

Characterization of World's Foxtail Millet Germplasm Collections for Morphological Traits

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Introduction

Foxtail millet [*Setaria italica* (L.) P.Beauv.] is one of the world's oldest cultivated crops. Its domestication and cultivation is estimated to have occurred over 4000 years ago (Chang 1968). It was the most important food crop of the Neolithic culture in China. Foxtail millet ranks second in the world's total production of millets and is an important staple food for millions of people in southern Europe and Asia (Marathee 1993). There is wide genetic diversity available in foxtail millet, and characterizing these resources is a prerequisite for the genetic improvement of its cultivars. In this article we report the characterization and classification of foxtail millet germplasm conserved at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)-Patancheru, India.

Materials and Methods

The ICRISAT-Patancheru genebank has 1535 foxtail millet germplasm accessions from 26 countries (Table 1). They were characterized from 1977 to 2005 after evaluation at ICRISAT's research farm at Patancheru (18°N and 78°E; altitude 545 m.a.s.l.; average annual rainfall 750 mm, Jun-Sep). The accessions were grown in alfisols, in single-row plots 4 m long with interrow spacing of 75 cm and intrarow spacing of 10 cm. Di-ammonium phosphate was applied at the rate of 100 kg ha⁻¹ as a basal dose to supply nitrogen and phosphorus, in addition to 100 kg ha⁻¹ urea applied as topdressing. Sowings were done in the last week of July, and when required one irrigation was provided to obtain uniform plant stands. All cultural practices and data recordings were the same for all the years of evaluation. Data were recorded on various morphological traits such as plant pigmentation and leaf color, growth traits such as days to 50% flowering, plant height, growth habit, culm branching, and inflorescence traits such as bristle length, lobe compactness, exertion, inflorescence length and width, weight of 5 panicles, grain color as per descriptors for *Setaria italica* and *S. Pumila* (IBPGR 1985). The accessions were classified into races and subraces on the basis of inflorescence morphology (Prasada Rao et al. 1987).

Results and Discussion

Plant growth traits. The accessions varied considerably for days to 50% flowering (32–135 days) both within a country of origin and amongst countries (Table 1). Diversity for days to 50% flowering was greater in germplasm accessions originating from Sri Lanka (55–135 days) while it was narrowest in Russian germplasm (32–50 days). Plant height varied from 20 cm to 215 cm, with accessions from China tending to be dwarf (20 cm) and those from India taller (215 cm). Based on plant color, accessions were classified into three classes: green, pigmented and deep purple. The majority were green (74.6%), followed by pigmented (23.6%), and deep purple (1.8%). Among the four types of growth habit — decumbent, erect, erect geniculate and prostrate — observed in the accessions, about 96.5% were erect. Leaf color of the accessions was classified as green, pigmented or yellow. The majority of the accessions were green (80.7%), followed by yellow (10.6%) and pigmented (8.7%). About 44% of the accessions had less culm branching and the rest had medium to high.

Inflorescence characters. Exsertion of the inflorescence ranged from 10 mm to 360 mm (excluding countries represented by lone accessions). Accessions with the least exsertion (10 mm) were from China and those with the maximum exsertion (360 mm) from Russia and the Commonwealth of Independent States (CIS). Inflorescence length ranged from 10 mm to 390 mm. Accessions with the shortest inflorescence length were from Russia and the CIS, and those with the longest were from India. Accessions with long inflorescences were in general better yielders than those with short inflorescences. Accessions with the minimum inflorescence width (5 mm) were from Cameroon, China, India and Syria, and those with the maximum (120 mm) were from India. About 50% of the accessions had long bristles (>5 mm), followed by 25% with medium bristles (>3 mm to <5 mm), and 22.5% with short bristles (<3 mm). Of the three types of lobe compactness — loose, medium and compact — accessions with compact lobes were predominant (64.4%), followed by medium (32.8%). We observed a wide range of grain colors from black, combination of black and white, dark grey, light grey, red to yellow. The

Table 1. Range of variation for plant growth and inflorescence traits in foxtail millet germplasm accessions conserved at ICRISAT-Patancheru, Andhra Pradesh, India.

