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FINGER MILLET RESEARCH IN THE SADCC (SOUTHERN AFRICAN) REGION

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INTRODUCTION

Among the millets of the world, finger millet ranks fourth after pearl millet (*Pennisetum americanum* L.), foxtail millet (*Setaria italica*), and proso millet (*Panicum miliaceum*). There are two regions of the world where finger millet is most intensively grown; immediately surrounding Lake Victoria in East Africa, the south-eastern parts of Karnataka and parts of Tamil Nadu and Andhra Pradesh in southern India. These regions account for nearly 75 per cent of the world's production of this cereal (Rachie, 1975).

In Africa, fingermillet is produced principally in Uganda, Tanzania, Rwanda, Burundi, Eastern Zaire, Kenya and to a lesser extent in Ethiopia, Sudan and Somalia. It is also grown in Zimbabwe, Malawi, Zambia, Tanzania, Botswana and Madagaskar. In central and western Africa, it is grown to a limited extent in central Africa, southern Chad and northeastern Nigeria. In Uganda, finger millet is the most important cereal crop equalling the acreage and production of other cereals combined. It is really the only other millet of consequence after pearl millet throughout Africa (Leonard and Martin, 1963; Rachie, 1975). The most important region is in the vicinity of Lake Victoria and Lake Kyoga and between Lake Tanganyika and Lake Victoria (Johnson and Raymond, 1964).

The Southern African Development Coordination Conference (SADCC) Region consists of nine countries: Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, and Zimbabwe. All these countries are south of the equator. Finger millet is the most important small millet grown in this region. Teff is planted in certain areas of Swaziland but no scientific information is available on this crop. Some research work and germplasm col-

lections of finger millet were carried out in the last few years in several SADCC countries. A systematic regional finger millet programme was started in 1985 by SADCC/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sorghum Millet Improvement Project at Matopos (Zimbabwe) for the SADCC region. In this paper, efforts are made to review the knowledge available on finger millet in the region.

AREA AND PRODUCTION

The area and production of finger millet is often combined with pearl millet and in some countries such as Angola and Malawi, the statistical division reports millets and sorghum combined together. The figures vary greatly from source to source and year to year. However, the area and production data on finger millet is available for Zambia and Zimbabwe which is presented in Tables 1 and 2 respectively. Over 100,000 ha of finger millet is grown in each of these two countries with an average yield of 500 kg/ha. Tanzania is the other important country where over 100,000 ha is grown. In Malawi, Mozambique and Botswana, finger millet is grown in patches. The crop is not reported in Lesotho and Swaziland.

GERMPLASM COLLECTION AND MAINTENANCE

Finger millet germplasm has been collected in certain regions of Zimbabwe, Zambia, Malawi, Mozambique, Tanzania, and Botswana during the past few years. The present status of germplasm collections country-wise is described here.

TABLE 1
Area and distribution of finger millet and sorghum in Zambia (1969-70)

Province	Finger millet		Sorghum	
	Area ('000 ha)	Production (tonnes)	Area ('000 ha)	Production (tonnes)
Central	7.4	4100	13.1	6500
Copper belt	0.8	300	8.8	13900
Eastern	11.9	6000	5.4	1000
Luapule	9.6	7600	0.3	50
Northern	43.6	38700	4.0	4500
N. Western	9.4	6500	11.7	6000
Southern	7.1	2200	15.0	8400
Western	40.7	19500	19.3	11100
	130.5	84900	77.6	51450

Source: World Bank Report No. 841-ZA, Agricultural and Rural Survey Coll-III, October, 1975.

TABLE 2
Area in Zimbabwe planted (in hectares) to maize, sorghum, finger millet and pearl millet in the 1980-81 summer season

Province	Maize	Sorghum	Finger millet	Pearl millet
Mashonaland West	66,534	1,910	2,755	151
Mashonaland East	85,960	1,507	4,833	2,560
Mashonaland North	44,696	5,663	3,124	3,260
Matebeleland South	92,770	59,322	6,735	97,621
Midlands	178,592	12,984	26,984	72,479
Victoria	275,572	32,775	53,244	40,938
Manicaland	88,220	44,818	21,931	26,162
Total	875,859	185,748	118,784	271,750

Source: Unpublished data from Agricultural Technical and Extension Services (Agritex), Zimbabwe.

Botswana

During 1985, the International Board for Plant Genetic Resources, (IBPGR)/ICRISAT in collaboration with the Department of Agricultural Research (DAR), Botswana, collected six cultivated samples of finger millet from the northern province (Appa Rao *et al.*, 1986a).

