Multiplication and Preliminary Characterization of West and Central African Pearl Millet Landraces

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Introduction

West Africa is a center of origin and diversity of pearl millet [*Pennisetum glaucum* (L.) R. Br.], but this diversity is neither well-understood nor fully accessible to and exploited by NARS breeders and farmers. The objective of the present study was to multiply and initially characterize 281 pearl millet accessions from all over West and Central Africa, with the final aim of promoting a more systematic and targeted exploitation of genetic diversity in adapted germplasm in West African pearl millet improvement programs.

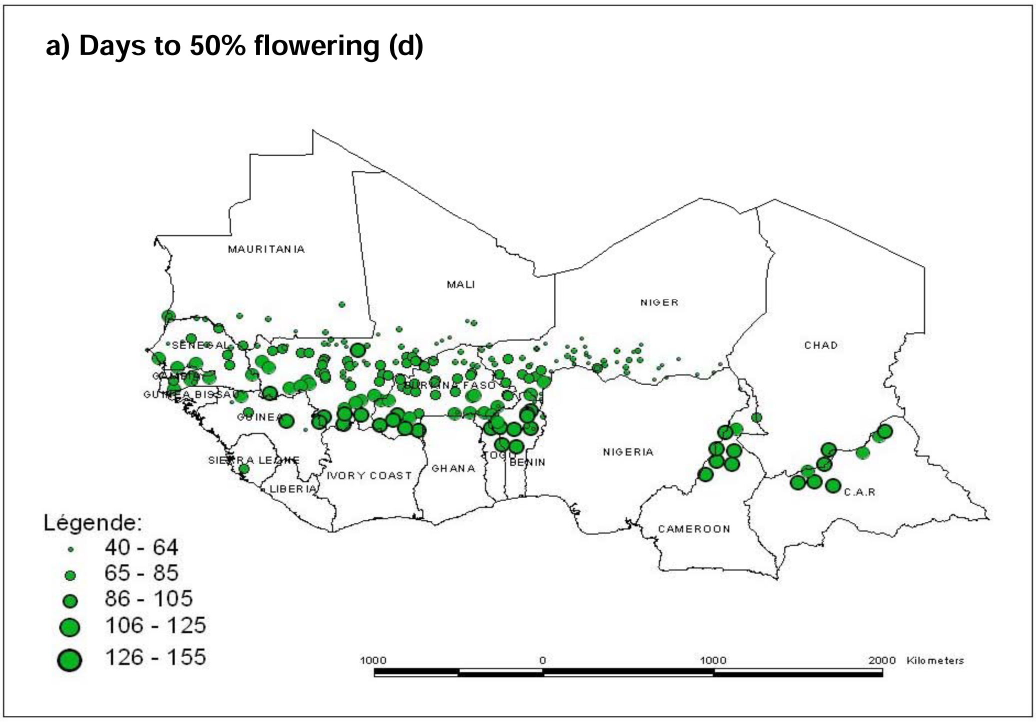
Materials and Methods

The 281 pearl millet accessions originated from nine countries of West and Central Africa: Benin (22 accessions), Burkina Faso (42), Cameroon (10), Central African Republic (9), Guinea (10), Mali (80), Mauritania (8), Niger (70) and Senegal (30). The accessions had been assembled during joint collections by the Institut de la Recherche pour le Développement [IRD; formerly called the Office des Recherches Scientifiques et Techniques d'Outre-Mer (ORSTOM)] and ICRISAT in 1976 and 2003, and were obtained from IRD-Montpellier and IRD-Niamey. Geographically, these accessions cover longitudes from 8°44′E to 17°28′W and latitudes from 6°49′N to 20°26′N. Since the primary objective was to multiply each accession to an adequate effective population size, the accessions were grown in nonreplicated plots of 3–10 rows (depending on seed availability) in the rainy season of 2005 at the ICRISAT station at Sadoré, Niger. The row length was 4.8 m with 0.75 m interrow distance and 0.4 m distance between hills within a row. Thinning was done to 2 plants per hill. Multiplication of materials was performed by controlled sibbing within each accession, aiming at a minimum effective population size (N_e) of 60 plants contributing to the next generation. This limit was set to avoid inbreeding and random loss of diversity under the given budgetary constraints. With self-fertilization excluded, the inbreeding rate in small populations follows the equation $\Delta F = 1/(2N_e+1)$ (Falconer 1989). With the limit set at $N_e = 60$, the expected inbreeding rate would be $\Delta F = 1/121 = 0.0083$, which was considered acceptable. For regeneration of highly-outbreeding, open-pollinated cultivars of carrot (*Daucus carota* L.), Le Clerc et al. (2003) had recommended an effective population size of only 50 plants. Pollen donors were simultaneously selfed to obtain S_1 seed of each accession for line development. Simultaneously with the multiplication, the accessions were preliminarily characterized for days to 50% flowering, plant height, panicle length, circumference, exsertion, form and compactness of the panicle, yield per sibbed panicle, 1000-grain weight, and grain color.

