6250305 (9)

PD-AAB-621-B1

MEMORANDUM TO: See Distribution

DATE: January 28, 1976 14p.
Progress Rpt.

FROM: AFR/RA, Charles A. Sanders
Agricultural Development Officer

SUBJECT: Major Cereals - West Africa - 698-11-130-305(620)
PASA AG/NIG-305-26-70 - Project Research Review
prepared by Dr. Karl R. Stockinger

Subject review paper was prepared for and distributed to participants attending the Conference on Semi-Arid Food Grain Research and Development in Africa conducted January 8 - 9, 1976 in Ouagadougou, Upper Volta.

The paper gives a summary of research accomplishments of this important project which is thought to be of considerable interest to individuals who may not otherwise receive a copy through OAU/STRC's distribution system. Attached herewith is a copy (or copies) of the research review for your information. A few additional copies can be made available upon request.

Distribution:

Dr. Leon Hesser, TA/AGR	(1)
Dr. Glen Beck, TA/AGR	(1)
Dr. G. Baird, TA/AGR	(1)
Dr. W. Garman, TA/AGR	(1)
Mr. J. Malcolm, TA/AGR	(1)
Mr. W. Leake, AFR/DS	(1)
Mr. H. Kugler, AFR/ESA	(1)
Mr. E. Headrick, AFR/ESA	(1)
Mr. L. Clyburn, AFR/DS	(1)
Mr. S. Peek, AFR/CWR	(1)
AID Reference Library	(4)
Dr. John Axtell (Purdue)	(2)
Dr. Ken Laurent, USDA	(10)
Mr. Leon Pukasch, USDA	(15)
Dr. M. Dow, NAS	(2)

Mission Directors/RDOs:

Mr. W. Haven North, Ghana	(2)
Mr. S. J. Siegel, Monrovia	(2)
Mr. William Ford, Lagos	(2)
Mr. John Lundgren, Ndjamena	(2)
Mr. Ronald Levin, Bamako	(2)
Mr. E. Bable, Nouakchott	(2)
Mr. John Hoskins, Ouagadougou	(2)
Mr. J. Koehring, Yaounde	(2)
Mr. Albert Baron, Niamey	(2)
Mr. N. Schoonover, Dakar	(2)
Mr. M. Wedeman, Abidjan	

Major Cereals Project Research Review

Karl R. Stockinger

The project was the result of a series of meetings and discussion between the United States Agency for International Development, the United States Department of Agriculture, the Scientific and Technical Research Committee of the Organization of African Unity, and various West African countries from 1962 to 1964. The meetings dealt with the need for research on food crops, primarily in the semi arid tropics of West Africa. Since the principle food crops of this area are the cereals, maize, sorghum, and millet, it was decided that work on these crops was most urgently needed. It was decided that a team of scientis would be stationed at the Institute for Agricultural Research, Samaru, Nigeria, to work with the scientists there, and in the other countries of West Africa to improve the yield and quality of these cereals. The project was to be funded by USAID, staffed and administered by USDA, and coordinated by the OAU-STRC.

The plant breeder-team leader and the plant pathologist arrived in Samaru in August, 1964, to start the project. In 1966, the soil scientist, entomologist and another plant pathologist (stationed at Ibadan to work on maize) arrived. In 1972, a seed production specialist was added to the team. In 1971, four field trials officers (FTO) weroadded to the project. Two FTO's (salary paid by France) are stationed in Dakar, Senegal and Maroua, Camerouns and work in the

Francophone countries. The other two FTO's (salary paid by the United Kingdom) are stationed in Kano, Nigeria, and Kumasi, Ghana. In addition to organising field trials, the FTO's have been extremely helpful in promoting exchange of information and materials between countries and the project.

The research findings from the project will be discussed by crops rather than by discipline.

