Evaluation of Forage Sorghum Germplasm

R Yadav, SK Pahuja and RPS Grewal
Forage Section, Department of Plant Breeding, CCS Haryana Agricultural University, Hisar-125 004 (Haryana)

The germplasm lines generated at Hisar and collected from different sources were evaluated for forage traits like multicut traits, leaf characteristics, height, fodder yield and biotic stresses for over three to five years. Wide range of variability was observed for all the characters studied. Maximum variability was observed for days to 50% flowering followed by leaf area index, leaf length, number of leaves per plant, plant height, regeneration potential, TSS, green fodder yield and dry fodder yield per plant. To exploit the fodder yielding potential and for improvement in other traits of forage sorghums, taking into account different aspects of the current and future emphatic areas these germplasm resources can be utilized.

Key words: Forage sorghum, Evaluation, Germplasm, Growth rate, Regeneration

Presence of remarkable range of adaptability of sorghum in varying altitude, temperature, moisture, fertility, disease and pest regimes makes it a favourable choice to bridge the gap between demand and supply of fodders. Developing superior varieties/hybrids offers solution to the problem of sustained and increased fodder supply per unit area and per unit time. The greater utilization of the genetic diversity in developing sustainable solutions to basic crop constraints or enhancing the productivity is desirable. Germplasm forms the base material for any crop improvement programme and the importance of broad genetic base in evolving new cultivars and for incorporating new genes in the existing ones is well recognized. However, only a small fraction of total available collection could be fully utilized at a time due to certain limitations. For its efficient utilization, it must be properly evaluated, characterized and documented. Therefore, careful characterization and evaluation of sorghum germplasm for morpho-physiological characters and resistance to insect-pests and diseases is required.

Materials and Methods

The changing biotic and abiotic environments over years allow differential expression of entries. Therefore, about 200 to 250 germplasm lines were evaluated over three to five years during 1996 to 2002 for different traits at Forage Research Area, CCS HAU, Hisar (Haryana). An important aspect often ignored and underestimated is the tremendous knowledge about sorghums available with local farmers. Considering this aspect, 56 lines collected from fields of farmers of Western Uttar Pradesh and Uttaranchal, the major forage sorghum growing areas, were also incorporated in this study.

Most of the material (having G and S numbers) was generated at CCS HAU, Hisar and the lines with IS numbers were obtained from ICRISAT, others which are denoted by names of the places were collected from different places in Western Uttar Pradesh and Uttaranchal. These lines were grown along with two checks (HC 308 and SSG 59-3) in augmented design. Each block consisted of ten germplasm lines and two checks. Number of blocks varied from 20 to 25 every year depending on the number of lines evaluated. Each entry was grown in two rows of 4 m length for 3 or more years. All the package of practices to raise a good crop were followed. The observations were recorded on five randomly selected plants for important forage traits *viz.*, early vigour (score), days to 50% flowering, plant height (cm), leaf length (cm), leaf breadth (cm), leaves per plant, stem girth (cm), tillers per plant, leaf stem ratio, leaf area index (cm^2), nodes per plant, regeneration potential (%), growth rates (0-30, 30-45 and 45-60 DAS), TSS (Brix %), grey leaf spot (score), zonate leaf spot (score), sooty stripe (score), stem borer (score) and green and dry fodder yield per plant (g). For obtaining regeneration potential of a genotype, tillers per plot before taking cut and after taking cut (regenerated crop) were counted and their per cent increase or decrease was taken as regeneration potential. For growth rates, plant height was recorded in centimeters at 30, 45 and 60 days after sowing (DAS). Growth rate per day was calculated by dividing the height gained by number of days of that particular growth period. Analysis was carried out on the basis of averages calculated over the years.

Observations were recorded at 35 and 55 days after sowing for three foliar diseases *viz.*, grey leaf spot (*Cercospora sorghi*), zonate leaf spot (*Gloeocercospora sorghi*) and sooty stripe (*Ramulispora sorghi*). Scoring was done using visual standards employing the 1-5 scale,

Table 1. Range and top ranking genotypes for various characters in forage sorghum

