COLLECTION AND EVALUATION OF PEARL MILLET (*PENNISETUM*) GERMPLASM FROM MALAWI

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Collection and Evaluation of Pearl Millet (*Pennisetum*) Germplasm from Malawi[1]

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A germplasm collecting trip to Malawi was launched during March/April 1979, resulting in the collection of 260 traditional cultivars of pearl millet (Pennisetum americanum), *11 intermediate forms, and 6 accessions of wild* Pennisetum. *Most of the cultivated pearl millet samples were obtained from the hot lowlands of the lower Shire Valley, with a few samples from the cool highlands of Mulanje and Mangochi. A mixture of different types that varied in plant height, maturity, and spike characters were observed in farmers' fields. In the south, early types with loose, thin, cylindrical spikes and in the north, late-maturing types producing many tillers with stout spikes having long bristles were found. The grain is used to prepare a thick porridge,* nsima, *or to brew local beer,* chimera. *When the collection was evaluated at ICRISAT Center, Patancheru, considerable variation was observed for days to 50% flowering and plant height, but not for spike and grain characters. During the rainy season, the majority of the accessions flowered early (70 days), grew very tall (250 cm), and produced thin (22 mm), short (22 cm) spikes with small, obovate to elliptical, corneous grey grain. In the postrainy season, most of the accessions flowered a week earlier accompanied by reduction in plant height. Millet germplasm from Malawi belongs to the race* typhoides *and serves as a good source of genes for earliness, tillering, and corneous endosperm.*

Malawi, a republic in east-central Africa, lying between latitudes 9°45' and 17°16'S covers the southern part of the Rift Valley. Pearl millet (*Pennisetum americanum* [L.] Leeke) might have reached southern Africa during the 8th or 9th century A.D., as evidenced by a single grain uncovered in the Ngonde region of northern Malawi (Robinson, 1966). Though pearl millet is grown essentially throughout the country, its concentration is in the lower Shire Valley, the southern part of Malawi. Although, pearl millet is not very much appreciated as food by people now accustomed to eating maize (*Zea mays* L.), it is grown to maturity at such a time when farmers have depleted their stock of food grains, and sorghum (*Sorghum bicolor* [L.] Moench) and maize are not yet ready for harvest. It is a common practice to harvest a head load of pearl millet spikes in the morning, dry, thresh, and grind the grain to make flour and prepare it for a meal the same day. This practice continues for quite some time since most of the material grown by the farmers is asynchronous. After this time, pearl millet is mainly used for brewing beer.

Of the 8 accessions previously assembled and evaluated from Malawi (Murty et al., 1967), only 2 are available at ICRISAT Center, hence the need for systematic germplasm collection in Malawi. The purpose of this paper is to document the

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germplasm collection expedition to Malawi, describe the variation in pearl millet observed in farmers' fields, and describe the evaluation for morphological and agronomical characters at ICRISAT Center, Patancheru.

PLANNING AND COLLECTION PROCEDURES

A planning and organization trip to Malawi in February 1979 (Mengesha, 1979) enabled a smooth and successful collection expedition during April–May 1979. The collecting team included P. K. Sibale, Principal Agricultural Research Officer (PARO), Chitedze Agricultural Research Station (CARS), Lilongwe, Malawi, J. Kumwenda, Dryland Agronomist, Shire Valley Agricultural Consolidation Project (SVACP), Ngabu, Malawi, I. R. Denton, FAO consultant, and S. Appa Rao, Germplasm Botanist, ICRISAT. Agricultural officers of the area concerned served as local guides.

Collection started at Ngabu (lower Shire Valley) in the extreme south, and progressed through Lakeshore, Lilongwe, Kasungu, to Rumphi in the north (Fig. 1). All areas covered were sampled systematically to obtain representation of their genetic diversity of ICRISAT mandate crops: sorghum, pearl millet, pigeonpea (*Cajanus cajan* [L.] Millsp.), and groundnut (*Arachis hypogaea* L.). Sampling procedures were similar to those followed for collecting the germplasm in Ghana (Appa Rao et al., 1985). As the expedition was planned to coincide with harvest time, it was possible to obtain samples from farmers' fields. These were supplemented by samples from threshing floors, farmers' seed stores, granaries, and local markets.