Malawi

During March-April, 1979, ICRISAT/IBPGR organized germplasm collecting expedition to Malawi in collaboration with the Ministry of Agriculture and Natural Resources of the Government of Malawi. A total of 1106 accessions were collected including 190 of finger millet (Appa Rao, 1979). These accessions were deposited at the Chitedze Agricultural Research Station. The collecting mission moved from Shire Valley in the extreme south to north through the Lakeshore, Lilongwe, Kasungu and up to Rumphi. The local name of finger millet is "Mawere" in the south, "Kapuku" in the central region and "Lupoko" in the northern region. It is extensively grown in the northern region around Mzimba and Karonga. There are two distinct types based on the head characters. The open type has long thin ribbon like fingers that open outward. It is called 'Phazi-la-ngobuu' which means elephant foot. The fist type in which short fingers fold inwards, is called 'Fumbata'. The landraces are classified into two maturity types. The early type which matures in about three months is called 'Nthanga' which is common around Mzimba. It has incurved heads and the seed is very small. The late maturing types which take more than 120 days to mature produce large heads and bold grain (Appa Rao, 1979).

Mozambique

During 1981, IBPGR/ICRISAT in collaboration with University of Edurado, Mondlane (UEM) and National Institute of Research in Agronomy

(INIA), Maputo organized a germplasm collection mission in Mozambique. This mission was mainly aimed at collecting groundnuts along with other crops which matured during the collection period. Two samples of finger millet were collected (Rao, 1981). Locally finger millet is known as 'Marupi'. It was suggested that an expedition timed during May-June should recover much variability in sorghum, pigeonpea, pearl millet and finger millet from most of the regions of Mozambique.

Tanzania

Two collecting missions were organized by IBPGR/ICRISAT in July 1978 and in May 1979. The regions covered were Morogoro, Dodoma, Singida, Shinyanga, Mwanza, Musoma, Babati, Kondoa, and Iringa. From these regions five finger millet accessions were collected. The important regions for finger millet are Rukuwa, Mbeya, Dodoma, Ausha, and Moshi where collection trip should be organized in near future. *E. indica* and *E. multiflesa* are the wild types which are commonly found in Tanzania (Rao and Mengesha, 1980).

Zambia

From 1980 to 1984, four collecting missions were organized by the IBPGR in collaboration with ICRISAT and other organizations in which a wide range of crops and diversity were collected from all parts of the country. This included 273 samples of finger millet (Attere, 1985). Finger millet is locally known as 'Luku Kachiaye', 'Katombela Massa'. Attere (1985) has indicated that the crop genetic resources in Zambia have been well collected. To conserve this germplasm, the Zambian Government is establishing a cold storage facility with assistance from the Swedish Government at the Mount Makulu Research Station. Zambia has been identified as a possible site for the SADCC centre for the mobilization of plant genetic resources.

Zimbabwe

Finger millet is the third important crop next to maize and sorghum in the communal areas of Mashonaland, Midlands and Manicaland provinces. It is referred by one of its vernacular names, such as 'Rupoko', 'Rukweza', 'Njera' or 'Zviyo'. Two germplasm collecting expeditions were launched in Zimbabwe during 1982 and 1985 jointly by IBPGR and ICRISAT in collaboration with the Department of Agriculture of Zimbabwe (Appa Rao and Mengesha, 1982 and Appa Rao *et al.*, 1986b). Variations existed for head compactness, number, length and type of finger, and grain colour. In some samples the fingers were stiff, erect and more or less divergent while in others they tend to curve inwards at the top. At several locations a mixture of wild and weedy types were found along with the cultivated types. In addition to cultivated finger millet, six wild accessions were also collected (Appa Rao and Mengesha, 1982).

VARIETAL IMPROVEMENT

In Southern Africa, breeding work on finger millet has been carried out in Zambia and Zimbabwe. Recently in other countries, evaluation of local accessions has started.

Zambia

At Mount Makulu Research Station in Zambia, breeding work started in the early sixties. This work produced a high yielding variety called M 144. This variety was very susceptible to lodging and had a less than desirable grain colour. Selections were made from natural outcrosses of M 144 for yielding ability and lodging resistance. During the course of breeding, the single plant selection method was used initially mainly to obtain pure strains. Later hybrid plants were selected and further developed by using the pedigree method. Varieties and selections were tested in two groups of variety trials in the main finger millet growing areas. Mean yields of the experiments were never under 2000 kg/ha while the best yielding strains often exceeded 4000 kg/ha level (Sarmezy, 1978).