S.No.	Character	No. of Genotypes	Range (all genotypes tested)	Criteria for best genotypes	Names of top ranking genotypes
1	Early Vigour (score)	312	1-4	=4	IS 3234-1, IS 3375-2-1, IS 4478, IS 4526, IS 4636, IS 4735-1, IS 4736, IS 4782, IS 23324, IS 23959, IS 71633, IS 71683-1, G 40-1, G 54, G 73, G 102, G 116, G 116-1, G 116-1-1, G 131, G 151, G 163, G 164, G 175, G 169, S 437, S 490, S 500-1
2	Days to 50% flowering	278	49.5-98.0	<55	IS 4526, IS 1032, S 520, G 123, G 151, IS 5717, IS 5469, G 45
3	Plant height (cm)	517	43.3-380.0	>320	G 177, G 133, G 161, G 146, G 141, G 199, G 145, Simbhaoli-3, G 185
4	Leaf length (cm)	490	39.0-96.0	>87	G 182, G 178, S 525, G 177, S. roxburghii, G 104-1-2, IS 3042-1, Sweet Sudan-1, SDSL 92111
5	Leaf breadth (cm)	490	2.3-11.5	>9.0	IS 3237-2, Harsherpur-3, NRCS 339, Dalpatpur-3, Jaya-3, Simbhaoli-3, Pant Chari 3, Bareilly-4, Hapur-1
6	No. of leaves/plant	517	5.0-53.0	>45	IS 3379, NRCS 177, PL 25, IS 3042-1, IS 5417-2, IS 5469-2, IS 70744-2, IS 3375-1, IS 5469-1
7	Stem girth (cm)	490	2.1-8.5	<2.5	IS 31130, IS 70764, G 195, IS 3275-1, IS 3370, IS 3351, G 189, IS 3214, RSDP 1, IS 3314,
8	No. of tillers/plant	437	1.0-7.4	>5.0	IS 722, IS 3238, SSG 59-3, IS 3042-1, IS 3351, G 148, NRCS 177, S 517, WT-2
9	Leaf stem ratio	208	0.2-1.0	>0.60	IS 6018, Simbhaoli, Bhitkhera-1, IS 722, Gajraula-1, Brijghat-4, Brijghat-3, IS 3313
10	Leaf area index (cm2)	106	1401.2-8801.6	>6500	SDSL 92113, G 150, G 127, IS 3262, G 146, G 110, S 199, G 143, G 139
11	No. of nodes/plant	106	3.2-10.6	>9.0	S 520, G 143, G 124, S 500, IS 4478, IS 5413, IS 3359, IS 4636, G 46, G 138, IS 14374, IS 1032, IS 1052, IS 4782, IS 10954, G 150, IS 4526, IS 4736, G 140
12	Regeneration potential (%)	106	-49-91.1	>40.0	IS 3234, IS 3228, IS 6018, G 46, G 149, S 184, IS 3075, IS 3359, S 490
13	Growth rate 0-30 DAS	106	1.0-2.6	>2.2	IS 3075, S 500, SDSL 92113, IS 3312, IS 1032, IS 3001, IS 4736, IS 2205, IS 3374, IS 23324, G 45
14	Growth rate 30-45 DAS	106	2.0-6.1	>5.5	S 520, IS 20441, G 127, G 142, IS 3075, IS 23324, IS 70746, IS 4636, IS 23234, G 145, G 151, IS 1032, IS 3374
15	Growth rate 45-60 DAS	106	1.9-7.1	>6.2	G 142, S 184, IS 3075, G 143, G 127, S 518, IS 3262, IS 20441, G 124, G 130, SDSL 92113
16	TSS (Brix %)	154	3.3-16.7	>14.0	APSSVT 10, UPMC 511, JHV 4, SRF 252, IPSSVT 50, J SEL 18, IS 3389
17	Grey leaf spot (score)	146	1.0-5.0	=1.0	IS 651, IS 3075-6, IS 3225, IS 3225-1, IS 3237-2, IS 3266-1, IS 3274, IS 3289, IS 3362, IS 3374, IS 3375-1, IS 5417, IS 5417-1, IS 5417-2, IS 5469, IS 5469-1, IS 5469-2, IS 6014, IS 5717, IS 14374-1, IS 19280, IS 23324, IS 23924, IS 70733, IS 71683, IS 71633-2, G 40-1, G 102, G 110, G 110-1, G 118, S 199, S 375, S 391, S 491, HC 171, HC 308, P 33-1, SDSL 92102-2, SDSL 92116, SDSL 92116, SDSL 92126-1, SDSL 92134, WT(GP), CSH 13R, S 490, S 437,
18	Zonate leaf spot (score)	146	1.0-3.0	=1.0	IS 651, IS 703, IS 3075-6, IS 3192, IS 3262-1, IS 3266-1, IS 3274, IS 3289, IS 3313-4, IS 3374, IS 5417-1, IS 5417-2, IS 5469-2, IS 5469-3, IS 5622, IS 5717, IS 14374-1, IS 19280, IS 23924, IS 70733, G 40-1, G 102, G 118, S 199, S 375, S 500, P 33-1, SDSL 92102-2, SDSL 92134, CSH 13R, S 437
19	Sooty stripe (score)	146	1.0-3.7	=1.0	IS 722, IS 1032, IS 1052, IS 2011, IS 3001, IS 3074, IS 3074-1, IS 3075, IS 3075-1, IS 3075-2, IS 3075-3, IS 3203-2, IS 3218, IS 3228, IS 3228-2, IS 3234, IS 3234-1, IS 3234-2, IS 3237-1, IS 3262-1, IS 3266-1, IS 3275, IS 3275-1, IS 3275-2, IS 3289, IS 3304, IS 3312, IS 3313, IS 3313-4, IS 3359, IS 3365, IS 3374-2, IS 3374-3, IS 3389, IS 4275, IS 4478, IS 4526, IS 4636, IS 4718, IS 4735, IS 4736, IS 4782, IS 5469-3, IS 4725, IS 5622, IS 10954, IS 23924, IS 23959, IS 71683-1, G 45, G 46-1, G 48, G 71, G 97, G 104-1, G 116-1, S 491-1-1, SSG 59-3, R 472, SDSL 92101, WTMC-1, WTMC-2
20	Stem borer (score)	291	5-Jan	=1.0	IS 722, IS 1005, IS 2483, IS 3152, IS 3214, IS 3234-1, IS 3318, IS 3365, IS 3370, IS 3389, IS 3679, IS 19280, IS 20441, IS 20441-1, IS 21891, IS 23324, IS 70764, IS 71691, ICSV 1, ICSV 5469, ICSV 93091, G 76, G 118-1, G 121, G 124, G 135, G 172, NRCS 179, NRCS 198, NRCS 297, S 184, S 510, S 519, *S. roxburghii*, Sweet Sudan, P 33-5, R 152, R 565, RSDP-1, RS 123, SDSL 92101, SDSL 92134, S 490, S 437
21	GFY/plant (g)	271	36.1-2500	>1500	IS 3375-1, NRCS 198, SDSL 92126-2-1, S 491, IS 70746-1, IS 3275-1, S 375, S 517, G 46-1, NRCS 179, IS 703-1
22	DFY/plant (g)	224	6.1-473.5	>120	IS 3312, IS 3313, S 199, Huzur Gurdar, G 139, G 144, IS 23324, IS 10954, G 84

