PD-AAQ-272
ISN 37334

Intsormil

TRIP REPORT

BY

W. M. ROSS, RESEARCH GENETICIST
USDA/ARS
UNIVERSITY OF NEBRASKA

BOTSWANA

MARCH 1, 1984 - MARCH 10, 1984

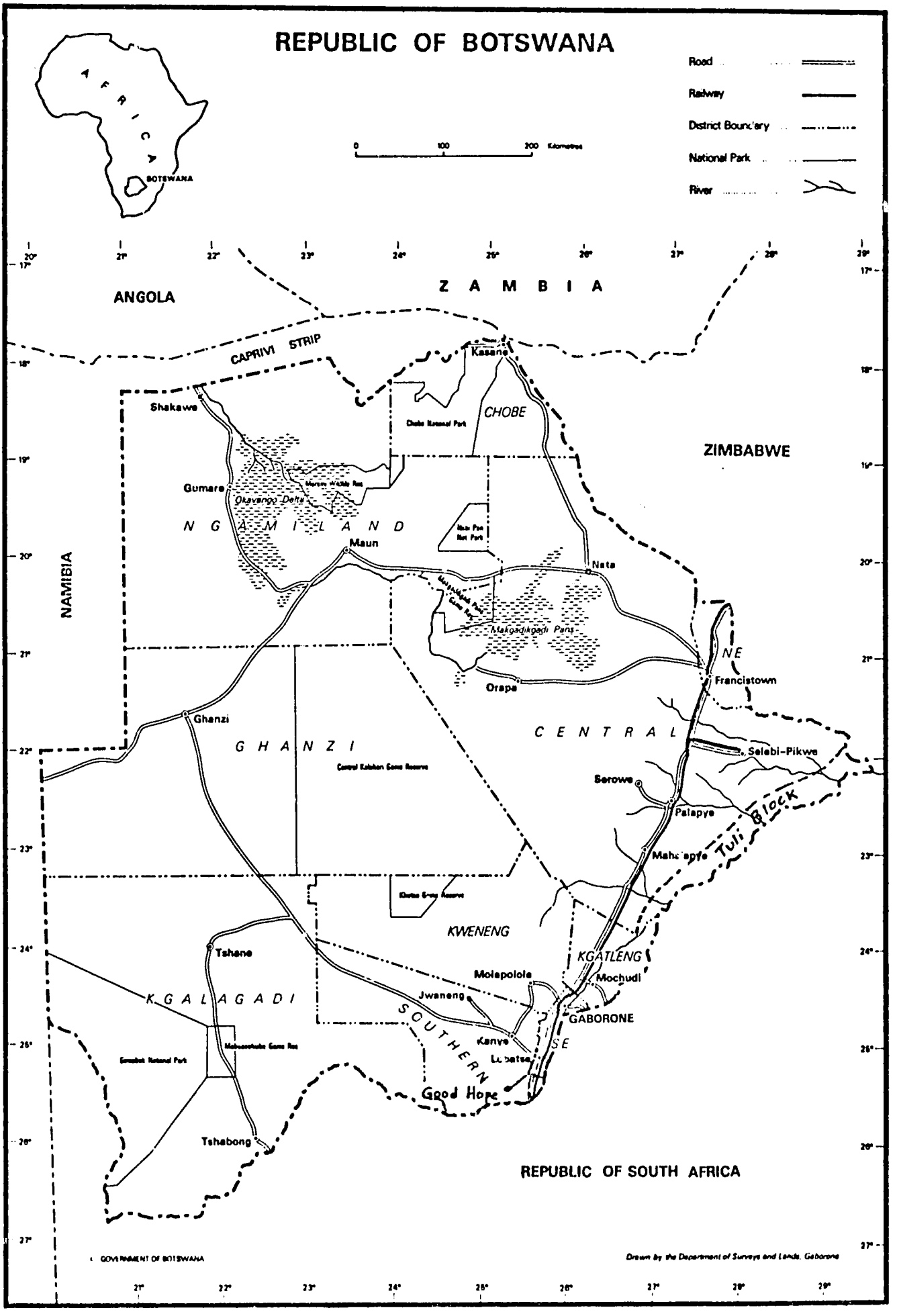
CONTRACT NO.: AID/DSAN/XII-G-0149

☆ International
Sorghum/Millet

☆ Collaborative Research
Support Program
(CRSP)

A Research Development Program of the Agency for International Development. Participating Land-Grant Universities, Host County Research Agencies and Private Donors.

