Evaluation of Ninety International Pearl Millet Germplasm Collections for Morpho-Physiological Characters in Nuevo Leon, Mexico[1]

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ABSTRACT

Ninety international pearl millet germplasm collections were introduced from ICRISAT, India and evaluated at the Agricultural Experimental Station, FAUANI, Marin, Nuevo León, Mexico for different morpho-physiological characters in early 1985. The objective of the study was to characterize and identify genotypes with good agronomic traits for adaptation and potential forage production in semi-arid regions of Nuevo Leon. Data were collected on days to flowering, plant height, leaf number, leaf blade length and width, sheath length, stem thickness, productive tiller number, spike length and thickness, peduncle exsertion and for 1 000 seed weight. There exists large phenotypic variability among genotypes in all characters studied. The study demonstrated significant positive correlation among different yield components. The genotypes IP7897, IP7928, IP7968, IP9161, IP7922, R2938, IP9845, and IP7890 had high potential forage yield and high forage quality (high protein and ash content). These genotypes with good agronomic attributes could be recombined through population breeding methods for high-quality forage yield to meet the demand for forage in semi-arid Nuevo Leon.

COMPENDIO

Noventa germoplasmas de mijo perla fueron introducidos del ICRISAT, India y evaluados en la Estación Experimental Agrícola, FAUANI, Marín, Nuevo León, México para diferentes caracteres morfo-fisiológicos en Primavera de 1985. El objetivo del estudio fue hacer una caracterización e identificación de genotipos con buenos rasgos agronómicos para adaptación y su potencial en producción de forraje en regiones semiáridas de Nuevo León. Los datos que fueron tomados son días de floración, altura de la planta, número de hojas, largo y ancho de la hoja bandera, longitud de la vaina, grosor del tallo, número de hijuelos productivos, longitud y grosor de la espiguilla, excersión del pedúnculo, peso de 1 000 semillas, etc. Existe gran variabilidad en todas las características estudiadas. El estudio ha demostrado correlaciones con significancia positiva entre los diferentes componentes de producción. Fueron severamente identificados genotipos con potencial en producción de forraje y alta calidad del forraje (alto contenido de proteína y ceniza). Esos genotipos con buenos atributos agronómicos pueden ser recombinados a través de métodos de mejoramiento de la población para alta calidad y producción de forraje para mejorar la demanda de forraje en los Trópicos semiáridos de México. Los genotipos IP7897, IP7928, IP7968, IP9161, IP7922, R2938, IP9845 e IP7980, fueron seleccionados por ser de alto potencial en producción de forraje.

INTRODUCTION

Pearl millet is one of the most important cereals for humans and animals in the arid and semi-arid tropics, characterized by an annual rainfall of 200-600 mm concentrated over a short period of two to four months, high temperatures, high evapotranspiration and sandy soils (3, 10) Its adaptation is thought to be largely due to its short life cycle and tolerance of high temperatures (1, 13) Northeastern Nuevo Leon exhibits the typical climatic conditions required for pearl millet growth, with an annual rainfall of less than 600 mm, an average temperature of 22°C, and high evapotranspiration Pearl millet cultivars have been found to be well-adapted (6, 11), in Nuevo Leon Evaluation, documentation and distribution are some of the important steps in the process of the introduction of a species in a region where it is not known.

The objective of the present study was to characterize international pearl millet germplasm in Mexico for some morpho-physiological traits, to identify and select desirable genotypes with superior agronomic performance, and to correlate these traits with yield components.

MATERIALS AND METHODS

The present study was conducted in the Agricultural Experimental Station of the Agronomy Faculty,

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University of Nuevo Leon (FAUANL) in Marin, Nuevo Leon, Mexico (latitude 25°53' N, longitude 100°03' W, and altitude 367 m) during the spring of 1985. The average monthy precipitation and temperatures during the growing period of the crop of the present study are given below.