COLLECTION AREA

Crop ecology

The agroclimatic conditions of Malawi were described by Agnew (1970). In the lower Shire Valley, where pearl millet is extensively grown, the average annual rainfall is about 813 mm in the north and 711 mm in the centre around Ngabu (SVADP, 1975). About 85% of the total rainfall occurs from mid-November to late March. The Shire Valley and Lakeshore lowlands have average annual temperatures between 23° and 26°C. The highest temperature of 44°C was recorded at Nsanje in the extreme south of the lower Shire Valley (SVADP, 1975). Pearl millet is grown at elevations around 100 m in Shire Valley to 2,000 m at Mulanje. In general, alluvial soils are found in the lowlands of the Shire Valley, ferrallitic soils around the Lakeshore area, and stony lithosols in the north. We observed pearl millet being grown in all types of soils.

Ethnobotany

To generalize, the ethnic composition of Malawi is predominantly Bantu, agricultural people who cultivate a variety of crops and speak several languages (Agnew, 1970). Chi-chewa speakers, found from the Luangwa River in the west to the Zambezi in the south, cultivate pearl millet, sorghum, and maize. The Tumbuka people living in the north of the Dwangwa River cultivate finger millet (*Eleusine coracana* [L.] Gaertn.) extensively. The Lomwe and Sena people, occupying the southern region, usually grow pearl millet and sorghum.

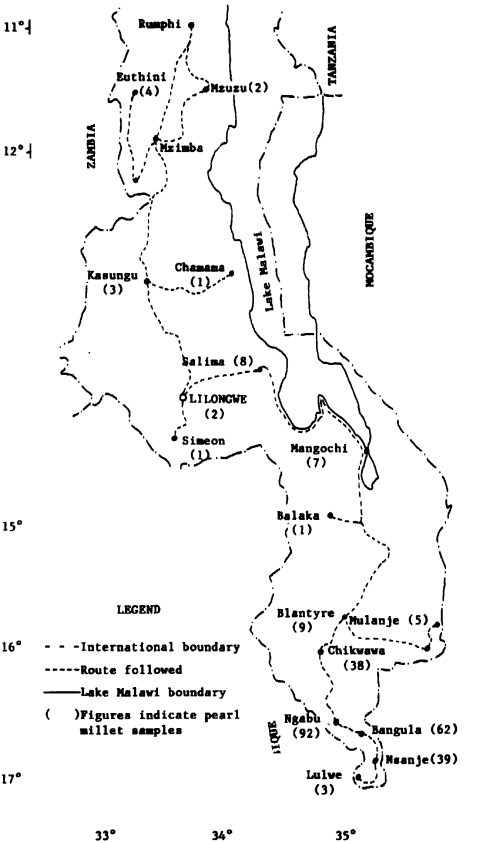


Fig. 1. Route followed and number of pearl millet germplasm samples collected from different locations in Malawi during March–April 1979.

TABLE 1. THE RANGE, MEAN, AND STANDARD ERROR (SE) OF SOME IMPORTANT CHARACTERS OF PEARL MILLET (*PENNISETUM*) FROM MALAWI.[a]

Character	Range	Mean	SE
Days to 50% flowering—R	56–116	63.5	0.68
Days to 50% flowering—PR	50–78	62.3	0.38
Plant height (cm)—R	146–380	249.1	1.68
Plant height (cm)—PR	79–225	154.3	1.77
Total tillers (No.)—R	1–6	2.6	0.05
Productive tillers (No.)—R	1–5	2.4	0.04
Spike exsertion (cm)—R	−16–10	1.4	0.24
Spike length (cm)—R	16–33	25.3	0.19
Spike length (cm)—PR	15–39	24.8	0.29
Spike thickness (mm)—R	16–35	21.9	0.18
Spike thickness (mm)—PR	15–45	22.2	0.22
Spike shape—R[b]	1–2	1.2	0.03
Spike density—R[b]	2–7	4.6	0.06
Bristle length—R[b]	1–9	2.2	0.06
Grain shape—PR[b]	1–5	2.0	0.08
Grain color—PR[b]	4–7	5.6	0.04
1,000 grain weight (g)—R	2–9	6.7	0.07
Endosperm texture—R[b]	2–8	4.8	0.08

[a] Data are based on a study of 243 landrace populations grown in uniform nurseries at Patancheru, India, with planting on 24 June 1980 (rainy—R) and 2 November 1979 (postrainy—PR).
[b] See descriptors for pearl millet, IBPGR/ICRISAT, 1981.

