of labour or cash to hire labour to cope with heavy flush of weeds at peak season. Hand weeding is seldom regarded as a problem worthy of scientific investigation. Nevertheless, sometimes farmers use 2 to 3 hand weedings in wheat fields regardless of the threshhold level of weed population. Although insignificant yield increase can be obtained by more frequent weeding than single hand weeding sometimes it may not pay for the extra labour cost incurred more over, in Ethiopia where the future trend is to have large cooperative farms, handweeding alone as a weed control method on extensive acreages may not be practical for it is expensive, labourous and time consuming.

At present, the use of herbicides is mainly limited to state farms and agricultural research stations where the scale of operation, quality of work and the available resources, seem to command their utilization. About 4% of the farmers are using herbicides as a supplementary weed control method to hand weeding.

Some of the widely used herbicides on large acreages of wheat, maily at state farm levels are Phenoxy or U-46 herbicides (24D, MCPA, Dichloroprops) and Britox for the control of broad leaved weeds, Terbutryne for the control of grassy weeds, and illoxan, suffix as well as Avenge for the control of Avena sp.

The major insect pests

There are very few insect pests of wheat in Ethiopia. In most seasons they are of little importance, but occasionaly can become a problem.

Worth mentioning are:

Aphid species. The five species of aphid identified are Duraphis noxius, Rhopalosiphum maidis, Schizophis graminus, Sitobion avenae and Rhopalosiphum padi. In 1978, Aphid sp. mainly D. noxius resulted in more than 95% of crop loss in one of the wheat growing areas. This insect is still present with low population on wheat with no significant impact on crop yield.

Control: Early date (mid July) of planting.
Systemic insecticides (Dimethoate, Phosphamidon)

Barley fly (Helemya arambourgi) This insect attacks both barley and wheat. In some fields most plants are attacked, but since the degree of recovery seems to depend on several factors the most importent of which may be nutrient status of the soil, the yield loss is difficult to state. Hence, significant crop loss was not recorded due to this insect.

Control: delay in planting
Seed dressing with insecticides
resistant variety.

Army worms:- Spodoptera spp. most likely S. exempta is also claimed to be serious in some years. Its attack is said to be irregular, the fields invaded about the end of July and at the beginning of August, which is the wet season after a prolonged dry period. In 1976 there was a serious outbreak in some of the wheat growing areas.

Control: DDT dust, Malathion, Endosulphan.

Cut worms: Agrotis spp. are frequently reported by farmers. They damage roots of cereals in the beginning of August when the crop is in its young stage. The crop loss due to this insect is insignificant. Hence no control method is used.

Storage pests: Rice weevil (Sitophilus oryzea) is the most important pest. According to the farmers report the pest causes losses but definite estimate is not known up to now. Presumably, the total loss does not exceed 10-15% though severe damage is likely to occur at lower altitudes.

Control: Use of Actellic dust, DDT dust, Folithion, Lindane, Malathion.

RESEARCH ACTIVITIES

Weed control

Some of the major ongoing research activities are:-

General weed population survey has been conducted to assess the impact of weeds on crop production and identify the major weed species in different regions of the country.

Crop loss assessment due to weed competition.

Effect of cultural practices (hand weeding, cultivation, seed rate, swing date, on weed control.

Screening of promising herbicides compared with hand weeding in wheat.

Promising herbicides from previous years' trials are tested on a large scale basis at peasant and state farms.

Entomology

General insect pests survey to assess their importance on the crop.

A study on the effect of cultural practices and insecticides in the control of aphid species, grasshoppers and army worms is carried out in outbreak areas.

CONSTRAINTS:

There is a shortage of trained man power in crop protection. There is no expert in the country with full specialization in weedscience although there are a few entomologists. Hence, most of the weed control research activities are carried out either by agronomists or crop protection personnel. The field of weed science is more neglected than entomology. It was only 3 years ago that a weed science course was started for students in crop science in the College of Agriculture.

Many farmers are interested in innovation in control of insect pests and weed control methods. Nevertheless, there is lack of communication between the researcher and users. Also, lack of knowledge in the use of pesticides coupled with insufficient supply or unavailability of materials contributes much to ignorance of the peasant farmer about the use of new technologies in crop protection.

There are only limited quarantine measures to prevent the introduction and/or spread of insect pests or weeds. Moreover, there are no pesticide registration and regulatory mechanisms in the country.

WEED COMPETITION IN DRYLAND WHEAT IN MALAWI

P. H. Mnyenyembe

SUMMARY

Effects of weeds on wheat (Triticum aestivum) were studied at Tsangano, Bembeke and Makhanga from 1979/80 to 1981/82 seasons. Weed competition for more than 40 days significantly reduced grain yields at all sites in all seasons. When weeds were competing for the whole season (±150 days), grain yields were significantly lower (p=0.1) in all three seasons. Grain yields were related to number of tillers per square meter and number of ears per meter row. Mass of individual grains had very little influence on the yield of wheat.