Month	Monthly mean temperature (°C)	Rainfall (mm)
March	21.1	17.6
April	23.2	12.2
May	27.1	22.8
June	28.2	30.2
July	29.4	35.7
August	30.1	28.1
September	28.8	118.9

Two hundred international pearl millet collections were introduced from the germplasm collection held by the International Crops Research Institute for the Semi-arid Tropics (ICRISAT), located in Patancheru, Andhra Pradesh, India. These were sown on March 4 under dry conditions in single 3 m rows 80 cms apart, with a plant-to-plant distance of 10 cm. Irrigation by canal was applied following planting, and its application continued throughout the growing season at levels for optimal growth (one month intervals). A 100-50-00 (NPK) fertilizer dose was applied to the soil surface using urea (46% N) and triple superphosphate (46% P) seven days after emergence. Plants were thinned to 125 000 pl/ha. Plant protection measures were adopted to control insects like thrips and aphids.

Both qualitative and quantitative variables were taken according to the descriptors of pearl millet adopted by IBPGP-ICRISAT (9). Out of 200 germplasm collections, only 90 were evaluated for morpho-physiological characters; the remaining 110 were discarded mainly because of poor emergence or of photosensitivity; many of them did not flower (40).

Qualitative characters: Visual scores (following IBPGR descriptors) were taken on emergence and seedling vigor, leaf canopy, tiller orientation, stigma pigmentation, anther color, foliage and sheath pigmentation, degree of leaf senescence, lodging susceptibility, principal spike form and density, glume color, grain cover, color and form, and overall agronomic potential.

Quantitative characters: These were taken from seven plants from each plot. Plant height (cm), leaf number, leaf blade length and width (cm), sheath length (cm), stem thickness (mm), and peduncle exsertion (cm), 1 000 seed weight (g) were taken from a single sample of each genotypes. Yield could not be measured because of damage caused by birds and insects. Agronomic potential was assessed on the basis of panicle and seed size.

The quantitative results will be explained for each character on the basis of its range, mean and variance among the cultivars studied. Correlation analysis was performed among all characters.

RESULTS

Qualitative characters

At emergence, using the visual score scale of one to five, 30 genotypes got the best score (1), 56 were intermediate and four got the poorest score (5). For seedling vigour, only four genotypes received the best score; eight were intermediate and five got the poorest score. For leaf canopy, only six were erect, 49 were intermediate and 35 were of lax type. Eighty-nine had erect tillers and only one was a divergently tillered type. Three genotypes had purple stigmas and 87 had the normal white pigmentation. Anther color ranged from cream white to purple, with 27 cream white, 20 cream yellow, 31 yellow, nine purple. Eighty-eight had green foliage and sheath pigmentation and two had purple. Twenty-six cultivars showed a minimum degree of leaf senescence, 57 were intermediate and seven showed the maximum rating. Fifty-nine showed minimum lodging susceptibility, 29 were intermediate and two showed maximum susceptibility. Variation in panicle form was stronger, with 47 genotypes having a cylindrical panicle, 2 conical, 1 spindle, 27 candle-shaped, 10 lanceolate and 3 globose (Fig. 1). There was large variation in spike density: 9 genotypes were of the open type, 36 were intermediate and 45 were of the compact type. Seventy-eight had clear glume color, 2 were intermediate and 10 were dark. Seven different grain colors were observed: 4 had white grain, 8 were cream white, 16 yellow, 36 brown, 11 moderately brown and 6 dark brown. The grain covering was also quite variable: 36 were exposed, 32 intermediate and 23 enclosed (Fig. 2). Grain form ranged from obovate (18) to lanceolate (9), elliptical (5), hexagonal (9) and globular (39) (Fig. 3).

Agronomic characters

Frequency distributions for days to flowering, plant height, spike length and thickness, and 1 000 seed weight are shown in Fig. 4.

