RASHI 1 (2) : 71-76 (2016)

Genetic variability, heritability and expected genetic advance for yield and yield components in forage sorghum [*Sorghum bicolor* (L.) Moench]

S. KOUR and [1]U. K. PRADHAN

Department of Agricultural statistics, B.A. College of Agriculture, Anand Agricultural University, Anand – 388 110

[1]*ICAR-Indian Agricultural Statistics Research Institute,Library Avenue,Pusa,New Delhi-110012*

ABSTRACT

Genetic variability, heritability and genetic advance studies were necessary for crop improvement which must be exploited for yield improvement. The present investigation was undertaken for 40 diverse genotypes of forage sorghum [Sorghum bicolor (L.) Moench], which were grown in a RCBD with three replications and were evaluated for fifteen characters, including of green fodder yield and its components characters. The 'analysis of variance' revealed the significant differences among the genotypes for all the character under study. This indicated the presence of sufficient variability in the experimental material. In the present study, magnitude of genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance as percentage of mean were recorded. It was observed that the results were high for characters like leaf: stem ratio, number of leaves plant^{-1}, green fodder yield plant^{-1}, stem girth and dry matter yield plant^{-1}. Therefore, more emphasis should be laid on these component traits during selection for further improvement of green forage yield.

Keywords*:* Genetic advance, Genetic coefficient of variation, Heritability, Phenotypic coefficient of variation

Introduction

Livestock is the most important component of rural economy as well as back bone of Indian agriculture characterized by mix farming system involving crop and animal enterprises. Like green revolution, India is contemplating for white revolution, which is possible only with adequate supply of nutritious feeds and fodders. The importance of forage crop in Indian agricultural economy is obvious from the fact that of the cattle wealth. In dairy production, the cost of feed constitutes about 60-65 per cent of the total cost of milk production. To reduce the cost of milk production, continuous supply of green fodder to the animal is necessary. There is a need for continuous and steady supply of green fodder to increase milk production of animal under different intensive programmes executed for the success of white revolution. It is estimated that the 60-70 per cent of total cost in livestock production is due to feed and fodder. In India, hardly 5 per cent of the net cropped area is utilized to grow fodder. India is deficit in dry fodder by 11 per cent, green fodder by 35 per cent and concentrates feed by 28 per cent. The common grazing lands too have been deteriorating quantitatively and qualitatively (Anon., 2012). This situation leads to poor feeding of the animal, resulting in low milk and meat yields. Due to low per capita availability of the quality products from livestock, our nation is facing the problems of malnourishment, high disease incidence and low life expectancy. Demand for animal products for human consumption is increasing day by day because of expanding human population and improvement in life style of citizens. At present as cattle population survives up to a large extent on crop residues, they are nutritionally poor hence, nutritious forage is very crucial for ensuring optimum level of milk, meat and wool production. Therefore, target could be achieved by developing the varieties or hybrids of forage crop giving high yield per unit area and better quality.

Sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most important crop in the world. It is a member of *Poaceae* family with chromosome number 2n=20. Its centre of origin is Ethiopia (Africa). It is an often cross pollinated crop, having average six per cent natural cross pollination. Major sorghum growing countries are USA, India, Nigeria, China, Mexico, Sudan and Argentina. Sorghum ranks first among the cereal fodder crops because of its growing ability in low fertile soil, faster growth habit, higher yield, palatability and nutritious quality. It gives almost uniform green fodder yield throughout the year. Sorghum is preferred over maize and pearl millet for forage because of its high tolerance to wide variation in soil and moisture conditions as well as better regeneration capacity. During the last 30 years the role of sorghum as a major source of fodder has not diminished while its importance as a forage crop has increased (Tonapi *et al.*, 2011). It is locally known as *Jowar*, an important food and fodder crop of dry land agriculture. The important sorghum growing states in India are Maharashtra, Karnataka, Andhra Pradesh,