SORGHUM

The traditional cereal crop of much of the savanna zone of West Africa is sorghum. Centuries of growing the crops have developed cultural practices and selected varieties, which are very well adapted to producing enough food for the family year after year, with little or no inputs other than labor. Land is cleared of bush and grasses and the plant residues are burnt. This results in the phosphorus in the plant residues being made available to the crop. The farmer then constructs ridges and plants his sorghum on the ridge. This concentrates the plant nutrients in the ash and surface soil near the seed. He practices wide spacing and interplants with crops whose requirements for light, water and nutrients are less competitive. He plants early with the establishment of the rains and so his sorghum can take advantage on the flush of nitrogen released by the soil and also be well established before the shoot fly becomes a serious pest. His variety is full-seasoned, accumulates plant nutrients over a long period of time and translocates them into the grain at the end of the season. The variety is resistant to stem borer attack and to striga. It flowers just as the rains stop, and produces its grain on the residual moisture in the soil, thus minimizing the development of head mold and also avoiding a build-up of the sorghum midge, because all sorghum in the area heads at the same time. His labor requirements for weeding are very high and limit the amount of land

he can cultivate. It is an integrated package beautifully adapted to subsistence farming, but difficult to change, and change it must because of the rapid increases in population in the region.

Attempts to increase the yields have met with limited success. Improved varieties by selection techniques have given 10 - 15% increases in yield. Use of fertilizer gives marginal benefits, because the varieties used are not very responsive, and have a low yield ceiling. Shortening the plant helps some, but the long growing season results in the dwarf plants having just as many leaves as the tall local varieties and thicker stands result in more mutual shading and little increases in yield. Shorter-seasoned improved sorghums adapted to the shorter rainfall seasons of the Sudan savanna are much higher yielding , and some varieties yielded 4 - 5000 kg/ha in the 1974 West African short season sorghum trials. Some of the constraints on using short seasoned varieties in the Guinea savanna are head mold, if seed is set and matured during rains, and shoot fly and midge attack on sorghum planted late enough to mature after the end of the rains. Introduced sorghums with high yield potential have little or no resistance to striga, which is a serious problem in much of the savanna region of West Africa. The introduced sorghums are also more susceptible to stem borer attacks.

The project entomologists have discovered resistant or tolerant

strains of sorghum to shoot fly and midge, and strains which show some resistance to stem borers. The plant pathologists have found strains resistant to head mold and striga. These strains have been turned over to plant breeders for incorporation into new varieties which can be planted later and flower before the end of the rains without damage to shoot fly, midge, head mold or striga. Such varieties will have a shorter growing season, be shorter with fewer leaves, and respond to higher plant populations and fertilizers. Resistance or tolerance to shoot fly, midge, stem borer, head mold and striga removes many of the constraints on the type of plant, the date of planting, and the date of flowering on the plant breeder, and means that varieties can be bred which are more widely adapted rather than being grown in narrow ecological zones in which they were developed.

Agronomic trials with the long-seasoned, photo-periodic, Guinea Savannah varieties show very little yield response to increased plant populations and fertilizer. The yield response surface of trials with fertilizer and population are practically a flat plane. There is a good response to both fertilizer and population in the production of total dry matter, but it has little effect on the yield of grain.

MILLET

Bulrush or pearl millet is grown throughout the savanna, but its importance increases the farther north one goes until it is the dominant crop in the Sahel. In the Guinea savannah, a long seasoned photoperiodic millet is grown with cultural practices similar to the long seasoned sorghums. Short seasoned millets are grown throughout the region, but are planted with the first good rain for early harvest to provide food until sorghum is ready. It is not as susceptible to head mold as sorghum. The varieties of millet grown are well adapted to subsistence agriculture and when planted with wide spacing and later interplanted with other crops, give a low but consistant yield except in years of extreme drouth. Millet survives drouth extremely well especially before flowering, enabling it to be planted before the rains become well-established, and also to be grown in the Sahel. It is more drouth tolerant than sorghum.

However it does have some problems. It is attacked by birds during grain maturation until harvested. It is preferred by birds to the sorghums, and one of our breeders plants millet around his early sorghums, and has no problems with bird damage of his sorghum, but the millet is a complete loss. It is also susceptible to downy mildew, smut and ergot. The local varieties of millet are resistant to downy mildew, but introduced strains are usually not.