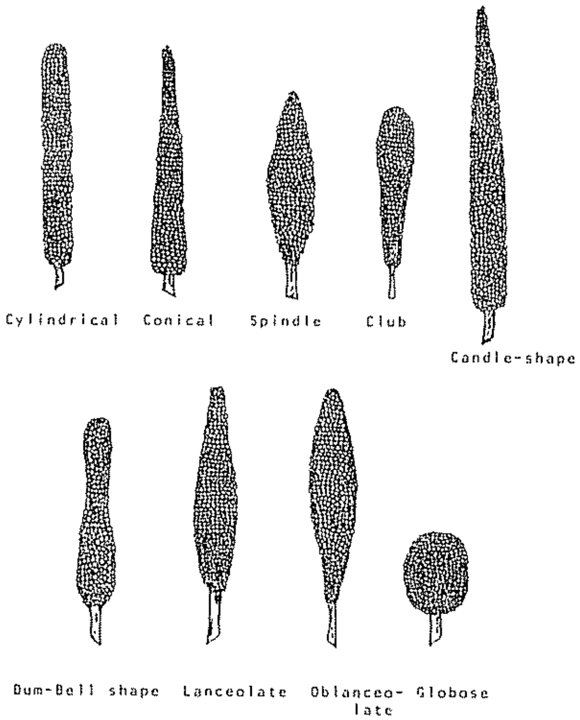

Fig. 1. Spike form (after pearl millet descriptors).

Days to flowering ranged from 64 to 137. ICP-241, IP-9115, IP-4201, IP-6115, and IP-7849 were early-flowering (64-77 days). ICMPES-1, IP-3748, IP-7849, IP-3122 and IP-3727 were intermediate (78-91 days) and IP-8836, IP-11220, IP-8794, IP-8017 and IP-9983 were late types (over 91 days). Plant height ranged between 64 and 221 cm, showing a normal distribution with minimum and maximum variance of 31 (ICMPES-9) and 3549 (IP-1983) respectively. Among the genotypes studied, the shortest were IP-11673, IP-7873, IP7009 and the tallest were IP-2612, IP-5411, IP-7367 and IP-11725. IP-7890 had the minimum leaf number per plant and ICMPES-16 had the maximum (10.29). The minimum within-cultivar variance for this character was found in IP-7913 (0) and the maximum was for IP-5720 (181). Leaf blade length ranged from 24.4 to 63.3 cm on with a minimum within-genotype variance of 10 (EB-112-1-2-1-1) and a maximum of 238 for IP-8085. Leaf blade width ranged from 1.71 to 40.53 cm with a minimum variance of 0.03 (ICMPES-1) and a maximum of 1.69 (IP-5411). The leaf sheath length varied from 9.43 to 26.93 cm with a minimum variance of 0.4 (ICMPES-16) and a maximum of 109 (IP-7926). The stem thickness ranged from 5.5 to 15 mm with a minimum variance of 0.5 (IP-7849) and the maximum of 23.9 (IP-2612). The average productive tiller number ranged from 0.14 (IP-7904) to 11.14 (IP-11208) with a minimum variance of 0.14 and a maximum of 70.14 in each case.

The spike length varied from 7.56 cm in IP-11673 to 77.4 cm for IP-5411. Minimum variance recorded was 2 in EB-132-2-S-2-DM-1 and maximum was 673 in IP-5411. The spike thickness ranged from 10 to 38 mm for IP-8056 and IP-11725 respectively. This trait showed minimum variance. For peduncle exsertion, the longest was 12 cm in IP-7849 and the shortest was 27.14 cm in IP-5411. The lowest variance was 2 for ICMPES-9 and the highest was 126 recorded from IP-9965. The 1 000 seed weight varied from 3.17 to 12.69 g corresponding to IP-11673 and IP-8044 respectively. With respect to overall agronomic potential, 39 were identified as good, 43 were intermediate and eight were poor on the basis of visual score of panicle length, productive tiller number and grain number.

Correlations

The productive tiller number showed a highly positive correlation with the total tiller number ($r = 0.90$). Spike length was significantly correlated with stem thickness ($r = 0.56$), plant height ($r = 0.50$), peduncle exsertion ($r = 0.62$) and sheath length ($r = 0.52$). Spike thickness showed a highly significant positive correlation with the total leaf number ($r = 0.44$), leaf blade length ($r = 0.61$), leaf blade width ($r = 0.50$, stem thickness ($r = 0.62$), plant height ($r = 0.50$) and exsertion length ($r = 0.49$). Total leaf number was highly positively correlated with leaf length ($r = 0.35$), leaf blade width ($r = 0.56$), stem thickness ($r = 0.44$) and plant height ($r = 0.43$).