Pearl millet is grown almost everywhere in Malawi. It is found in small areas by most households in the north, while in the Nsanje lowlands, south from Bangula, it is extensively cultivated. In the Shire Valley, it is predominantly a sole crop. However, it is also mixed with cowpea (*Vigna unguiculata* [L.] Walp.), or a species of cucurbits. On the hill slopes, it is mixed with maize, cassava (*Manihot esculenta* Crantz), sorghum, or pigeonpea.

Material collected

During this expedition, we collected a total of 1,106 accessions of which 277 were wild, weedy, and cultivated types of pearl millet, sorghum (417), finger millet (190), groundnut (33), pigeonpea (19), and 170 samples of other crops (Denton and Appa Rao, 1979). Information on latitude, longitude, and altitude of the collection site from which a sample was obtained and the agricultural practices followed was gathered while collecting the samples (Appa Rao, 1979).

AGRONOMIC EVALUATION

Of the 277 pearl millet samples collected, 243 were released by the quarantine services of the Government of India. All 243 accessions were evaluated at ICRISAT Center, Patancheru (17°27'N), in alfisols with planting in the postrainy season on 2 November 1979 and rainy season 24 June 1980. Each accession was planted in 4 rows of 4 m length, spaced 75 cm apart and 10 cm within rows. Supplementary irrigation was provided during the rainy season and regular irrigation in the postrainy season. Morphological and agronomical characters were recorded at the appropriate stages of development on 5 randomly selected plants as per the list

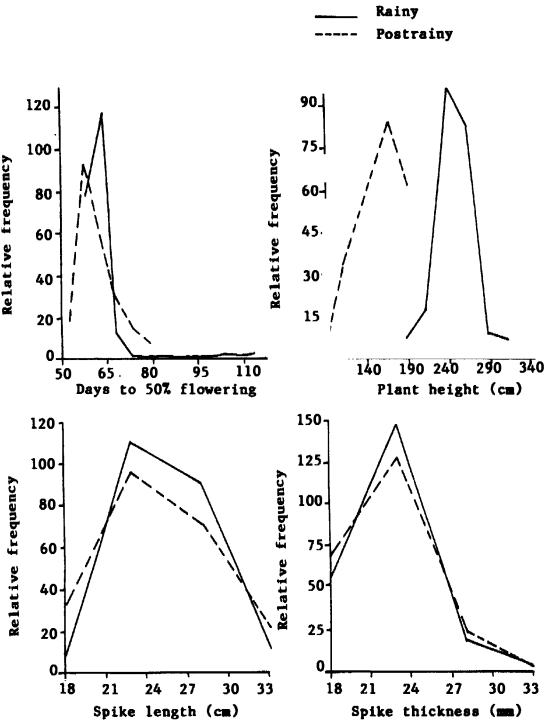


Fig. 2. Days to 50% flowering, plant height, spike length, and spike thickness of pearl millet germplasm from Malawi when planted during rainy (June 24) and postrainy (November 2) seasons at ICRISAT Center, Patancheru.

of pearl millet descriptors (IBPGR/ICRISAT, 1981). The range, mean, and standard error for 18 characters are given in Table 1. Most of the accessions produced 1–6 basal tillers with thin stems. Leaf blades are lanceolate, short, and glabrous. Considerable variation was observed for days to flowering, plant height, and bristle length.

Flowering

Number of days from planting to flowering varied depending on the sowing date at ICRISAT. During the rainy season, most of the accessions flowered within 70 days, and only 12 took more than 100 days, while in the postrainy season, most flowered about 1 wk sooner (Fig. 2). Differences in the time taken to flower during the 2 seasons suggest that most of the material is photoperiod-sensitive, as the 2 seasons at Patancheru differ in day length and temperature. It was known that time to anthesis in pearl millet can be reduced by imposing short days (Helmers and Burton, 1972).