To improve the yield of millet, the stand density will have to be increased and the lodging decreased. To do this dwarf varieties

resistant to lodging and responsive to fertilizers must be developed. However, introduced strains with the desirable characteristics are very susceptible to downy mildew. Breeders have combined the resistance of the local varieties with the desirable characteristics of the introduced material, resulting in short high yielding varieties. However, they are only resistant to downy mildew in the area in which they were developed. Work by the JP-26 plant pathologist in cooperation with the plant pathologist at Bambey, Senegal, shows that there are races of downy mildew, and present varieties are suitable only in the areas in which they originated or were developed. The plant pathologists need to determine the number and distribution of the races, and the geneticists need to determine the mode of inheritance of resistance to the various races. Then varieties with a broad based resistance to several races can be developed which can be used in a much wider area. Close cooperation on a regional basis for all of West Africa will be needed for this work.

Plant physiology studies have shown that millet is very drouth tolerant, produces dry matter as rapidly as maize, and is an excellent forager for plant nutrients. In intercropping experiments with sorghum, it rapidly outgrew sorghum and captured about 75% of the nitrogen available to the plants. However, only about 25% or less of the dry matter produced goes into the grain, the rest is in the stalk and leaves compared to 40 to 50% for maize. There is a lot of room for

improving the performance and efficiency of millet as a food producer. Plant breeders need to develop short, high yielding varieties which can respond to fertilizers and other improved cultural practices.

MAIZE

When Dr. Webster first arrived in Samaru, Nigeria, he found maize only being grown as a garden crop to be eaten green. It was said that maize could not be grown in the northern guinea savannah because of insufficient rainfall and that the season was not long enough. However, the amount of rainfall was greater than in the corn belt of America, and the rains were concentrated in a five month growing season rather than being spread throughout the entire year. When the crop was grown with adquate fertilizer, yields of 6,000 to 8,000 kg/ha were common. It was also found that yields were nearly double those obtained in the traditional maize areas in the south. Also the yields were more than double the yields of sorghum and millet. Because of these considerations, and the' fact that there were two sorghum breeders at Samaru, Dr. Webster decided to put most of his efforts as a breeder, on maize.

Meanwhile Dr. Craig was stationed at Ibadan to work on the disease of maize at Moor Plantation, the Nigerian Federal Research Center, with responsibilities for maize research. His work was concentrated on finding resistance to maize rust, leaf blight and root rot, and help develop varieties incorporating this resistance. In 1968 a meeting of plant breeders was held in Ibadan to discuss breeding techniques and coordinate the breeding program in Nigeria. Dr. Eberhart, a USDA plant breeder working

on maize breeding in Kitale, Kenya, described a method of composite breeding which could be used to continuously improve the yield and performance of broad-based composites. It was decided to set up three composites called Nigerian Composites A, B, and C, with lines from America, Columbia, Mexico, and Africa, incorporated in them. Four cycles of synthesis of maize selections to form the composites were used. These composites are the basis of the breeding programs at Samaru and Ibadan, and are used in a program of recurtent selection for improving yield and other characters. Included in each composite were lines with high lysine. Selections are being made for improved protein quality and quantity at Samaru, using the Udy meyhod for protein analysis to test the selections. Also an earlier composite, Samaru 1, 2, 3 is being used at Samaru. The program gives improved varieties which can be used by farmers as the source of seed, rather than needing new seed every year, as is the case with hybrids.

Trials in the northern guinea savanna show that the limiting factor in growing maize is fertility. Most soils are deficient in nitrogen and phosphorus and yields of 100 to 700 kg/ha are obtained without fertilizer. With fertilizer and adequate stands, yields as high as 10,000 kg/ha have been obtained. A group of farmers near Dambatta, Nigeria were introduced to growing maize with fertilizers in 1971. They have averaged over 3000 kg/ha, and the best farmer

has had yields of 5000 kg/ha. Their costs were carefully recorded including labor, and all farmers made a good profit on their 0.4 ha plots. Enquiry showed that they used about half of their production for food and sold the remainder. Their only complaint was that maize was difficult and more expensive to grind. These were farmers who were accustomed to eating sorghum previously and still grew sorghum.

Soil tests and field trials show that nearly all soils are deficient in phosphorus. When phosphate fertilizer is supplied, nitrogen quickly becomes limiting, especially following cotton, sorghum, or cowpeas. In some areas, especially where the soils are derived from sandstone, potassium is also limiting and can cause yield reductions. Continued use of nitrogen fertilizer, especially ammonium sulfate, can cause soil acidity to develop and lime must be used to correct this condition to maintain good yields. Research is underway to determine how to apply the nitrogen fertilizer to minimize its acidifying effects.