Results and Discussion

Seed multiplication. Out of the 281 accessions, 12 were completely lost due to lack of germination or severe downy mildew attack, and others had too few plants to assure proper multiplication. Seed multiplication through sibbing was finally achieved for 248 accessions, with the amount of seed produced ranging from 22 g to 2474 g. The effective population size of $N_e \geq 60$ was achieved in only 117 accessions (minimum of 30 sibbed panicles). Twenty-five accessions were multiplied to an effective population size of less than 20 (<10 sibbed panicles) due to poor germination or lack of adaptation of the accessions. An increase of the inbreeding coefficient by 0.02 to 0.2 units has to be noted for these accessions when further used. Selfed seed was produced from 240 accessions with the seed quantities obtained ranging from 14 g to 2901 g.

Initial characterization. The pearl millet accessions revealed wide ranges for all the phenotypic traits assessed (Table 1) and are therefore a most valuable source of variation for specific breeding objectives. Frequency distributions of the accessions were normal for plant height but skewed for most other traits (data not shown). Accessions from Benin, Burkina Faso, Cameroon and Mali showed particularly large ranges for days to 50% flowering (at least 95 days, difference between the earliest and the latest flowering accession). Accessions from Niger revealed the widest range for panicle length (91 cm difference between accessions with the shortest and those with the longest panicle).