where, 1 = no symptoms, 2 = few scattered lesions/spots, 3 = typical lesions developed on leaves covering up to 25% leaf area, 4 = coalescing spots covering about 26-40% leaf area, and 5 = symptoms severe, covering more than 40% of leaf area. For stem borer (*Chilo partellus*), scoring was done at 35 and 45 days after germination on leaf feeding using 1-5 scale, where, 1 = no leaf damage, 2 = 1 -10% of plants with one or more leaves damaged, 3 = 11 - 25% of plants with one or more leaves damaged, 4 = 26 - 40% of plants with one or more leaves damaged, and 5 = > 40% of plants with one or more leaves damaged.

Results and Discussion

Range, number of genotypes studied and top ranking genotypes for different characters are presented in Table 1. Figure 1 depicts the means, standard deviation and frequency distribution of different genotypes for various characters in forage sorghum. The perusal of Table 1 and Figure 1 revealed a wide range of variability for all the characters studied. Maximum variability was observed for days to 50% flowering followed by leaf area index, leaf length, leaves per plant, plant height, regeneration potential, TSS, green fodder yield and dry fodder yield per plant. In grain sorghum numerous studies were conducted to judge the variability. The studies indicated presence of enough variability for various characters in forage sorghum (Kang and Lee 1996, Teshome *et al.* 1997; Greneir *et al.* 2000). Similar exhaustive studies in forage sorghum germplasm were also undertaken by Mathur *et al.* (1991 and 1992), Grewal *et al.* (1996) and Yadav *et al.* (2002, 2003 and 2004).

In forage sorghum, germplasm available in the form of multitudes of lines needs critical evaluation for choice of parents in any breeding programme, particularly if the aim is to improve complex quantitative traits. Such work becomes easier if the available germplasm is evaluated on the basis of a given set of characters and then pick up the parents for hybridization either to exploit heterosis or for getting transgressive segregants (Bhatt, 1970; Chandra, 1977; Singh and Gupta, 1979). Lines showing better performance for five or more characters and are extracted from the germplasm evaluated in the present study are given in Table 2. Depending on the objectives of the breeding programme, genotypes from Table 1 and 2 can be selected and further utilized for forage sorghum improvement programme. Considering different aspects of the current and future emphatic areas these germplasm resources can be exploited to tap the fodder yielding potential and for improvement and exploitation of other traits in forage sorghums.

Table 2. Promising genotypes for cluster of traits

Genotype	Character
IS 722	NL, NT, LS, SS, SB
IS 1032	DF, NN, G1, G2, SS
IS 3262	LAI, G3, TSS, ZLS, SS
IS 3313	LS, R, ZLS, SS, DFY
IS 3359	NN, R, G2, TSS, SS
IS 3374	G1, G2, GLS, ZLS, SS
IS 3375-1	NL, NT, GLS, GFY
IS 4478	EV, LS, NN, R, G1, G2, SS
IS 4526	EV, DF, NN, G3, SS
IS 4636	EV, NN, G1, G2, SS
IS 4736	EV, DF, NN, G1, SS
IS 5469	DF, NL, NT, LS, R, GLS, ZLS, SS
IS 23324	EV, G1, G2, G3, GLS, SB, DFY
G 40-1	EV, NL, NT, GLS, ZLS
G 46	NN, R, SS, GFY
G 124	DF, PH, NT, LAI, TSS, DFY
G 127	DF, NT, LS, LAI, G2, G3, TSS, DFY
G 143	DF, LAI, NN, G3, DFY
G 146	DF, PH, NT, LAI, TSS, DFY
G 151	EV, DF, LAI, G2, G3
S 184	DF, R, G2, G3, SB
SDSL 92134	GLS, ZLS, SB, GFY