Institute of Agriculture and Natural Resources
University of Nebraska-Lincoln


REPUBLIC OF BOTSWANA
AFRICA
BOTSWANA
Road
Railway
District Boundary
National Park
River
0
100
200 Kilometres
ANGOLA
ZAMBIA
ZIMBABWE
NAMIBIA
CAPRIVI STRIP
Kasane
CHOBE
Shakawe
Gumare
Okavango Delta
NGAMILAND
Maun
Nata
Makgadikgadi Pans
Orapa
Francistown
NE
CENTRAL
Selebi-Pikwe
Serowe
Palapye
Mahalapye
Tuli Block
Ghanzi
GHANZI
Central Kalahari Game Reserve
KWENENG
KGATLENG
Mochudi
Molepolole
Jwaneng
GABORONE
Kanye
Lobatse
SOUTHERN
Good Hope
Tshane
KGALAGADI
Tshabong
REPUBLIC OF SOUTH AFRICA
© GOVERNMENT OF BOTSWANA
Drawn by the Department of Surveys and Lands, Gaborone

Purpose of Trip

Technical assistance was requested by USAID/Gaborone and the Ministry of Agriculture to review the sorghum/millet breeding program in Botswana conducted by the Department of Agricultural Research (DAR), to offer recommendations for future work, and to strengthen INTSORMIL/University of Nebraska plant breeding ties with Botswana. Linkage with Botswana was made through L. M. Mazhani, former plant breeding graduate student at the University of Nebraska-Lincoln, who returned home in 1983.

Primary

Mr. L. M. Mazhani, Sorghum Research Officer, DAR, Sebele
Dr. D. E. Gollifer, Chief Arable Research Officer, DAR, Sebele
Dr. K. Oland, Director, DAR, Sebele
Dr. Anita Mackie, Agricultural Development Officer, USAID/Gaborone

Itinerary

March 1-3	Leave Lincoln 1400, travel to Gaborone via London and Johannesburg, arrive Gaborone 1500.
March 4	Rest and tour Gaborone.
March 5	Meet with personnel listed above and inspect sorghum/millet work at Sebele.
March 6	Visit Malahapye Station and inspect sorghum seed production field near Leshibitse.
March 7	Visit Good Hope Station and tour Botswana Meat Commission (BMC) packing plant at Lobatse.
March 8	Visit Integrated Farming Pilot Project (IFPP) at Pelotshetlha and tour sorghum mill at Gabane.
March 9	Wrap-up with Mazhani and Gollifer. Depart Gaborone 1600.
March 10	Arrive Omaha 1800.

A week's visit to a country does not create an expert, and no claim to authority is made. One does, however, make observations and assessments on a trip like this, and it is hoped that they are correct. If not, I take responsibility for the errors. At the risk of redundancy with respect to the Botswana-based readers, considerable background information is provided for the varied audience in the United States who may know little about the country.

Botswana--an Overview

Botswana is slightly larger in area than France, but it has no further resemblance to that country (see map). Botswana has less than 1 million people, about 80% of whom are rural or village dwellers engaged in agriculture. The nation is landlocked, is transected by the Tropic of Capricorn, and has many characteristics of the arid southwestern region of the United States. Even in the more favorable eastern part of the country, the terrain and rangeland vegetation are reminiscent of parts of west Texas, New Mexico, and Arizona. The country has no true mountains and is relatively flat, ranging from 900 to 1200 m above sea level. The western two-thirds of the country is comprised of the Kalahari desert, most of which is savannah.