E-mail : ukpradhan@iasri.res.in

Madhya Pradesh, Rajasthan, Tamil Nadu and Gujarat. In Gujarat, it is mainly grown in North Gujarat, Saurashtra and Kutchh region. Fodder sorghum occupies an area of 2.68 million hectares with a production of about 3.00 million tonnes with average yield of 1117 kg ha^{-1} (Anon. 2010-11a) in India; while in Gujarat, it was grown on 0.16 million hectares of land with a total production of about 0.17 million tonnes with average yield of 1049 kg ha^{-1} (Anon. 2009-10b). The average fodder yield of sorghum in Gujarat is low because major area is covered by local and out-dated varieties and selection which are not responsive to improved cultural and fertility practices. Green fodder is the cheapest source of feed for milch, beef and draft animals. Therefore, development of fodder resources of the country becomes a high priority national programme. This could be achieved through bringing more area under fodder cultivation and improving productivity of fodder crop. As there is little scope of increasing area under cultivation of fodder crops due to urbanization, industrialization and traditional inclination among farmers. Only 4.4 per cent of the total cropped area of the country is under fodder crops cultivation. Hence, only optional strategy to meet fodder requirement is to exploit crop productivity through better yielding varieties and efficient agronomic management.

In order to make forage sorghum as an enterprising and remunerative crop, there is need to develop varieties or hybrids having early maturity, faster growth and high forage yield coupled with high protein content and low HCN content at flowering stage. Assessment of genetic variability in the base population is the first step in any breeding programme. Durrishahwar *et al*. (2012) showed significant variability for days to 50 per cent flowering, leaf area, plant height and green forage yield, while the differences of smaller magnitudewere observed for number of leaves. Ghasemi *et al*. (2012) evaluated fifteen forage sorghum cultivars to determine the high yielding cultivars. Patel (2012) reported 102 land races of sorghum for genetic variability. They concluded that forage yield has a positive correlation with number of leaf $plant^{-1}$, leaf width and leaf length. They observed heritability along with higher genetic advance for days to 50 per cent flowering revealing positive direct effect on forage yield. Jain and Patel (2013) found higher genotypic coefficient of variation (GCV) was higher for green fodder yield than dry fodder yield. High genetic advance with high heritability and high GCV was observed for green fodder yield and it's per day productivity, leaf breadth and plant height. Significant correlation was present for green fodder yield day^{-1}, number of leaves $plant^{-1}$, plant height and leaf length. Singh *et al*. (2013) found different magnitudes of GCV, PCV, heritability, dry matter accumulation and genetic gain at different cuts. These characters also had correlation between them at different cuts. Root volume, stem girth and leaf length had positive and high direct effect on green fodder yield $plant^{-1}$ day^{-1} at third cut. The results showed the importance of these characters that could be used to increase the green fodder yield of sorghum. Thus, the knowledge of existing genetic variability and estimation of heritability for yield and its components in a population is very important in determining the influence of environment for the expression of the characters, and the extent to which improvement is possible after selection. The yield is a complex character resulting from interplay of various yield contributing characters, which have positive or negative association with yield and among themselves. The magnitude of correlations between various characters with yield would be helpful in the selection of characters for the improvement of yield. Keeping in view the importance of sorghums as fodder crop, the present study was therefore initiated to know the variability and select high fodder yielding varieties for Gujarat.