NT-Number of tillers/plant; LS- Leaf:stem ratio; LAI- Leaf area index; NN- Number of nodes/plant; EV-Early vigour; DF- Days to 50% flowering; PH- Plant height; NL- Number of leaves/plant; R-Regeneration potential; G1, G2, G3- Growth rates (0-30, 30-45 and 45-60 DAS, respectively); TSS- Brix %; GLS- Grey leaf spot; ZLS-Zonate leaf spot; SS- Sooty stripe; SB- Stem borer; GFY- Green fodder yield/plant and DFY- Dry fodder yield/plant.

References

Bhatt GM (1970) Multivariate analysis approach to selection of parents for hybridization aiming at yield improvement in self-pollinated crops. *Australian J. of Agric. Res.* **21**: 1-7.

Chandra S (1977) Comparison of Mahalanobis's method and Metroglyph technique in the study of divergence of *Linum usitatissimum* L. germplasm collection. *Euphytica* **26**: 141-148.

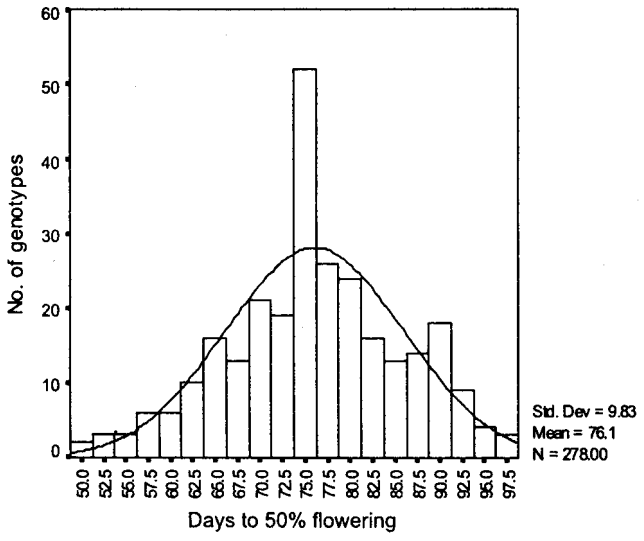
Grewal RPS, GP Lodhi, PS Sabharwal, (1996) Forage sorghum germplasm: Evaluation in the past two decades. *Indian J. Plant Genet. Resour.* **9**: 287-293.

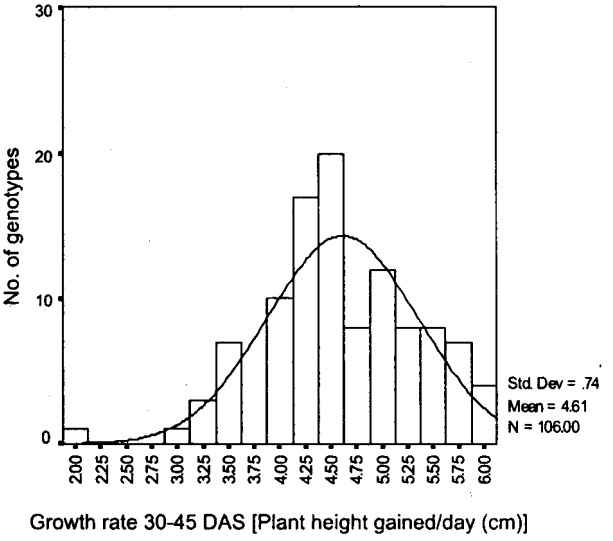
Grenier C, PJ Bramel-Cox, M Noirot, KE Prasada Rao and P Hamon (2000) Assessment of genetic diversity in three subsets constituted from the ICRISAT sorghum collection using random *vs.* non-random sampling procedures. *Theor. Appl. Genet.* **101**: 190-196.