The soils on the three experiment stations visited were reddish in color and classed as sandy loams. These and loamy sands make up the major cultivated soils although there are sands, clays, and sandy clay loams. Organic carbon content is generally low (under 0.6%), and topsoil pH values range from 4.3 to 7.4 with acid soils common. Most soils are low in N and P, and the soils in the Maun area (not visited) are low in Zn. Aluminum toxicity was not mentioned as being a probelm with the acid soils.

Average annual rainfall ranges from 250 mm in the southwestern part of the country to about 650 in the northeast. Generally, most of the rainfall occurs October through April, but frequencies and distributions are erratic. Temperature are mild compared to Nebraska though, on the whole, the country seemed more temperate than tropical. The northeast area was not visited, and it reputedly has more tropical attributes.

Table 1 gives long-term rainfall and temperature data at Gaborone, the capital, which is 24° 40' S, 25° 55' E. The experiment station at Sebele is 11 km north, and data would be similar. Mean annual rainfall data at the other experiment stations are as follows: Good Hope (120 km southwest of Gaborone), 450 mm; Malahapye (200 km northeast), 475 mm; and Maun (600 km northwest), 490 mm.

Table 1. Mean temperature and rainfall data, Gaborone, Botswana.

Month	Temperature, 1958/59-1967/68	Rainfall 1939/40-1968/69
	C	mm
October	23.3	44
November	24.5	59
December	24.7	88
January	25.5†	82
February	25.1	81
March	23.1	69
April	19.4	51
May	15.2	15
June	12.0‡	10
July	12.1	4
August	15.3	3
September	20.3	13
Mean/Total	20.0	519

† Mean minimum 19.4, mean maximum 32.6; daily maximums can exceed 38.0 (100 F).
‡ Mean minium 4.2, mean maximum 21.8; daily minimums can be less than 0 (32 F).

Botswana has no equivalent of the Great Plains or Corn Belt of the United States to furnish food and feed and must rely on dryland production for grain and edible legumes except for limited irrigation in the Tuli Block area along the Limpopo River. Moreover, the last 3 years have been extremely dry. Only 177 mm of rain have been received at Sebele since July 1, 1983, and the dry season approaches. It is under these rigorous conditions that the country's crop production and the sorghum/millet breeding and testing work are being done. Needless to say, water is a limited natural resource and is revered by the Botswana. Its symbol appears on the national flag, and the word pula, which also is the monetary unit, means rain.

The Livestock Industry

Before discussing crop production in Botswana, some remarks about livestock are in order. Most of the country is rangeland, and cattle have long been regarded as a source of status and wealth. Foot-and-mouth disease is omnipresent in present-day Botswana, and diligent efforts are made to prevent and contain outbreaks. The 1982 agricultural census estimated that the country had about 3.0 million cattle, 635 000 goats, and 140 000 sheep. Many traditional farmers have chickens, but swine seemed to be limited. Meat and milk are used in the diets of many Botswana and along with edible legumes are important sources of protein. These facts relate to the quality of the cereal grains in that they need furnish only carbohydrates.

The indigenous cattle of southern Africa apparently were straight backed and long horned, but the present cattle show considerable infusion of other breeds, particularly Brahman. Segregates with obvious European beef and dairy blood also are common. The average herds cannot be classified by specific cross or breed as in the United States but instead are random-mating populations because of interbreeding during communal grazing. The cattle of Botswana represent an animal geneticist's paradise.

Because of high calving losses, high death rates on the range, the retention of many animals for breeding stock and draft purposes, and an extended grazing period before marketing, only about 400 000 animals are slaughtered each year. About half of the cattle slaughtered appear to be marketed through the BMC, a government-owned packing plant. The major packing plant is located at Lobatse, south of Gaborone, and a newer plant with less capacity is located at Maun.