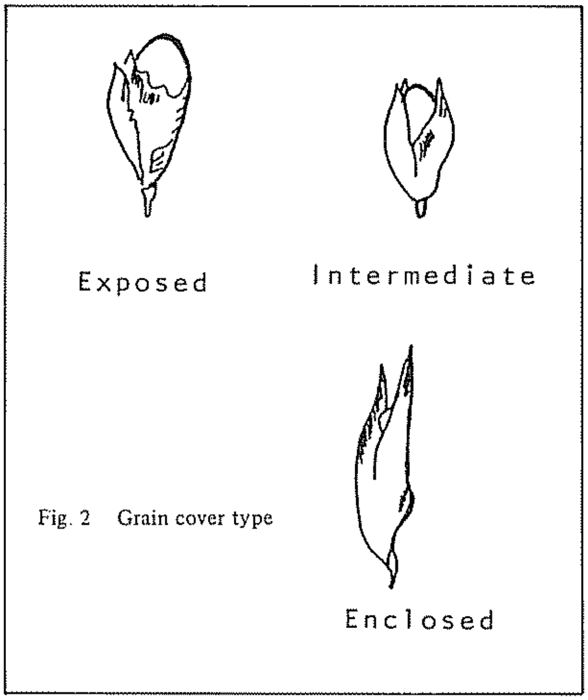

Fig. 2. Grain cover type

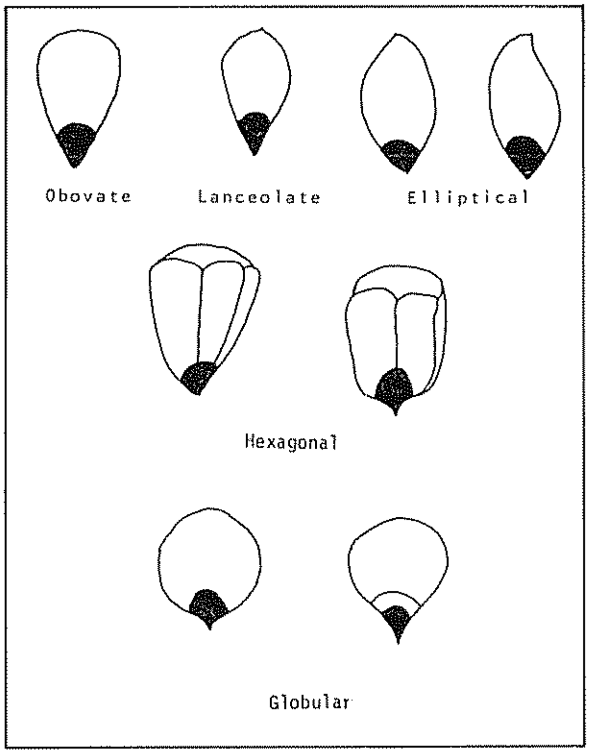

Fig. 3 Grain shapes

Leaf blade length was found to be positively correlated with leaf blade width (r = 0.59), stem thickness (r = 0.61) and plant height (r = 0.42). Similarly, leaf blade width was highly correlated with stem thickness (r = 0.60) and plant height (r = 0.40). The peduncle exsertion was found to show a significant positive correlation with productive tiller number (r = 0.29), spike length (r = 0.62), total tiller number (r = 0.25) and sheath length (r = 0.49), but was significantly negatively correlated with leaf blade length (r = 0.39), leaf blade width (r = 0.34) and stem thickness (r = 0.57).

DISCUSSION

Variability

The germplasm showed large variability for different morphological characters. This is attributed to the climatic and edaphic conditions of the 15 African countries and India where they were collected. These materials were adapted to certain conditions; once moved to another environment, their morphological and phenotypic traits became modified by that environment.

Brunken *et al.* (2) states that it is important to group the germplasm on the basis of common characters, names and races. Since it was not possible to study the specific characteristics of the genotypes of each country, it was observed that lines that originated from different countries of Africa showed a large variability in characters like spike size and compactness. For instance, in the lines from Niger, the spike length showed a range from 18.3 to 61.0 cm and the

Table 1. Range of variation of quantitative and qualitative characters in 90 pearl millet germplasm collections (IP).