INTRODUCTION

Wheat was considered as a very minor crop in Malawi until recently. Farmers grow wheat on a very small scale for their own use and sold the surplus to local traders or Agricultural Development and Marketing Corporation (ADMARC). Recently wheat was upgraded as one of the major crops in Malawi and as a result wheat production on small farms has increased rapidly in many of the cool highland areas.

Weeds were present in a number of crops and there was no knowledge of the effects of weed competition. Consequently, an experiment was initiated in 1979 to investigate the competitive effects of weeds on wheat and to determine the critical period of weed interference for wheat.

Thomas and Schwerzer (1976) who worked on weed competition in Zimbabwe found that competition had no effect on mass of individual grains and only a slight effect on the number of ears produced. Similar studies in Turkey by Mann (1975) showed that higher yields can be obtained when wheat is weeded at 40 days than when weeded at 75 days or not weeded at all. Jooste (1969) reported that the earlier weeds were controlled, the higher the yields and suggested that if herbicides are used, the application should be at three-leaf stage in preference to five-leaf stage of wheat.

METHODS AND MATERIALS

The experiment was conducted in three successive years. A recommended variety (Kenya Nyati) was drilled at a seeding rate of 80kg/ha in 30cm rows. Fertilizers were broadcast at the rate of 60kg/N/ha and 40kg P_2O_5 /ha all at planting. Planting took place from early to Mid-March depending on soil moisture at planting.

Two sets of treatments were used plus two controls. The first set of treatments was free of weeds for the first 10,20,30,40, 50, or 60 days then left unweeded up to harvest. The other set included no weeding for 10,20,30,40,50 or 60 days then kept weed free up to harvest. The two controls included no weeding and weed free up to harvest.

Once the wheat and weeds were established, differential treatments were applied with four replications of each treatment in a randomized block design. All weed control treatments were done by hand hoe.

Parameters taken were grain yield, plant height, percent lodging, ears/m-row, tillers/m and 1000 grain weight or test weight. The crop was harvested in late-July to early-August. Grain yield was determined from an area of $6m^2$ from each plot.

RESULTS

Tables 1 and 2 show the effects of different treatments on grain yield components.

Plots which were not weeded for the whole season gave significantly lower yields than most others treatments. There was no significant yield reduction in plots which were weedy for the first 30-40 days at all sites.

Table 2 shows the effect of weeds on other agronomic data. Plots which were weedy for more than 30 days resulted into significantly less tillers/m^2 and shorter ear length. Plant height and 1000 grain weight or hectoliter mass tended not be affected much by weed competition.

DISCUSSION

In the three seasons weed competition for more than 40 days had a big effect on the grain yield (Table 1). Weeds which competed for at least 30 days did not reduce yields significantly. However, in this experiment weed competition had less effect on wheat than recorded in other countries. Thomas and Schwerzer (1976) working on weed competition in Zimbabwe found similar results and suggested that probably weeds in the tropics have less effect on yield of wheat because wheat in the tropics matures in approximately ±150 days while in other countries wheat mature in excess of 180 days.

The difference between our results and those elsewhere may be due to types of weeds present in wheat fields in Malawi. Competition had only a slight effect on plant height and 1000 grain weight. This most likely so because wheat grown under dryland conditions in Malawi uses residue moisture in the soil which is not very available on the top soil to germinate most weeds which are very abundant during summer.

These results indicate that an effective weed control programme that can keep wheat free of weeds for the first month should give reasonable yields. This is the period when crown root is being formed and the elongation, the initiation of tillering and reproductive parts are at their maximum. Competition with weeds at this stage will retard the development of reproductive parts: hence less tillers resulting into less grains per plant thus low yields.

CONCLUSION:

From the results it can be said that the final yield of wheat is unaffected by the presence of weeds up to a particular stage after crop emergence, if the weeds are then removed and the crop is kept clean. Conversely, if kept free of weeds up to some growth stage, weeds that emerge and develop subsequently do not affect the yield. In between these stages 30-40 days there is a period during which weeds must be eliminated if high yields are to be obtained. This period is termed as critical period of weed competition (Friesen 1979) and once known can have practical value in defining the requirements for chemical and cultural control methods.

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Table 1. Wheat grain yield (Kg/ha) as influenced by different periods of weediness in three seasons