The Lobatse plant was not killing the day we visited, but a thorough tour was made of the facilities. Sanitation was rigid in the plant, and the reason for the temporary shut down was to clean up, disinfect, and make ready for slaughtering for the European Economic Community (EEC), which imposes high standards on processing and products. The plant is modern in every respect and appears to have an efficient assembly line production. Emphasis is placed on frozen boned boxed beef, carcass beef, and canned (corned) beef. About half of the meat products go to the EEC; and the other approximate half goes to the Republic of South Africa (RSA) and other African nations, with minor amounts elsewhere. The export of beef is critical in maintaining favorable foreign trade balances. Hides, bone meal, carcass meal (meat scraps), and blood meal are important byproducts. BMC also has a pet food division, most of whose products go to RSA.

The cattle in pens awaiting slaughter were mostly 2 to 3 years old (or older) and were in fairly good condition considering that drought had seriously depleted the grass on the rangelands and the fact that many of the cattle were driven on foot over considerable distances to market. Figures from the BMC annual report indicated that the Lobatse plant slaughtered 237 000 beeves in 1982, and their newsletter indicated that about 10 000 goats and sheep were slaughtered in 1983.

Average live weight of the cattle in the pens was estimated to be about 550 kg or 1200 lb. Based on figures in the 1982 annual report, the average return to the producer figured to be about $20 per cwt. live weight or $240 per head. These prices appear to be considerably better than those received locally or noncommercially. The $20 per cwt. is even more favorable when one considers the little investment in feed except pasture.

The livestock producer actually is paid by BMC on the basis of grade and cold dressed mass (CDM) rather than by live weight as in the U.S. Average CDM per animal in 1982 was 200 kg. About one-half of the animals graded super, 1, and 2, and the other half graded 3, 4, detained, and condemned. About three-fourths graded 1, 2, and 3. The Botswana T-bone steak I had in the hotel at Lobatse was tender and flavorful and in no way was inferior to American steaks, but I suspect it represented the super or possibly no. 1 grade.

Should Botswana become self sufficient in cereal grains, it seems that any surplus might profitably be used to feed livestock, particularly beef. Whether or not the traditional farmer/livestock producer would accept this practice is unknown. At this time, the immediate problem is to increase grain production to meet human needs.

Crop Production in Botswana

The major field crops in Botswana are sorghum, maize, millet, beans and pulses (mostly cowpeas), groundnuts, and sunflower with small amounts of cotton and wheat. There are some 57 000 traditional farms whose average area planted to crops per farm is slightly over 3 ha. About 60 commercial farms exist that compare more or less to some medium-sized farms in the United States. Cropland per farm in the commercial category averages about 260 ha.

The traditional farmer relies heavily on oxen and mule/donkey draft power for plowing. In many cases, he owns neither and must hire the plowing done. Tractors are common on the larger farms, and I saw several medium-sized John Deere and Massey-Ferguson tractors in the 50-hp class. It was estimated in the 1982 agricultural census that about 14% of the farmers used (owned or hired) tractors for plowing. The high cost of importing tractors and fuel (gasoline costs $2.15 per U.S. gallon) are deterrents to mechanization.

Crop yields are low in Botswana, and abandonment of crops is high. Table 2 illustrates this for the three cereals in the droughty 1981-82 crop year. Yields of 100 to 130 kg per ha for sorghum and millet are indeed meager as is 774 kg per ha for maize on commercial farms. Under more normal circumstances, average yields are not much better and seldom exceed 400 kg per ha for sorghum

or millet. Data are not readily available for maize, but it is expected that the yield might at least double. Some maize is produced under irrigation while sorghum and millet are produced nearly all on dryland.

Table 2. Areas planted, areas harvested, and yields of three cereal crops in the 1981-82 season.†

Practice by farm type	Sorghum	Millet	Maize
Area (ha) planted--traditional	91,000	16,000	52,000
--commercial	1,700	0	12,000
Area (ha) harvested--traditional	36,000	3,400	12,400
--commercial	1,300	0	11,500
Yield (kg/ha)--traditional	103	132	282
--commercial	131	0	774

† Source: 1982 Botswana Agricultural Census.