Character	Population		
	Min-Max	Mean	SE[a]
Days to flowering	64.00–137.00	87.00	17.29
Plant height (cm)	63.71–221.00	139.67	31.76
Leaf number	3.86– 10.29	6.36	1.28
Leaf blade length (cm)	24.40– 63.30	48.51	6.99
Leaf blade width (cm)	1.71– 4.53	2.99	0.60
Sheath length (cm)	9.43– 26.93	13.13	2.43
Stem thickness (mm)	5.50– 15.43	9.61	2.01
Productive tiller number	0.14– 11.14	2.61	1.99
Spike length (cm)	7.56– 77.43	27.31	11.42
Spike thickness (cm)	10.07– 38.00	21.36	5.37
Peduncle exsertion[b] (cm)	–27.14– 12.00	–2.60	6.46
1000 seed weight (g)	3.17– 12.69	6.92	1.71
Stigma pigmentation[b]	Present-Absent		
Glume colour[b]	Clear-Purple		
Grain cover[b]	Exposed-Completely covered		
Grain colour[b]	Clear-Dark brown		

a Standard error.

b See pearl millet descriptors, IBPGR-ICRISAT, 1981.

spike form showed variation from cylindric to lanceolate In the germplasm from Botswana, the spike length varied from 10.9 to 44.60 cm and the forms included cylindric, candle, lanceolate and globular. Among Indian genotypes, there was much variability for the 1 000 seed weight. Among the 90 genotypes are draces for which 1 000 seed weight ranged from 5.13 to 8.33. The study indicates, however, that a great source of genetic potential exists among genotypes that can be used for breeding purposes in other countries where the crop is being introduced.

Many of the morphological characters in the 90 entries studied showed normal distributions and large standard deviations. These results suggest that a good opportunity exists to select desirable characters for grain and forage production. Though there was no opportunity to compare the morpho-physiological traits of the germplasm collections in both ICRISAT and Marin, Nuevo Leon, it appears that the expressions of traits were different in both centers (Maiti-personal observations)

Utilization of the variability in genetic improvement

Much of the genetic variability in pearl millet was observed in the areas of primary domestication in Africa and the region of early introduction in Asia (5, 7). Geberekindan (5) suggests that adequate evaluation and genetic characterization of collections are an important requisite for their use in genetic improvement programs. At the same time, one may identify the sources of resistance to different biotic stress factors.

Twenty-two genotypes were selected visually for forage production potential, taking into consideration the previously evaluated traits of dry matter percentage, ash content and protein percentage (8). There is a large variability in these quality parameters among the genotypes studied. Some have over 12% ash content and over 11% protein (P-2938 and IP-7922 respectively) (8) There is a great demand for animal feed in the semi-arid tropics of Mexico, especially during the spring-summer season. Germplasm selected for good forage quality could offer a potential source of forage production to meet the forage requirement of this part of the country The selected cultivars with potential forage production associated with high forage quality could be recombined to form a population for further improvement.

Association among variables

There exists a highly significant positive correlation among some of the yield components, confirming findings reported by others (4, 12). Pearl millet varieties with a short and thick stem, but with a broad flag leaf are more productive than those with thin stems and small flag leaves, because this leaf has a smaller photosynthetic area (12) It is expected that cultivars with a smaller number of erect leaves and with thick stems will be high yielding, although