From this programme a new non-lodging variety named Steadfast was selected. This variety was derived from an outcross of M 144 × Line 197. The grain colour was light brown and more acceptable than M 144. The variety Steadfast is recommended for all areas, especially where management levels are good. Attempts to produce improved strains from M 144 × *E. africana* outcross failed, and the selections were discarded after five generations (Sarmezy, 1978).

The work was restarted in 1984 by evaluating 175 local collections and the introduced genotypes. Twenty lines were retained for retesting during this year which were superior to Steadfast.

Zimbabwe

A brief reference to the selection of high yielding strains of *E. coracana* in Zimbabwe was made by Hill (1945) and the author concludes that slow-growing millets like *Eleusines* and *Pennisetums* are considerably lower yielding than sorghum and are therefore of lesser value for food consumption. He indicated that the chief advantage is their immunity against stem borer under Zimbabwe conditions.

Breeding of finger millet was initiated in as early as 1968 at Chibero Agricultural College, where students from African areas throughout Zimbabwe were asked to bring in unthreshed heads from standing plants of genetically mixed populations. Sixty-four pure lines were obtained by threshing single plants. These lines were evaluated for four years. The main conclusions were: there were significant differences among pure lines for yield, threshing percentage, grain weight per head, grain size, days to maturity and plant height. Grain

yield was highly significant and positively correlated with grain weight per head, seed number per head, and threshing percentage. There was positive correlation between grain weight per head and the number of seeds produced per head. It appears that under local conditions the important characteristics of high yielding pure lines are high grain weight per head, which is brought about by high number of seeds per head, high threshing percentage and early maturity (M'shonga, 1974).

Systematic efforts were made in 1982 in the research project that was initiated by the Crop Breeding Institute of the Research and Specialist Services. The project started with the collection of different varieties grown by communal farmers throughout the country. All the samples collected were evaluated at Gweti variety testing centre and Panmure Experiment Station during the 1984-1985 rainy season. Promising lines were further evaluated during the 1985-86 season. The selected lines will be used to make crosses among themselves and with the introduced lines from elsewhere to produce high yielding varieties.

The reports on a variety trial of finger millet at the Lilongwe station near Mzimba was reported in Nyasaland quarterly (Nyasaland, D.A. 1952). The varieties, Phagalala and Fumbata gave the highest grain yields of 1937 and 1880 kg/ha respectively at this location. Some work was carried out in the seventies and four lines were identified.

SADCC programme

SADCC/ICRISAT regional program has evaluated 394 accessions collected from Zimbabwe (374), Zambia (14), Malawi (4) and Tanzania (2) during the 1985-86 rainy season. Sixty-seven accessions were retained for further testing. A total of 1285 accessions have been obtained (Table 3) and the seed is being multiplied. The selected accessions from the previous season and the newly introduced accessions will be evaluated at four or five locations during the coming rainy season. The selected entries will be utilized in a breeding programme.

CROPPING SYSTEMS

A kind of primitive agriculture is practised in Tanzania as described by Lunan (1950). This consists of turning over grassy chunks of sod to form mounds about 1 m in diameter and 60 to 75 cm high. Sometimes trees and bushes may be incorporated with the mound to be burnt during the dry season. The first crops to be planted are beans, cassava, sweet potatoes, chickpeas and wheat during the first season from February to April. Following summer rains, the mounds are broken and spread in November and finger millet or maize are sown. After harvesting in July, the mounds are again formed to cover the weed patches, resown with finger millet, and harvested the following June.

TABLE 3
Finger millet germplasm accessions available at SADCC/ICRISAT Regional Centre at Matopos (as on 20 September 1986)

Country of origin	Number of accessions		
	NP[a]	PCQ[b]	Total
Zimbabwe	376	1	377
Zambia	14	0	14
Malawi	194	0	194
Tanzania	2	1	3
Uganda	27	6	33
Kenya	0	3	3
Ethiopia	0	3	3
Zaire	0	3	3
Mali	5	0	5
South Africa	0	1	1
India	0	649	649
Total	618	667	1285

a = Accessions contributed by national programmes
b = Accession contributed by Plant Germplasm Quarantine Centre, Beltsville, U.S.A.

In Kenya and Uganda, a similar practice is followed known as Chitemane cultivation: This consists of chopping down trees or lopping tree branches from a wide area, piling them over a much smaller area, burning and then sowing millet in the ashes at the beginning of the rains and without any further cultivation.