The traditional farmers use about 70% of the area of each of the cereal crops for mixed cropping and about 30% for monoculture. The commercial farms use monoculture totally. About 90% of the traditional farmers broadcast their seed, and about 8% use row planting (half of which is hand planted). The seed is commonly broadcast onto plowed ground and then plowed under again. Weed control is difficult and is done through hand hoeing because herbicides are not used. Bermuda grass is a major pest. Abandonment is extremely high on the broadcast fields, and yields of harvested broadcast fields are generally about one third of the row-planted fields. Considering all crops, it was estimated for 1981-82 that the row-planted area produced as much as the broadcast area which was eight times larger when planted but only 2.7 times larger when harvested because of abandonment.

The use of commercial fertilizer is extremely low, but use of manure is more widespread. Even so, only 7.5% of the farms receive any kind of fertilizer. As judged from reports of the DAR, response to fertilizers is good, but lack of capital prevents the traditional farmer from making this investment. Although manure might appear to be plentiful, it is not readily collectible because of the absence of confined feeding.

All points considered, drought is the primary constraint to crop production in Botswana. In more favorable years there are others, particularly for sorghum, such as *Striga*, aphids (*Melanaphis* or *Aphis sacchari*), stalk borers (*Chilo partellus*), downy mildew, loose and covered smut, and *Helminthosporium* leaf blight. The smuts can be controlled with fungicides, but many farmers do not treat their seed. One sample of sorghum, from the Tuli Block, was infected with downy mildew, but it was an isolated case. Charcoal rot may have been a problem in the current crop but was badly confounded with drought. Birds, particularly *Quela* spp., can be a problem any year though damage was not noticed on this trip.

In travelling from Good Hope to Malahapye, I did not see one harvestable field of maize and very few harvestable fields of sorghum or millet. Many fields were planted late, only after a rain wet the seedbed, and they will not produce a crop. These fields will be grazed as will the residues of the fields harvested. The best farmer's field of sorghum was noted in the IFPP area at Pelotshetlha near Kanye. It was about 10 ha in size and was a red-seeded hybrid. It was planted in 75 cm rows, was relatively free of weeds, and will likely yield 2000 to 2500 kg/ha. The IFPP is a British-funded project, and Richard Edwards, an extension agronomist from the U.K., showed us this and another farm where three small fields existed side by side. Again little or nothing will be harvested from the maize, whereas both the sorghum and Tswana beans (cowpeas) will produce a partial crop. In fact, the farmer was already hand harvesting some of the beans.

The IFPP is trying to promote better culture of field crops and has a battery of small walking plows and single-row planters that are loaned to the local farmers. Although the practices of broadcast planting and intercropping are strong among the traditional farmers, they are receptive to new ideas and will likely adopt them if the changed techniques are repeatedly successful.

Because of my experience in Kansas, I asked about the possibility of summer fallowing as is done in the western Great Plains. The answer was that the cost of intervening tillage and control of weeds would be prohibitive. Moreover, water retention in the sandy soils is not as good as in the heavy silty clay loams of western Kansas, which makes summerfallow less worthwhile.

One of the main reasons farmers persist in growing maize is that it escapes Quela damage. Also people like the taste of maize meal, which is made from white varieties, and seed for planting is normally available from RSA.

Although millets are reputedly more drought tolerant than sorghum, I would not say that this was apparent. They seemed to show about equal tolerance as sorghum. Millets are less preferred than sorghum in Botswana. Perhaps problems concerned with threshing the heads and grinding the grain influence this preference.

Seed Multiplication

There are no private seed companies producing cereal seed in Botswana although some exist in RSA. The market is small by U.S. standards, and farmers tend to save and replant their own seed. Government-sponsored seed multiplication seems to be very appropriate, and in the 1983-84 crop year there were 18 contract sorghum growers producing five cultivars on 650 hectares. There were also 18 maize producers of two cultivars on 600 hectares. The maize fields in the Tuli Block area apparently were partially successful. Most of the sorghum fields, however, failed, but one exceptionally good (considering the year) field of perhaps 20 ha was seen near Leshibitse on the way to Malahapye. It was the variety Segaolane, which was selected at Sebele from a local type, and probably will produce 1000 kg/ha. An adjacent field of maize was a complete failure. Wide (at least 150 cm) rows were used, and production would have been even greater had the same plant population been used in 75 cm rows. The field was extremely clean, having been tractor cultivated, and the crop will be combine harvested. The wife of the farmer, Mr. Dikgale, who was away from the premises, was building a smooth threshing floor of mud and cow dung on which the combined

seed will be dumped prior to cleaning and sacking. The traditional farmer uses the same type of threshing floor on which he flail threshes the grain.