		1981/82			1980/81		1979/80		
	Treatment	Bvumbwe	Tsangano	Bembeke	Bvumbwe	Tsangano	Tsangano	Makhanga	Mean
1	F10	3050	3133	3567	1150	1900	1700	2200	2386
2	F20	3133	3417	2716	1633	2250	1783	1433	2337
3	F30	3083	3566	3150	1383	2200	2363	2400	2592
4	F40	3000	3350	3383	1350	2300	2008	2533	2561
5	F50	3167	3167	2950	1700	2083	1717	2267	2435
6	F60	2800	3400	2517	1550	2267	1867	3250	2522
7	W10	3250	3150	3783	1700	1967	2100	2683	2661
8	W20	3050	2550	3500	1467	2200	1450	2267	2354
9	W30	2717	3000	3450	1317	2117	1675	2433	2387
10	W40	1417	2417	3067	1417	1783	1467	2467	2005
11	W50	1383	2700	2733	1250	1767	1483	1750	1867
12	W60	1333	2617	2400	1183	1650	1450	1383	1717
13	CF	3383	2733	3967	1567	2467	1692	3283	2727
14	CW	1083	2733	1816	1017	1783	1575	733	1534
	Mean	2560	3000	3133	1407	2404	1738	2217	—
	SE	±157.1	±206.1	±364.0	±129.4	±130.7	±227.0	±267.0	—
	CV	8.7%	13.7%	23.3%	18.5%	10.9%	26%	25.0%	—

F 10,20 = Free of weeds for, 10,20 days etc

W 10,20 = Weed Infested for 10,20 days etc

CF = Control free of weeds up to harvest

CW = Weed infested up to harvest

Table 2.

		BVUMBWE			TSANGANO		BEMBEKE	
		Hgt (cm)	Tillers/M²	Ear Length (cm)	P/nt Hgt (cm)	Ears/M - row	P/nt Hgt (cm)	Ear Length (cm)
1.	F10	71	280	57	73	79	71	68
2.	F20	74	290	57	74	83	74	70
3.	F30	73	229	52	75	87	72	66
4.	F40	73	280	55	72	81	71	66
5.	F50	75	305	60	72	86	69	68
6.	F60	75	276	60	71	85	68	69
7.	W10	74	280	63	70	69	71	70
8.	W20	75	277	60	71	67	73	71
9.	W30	73	240	55	72	74	69	68
10.	W40	73	178	50	70	68	66	66
11.	W50	75	137	48	82	76	66	68
12.	W60	75	129	54	71	68	69	63
13.	CF	77	278	62	68	85	71	70
14.	CW	73	162	48	77	76	71	66
		74	238	55	72	77	70	67
		±1.35	±23.1	±2.25	±2.4	±4.6	±1.58	±0.27
		3.7%	19.3%	8.2%	4.6%	12.1%	4.5%	7.3%

PROGRESS ON WEED CONTROL IN WHEAT IN TANZANIA

M. J. Mkunga

INTRODUCTION

Weeds are increasingly becoming a serious problem in wheat production in Northern Tanzania. The following weeds have been noted to be of economic importance; annual grasses such as Lovegrass (Setaria verticillata), Eragrostis spp and wild sorghum (Sorghum verticilliflorum); sedges such as nutgrass (Cyperus spp). annual broadleaved weeds such as Chinese lantern (Nicandra pysalodes), Thorn apple (Datura stramonium), Mexican poppy (Argemone mexicana) and Red root pig weed (Amaranthus retroflexus). The good growing conditions for wheat such as ample soil moisture and nutrients are also excellent growing conditions for weeds. Weeds have generally been observed to have more competitive ability over wheat in terms of moisture utilisation and nutrient uptake the end result being severe yield reduction. At the Hanang Wheat Complex, lovegrass (S. verticillata) has been noted to provide temporary cover for the Quelea quelea birds.

CULTURAL WEED CONTROL

Tillage is by far the most common method of cultural weed control in use. The number of tillage operations to be carried out on a particular field depends upon the prevailing weather conditions, previous weed control management, previous crop(s) grown in the field, the extent of weed infestation and the kinds of weeds growing at that particular time. In areas like Arusha where the rainfall pattern is bimodal (short and long rains) and the wheat crop is grown during the long rains period, not less than four tillage operations are required to keep down the high population of weeds during the post-harvest period prior to seeding.

Tillage alone can not produce a desirable level of weed control required in a growing crop of wheat. Together with tillage there should be a careful choice of seeding date. The seeding should be done when conditions are ideal for rapid, even germination and emergence of wheat. The wheat seed must be free of weed seeds and of high quality, an optimum seed rate should be used and the seeding depth properly adjusted on the seed drills. These are some of the recommended practices and if carried out they are expected to give the wheat crop a competitives advantage over the weeds.

Efforts to control weeds by cultural practices are not always fruitful. In most cases flushes of weeds are experienced following seeding and subsequent rainfall. In such situations the logical answer is chemical weed control.

CHEMICAL WEED CONTROL

Specific Chemical Weed Control research projects have been designed and most of them are still in progress. These research projects are of the screening nature aimed at identifying herbicides which give the best weed control and crop tolerance under our local conditions.

The broad objectives of the chemical weed control program are:-

To determine the efficacy of herbicides recommended for the control of grass weeds in wheat on annual grasses such as lovegrass (S. verticillata).

To determine the efficacy of herbicides recommended for the control of broad-leaved weeds in wheat on annual broad-leaved weeds such as Thorn apple (Datura stramonium).

To determine the tolerance of wheat to the applied herbicides.