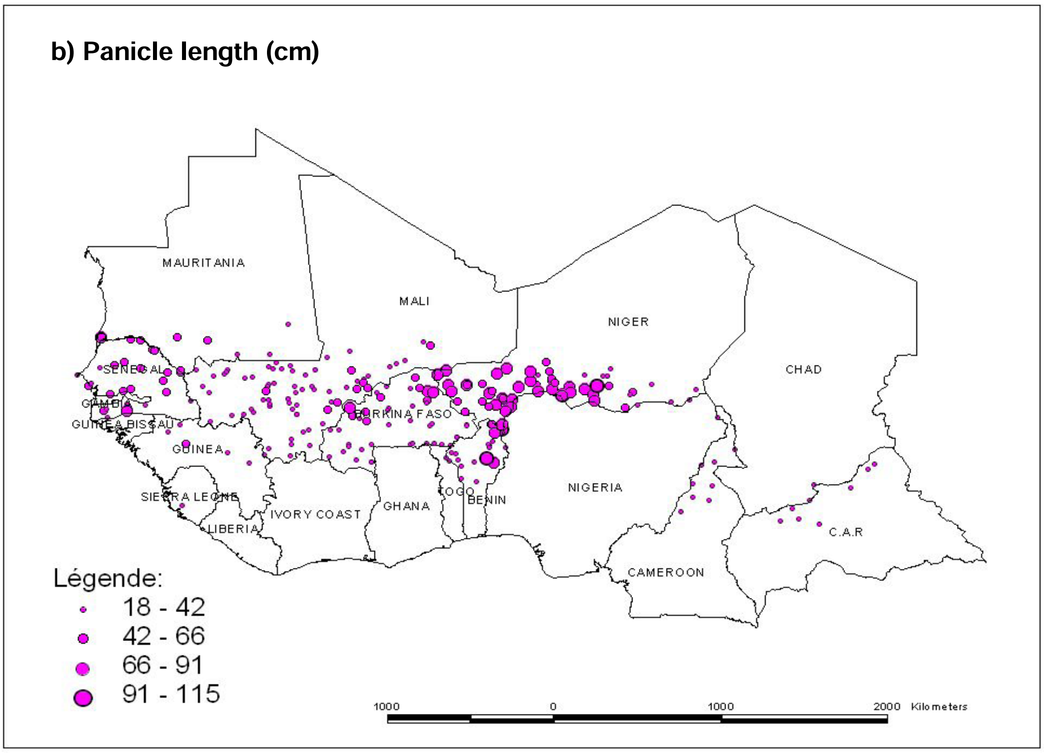


Figure 1. Geographic differentiation of West and Central African pearl millet landraces for (a) days to 50% flowering and (b) panicle length.

Table 1. Mean values of 269 West and Central African pearl millet accessions and minimum and maximum observed values[1] for different traits evaluated at ICRISAT-Sadoré, Niger, rainy season, 2005.

Trait	Mean	Minimum	Maximum
Days to 50% flowering	89	40	155
Seedling vigor (1–9 scale)[2]	2	1	7
Plant height (cm)	274	153	405
Panicle length (cm)	43	18	115
Panicle diameter (cm)	2	1	6
Panicle exsertion (cm)	–3	–23	13
Grain weight per pollinated panicle (g)	22	1	78
1000-grain weight (g)	9	4	14

1. No statistics indicated here because materials were grown without replication with the main objective of multiplying them to a sufficiently large population size.
2. 1–9 scale for seedling vigor: 1 = excellent, 3 = good, 5 = medium, 7 = poor and 9 = very poor.

Geographic differentiation. Linking the phenotypic observations to the geographic origin of the pearl millet accessions revealed patterns of geographic differentiation mainly for days to 50% flowering and panicle length (Fig. 1). Days to 50% flowering was correlated to latitude (coefficient of correlation $r = -0.61$, significant at $P = 0.01$), reflecting the predominance of early-flowering accessions in the north and later-flowering accessions in the south (Fig. 1a). This differentiation corresponds to the increasing amount of rainfall from north to south, which results in increasing the length of the life cycle of the cultivated landraces. Geographic differentiation for panicle length revealed two groups: (1) accessions originating from western Niger, northeastern Benin, northern Burkina Faso and Senegal with generally longer panicles; and (2) accessions originating from eastern Niger, western Benin, Cameroon, Central African Republic, southern Burkina Faso and Mali with overall shorter panicles. These results confirm earlier observations by Bono (1973) and Marchais (1982) who equally divided West African pearl millets into two morphologically different groups, one comprising accessions from Mali, Mauritania and Burkina Faso, and the second from Niger and Senegal.

Future plans. The materials have been complemented with further accessions multiplied in the off-season of 2005/2006 (less well-characterized because of large off-season effects on phenotypes), including landraces from Nigeria, Chad and Sudan which were missing in our study. Small amounts of the regenerated seed were returned to IRD and ICRISAT genebanks for further long-term conservation. But the main part of the seed produced from a total of 424 accessions (including off-season multiplication) will be exploited in multilocation diversity analysis and heterotic grouping of West African pearl millet genetic resources. A three-year project (2006–2009) funded by the Federal Ministry for Economic Cooperation and Development, Germany (BMZ) has started to work on these aspects since April 2006. Besides enhancing access to and use of local diversity by NARS colleagues in Senegal, Mali, Burkina Faso, Niger and Nigeria, this project strives toward a more systematic and efficient, regionally coordinated use of diversity in breeding open-pollinated and hybrid cultivars of pearl millet in West Africa. Inbred lines are also being developed out of the selected accessions to widen the genetic base for potential pearl millet hybrid development based on West African adapted materials. Further information and seed samples of the multiplied accessions may be obtained from the corresponding author.

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