Field crop seed for planting is heavily subsidized by the government with open-pollinated varieties of sorghum, millet, and maize costing the farmer only about 9 cents per pound for 1983-84. Hybrid sorghum and maize shipped in from RSA is only about 2 cents per pound higher. Low costs are incentives to plant improved seed even though the RSA hybrids may not be as well adapted as is desired. Unlike the U.S., the price of seed planted may be little different from the price received for the grain produced. According to the 1982 census, average prices received for the 1981-82 crops were as follows: sorghum, 13 cents per pound; millet, 10 cents per pound; and maize, 22 cents per pound. These prices vary from year to year.

Sorghum Meal (Flour)

Sorghum is usually consumed as a thick porridge, cooked with water. The flour may be coarse if it is hand pounded to produce 'stamps' or it may be finer if commercially ground. I checked two grocery stores in the mall in Gaborone and did not find any sorghum flour available although there was white and unbleached wheat flour, and maize-'rice' (finely cracked corn that casually appears to be rice). In one of the stores in an outlying part of town, the shelves were well stocked with sorghum flour. One brand was lighter colored than the others and was made from a local white-seeded type. The darker flour was probably from a red-seeded hybrid sorghum shipped in from RSA. The average price for sorghum flour was about 25 cents per pound. For some reason, corn meal (flour) was priced slightly lower.

We visited a small sorghum mill at Gabane which is west of Gaborone. Because of the lack of a local grain supply, they were processing imported red-seeded grain. The first step was removal of the pericarp by a pearling process, and the bran was sacked for animal (chicken) feed. The remaining seed, including the germ, was ground and sacked in 5 kg clear polyethylene bags preprinted with a black and red label that said BEST QUALITY-BOPI JWA MABELE-SORGHUM MEAL. The Tetswana words mean "flour of sorghum". Although the flour was of acceptable quality, improved varieties with white, thin pericarps would be more desirable. A report on the milling industry in Botswana stated that the mill processed about fifty 70-kg bags of sorghum per day. Both commercial and service milling are done at Gabane. At least one other (and there may be more) mill exists at Pitsane in extreme southeast Botswana, but many rural dwellers still stamp their own grain.

The Sorghum/Millet/Maize Project

The work on the cereal project to date has involved yield evaluation of cultivars and potential cultivars of all three crops, and breeding has centered largely on selection in local varieties of sorghum which are heterogeneous. In 1983, sorghums were sent from Nebraska and from the Southern African Development Coordinating Conference (SADCC), and more material will be sent for the November 1984 planting so that the breeding work can be expanded.

Sebele was the most drought stricken of the three experiment stations visited, but some sorghum germplasm was identified as having drought tolerance. Of the local varieties, Segaolane (pearly white grain) appeared to be the best, and 8D and 65D also were good. The 8D line (red seeded) was introduced from Texas in the 1950's and appeared to be similar to Redbine-60. The 65D line (white seeded) was introduced from Oklahoma about the same time and appeared to be similar to 44-14 although when asked about its standability, Mazhani said there were no problems. The pedigrees of 8D and 65D could not be traced further. Over time, Town, Kanye, Marupantse, and Mokula have been shown to be other dependable local varieties.

Of 33 A & B lines sent from Nebraska, Wheatland, CK60, N48, Tx 623, and KS46 were the most drought tolerant. The best local varieties were crossed to these steriles to determine their B or R reaction and genetic heights. I recently learned from ICRISAT that Segaolane is a B-line, so this variety is already earmarked as a potentially useful female parent of hybrids or top-crosses. Of the remaining A & B lines, KS47, KS50, KS51, and KS56 were classed as fair. It is not too surprising that these kafir derivatives were the most outstanding because kafirs had their origin in southern Africa.