Materials and Methods

The trials have been conducted at Basotu Plantations Ltd in the Hanang Wheat Complex and at A.R.I., Arusha. At Basotu the lovegrass control experiment was located on a clay loam soil classified in the order Mollisols (M. Fenger, V. Hignett and A. Green, Soil Survey Report of Basotu Map Sheet, 1982) while at Arusha the chemical weed control trials were located on a loam to silt loam soil classified in the order Inceptisols (R. MacMillan, Soil Survey Annual Report 1982). At both locations the experimental sites were prepared with a cultivator fitted with 40cm wide shovels. The Mbuni variety of wheat was seeded in all trials at the recommended rate of 110kg/ha with a double disc press drill.

The experiments were conducted in randomised complete block design. The gross treatment plot area was $64m^2$ (16m x 4m) and the net plot area was $12m^2$.

The herbicides were applied with a power-operated bicycle wheel sprayer fitted with 80° nozzles. The sprayer was calibrated to deliver 100 litres of solution per hectare at a pressure of 2·81 kg/cm^2. In most cases the herbicides were applied at a rate and stage of crop and weeds recommended by the manufacturer.

The visual ratings of tolerance of wheat to applied herbicides and weed counts were carried out when the crop had headed out. The weed counts were carried out using an appropriate quadrant which was placed three times at random in each plot. Weeds enclosed by the quadrant were counted and recorded.

The harvesting of wheat was done with a plot combine by cutting an area of $12m^2$ in each plot. The plot samples were then cleaned and weighed.

Evaluations:

(i) Weed counts were used to compute Percent Effectiveness Indices (P. E.I.) for the various herbicides. This technique serves as a means of ranking the herbicides in terms of efficacy on the target weeds.

$$PEI = 100 - \frac{(X \text{ in treated plot} \times 100)}{(X \text{ in control plot})}$$

where X = Mean weed count.

(ii) Tolerance of wheat to applied chemicals was rated on a 0 to 9 scale, where

0 = No tolerance (ie complete crop kill).

9 = Complete crop tolerance.

(iii) Grain yield was analysed statistically.

Results and Discussion

1. Lovegrass herbicides trial in wheat.

Table 1 Lovegrass control with miscellaneous herbicides at Basotu, 1981 and 1982 (P.E.I., Tolerance and grain yield).

TREATMENT CHEMICAL	RATE a.i.kg/ha	P.E.I.		TOLERANCE	GRAIN YIELD kg/ha	
		1981	1982	1982	1981	1982
isoproturon	1.5	95	89	8	2,560	1,840b
control	—	—	—	—	2,000	770d
metoxuron	4.0	96	91	6	2,100	1,010cd
diclofop-methyl	0.71	92	91	8	2,630	1,560b
diclofop-methyl + bromoxynil	0.74+0.33	—	94	8	—	2,280a
propanil	10.2	73	77	8	2,520	1,130c
propanil + MCPA	0.99+0.28	—	83	8	—	1,180c
						MEAN = 1342 LSD 5% = 290 CV = 14.9%

From the data above it is apparent that isoproturon, diclofop-methyl, metoxuron, and mixture of diclofop-methyl and bromoxynil gave the best control of lovegrass. The perfomance of diclofop-methyl has been consistently better ever since it was introduced in the trial, while metoxuron has always given good weed control results but grain yield has remained below expectations, probably due to a fair amount of crop damage noted in plots sprayed with the chemical.

The effect of propanil needs more observation because its relative performance in 1981 was far better than in 1982 although efficacy on lovegrass has remained almost the same for the two seasons. A mixture of propanil and MCPA was introduced in the trial and it showed good weed control which was probably due to presence of MCPA which broadened the weed control spectrum.

2. Broadleaved weed control in wheat.

Table 2. Broadleaved weed control (PEI), tolerance and grain yield, 1982, Arusha.

TREATMENT CHEMICAL	Rate a.i. kg/ha	P.E.I		Crop tolerance	Grain Yield kg/ha
		Argemone mexicana	Portulaca oleracea		
Control	—	—	—	9.0	2,560
MCPA	1.20	100	100	8.5	2,750
bromoxynil	0.35	100	68	8.5	2,750
dicamba + CMPP	0.10+1.62	100	100	8.5	3,060
dicamba	0.12	80	100	8.0	2,560
2, 4-D ester	0.56	100	100	8.5	3,290
2, 4-D ester	0.84	100	100	8.0	2,800
					MEAN=2,820
					CV = 15.1%

The F-test (Analysis of Variance) indicated no significant yield difference among the treatments.

The major broadleaved weeds which were prevailing at the site at the time of herbicide application were (in order of decreasing abundance) chinese lantern (Nicandra physalodes), Mexican poppy Argemone mexicana), thorn apple (Datura stramonium), Lamb's quarters (Chenopodium album), purslane (Portulaca oleracea) and pig weed (Amaranthus sp). Most weeds were effectively controlled by all the five applied herbicides. The major exceptions occurred with dicamba and bromoxynil which did not give effective control of Mexican poppy and purslane, respectively.