Plant height

Plant height varied enormously depending on the season. During the rainy season, plants were 200–300 cm tall with a modal value around 250 cm, while in the postrainy season, plant height was drastically reduced, with a range of 100–200 cm, with a modal value around 170 cm (Fig. 2). In pearl millet, both temperature and photoperiod are known to influence plant growth (Fussell et al., 1980). The differences in plant growth observed during the 2 seasons were most likely due to temperature and photoperiod.

Spike and grain characters

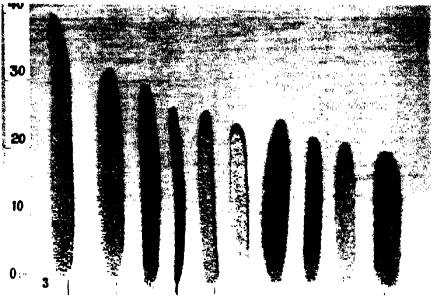
Spike length varied between 18–33 cm, with a modal value around 22 cm in both seasons (Fig. 2). Changes in temperature and photoperiod during crop growth altered days to flowering and plant height but not spike length. However, the spike length at ICRISAT Center (Fig. 3) was reduced compared to the spike length in Malawi (Fig. 4). Spike thickness varied between 18–33 mm, with a modal value of 22 mm in both seasons. Most of the accessions produced thin, loose, cylindrical spikes. Of all the characters evaluated, spike length appeared to show the least variation in the 2 contrasting growing seasons.

Most of the accessions from Malawi produced very small, obovate to globular, grey grain that is completely covered by the glumes. The endosperm is mostly corneous. Variation in grain size, color, and shape is relatively low. Grain shape of the accessions suggests that pearl millet from Malawi belongs to the race *typhoides* (Brunken et al., 1977).

Variation and adaptation

A mixture of different types displaying variability for height, maturity, spike size, shape and compactness, and color, size and density of bristles are usually grown in one field by farmers. Various pearl millet types were found in different geographic areas that are adapted to the prevailing agro-climatic conditions and farming systems. Pearl millet is usually intercropped with pigeonpea and sorghum

Fig. 3–5. Fig. 3. Different spike types and sizes of pearl millet (*Pennisetum*) from Malawi when grown at Patancheru. Fig. 4. A traditional farmer of Shire Valley holding the long, compact, and cylindrical spikes of pearl millet and sorghum spikes. Fig. 5. Pearl millet is usually grown mixed with pigeonpea and sorghum on hill slopes.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(Fig. 5). Material collected from the lower Shire Valley produced thin, loose, and cylindrical spikes (Fig. 6) and were early-maturing because of the local demand for a cereal that matures before sorghum of maize. Early-maturing types might have evolved due to strong selection pressure by farmers as suggested by Hawkes (1983).

At higher altitudes in places like Mulanje, Bvumbwe, and Kasungu where the rainfall is greater, photoperiod-sensitive types were found that mature with the cessation of rains. In these areas, the cultivars produce very stout, long, and compact spikes. Large spikes with long dense bristles with profuse tillering (Fig. 7) were found in isolated stands in the central region. These resemble the 'Sanio' types of West Africa in flowering and spike characters (Bono, 1972). In general, frequency of cultivation and associated genetic diversity decreases from south to north probably because of selection pressure by farmers for early-maturing types. Pearl millet of Shire Valley resembles the germplasm from north India for characters like flowering, plant height, and spike size (Appa Rao et al., 1983).

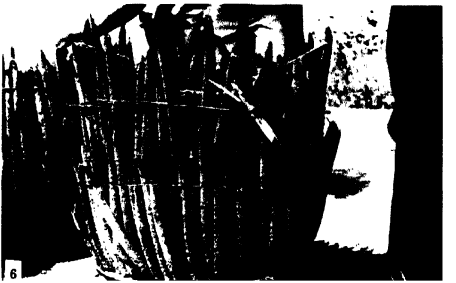
Most of the pearl millet germplasm collected from Malawi has been found to be early to medium maturing in rainy season when grown at ICRISAT Center. However, 12 accessions collected from the cool highlands of Mulanje and Mangochi flowered after 100 days and were photoperiod-sensitive. This material is different from the majority of west African material available in ICRISAT gene bank as they flower early and produce short, thin spikes with small grains. The material from Malawi is earlier in flowering than the material from eastern and southern African countries like Kenya, Mozambique, Tanzania, and Zambia, which is mostly sensitive to photoperiod. However, the tillering habit, grain size, and endosperm texture are similar. The earliness which is not very common in eastern and southern African material is a desirable character in the Malawi germplasm that can be exploited for future use.