Four random-mating populations were sent from Nebraska. NP5R and NP6B looked better than NP20BR and NP21R. The first two populations have 50% exotic (mostly African) germplasm. These populations will be used as bases for building new populations involving local germplasm. Additional populations will be sent from Nebraska, particularly those that have a high frequency of yellow endosperm and good grain quality.

About 7200 lines were obtained from SADCC, and 40 to 45 were identified for further evaluation. A number of the lines that showed drought tolerance in this nursery were hegari/feterita types with purple testa. They would not be acceptable for food but might be used as parents in pedigreed crosses with more desirable types.

Little additional sorghum germplasm could be effectively evaluated in an R-line nursery and a collection of Botswana types. Two replicated yield trials of 10 genotypes each also essentially were failures as was a replicated yield trial of 50 maize genotypes and a replicated trial of 15 to 20 millet genotypes. Another collection of about 60 millets also burned up. One promising lot of millet was seen. It was a bulk (in effect, a random-mating population) from ICRISAT planted on about a 0.5 ha tract. It showed considerable drought tolerance and would be a source of germplasm for more intensive breeding.

Crops at the Malahapye station were less stressed, but they were late, and relatively few heads of sorghum had emerged. The sorghum yield trials will furnish usable data only if the crop matures. In the observation nurseries and yield trials, the standard adapted locals again appeared to be the best. Maize was a near failure.

The best crops were seen at Good Hope, but plant stands were generally poor. The local sorghum checks (Segaolane, 8D, and 65D) again were the best. By harvesting segments of rows with good stands it may be possible to acquire some yield data. The yield trials at Good Hope were the only ones with filled maize ears, but the crop was far from good. Material was also being evaluated at Maun in northwest Botswana, but we did not make a trip there because of time constraints.

Physical facilities, including land, for the cereal project seemed to be adequate except for irrigation and seed storage which will be discussed under Recommendations. A cone planter, plot thresher, head thresher, scales, and balances were available as was work space for setting up nurseries and threshing. One or two technicians are assigned to the project at Sebele, and technicians are present at the other locations to do planting, plot maintenance, and note taking. They are shared by other projects.

Recommendations

1. Testing--The evaluation of cultivars for farm use serves an important function and should be continued with the three cereal crops. Even though maize is not well adapted for dryland production, there is persistence in growing it, and the best performers might as well be recommended to the farmers. Multi-site testing at Sebele, Good Hope, Malahapye, and Maun provides the opportunity for rapid evaluation of cultivars of all three crops and of sorghum and millet breeding materials.

2. Plant Breeding

   a. Maize--No breeding work is being done with maize, and it is questionable if any should be. The effort would be more profitably devoted to sorghum and millet.

   b. Millet--Increased breeding effort with this crop might pay dividends. The bulk (population) planted at Sebele was impressive, considering the drought. I have written a letter to Mr. Mazhani suggesting a plan for recurrent selection that should take minimum effort. I will attempt to obtain for him some additional millet germplasm, particularly from the Hays, Kansas, experiment station and perhaps elsewhere.

   c. Sorghum--Major breeding effort should be devoted to sorghum. I recommend a varied approach that includes making hand crosses among good genotypes and selecting new inbreds through pedigree breeding, the testcrossing of cultivars and lines to determine if they are B-lines or R-lines, the backcrossing of B-lines to develop new A-lines, the crossing of R-lines to A-lines to make F_1 hybrids, the crossing of different A- and B-lines to make sterile F_1's to be crossed with R-lines for making three-way crosses, and the crossing of populations to A-lines and sterile F_1's to make topcrosses. The best hybrids/crosses should then be determined for farmers who buy new seed each year. Because many farmers save their own seed, it seems necessary also to yield test the F_2's or segregating generations of F_1's, three-way crosses, and topcrosses. Just as different crosses vary in yield and adaptation, so do their segregating generations, and the best hybrids/crosses should be identified for those who do not buy new seed each year. Hopefully, the crosses would be the same for both classes of farmers. For long-term objectives, new Botswana random-mating populations can be developed using U.S. populations as bases. It might be possible to reselect some of our U.S. populations, confining the selections to good grain quality types. In all of the breeding undertakings, attention should be given to drought tolerance and grain quality (e.g. pearly white seed) first, and pest resistance second. Details of specific plant breeding procedures will be sent later to Mr. Mazhani.