3. Mexican poppy (Argemone Mexicana) control in wheat.

Table 3 Mexican poppy (Argemone mexicana) control by various rates of 2,4-D alone and 2,4-D mixed with dicamba in 1982 at Arusha.

TREATMENT	Rate of Application a.i. kg/ha		P.E.I. (Argemone) (mexicana)
	2,4-D amine	dicamba	
T1	0	0	—
T2	0.28	0	63
T3	0.56	0	78
T4	0.84	0	91
T5	0	0.11	68
T6	0.28	0.11	89
T7	0.56	0.11	95
T8	0.84	0.11	98

The control of Mexican poppy (Argemone mexicana) was better in plots sprayed with 2,4-D amine at the 0.56 kg/ha a.i/ha and 0.84 kg a.i/ha rates of application. The addition of 0.11 kg a.i/ha of dicamba with each of the three rates of 2,4-D improved the overall efficacy on the Mexican poppy. 2,4-D amine at 0.28 kg a.i/ha and dicamba at 0.11 kg a.i/ha did not control the weed effectively. Late infestations of Mexican poppy were observed in plots treated with dicamba alone, and 2,4-D alone at the rate of 0.28 kg a.i/ha The weed was at flowering stage when the wheat was harvested.

Crop tolerance to all the treatments was generally good. Slight crop deformities were noted on wheat sprayed with 2,4-D alone at 0.84 kg. a.i/ha but not in sufficient amounts to warrant lower ratings in crop tolerance.

WHAT FOR THE FUTURE

(i) The screening of herbicides recommended for the control of grasses and broadleaved weeds in wheat should continue.

(ii) A combination of tillage and herbicide work on nutgrass (Cyperus spp) will be initiated.

DISCUSSION CONCERNING THE PAPER ENTITLED "PROGRESS IN WEED CONTROL IN WHEAT IN TANZANIA"

B. KINFE, ETHIOPIA:

What is the correct time for application of illoxan?

M. J. MKUNGA: TANZANIA

The correct time for illoxan application is the two-to three-leaf stage of the grassy weed. However, the crop can tolerate illoxan at any growth stage.

C. C. H. ELLIOTT: TANZANIA.

I understand that aerial spraying was carried out on the Hanang wheat farms this year. Was this spraying designed to control lovegrass and if so, was it effective ?

M. J. MKUNGA, TANZANIA.

There was aerial application of a tank mix of arelon and 2,4-D. Broadleafed weeds were controlled well but the arelon was not effective against lovegrass because it was applied at the five-to six-leaf stage which was far too late

WEED CONTROL IN WHEAT IN KENYA

E. H. Stobbe

SUMMARY

Wherever wheat is grown, weeds severely reduce the yield potential of the crop by competing for water, light and nutrients.

Weeds vary in their competitive ability with wheat. In most cases, weeds do not grow in monoculture, but rather as a mixed stand. Since weeds are difficult to control in wheat using manual labour, most farmers rely on herbicides to control the weeds.

Many herbicides are available that selectively control weeds in wheat. However, no single herbicide can effectively control all weeds in wheat. Identification of weeds in the seedling stage is essential in order to select the best herbicide to be used. In some cases 2 or more herbicides will have to be used in combination or sequentially to obtain control of all weeds in the field.

HERBICIDES FOR BROADLEAF WEEDS CURRENTLY AVAILABLE IN KENYA:

1. Buctril M or Brominal M.

Advantages: Inexpensive. Controls wide spectrum of broadleaf weeds. Good to excellent control of mustard family, black bindweed, lambsquarter, goosefoot, Mexican marigold, **Datura** spp., black nightshade, fair control of Chinese lantern, gallant soldier, pigweed, black jack and poor control of devils thorn, double thorn and knotgrass. Excellent crop tolerance.

Disadvantages: Weeds must be small. Requires good spray coverage.

2. Maytril.

Advantages: gives excellent control of all weeds mentioned under Buctril M. Additional weeds - cleaves, mallow chickweed, cape gooseberry. Excellent crop safety.

Disadvantages: More costly than Buctril M.

3. Banvel Combi.

Advantages: Controls similar spectrum of weed as Maytril, but at a slightly lower level of control. Less expensive than Maytril.

Disadvantages: Some crop injury has been observed. Must be applied early to avoid crop injury.

4. 2, 4-D amine and 2, 4-D ester.

Advantages: Cheap, controls members of mustard family. Disadvantages: Narrow spectrum of control. Crop injury when applied early or at high rates. Can cause severe drift damage to adjacent susceptible crops.

HERBICIDES USED FOR GRASS WEEDS CURRENTLY MARKETED IN KENYA:

1. STOMP.

Advantages: Pre-emergence herbicide for **Setaria** spp. control. Very effective-controls more than 1 flush of weeds.

Disadvantages: Assume that there is a **Setaria** problem. Requires water for activation.

2. SUFFIX BW.

Advantages: Controls wild oats in a wide range of stages.

Disadvantages: Cannot mix with broadleaf herbicides.