2. Material and Methods

The present investigation was conducted at Main Forage Research Station, A.A.U., Anand, during *kharif* season of the year 2013. Anand is situated at $22^{0}35'$ North Latitude and $72^{0}55'$ East longitude and 45.11 m above the mean sea level. The soil of experimental field is sandy loam, which is locally known as "*Goradu Soil*." It is alluvial in origin, deep, well drained and has fairly good moisture holding capacity. It is poor in organic matter, medium in available phosphorous and rich in available potash. It responds well to irrigation and nitrogen application. The experimental material for present investigation comprised of 40 diverse genotypes of forage purpose sorghum [*Sorghum bicolor* (L.) Moench] obtained from the germplasm maintained at Main Forage Research Station, A.A.U., Anand. The experiment was conducted in RBD with three replications and 30 x 10 cm inter and intra row spacing respectively. The observations on green fodder yield and its fifteen components were recorded from five randomly selected tagged plants for each treatment in each replication and the average value $plant^{-1}$ was computed. The fifteen character are studied are (i) Days to 50 per cent flowering (ii) Plant height at 50 per cent flowering (iii) Number of tillers $plant^{-1}$ (iv) Number of leaves $plant^{-1}$ (v) Leaf length (vi) Leaf width (vii) Leaf: stem ratio (viii) Stem girth (ix) Green fodder yield per plant (x) Dry matter content (DM %) (xi) Dry matter yield per plant (xii) Crude protein content (CP %)(xiii) Hydrocyanic acid content (xiv) Neutral detergent fibre content (NDF %) (xv) Crude fibre content (CF %).

The mean values based on five randomly selected plants formed the basis for statistical analysis. The analysis of variance proposed by Panse and Sukhatme (1978) was followed to test the significance of differences between the genotypes for all the characters. The form of analysis of variance as given in table 1 provides comparison by partitioning of variance due to various sources and the statistical model was,

$$y_{ij} = \mu + r_i + t_j + e_{ij}$$

Where, y_{ij} = an observation of j^{th} genotype in i^{th} replication, μ = General mean, r_i = The effect of i^{th} replication, t_j = The effect of j^{th} genotype, e_{ij} = Uncontrolled random error associated with j^{th} genotype in i^{th} replication.

Table 1: ANOVA

Source of variation	Degree of freedom	Mean square	Expected mean square (EMS)
Replications	(r-1)	Mr	$\sigma_e^2 + g\,\sigma_r^2$
Genotypes	(g-1)	Mg	$\sigma_e^2 + r\,\sigma_g^2$
Error	(r-1) (g-1)	Me	σ_e^2
Total	**(rg-1)**		

Where, r and g are number of replications and number of genotypes, respectively; σ_e^2, σ_r^2 and σ_g^2 are variance due to error, replication and genotype, respectively; and Mr, Mg and Me are the mean sum of square of replication, genotype and error, respectively. The mean squares due Genotypic, Phenotypic and environmental variances were calculated as per suggested by Johnson *et al*. (1955) by manipulation of expected mean squares genotypes and error. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed using the formula given by Burton (1952). Heritability and expected genetic advance(GA) were calculated for each character by adopting the procedure as suggested by Allard (1960). The genotypic and phenotypic correlation coefficients were tested against standardized tabulated significant values of correlation as per the procedure suggested by Fisher and Yates (1943).

Result and Discussion

The analysis of variance for different characters studied in the present investigation is given in table 2. The analysis of variance revealed highly significant differences among the accessions for all the traits. The difference between accessions was significant for all the characters indicating presence of wide genetic variation for different characters in the genetic material of forage sorghum.

Table 2: Analysis of variance (ANOVA) showing mean sum of squares of fifteen characters in sorghum.

Sl. No.	Source	Replications	Genotypes	Error
	d.f.	2	39	78
1.	Days to 50 per cent flowering	5.29**	157.03**	0.44
2.	Plant height (cm) at 50 per cent flowering	1327.5**	2663.3**	150.3
3.	Number of tillers per plant	0.098	0.94**	0.055
4.	Leaf: Stem ratio	0.011**	0.40**	0.0012
5.	Number of leaves per plant	2.63*	41.6**	0.78
6.	Leaf length (cm)	64.09*	228.83**	13.31
7.	Leaf width (cm)	1.08	2.91**	0.39
8.	Stem girth	0.0040	0.15**	0.0070
9.	Green fodder yield per plant (g)	43.75	8858.25**	43.07
10.	Dry matter content (%)	4.37	130**	5.57
11.	Dry matter yield per plant (g)	2.23	1081.51**	6.76
12.	Crude protein content (%)	0.13	1.78**	0.089
13.	HCN content (ppm)	90.25	958.53**	112.48
14.	NDF content (%)	85.56	121.35**	43.00
15	Crude fibre content (%)	10.67*	110.63**	2.34

Note : *, ** Significant at 0.05 and 0.01 level of probability, respectively.