Country of origin	No. of accessions	Days to 50% flowering	Plant height (cm)	Peduncle exertion (mm)	Panicle length (mm)	Panicle width (mm)	Weight of five panicles (g)
Afghanistan	17	35–50	35–90	80–300	40–140	10–15	1.88–18.5
Cameroon	8	90–90	120–120	180–180	110–110	5–5	1.10–2.0
China	60	34–58	20–130	10–270	30–220	5–30	0.35–108.1
Ethiopia	1	62–62	120–120	190–190	170–170	15–15	19.3–19.3
Hungary	9	33–45	30–100	120–320	20–220	10–20	2.50–20.8
India	974	36–93	48–215	20–340	20–390	5–120	0.36–100.7
Iran	3	36–44	45–55	70–180	30–70	10–10	1.86–4.5
Kenya	8	50–64	100–145	140–260	140–220	15–30	18.85–45.5
Korea	52	34–55	55–115	80–300	60–240	10–40	3.60–109.1
Lebanon	33	36–50	45–90	80–300	30–300	10–15	1.70–18.7
Malawi	1	52–52	125–125	140–140	190–190	30–30	53.0–53.0
Mexico	2	40–42	55–55	180–250	70–80	5–5	5.50–7.80
Myanmar	6	49–62	105–145	120–170	185–245	10–25	19.35–44.0
Nepal	21	45–67	70–150	80–245	130–245	10–25	8.20–46.1
Pakistan	29	35–58	45–155	80–280	50–220	10–30	1.55–41.1
Russia & CIS	67	32–50	25–140	60–360	10–260	10–40	0.60–116.5
South Africa	3	55–60	100–160	130–180	130–200	15–20	23.95–32.2
Spain	1	36–36	90–90	220–220	110–110	15–15	6.0–6.0
Sri Lanka	14	55–135	125–150	60–180	200–320	20–40	32.50–77.4
Switzerland	1	59–59	115–115	120–120	190–190	20–20	23.7–23.7
Syria	119	33–68	25–145	40–340	20–280	5–30	0.76–76.8
Taiwan	28	43–49	55–130	50–250	85–235	15–35	23.20–78.6
Turkey	22	35–48	35–90	50–350	30–230	10–30	0.75–57.2
United Kingdom	4	50–69	105–145	170–200	160–210	15–30	13.30–29.0
Unknown	2	33–42	35–100	140–200	30–160	10–20	2.20–37.0
USA	48	35–62	55–155	40–350	80–280	10–30	6.80–83.0

majority of accessions had yellow grain (88.38%). A wide range of variation for weight of 5 panicles (0.35 g to 116 g) was observed. Accessions from Russia and the CIS had the highest panicle weight, while those from India tended to have the lowest.

Classification

The foxtail millet germplasm accessions were classified into races Moharia, Maxima and Indica and subraces on the basis of inflorescence morphology (Prasada Rao et al. 1987). Each race has subraces. Moharia consists of subraces Aristata, Fusiformis and Glabra; Maxima consists of subraces Compacta, Spongiosa and Assamense; and Indica consists of subraces Erecta, Glabra, Nana and Profusa (Table 2). A majority of the accessions (838) belonged to the subrace Nana, followed by Compacta (208), and Glabra (163). All the subraces except Fusiformis were available in Indian accessions.