3. ILLOXAN.

Advantages: Controls wild oats, ryegrass, club goosegrass, and some control of Setaria.

Disadvantages: Expensive. Cannot be mixed with broadleaf herbicides. Less effective under dry conditions.

4. IGRAN.

Advantages: Controls **Setaria** spp., Club goosegrass and many broadleaf weeds including the mustard family, Mexican marigold, black bindweed, black nightshade, Chinese lantern, pigweed, double thorn, devils thorn.

Disadvantages: Crop tolerance is rate dependant, effective rate varies with soil type.

5. DOSANEX.

Advantages: Controls **Setaria** spp. and gives marginal control of some broadleaf weeds.

Disadvantages: Scortching of the crop may occur. Control may be erratic.

Good weed control requires knowledge of the weed problem and when and how the effective herbicide must be applied. Application equipment must be used that applies the spray solution uniformly.

DISCUSSION CONCERNING THE PAPER ENTITLED "WEED CONTROL IN CEREALS" BY E. STOBBE: KENYA.

D. G. TANNER, TANZANIA.

Is cyanazine at all toxic to wheat ?

E. STOBBE, TANZANIA.

At the rates that we were using there was no crop injury. However, last year cyanazine was applied at only four-to five-leaf stage. This year we shall be applying it from the three-leaf up to beyond the eight-leaf stage of the crop so that we should have much better information after this year. Cyanazine seemed to give very broad spectrum weed control and at the rate we were using, it shouldn't be an expensive compound either.

CONTROL OF KIKUYU GRASS

M. Kamidi

(read by E. Stobbe)

Kikuyu grass **(Pennisetum clandestinum)** is a wide spread weed in East Africa. Studies have been initiated to evaluate cultural and chemical control of kikuyu grass and a combination of these two methods to establish a method that gives maximum control of kikuyu grass. Studies are also being conducted to determine what time of the year kikuyu grass should be controlled to give the most effective control and the highest crop yields.

In comparing tillage implements it was evident that the chisel plough was not suitable for kikuyu grass conrol under the prevalling condition of a dense cover of kikuyu grass. The chisel plough kept plugging, leaving large heaps of kikuyu grass rhizomes making the seedbed too rough for seeding. It would appear a mouldboard plough or disc harrow is required in the initial tillage opeation.

Glyphosate gave good control of Kikuyu grass regardless of when the spraying was done. The control of kikuyu grasss was similar when tillage operations follow glyphosate application after four to twenty one days. When spraying was done in October and tillage delayed up to April poor control of kikuyu grass resulted. All the plots sprayed on October had significantly higher yields than plots sprayed in April. Since the amount of kikuyu grass in the plots was not significantly different (except for the plot sprayed in October and tilled in April), it would appear that the difference in the yield of wheat was not due to the amount of kikuyu grass, but was due to some other factor(s). It would appear that kikuyu grass which was left to grow during the off-season utilized much of the stored soil moisture resulting in lower yields of grain in the following year. It is also possible that decaying kikuyu grass produced toxic exudates which caused the decrease in grain yield. Our results would suggest that to obtain good kikuyu grass control and high grain yield, glyphosate should be applied as soon as the crop is harvested.

In crop kikuyu grass control can be obtained when growing sunflowers. Fusilade, EPTC and a combination of these two were evaluated at varying rates in sunflowers. All the treatments showed good control of kikuyu grass, with fusilade and a combination of fusilade and EPTC showing excellent control. These two chemicals are promising in the control of kikuyu grass in sunflowers. Kikuyu grass could, therefore be controlled if sunflowers are grown inrotation with wheat.

DISCUSSION CONCERNING THE PAPER ENTITLED "CONTROL OF KIKUYU GRASS"

BY M. KIMIDI READ BY E. STOBBE.

P. GROOT: ZAMBIA.

Have you done any work concerning the relative susceptibility of various wheat cultivars and various weed species to herbicides ?

E. STOBBE: KENYA.

We have not investigated variation in tolerance to herbicides among wheat cultivars. However, we do know that if one weed is controlled well by a herbicide another weed species may pop up and become very problematic. In one barley growing area of Kenya wild oats were numerous. These were controlled very well by the application of herbicides such as avenge. After the wild oat problem had been brought under control, ryegrass became a problem which was subsequently controlled by illoxan whereupon bromegrass became a problem. Unfortunately, bromegrass is not as easily controlled. Therefore, we do have shifts in weed populations. We have also observed this in broadleafed weeds. Those broadleafed weeds easily controlled by 2, 4-D are no longer around.

R. LITTLE: ZAMBIA.

Concerning the cultural control of Kikuyu grass we found that using disk ploughing helped tremendously because the disk harrow helped cut up the sword so that there weren't enormous clods to cope with later.

E. STOBBE: KENYA.

In essence that is that we have done this year. We tried to avoid that up until this year because we feared that disk harrowing would cut rhizomes into small pieces and simply spread the grass problem.