In Zimbabwe, finger millet seed is broadcast and brushwood is drawn over immediately or the field is trampled with animals. Gaps in the fields are filled by transplanting after thinning when the soil is moist. Weeding is commonly done by hand and fertilizers are seldom applied to the crop except by a few farmers around urban areas. The dried heads are stored without threshing. The crop matures in three to five months depending on the variety and the temperature. Finger millet is often mixed with maize, sorghum, groundnut, beans or cowpeas. However, it is also grown as a sole crop especially on virgin land after slashing and burning the bush. The most common rotation is groundnut, finger millet, and maize. Cucurbits are also grown along with finger millet, pearl millet and groundnut.

PRODUCTION TECHNOLOGY

Fertilizer use

In Malawi, application of kraal manure to finger millet increased yields by 400 per cent at Zomba in 1950 (Nyasaland, D.A. 1952). Similar experiments

carried out at Lusaka (Zambia) in 1954, resulted in yields of approximately 1600, 500, and 350 kg of grain per hectare from manurial treatment of 6, 2 and 0 tons of farmyard manure per hectare (Rhodesia, C.A. 1955).

Agronomic studies during 1960 to 1971 in Zambia showed that finger millet respond well to ammonium sulphate at the rate of 200 kg/ha or, more preferably, in the form of top dressing applied six weeks after planting. The response to phosphorus, in the form of single superphosphate, was less marked and gave significant results only on virgin land which had previously received no fertilizer. The residual response to phosphorus was good when finger millet followed fertilized groundnut or soybean (Sarmezey, 1978).

Dhliwayo and Whingwiri (1984) studied the nitrogen and phosphorus response to finger millet at Makoholi Experiment Station of Zimbabwe. The responses of the crop to different nitrogen levels suggest 100 kg N/ha as the optimum level during 1980-1981 season. Inadequate nitrogen can limit yield in finger millet through a reduction in number of heads/m^2. This study also suggested that where the soils had moderate level of phosphorus, no fertilizer response was observed.

Seeding experiments

A factorial trial conducted at Baka, Karonga, in Malawi showed December sowing to be superior to February sowings; drilling on 45 cm row on the flat was superior either to broadcasting on the flat or to sowing two rows of hills on ridges 90 cm apart (Nyasaland, D.A. 1960).

Spacing and drilling experiments demonstrated that broadcasting was not the best or only method, as weed control and harvesting were easier to manage with drilled crop (Sarmezey, 1978).

Weeding and tillage practices

Finger millet is very labour-intensive at weeding time. The common practice of hand weeding in broadcast crops is time consuming and it is often difficult to distinguish rapoko grass (*E. africana*) from finger millet in the early growth stages (Howden, 1965). The crop cannot stand much weed competition in the early stages of growth.

Few generalizations can be made about tillage practices, planting patterns or land use patterns. Ploughing with animal traction, particularly oxen, is almost universally used in some countries such as Botswana, Lesotho and Swaziland, while hand tillage continues in some or most of the farming systems in the other SADCC countries. The majority of farmers plant crop mixtures but sole cropping has become more common in Swaziland and Lesotho. Historically important shifting cultivation and land use systems such as the Chitmene ash based system have given way to other systems in SADCC countries (Norman *et al.*, 1984).

PLANT PROTECTION

Diseases

Blast (*Pyricularia* sp.) has been recorded on finger millet in almost all regions where finger millet is grown . It is common in Uganda, and was particularly severe in very wet years such as 1961 and 1962 (Dunbar, 1969). The varieties Mozambique 359 was used as a source of resistance to *Pyricularia* in a programme to transfer its resistance to local Uganda strain (Uganda, D.A. 1958).

Phyllachora eleusinis Spet. has been reported from Uganda and Tanzania and causes tar spot on finger millet leaves (Small, 1922). *Cercospora fusimaculans* Atk. has been reported from Tanzania (Wallace and Wallace, 1947). *Gloeocercospora* sp. has caused severe blight of leaves in Malawi (Weihe, 1950).

Tar spot (*Phyllachora eleusines*) causes small, jet black, brown and slightly water-soaked spots or lesions which are irregularly distributed on both sides of the leaves. This disease usually appears late as the crop approaches maturity (Dunbar, 1969).

Striga

Striga hermonthica is an important pest of finger millet in east Africa. Control measures involve uprooting before seeding, crop rotation and the possible use of chemical herbicides.