In general on savanna soils, the amount of nitrogen available limits crop growth. Because of the low organic matter content of these soils, the total nitrogen content ranges from .01 to .1% with .04% being a typical value at Samaru, Nigeria. If 3% of this is mineralized and made available for plant growth during a growing season, approximately 24 kg/ha are available for plant growth. Assuming 100% efficiency, this would be enough for about 1000kg/ha

grain yield. Improved varieties may be somewhat more efficient and approach this yield figure more closely, but they will not help much. To improve yields beyond this figure, additional nitrogen must be made available from fertilizer or nitrogen fixed by soil microorganism. Cropping systems can be devised with grain legumes which can supply as much as 40 kg/ha nitrogen to the following crop. To make this succeed, however, phosphate fertilizer must be added to the soil for the legume to grow and fix nitrogen. Also phosphate will be necessary for the growth of the grain crop.

One method of minimizing phosphate fertilizer costs is to use rock phosphate from West African sources. Both work at Samaru and in the Francophone countries shows that the rock phosphate applied at heavier rates can give increased yields. At Samaru, it has been shown that a mixture of rock phosphate and sulfur, is nearly as effective as super-phosphate for groundnuts and maize. In countries with rock phosphate deposits, use of rock phosphate would cut out the cost of imported phosphate fertilizer. A rotation such as groundnuts, fertilized with rock phosphate, followed by a cereal crop, could increase production without importing expensive fertilizers.

In the race between the plow and the stork, more and more land is continuously cultivated. A fertilizer experiment at Kano and Samaru, Nigeria, shows that satisfactory yields are possible after 26 years continuous cultivation, if nitrogen and phosphorus fertilizers

are used or farm yard manure is supplied. The results indicate that the manure acts primarily as a source of nitrogen and phosphorus. Without a source of these two elements yields have declined to 100 kg/ha of maize or millet. If phoshpate is supplied, then nitrogen may be supplied by growing a legume crop and returning some residue to the soil. But to maintain yields, phosphate must be supplied and other essential elements such as potassium and sulfur. If they are not, then yields under continuous cultivation will decline to a point where the seed will not be regained. Improved varieties will not help. Usually improved varieties respond better to improved fertility conditions, but do no better than the local varieties on depleted soils.

Summary of Research Accomplishments

1. Demonstration that maize has the highest yield potential of the cereal crops in the guinea savanna region of West Africa.
2. Showed that the yield limiting factors were primarily soil fertility for maize, and not climate, in the guinea savanna. It was also shown that the deficiences could be corrected with chemical fertilizer or farmyard manure.
3. Introduced the system of recurrent selection of broad based composite population into the plant breeding program for maize in Nigeria. Helped set up and homogenize 4 composite populations to be used in this program.
4. Helped in the development of rust and leaf blight resistant maize varieties for Nigeria.
5. Started a breeding program using recurrent selection on the composites, to improve the quality and quantity of protein in maize.
6. Discovered lines of sorghum resistant to striga which can be used to develop resistant varieties.
7. Discovered lines of sorghum resistant to head mold.
8. Discovered lines of sorghum resistant or tolerant to shoot fly.
9. Discovered lines of sorghum resistant to sorghum midge.
10. Showed that there are several races of downy mildew of millet, and millet bred in one area for resistance is not resistant in areas with other races.

11. Proved that the maize disease known as Story streak is the same as the maize streak disease in East Africa.

12. Other diseases which have been identified, but are usually of minor importance, are the smuts of sorghum and ergot in millet. Also pokkah boeng (a fusarium) was first observed in 1975, as a disease of sorghum, millet and maize. Diseased plants usually grow out of it, and it is usually not too important.

13. Conducted the West African Uniform Trials of sorghum and maize to test and compare varieties from different areas. This gives breeders a chance to check the range of adaptation of their new varieties and their disease resistance under different conditions.

14. In addition to research, JP-26 had a training function. Starting in 1971 scientists from five West African countries have returned from additional training in America, usually for advanced degrees. Other scientists are still in America completing their course work. Their training was sponsored by the Major Cereals Project JP-26, and financed by USAID.