3. Plot Techniques--Having spent 18 years in western Kansas, I appreciate the difficulty of conducting good dryland yield trials under conditions of drought. The DAR annual report shows C.V.'s of 30 or 40% or more for yield tests which cloud conclusions on varietal performance. The following recommendations might be helpful: a) prepare the seedbed in as good condition as possible to assure uniform emergence of seed, b) overplant plots and nurseries at a higher rate to increase the chance of seeds emerging over the entire length of the row or plot, and 3) reduce plant stands through hand thinning to something less than the 66 000 plants/ha now used. In western Kansas under slightly more favorable conditions (chernozem soils and a mean rainfall of 580 mm) than Sebele, I used to use 50 000 plants/ha. This population level should probably not be exceeded at any of the dryland testing sites in Botswana. In favorable years, the plants will tiller and compensate for the yield that might be attained under higher populations. In dry years, the low population will better withstand drought. Because interest exists in genotypes that have high tillering capacity as a means of circumventing stalk borer damage (which is usually confined to the main culm), high-tillering types can be more clearly identified during the breeding stages of line development if low plant populations are used.

   Yield evaluations can be continued to be made in four-row plots as long as land is not limited and entry numbers are not high. If that changes, I would consider two-row plots but perhaps block the entries by height so that competitive effects are minimized. If families from populations are evaluated, it may be necessary to use one-row plots because of the large numbers. With one- or two-row plots and with single rows of breeding material, it is important to have one or two guard rows on the outsides of the blocks or ranges.

4. Facilities--Two shortcomings in this category were noticed: 1) Irrigation--lack of adequate water to perpetuate seed stocks can have an adverse effect on the breeding program, both in the short-term and in the long-term. The collection of Botswana landraces and cultivars is in jeopardy through continued depletion of seed. A few entries are down to only 3 grams. Some maintenance of collections could be done in the Tuli Block area if seed production schemes are developed and expanded in that area. Having not been there, I cannot offer specific suggestions for that locality, but the idea seems good. To be useful in breeding programs, however, the breeder needs access to these collections at Sebele so that entries can be utilized in crosses. In addition, at least limited irrigation for the portion of the field or nursery used for making hybrids and crosses would be desirable. Plants and heads would have better growth and development, and fewer pollinations per hybrid would be needed in making crosses. Yield testing and genotype evaluation can still be made under dryland conditions which are quite different operations from breeding per se.

   2) Seed storage--a small, refrigerated storage room used by all crop projects at Sebele is hardly adequate for the present level of activity. Increased and expanded programs will be accompanied by increased seed storage demands. Under the low humidity conditions of Botswana, additional refrigerated storage may not be necessary. As long as the seed is dry and free from insects, sorghum will retain its viability for a long time. At Hays, Kansas, under similar low humidity and non-cold storage conditions, sorghum seed had some viability after 15 years.

5. Finances--It is axiomatic that expanded breeding programs will require increased funding. The immediate need seems to be for irrigation facilities; whether this is done through building a reservoir or boring another well can best be determined by those on site. The second need seems to be for increased seed storage, and a continuing need exists for supplies (bags, tags, envelopes, stakes, etc.), some of which are best obtained from the U.S. but at an increased cost due to shipping.

   I propose to transfer some funds from my FY1984 INTSORMIL breeding project to Gaborone/Sebele and write an in-country project for sorghum/millet breeding in Botswana with continued nominal funding. Whether or not this will be successful remains to be seen because various administrative hurdles have to be overcome, and in addition, funds for the Nebraska INTSORMIL breeding project were reduced for FY1985. In any event, I am willing to offer technical assistance when needed.