Insects and animal pests: Common insects and pests are locusts and grasshoppers, stem borers and foliage caterpillars.

FOOD USES

Finger millet is frequently an important constituent in local beer making. Sometimes it is the major constituent, but frequently it is added to sorghum and other carbohydrate sources. The finger millet enzyme is reported to have a saccharifying power greater than the corresponding enzymes from sorghum or maize malt, but less than that of barley malt amylases (Patwardhan and Narayana, 1930).

In Africa, finger millet is mainly consumed either cooked as porridge or used in brewing (Dunbar, 1969). White finger millet is particularly well-suited for making porridge, with the dark brown grain colour preferred for making beer.

In much of central and southern Africa and India, finger millet is consumed as a thick porridge. It is called sadza in Zimbabwe, nsima in Malawi, ugali in Uganda or mudde or sankati in India. The porridge is prepared by adding the flour to boiling water with constant stirring to obtain the desired consistency. At times, dry cassava tubers are added to improve the texture of the porridge.

A fermented thin porridge called ambali is also consumed as food during lunch and breakfast. The flour is mixed with water. A small quantity of fermented flour is added as a starter and kept in a warm place for a day. This is then added to boiling water with constant stirring to obtain a porridge of free-flowing creamy consistency. It is cooled and eaten.

A particularly important feature in the humid tropics is the excellent keeping quality of finger millet grain which is the best of all the cereals.

As shown in Table 4, finger millet from Zimbabwe has a lower protein content than maize or the other tropical small grains. It is however, much richer in calcium than most of the other cereal grains (Johnson, 1968).

TABLE 4
Comparative analysis of Zimbabwe grains: percentage by weight

	Finger millet	Pearl millet	Sorghum	Maize
Dry matter	87.0	89.0	90.0	90.0
Carbohydrate	72.0	70.0	72.0	74.0
Crude protein	7.0	10.0	10.0	8.5
Fat	1.3	4.4	2.7	4.3
Fibre	3.4	1.8	2.1	2.1
Ash	4.0	2.6	1.7	1.5
Digestible protein	5.5	8.0	7.2	6.8
Total digestible nutrients	72.0	80.0	78.0	80.0

Feed uses

In a feeding study made in Zimbabwe, finger millet was fed to fatten pigs in combination with maize (75 per cent millet + 25 per cent maize) or pollards (70 per cent millet + 30 per cent pollards) and compared with maize; pollard blend (60:40). The protein contents in the above feeds were 15.5, 18.4 and 17.2 per cent, respectively (Calder, 1960). When 25 per cent of maize was replaced by millet, there was a small improvement in efficiency of feed conversion over maize alone or maize + pollards. However, the millet + pollards combination was less effeciently used than maize alone.

Grinding

Grinding of finger millet is considerably simpler than that of maize or kafir corn. Water is not used and the grain is merely ground in the pestle and winnowed, or sometimes sifted, winnowed and reground. This process resulted in meal recovery of 80 per cent with 18 per cent ofals and 2 per cent waste. It should be pointed out that rapoko is used commonly for brewing and is not commonly ground to a meal to make thick porridge. It was reported that the extraction rate by traditional method of grinding was 80 per cent for finger

millet whereas it was poor for maize (55 per cent), sorghum (65 per cent) and pearl millet (75 per cent). Loss of vitamins (Thiamine and Riboflavin) was negligible for finger millet whereas it was up to 90 per cent in maize (Carr, 1961).

SUMMARY

Finger millet ranks fourth in area and production among cereals next to maize, sorghum, and pearl millet in SADCC countries. This is a poor man's crop and grown by small farmers. Very little research work has been carried out on this crop. Germplasm has been collected from Botswana, Zambia, Zimbabwe, Malawi, and parts of Tanzania. There is a need to collect germplasm from Mozambique, Angola and Tanzania. Finger millet is used as food known as sodza, and nsima (thick porridge). It is also used for brewing. The beer from finger millet is preferred over the beer made from sorghum, pearl millet and maize. The protein content of finger millet is inferior to many cereals such as maize, sorghum, pearl millet and wheat but it is very rich in ash and fibre content.

A systematic research programme for the improvement of finger millet for grain yield and quality was initiated in 1985 at Matopos (Zimbabwe) by SADCC/ICRISAT sorghum and millet improvement project. A total of 1285 germplasm accessions have been collected locally or introduced from elsewhere for evaluation at four to five locations in different SADCC countries during rainy season of 1986-87. The selected lines will be used in finger millet improvement programmes.

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