Though the occurrence of *Pennisetum americanum* subsp. *monodii* (*maire*), wild progenitor of pearl millet, is not reported from Malawi (Brunken et al., 1977), we could find weedy forms *P. americanum* subsp. *stenostachyum* (Klotzsch) Stapf and Hubb. (*shibra*) in a few isolated pockets around Ngabu, Chickwawa, Bangula, and Chirome areas in southern Malawi. However, shibras are found throughout much of the area of pearl millet cultivation in Africa (Brunken et al., 1977). The fact that the progenitor species does not occur in Malawi and that the weedy forms occur rarely further strengthens the view that cultivated pearl millet had migrated to Malawi.

Wild Pennisetums

Napier or elephant grass (*Pennisetum purpureum* Schum.) was widely distributed and was found at altitudes from 100–1,200 m above sea level. It was commonly found along river banks and road sides on black, fertile soils. It grows over 2 m and produces several spikes with shattering spikelets (Fig. 8). The thick,

Fig. 6–8. Fig. 6. In the lower Shire Valley, women carry baskets full of millet spikes for immediate food preparation. Fig. 7. Profusely tillering and densely bristled types of pearl millet are found in isolated stands in the central region. Fig. 8. Napier grass (*Pennisetum purpureum*) is found along river banks and road sides in the lower Shire Valley.



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strong stems are commonly used for fencing, hut walls, and making mats. Natural crosses of *Pennisetum americanum* (2n) with *P. purpureum* (4n) are very rare and the hybrid is sterile, so there is no gene flow. Crosses can be made artificially and there is evidence however, that one of the genomes in *P. purpureum* resembles that of *P. americanum* and hence constitutes the secondary gene pool (Brunken et al., 1977). It is cultivated for fodder in several countries.

Pennisetum polystachyon (Linn.) Schult. was found widely distributed at higher elevations of 1,000–1,500 m on sandy soils. Its local name is *mchila wagaru* which means "dog's tail." It grows up to 1 m tall, produces many thin stems with long drooping spikes. Two distinct types were found: one with green stems, yellow bristles, and glumes, and the other with purple pigmentation on stems, leaf sheaths, bristles, and glumes. Though both forms grow together, and flower at the same time, intermediate forms were not observed. It is generally used as roofing material.

Utilization

The grain is pounded to remove the pericarp or bran. While pounding, water is sprinkled to moisten the grain. After removing the bran, the grain is again pounded into a fine flour. Sometimes the flour is made by grinding on a large stationary stone with a small stone. Almost every household has a pair of grinding stones. However, with the introduction and spread of hammer mills in the villages, the whole grain is ground in the mills.

The traditional food (*nsima*) is prepared by adding flour to boiling water with constant stirring until the consistency is judged to be correct. Sometimes, dry cassava tuber is ground along with millet which is supposed to improve the texture and quality of nsima. Usually nsima is eaten along with a cooked dish called *ndiwo*. Green leaves of pumpkin (*Cucurbita maxima* Duch.), cowpea, *Corchorus*, *Amaranthus* sp., and many other locally available herbs that are very soft and slimy are cooked to prepare a local dish called *theolal*. As soon as maize or sorghum is available, millet is usually used to brew a local beer, *chimera*. In central and northern regions, small quantities of millet are grown in backyards only for brewing beer.

Genetic erosion

Pearl millet was supposed to be the most important crop some 80 yr ago throughout Malawi, as evidenced by the frequency of old grinding stones in old village sites (Williamson, 1975). Only traditional cultivars are grown, and we did not come across any field with improved cultivars (Denton and Appa Rao, 1979). Hence, pearl millet may not be replaced by any improved cultivars in the immediate future. Maize is becoming more and more popular because of the preference for food prepared with maize. However, pearl millet is still grown in small areas by many farmers in the Shire Valley because of its early maturity and because of preference for the local beer prepared from pearl millet.

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