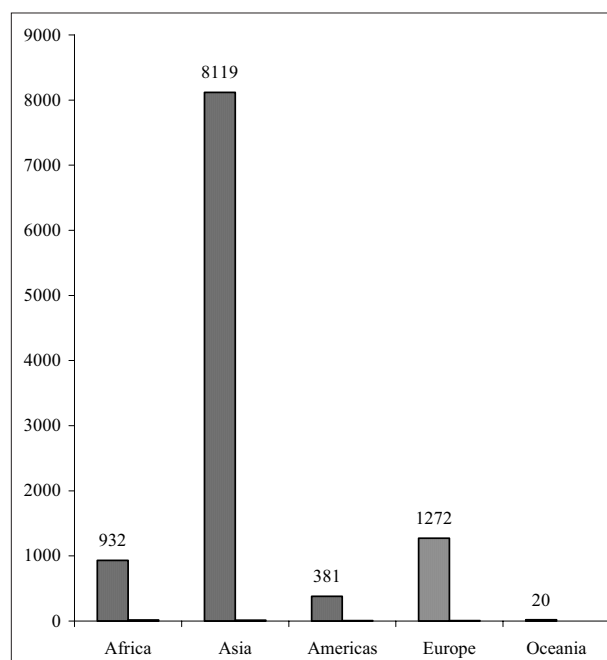


Figure 1. Foxtail millet germplasm shared with scientists in different countries in Africa, Asia, the Americas, Europe and Oceania (1978–2005).

Table 2. Geographic distribution of foxtail millet germplasm races/subraces from different countries.

Country	Moharia			Maxima			Indica				Total
	1 ¹	2	3	4	5	6	7	8	9	10	
Afghanistan	2	–	15	–	–	–	–	–	–	–	17
Cameroon	–	–	–	–	–	–	–	–	–	–	0
China	–	–	4	49	1	–	–	–	4	–	58
Ethiopia	–	–	–	–	–	–	–	–	1	–	1
Hungary	–	–	6	2	–	–	–	–	1	–	9
India	9	–	8	19	21	2	4	105	747	17	932
Iran	–	–	2	–	–	–	–	–	–	–	2
Kenya	–	–	–	–	–	–	–	1	7	–	8
Korea	–	–	–	52	–	–	–	–	–	–	52
Lebanon	33	–	–	–	–	–	–	–	–	–	33
Malawi	–	–	–	–	–	–	–	1	–	–	1
Mexico	–	–	–	–	–	–	–	–	–	–	0
Myanmar	–	–	–	5	–	–	–	1	–	–	6
Nepal	–	–	–	11	–	–	–	6	4	–	21
Pakistan	20	–	4	2	–	–	–	–	3	–	29
Russia & CIS	1	1	39	24	1	–	–	–	1	–	67
South Africa	–	–	–	–	–	–	–	–	3	–	3
Spain	–	–	1	–	–	–	–	–	–	–	1
Sri Lanka	–	–	–	–	–	–	–	12	2	–	14
Sudan	–	–	–	–	–	–	–	–	–	–	0
Switzerland	–	–	–	–	–	–	–	–	1	–	1
Syria	8	–	64	23	–	–	–	–	21	–	116
Taiwan	–	–	6	12	2	–	–	7	1	–	28
Turkey	1	–	11	8	–	–	–	–	1	–	21
UK	–	–	1	–	–	–	–	3	–	–	4
USA	5	–	1	–	–	–	–	1	41	–	48
Unknown	–	–	1	1	–	–	–	–	–	–	2
<i>Viridis</i>	–	–	–	–	–	–	–	–	–	–	18
<i>Glauca</i>	–	–	–	–	–	–	–	–	–	–	36
Unclassified	–	–	–	–	–	–	–	–	–	–	7
Total	79	1	163	208	25	2	4	137	838	17	1535

1. Subrace 1 = Aristata; 2 = Fusiformis; 3 = Glabra; 4 = Compacta; 5 = Spongiosa; 6 = Assamense; 7 = Erecta; 8 = Glabra; 9 = Nana; 10 = Profusa. Wild accessions of *Viridis* and *Glauca* have been included to tally with the total number of foxtail millet germplasm accessions conserved at the ICRISAT genebank.

Germplasm Sharing

A total of 10,724 seed samples of foxtail millet germplasm accessions have been distributed to 45 countries. Of these 932 samples were supplied to 15 countries in Africa, 8119 to 14 countries in Asia, 1272 to 8 countries in Europe, and 381 to 7 countries in the Americas (Fig. 1). The repeated requests for some of the germplasm accessions stands testimony to their value in the genetic enhancement programs of foxtail millet around the world. For example, the lines ISe 376, ISe 375 and ISe 865 have been requested very frequently, and have been released as varieties for commercial cultivation in India.

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