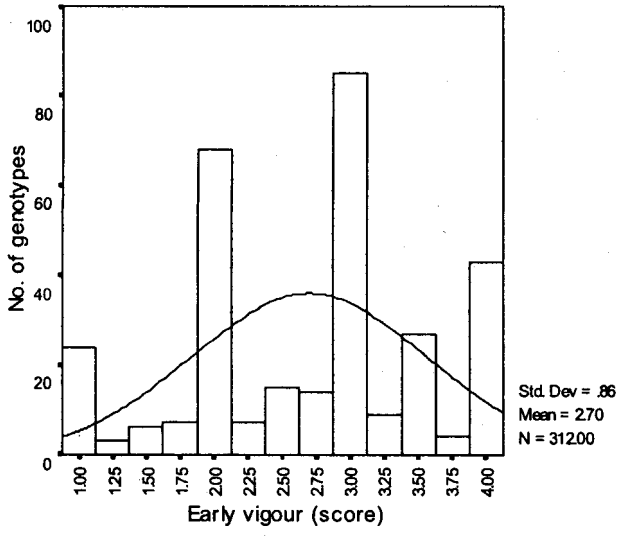
Kang Jung Hoon and Lee Hojin (1996) Growth and morphological characteristics of introduced sorghum germplasm. *Korean J. Crop Sci.* **41**: 207-214.

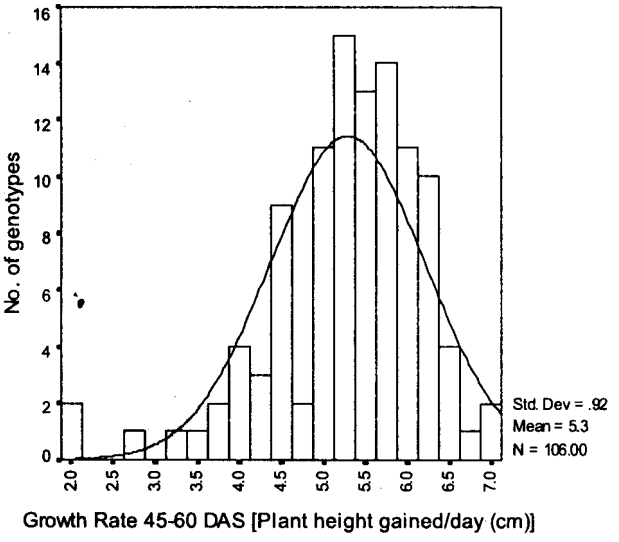
Mathur PN, KE Prasada Rao, TA Thomas, MH Mangesha, RL Sapra and RS Rana (1991) *Evaluation of forage sorghum germplasm. Part-I.* NBPGR-ICRISAT Collaborative Programme, NBPGR, New Delhi, India. 269p.

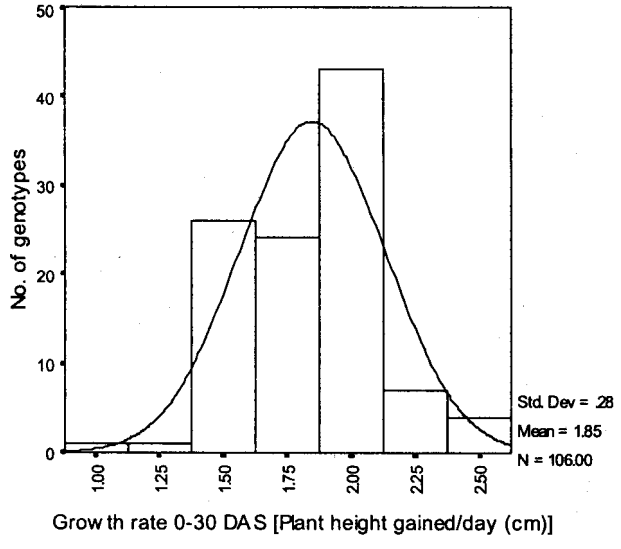
Fig. 1: The means, standard deviation and frequency distribution in genotypes for different characters











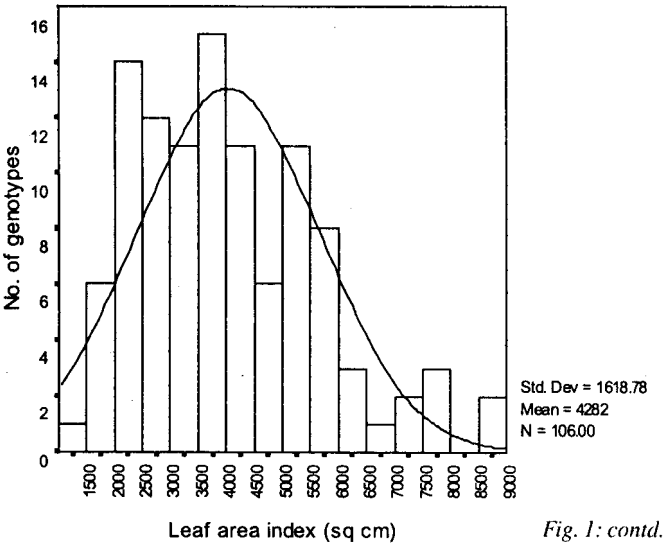


Fig. 1: contd.