R. BUTTON: TANZANIA.

What are the economics of wheat production in Kenya particularly where herbicides are used to control weeds ?

E. STOBBE: KENYA.

Although Mr. Mulamula pointed out our average yield is about 25 bags per hectare we have some farmers who are getting up to 25 bags per acre. Such yields are very profitable even where some farmers are using such expensive herbicides as stomp. In fact if they don't use it they get no crop at all. I should also mention that we don't have to make those decisions for the farmers because they are the ones that are footing the bill and reaping the profit. I also feel strongly that we should look for cheaper alternatives, particularly in developing countries where foreign exchange required to buy herbicides is very limiting.

B. KINFE: ETHIOPIA:

How easy is it for farmers in Kenya to secure herbicides ? This is one of the major problems we have in Ethiopia where chemicals are not readily aveilable to the farmer.

E. STOBBE: KENYA.

I think we are fairly fortunate in Kenya in that if a product is of value, the chemical companies are still able to get a licence to import it. One of he problems that we sometimes have is that the licences are not issued quite early enough and consequently the products may not be available at the right time.

NUTGRASS, THE MENACE OF THE TROPICS
L. Friesen

Sedge weeds are very common in the tropics and sub-tropics and in many fields are the worst weeds present. There are many different species of sedges (357 have been identified in East Africa) and this tremendous diversity, combined with the large amounts of intra-specific variability they display, makes identification often very difficult.

Correct identification is essential as they differ in their susceptibility to herbicides and cultivation methods. Five species of sedge weeds have been identified as being common (and troublesome) weeds in the vicinity of NPBS, Njoro, Kenya. They are Cyperus bulbosus var. melanolepis, Cyperus stuhlmannii, Cyperus rotundus, Cyperus esculentus, and Kyllinga pulchella.

Most sedges possess underground vegetative reproductive structures (tubers, bulbs, and/or rhizomes), thus, they are difficult to control and nearly impossible to eradicate once established. Many of these tubers and bulbs initially are dormant, and some are present in the soil 15-30cm deep rendering traditional means of weed control (i.e. tillage) ineffective, unless one is willing to fallow the field for 3 or 4 consecutive years.

In discussing herbicidal control of sedge weeds one must make the important distinction between eradication and season-long control. Currently, the only single-treatment chemical application that results in the eradication of all sedge weeds in the treated area are soil fumigants, such as methyl bromide. All other chemicals (both selective and non-selective herbicides) offer only imperfect control.

It is also important to realize that sedge species vary in their susceptibility to specific herbicides; application of a certain herbicide may be very effective in controlling one species and totally ineffective against other species.

EPTC (Eptam) and butylate (Sutan), pre-plant incorporated herbicides, when used at 3.0 to 5.0 kg/ha, give 3-month, selective control of sedge weeds in sunflowers. Equivalent sedge control should also be attainable in maize using the Eradicane and Sutanx formulations.

Alachlor (Lasso) and metolachlor (Dual), pre-emergence herbicides, also offer 2 to 3-month selective control of sedge weeds in sunflowers and maize. These herbicides require rainfall after application to be effective. However, more research is required before recommendations can be made.

Currently, the only marginally-effective, post-emergence, selective herbicide for sedge control is bentazon (Basagran). Researchers working with this compound have reported very mixed results. These mixed results may in part be due to the species present in the trials. It is selective on wheat, maize, and certain other crops.

The post-emergence, broad-spectrum, non-selective, non-residual herbicides paraquat (Gramoxone) and glyphosate (Roundup) offer fair-to-good control of sedge weeds when applied at 1.0 to 2.0 kg/ha. Glyphosate is translocated within the sedge plant and affects the viability of attached tubers and bulbs, whereas paraquat kills on contract only (i.e. kills only shoot growth). Repeated applications of glyphosate, over a long period of time shold result in eradication.

Two new herbicides (still undergoing pre-registration tests), glufosinate (Basta) and AC 252, 925, seem promising for sedge control. Glufosinate, also a broad-spectrum, non-selective, non-residual herbicides is similar to glyphosate, although it is not translocated to the same extent as glyphosate. AC 252, 925 is a residual, broad-spectrum, non-selective, highly translocated, soil active compound which demonstrates good activity against sedge weeds at rates as low as 0.25 kg/ha.

DISCUSSION CONCERNING THE PAPER ENTITLLED
"NUTGRASS, THE MANAGE OF THE TROPICS" BY L. FRIESEN, KENYA.

E. TORRES: CIMMYT, E.A.

Have there been any efforts made towards biological weed control with fungi or other pathogens in this region ? I am referring specifically to nutgrass. Rusts have been used very effectively to control some species of **Cyperus** in other parts of the world.

L. FRIESEN: KENYA.

I haven't heard anything about the use of rusts to control sedge grass. However, a moth to control sedge was tried in the United States but was not effective because some other organisms were parasitizing the eggs of the moth.

K. S. GILL: ZAMBIA.

Where human labour is readily available shouldn't mechanical weed control be considered as the preferred technique when compared to chemical weed control particularly for the small farmer who can afford to buy herbicides ?.