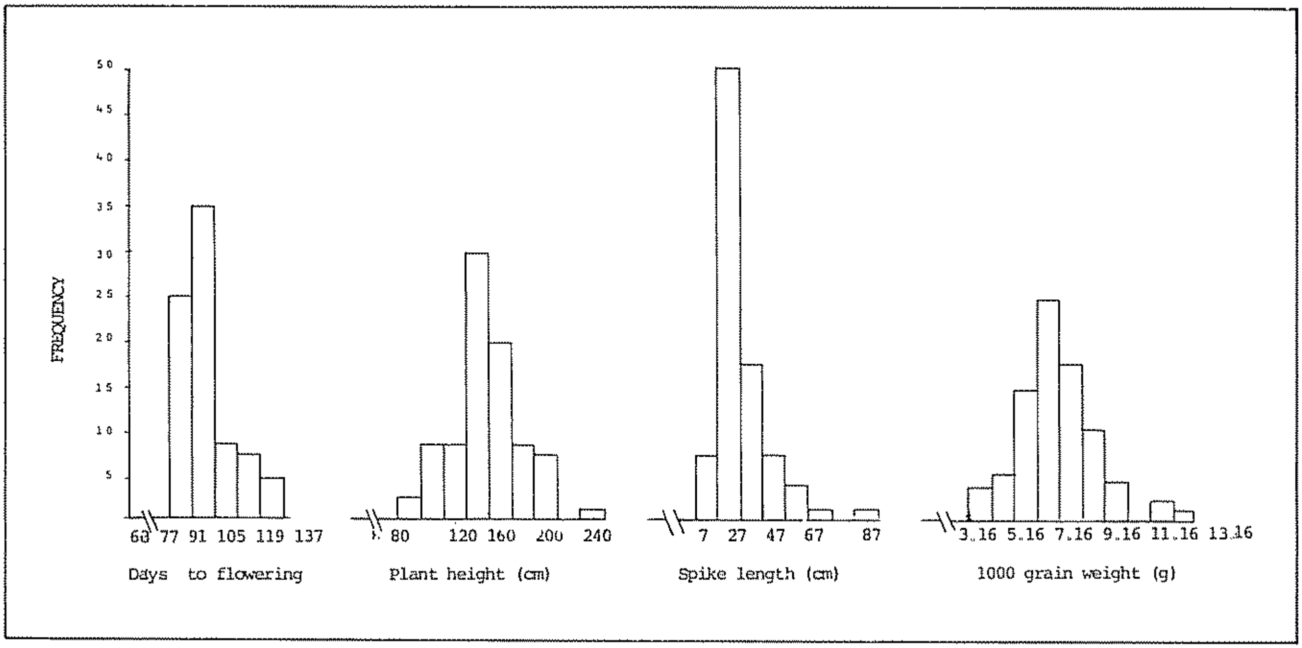

Fig. 4 Frequency distributions for days to flowering, plant height, spike length, and 1 000 grain weight of pearl millet germplasm

this depends on the panicle weight and the number of productive tillers. Leaf area, tiller number, plant height, days to flowering, grain filling period, panicle length and breadth, grain number and weight are considered the most important characters contributing to yield (4). Grain yield shows a highly positive correlation with plant height, productive tiller number and grain number per plant, as reported by these workers. Reddy and Sharma (14) found that grain yield was positively correlated with days to flowering, days to maturity and protein content.

Table 2. Linear correlations among some morphological characters in 90 pearl millet cultivars (γ).

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Productive tiller No	1.00											
2. Umproductive tiller No	-0 070	1 00										
3. Spike length	0.20^{+}	0.09	1.00									
4. Spike thickness	0.22^{+}	0.02	0.30^{++}	1.00								
5. Total tiller No	0.90^{++}	0 37^{++}	0.14	0 20^{+}	1 00							
6. Sheath length	0.28^{+}	0.05	0.52^{++}	0.20^{+}	0.24^{+}	1.00						
7. Leaf No	0.27^{++}	0 04	0.02	0.40^{++}	0.22^{+}	0.40^{++}	1 00					
8. Leaf blade length	0.36^{++}	0.15	0.54^{++}	0.13	0.27^{++}	0.61^{++}	0 35^{++}	1.00				
9. Leaf blade width	0.35^{++}	0.10	0.25^{++}	0.55^{++}	0.28^{++}	0 50^{++}	0 56^{++}	0.59^{++}	1 00			
10. Stem thickness	0 31^{++}	0.08	0.56^{++}	0.21^{+}	0.26^{++}	0 62^{++}	0 44^{++}	0 61^{++}	0 60^{++}	1.00		
11. Plant height	0 16	0.03	0.50^{++}	0.12	0.14	0 50^{++}	0.43^{++}	0 42^{++}	0.40^{++}	0.46^{++}	1.00	
12. Peduncle exsertion	0.29^{++}	0.03	0.62^{++}	0 15	0.25^{+}	0.49^{++}	0 21^{+}	0 39^{++}	0.34^{++}	0.57^{++}	0.33	1.00

\+ Significant from zero ($P < 0.05$)
++ Significant from zero ($P < 0.01$)

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