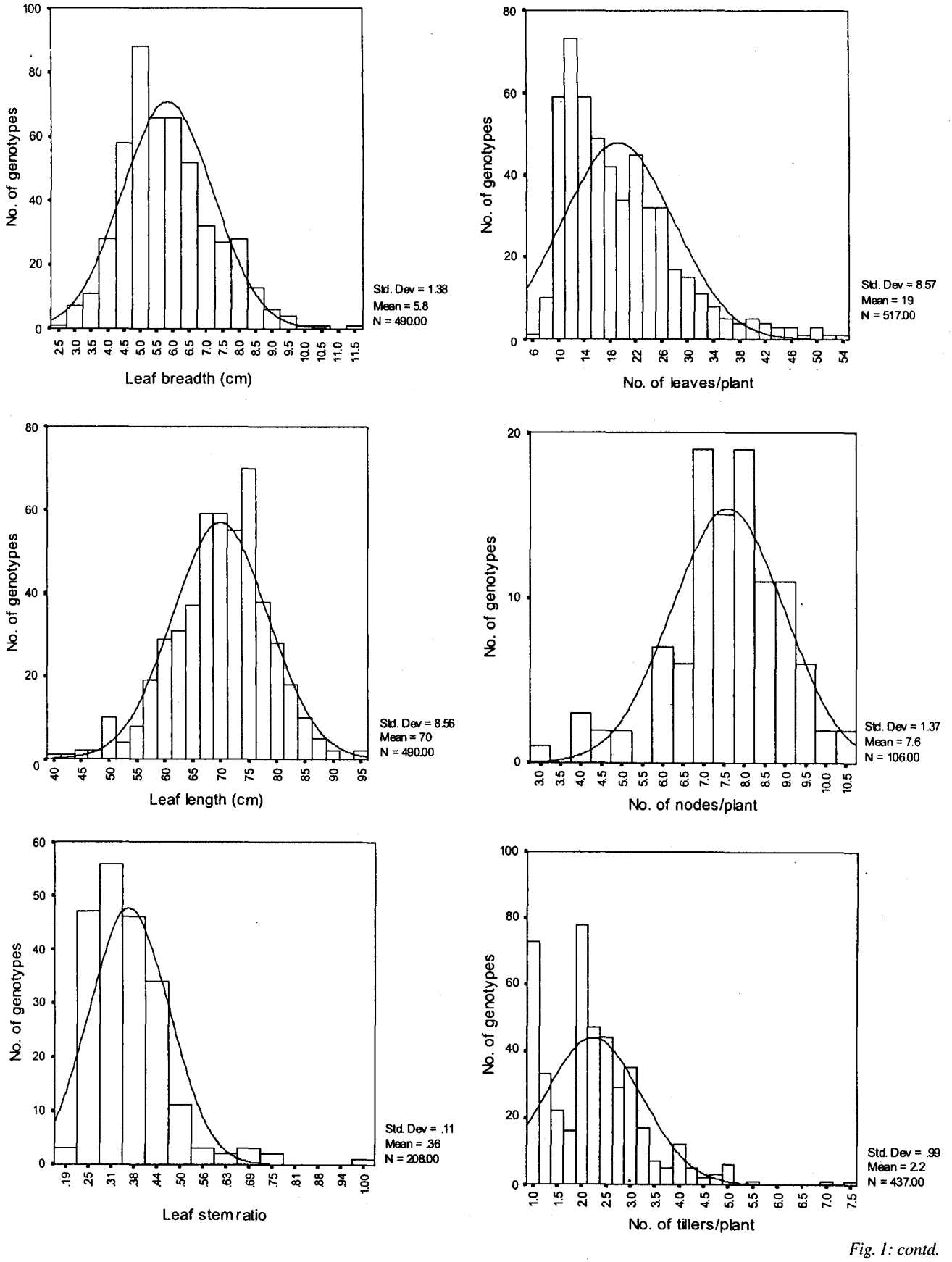

No. of genotypes
Leaf breadth (cm)
Std. Dev = 1.38
Mean = 5.8
N = 490.00
No. of genotypes
No. of leaves/plant
Std. Dev = 8.57
Mean = 19
N = 517.00
No. of genotypes
Leaf length (cm)
Std. Dev = 8.56
Mean = 70
N = 490.00
No. of genotypes
No. of nodes/plant
Std. Dev = 1.37
Mean = 7.6
N = 106.00
No. of genotypes
Leaf stem ratio
Std. Dev = .11
Mean = .36
N = 208.00
No. of genotypes
No. of tillers/plant
Std. Dev = .99
Mean = 2.2
N = 437.00

Fig. 1: contd.