E. STOBBE: KENYA.

Actually, farmers in Kenya are much more willing to use chemicals than one would expect. Most of our farmers are growing only as much crop as they can hand weed. They don't produce a crop on the whole field because they don't have enough hand labour to control the weeds.

P. GROOT: ZAMBIA.

I think there is a lot of research on chemical weed control. On the other hand as Dr. Gill indicated there is very little research concerning agricultural practices such as rotations, mixed cropping and winter ploughing to control weeds. In my view the kind of research that is going on at the moment is not balanced.

E. STOBBE: KENYA.

Mechanical weed control has been practiced for very many years but this technique was not found to be satisfactory. Hand weeding for example is a very tedious job and herbicides will help a lot in alleviating this problem.

P. GROOT: ZAMBIA.

It is also useful to look into the influence of other agricultural practices such as tractor ploughing on weed control. Such practices might actualy promote weed infestations. In Zambia for example, nutgrass populations have increased since the early seventies with the introduction of tractors for land preparation. Before the early seventies there was not much problem with nutgrass. So, I think method of land preparation might influence weed infestations.

N. S. SISODIA, ZAMBIA.

I think we should all appreciate that both chemical and cultural weed control practices are important and both have their respective places in different farming systems. In India, for example, weeds like nutgrass are very notorious and they occur in patches in the field. To control this weed, farmers spread some organic manure or wheat straw on the nutgrass patches which release some heat upon decomposition which in turn controls the nutgrass to some extent. Some farmers have modified their row widths in order to facilitate certain tillage operations which would result in better weed control. Recently farmers are moving slowly to fixed row planting whereby the farmer cultivates and applies fertilizer or green manure only in those rows that are to be planted. He then uses a wide blade to keep the area between the planted rows weed free. These are kinds of systems which the farmer himself with his own experience can develop. Of course we should not underestimate the importance of chemical weed control in large commercial situations.

SOME RESEARCH ON THE BIOLOGY AND CONTROL OF Bromus pectinatus

D. Wilcox

In many of the cereal and oilseed growing areas of Kenya, annual brome, Bromus pectinatus, is considered to be a major weed problem. Studies on the biology of annual brome and of procedures for its cultural and chemical control have been conducted over the past year.

Germination studies on annual brome have shown that the hull must be completely removed or else pricked before germination of freshly harvested seed will occur Removing the rachilla segment off of these hulled seeds also promoted germination. Exposure to continuous light during germination inhibited germination of dehulled annual brome seeds by as much as 49%. Soil p^H also influenced germination of annual brome. Optimum soil p^H for germination occured in a p^H range of 5.5 to 6.0. Annual brome seeding depth, to 8cm, did not influence germination. However, emergence decreased as seed depth increased.

In the field, when seeding was delayed into a prepared seedbed, the bromegrass emerged before the cereal and resulted in grain yield reductions which were correlated with the length of the delay. When the cereals were seeded 19 days after seedbed preparation Tumaini barley yield was reduced 47% and Paa wheat yield 37% as compared to the yields when the cereal was seeded 3 days after seedbed preparation

In wheat the herbicides Sencor. Glean, Isoproturon and Avadex BW were evaluated for their control of annual brome. Results of one season of field trials indicate that, of the four herbicides, Sencor and Glean are the most promising. In rapeseed the herbicide Fusilade was evaluated and it gave excellent control of annual brome.

In a pot experiment, a rate of 1.5 1/ha Roundup plus surfactant was shown to kill annual brome. A suboptimal rate of Roundup (0.5 1/ha + surfactant) induced increased tillering in surviving plants. Application of Roundup on young annual brome plants resulted in more complete kill than when applied at later growth stages.

CLOSING REMARKS

E. TORRES, CIMMYT, E.A.

On behalf of CIMMYT I would like to express our gratitude and our appreciation to TARO for the good hospitality given to all of us here, to the collegues of TARO and the Canadian team in Arusha for their involvement in the preparation of this workshop and very particularly to Doug Tanner and the members of the organizing committee for the very splendid arrangements and the flawless execution as well as to all the participants who came from outside Tanzania and from outside Arusha. Again CIMMYT and I personally have appreciated your contributions in terms of papers, lively discussions as well as your efforts in presiding over the various sessions. I hope the efforts from many different people will stir up new ideas and encourage you to seek better and closer relations with your neighbours. I wish all of you a happy trip back home.

Thank you very much.

A. S. MOSHA: TANZANIA.

Ladies and gentlemen, I would like to take this opportunity on behalf of TARO, particularly on behalf of Dr. Kasembe who could not stay with us throughout the entire workshop because of other commitments, on behalf of our institute in Arusha and on my own behalf to thank you all for your endurance. It was difficult to make everybody happy during the few days you stayed here. I am sure you will bear with us where we have fumbled. I can assure you that this was not intentional. Once again I wish you all the best and the safest trip back home.

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