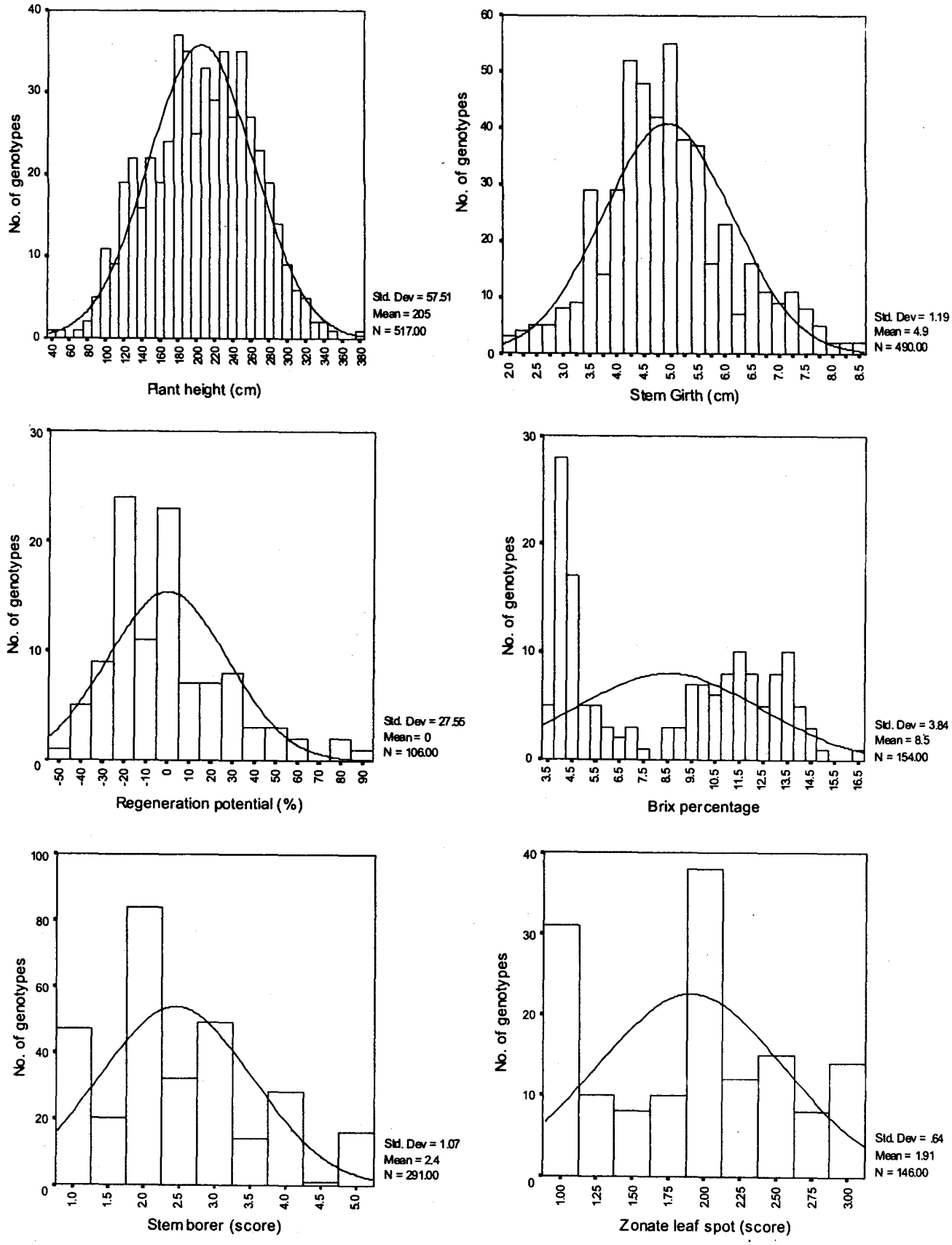
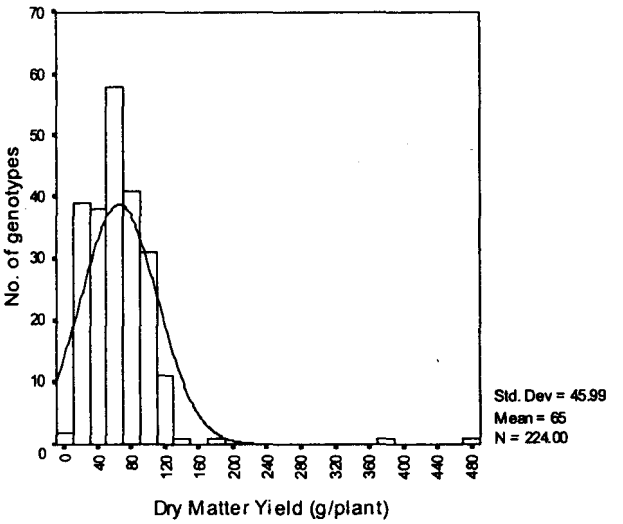
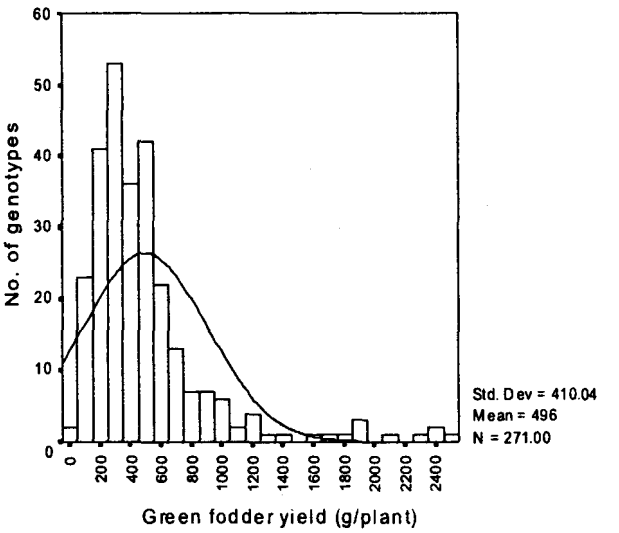
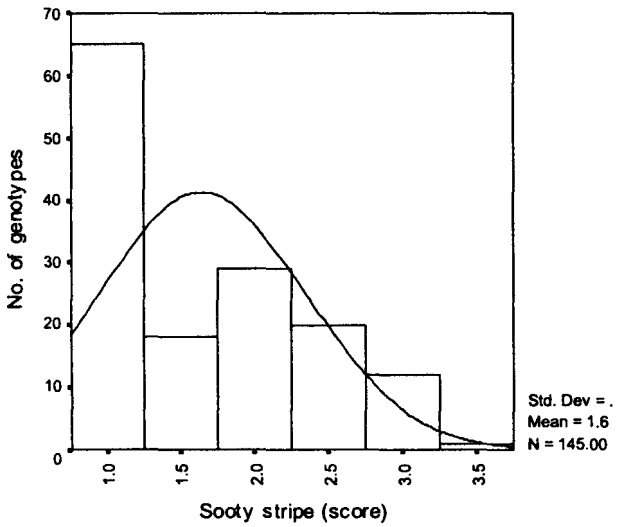
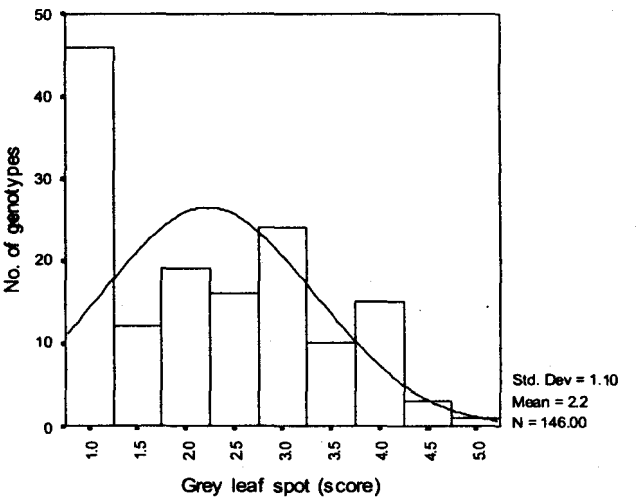

No. of genotypes
Plant height (cm)
Std. Dev = 57.51
Mean = 205
N = 517.00
No. of genotypes
Stem Girth (cm)
Std. Dev = 1.19
Mean = 4.9
N = 490.00
No. of genotypes
Regeneration potential (%)
Std. Dev = 27.55
Mean = 0
N = 106.00
No. of genotypes
Brix percentage
Std. Dev = 3.84
Mean = 8.5
N = 154.00
No. of genotypes
Stem borer (score)
Std. Dev = 1.07
Mean = 2.4
N = 291.00
No. of genotypes
Zonate leaf spot (score)
Std. Dev = .64
Mean = 1.91
N = 146.00

Fig. 1: contd.









Mathur PN, KE Prasada Rao, IP Singh, RC Agrawal, MH Mangesha and RS Rana (1992) *Evaluation of forage sorghum germplasm. Part-II.* NBPGR-ICRISAT Collaborative Programme, NBPGR, New Delhi, India. 296 p.

Singh SP and PK Gupta (1979) Genetic divergence in pearl millet. *Indian J. Genet.* **39**: 210-215.

Teshome A, BR Baum, L Fahrig, JK Torrance, TJ Arnason and JD Lambert (1997) Sorghum (*Sorghum bicolor* L. Moench) landrace variation and classification in North Shewa and South Welo, Ethiopia. *Euphytica* **97**: 255-263.

Yadav R, RPS Grewal, and SK Pahuja (2002) Assessment of variability for fodder yield and its component traits in forage sorghum. *Indian J. Agric. Sci.* **72**: 428-430.

Yadav R, SK Pahuja and RPS Grewal (2003) Evaluation of phenotypic variability in forage sorghum genotypes collected from western Uttar Pradesh using multivariate analysis. *Forage Res.* **29**: 123-128.

Yadav R, RPS Grewal and SK Pahuja (2004) Multivariate analysis in forage sorghum. *Indian J. Genet.* **64**: 39-45.