The phenotypic and genotypic components of variances have been calculated for all the fifteen characters under study are presented in table 3. The results revealed that magnitude of phenotypic components of variances was higher than genotypic component of variance for all the characters. Genotypic and phenotypic variances were close to each other for days to 50 per cent flowering, plant height, leaf : stem ratio, number of tillers plant^{-1}, number of leaves plant^{-1}, leaf length, stem girth, green fodder yield plant^{-1}, dry matter content, dry matter yield plant^{-1}, crude protein content and crude fibre content.

Table 3: Variance components of different characters in sorghum

Sl. No.	Character	Variance components	
		Phenotypic	Genotypic
1.	Days to 50 per cent flowering	52.63	52.2
2.	Plant height (cm) at 50 per cent flowering	987.98	837.69
3.	Number of tillers per plant	0.35	0.295
4.	Leaf: Stem ratio	0.13	0.13
5.	Number of leaves per plant	14.38	13.6
6.	Leaf length (cm)	85.16	71.84
7.	Leaf width (cm)	1.23	0.84
8.	Stem girth	0.054	0.047
9.	Green fodder yield per plant (g)	2981.46	2938.39
10.	Dry matter content (%)	47.05	41.48
11.	Dry matter yield per plant (g)	365.01	358.25
12.	Crude protein content (%)	0.649	0.56
13.	HCN content (ppm)	394.49	282.01
14.	NDF content (%)	69.12	26.12
15	Crude fibre content (%)	38.43	36.09

The genotypic and phenotypic coefficients of variation for all the traits are presented in table 4.The genotypic coefficient of variation for various traits is a measurement expressed in percentage, therefore is reliable for measuring relative magnitude of genotypic variation in a given population for different traits. Higher expression of genotypic coefficient of variation has been observed for leaf: stem ratio 83.08, dry matter yield plant^{-1} 51.65 gm., green fodder yield plant^{-1} 43.08 gm., number of leaves plant^{-1} 31, stem girth 29.11 and number of tillers plant^{-1} 23.45, crude fibre content 22.89 per cent and dry matter content 22.34 per cent. The moderate genotypic coefficient of variation has been noted for the character *viz.*, HCN content 19.96 ppm, leaf width 18.72 cm, crude protein content 13.60 per cent, plant height at flowering 13.11, days to 50 per cent flowering 11.79 and leaf length 11.59 cm, crude protein 9.35 and lower magnitude of genotypic coefficient of variation has been observed for NDF content 6.72 per cent.The estimated phenotypic coefficient of variation has been ranged from 10.94 (NDF) to 83.45 (leaf: stem ratio). Character such as dry matter yield plant^{-1} 52.13 and green fodder yield plant^{-1} 43.39 have been exhibited high phenotypic coefficient of variation. Whereas, phenotypic coefficient of variation was lower for crude protein content 10.07, days to 50 per cent flowering 11.84, leaf length 12.62 and plant height 14.23, while remaining characters showed moderate phenotypic coefficient of variation.

The estimates of heritability as percentage in broad sense and expected genetic advance for all the characters under study are presented in table 4. High heritability values have been recorded for days to 50 per cent flowering 99.2, leaf: stem ratio 99.1, green fodder yield plant^{-1} 98.6 gm., dry matter yield plant^{-1} 98.1 gm., number of leaves plant^{-1} 94.5. However, dry matter content 88.2 per cent, stem girth 87.6, crude protein 86.3, leaf length 84.4, plant height 84.8, leaf length 84.4 cm. and number of tillers plant^{-1} 84.1 exhibited moderate heritability. The expected genetic advance with respect to fifteen characters at 5.00 per cent selection intensity has been calculated. Since, these values are not comparable; they have been expressed as expected genetic advance in percentage and are presented in table 4. Genetic advance ranged from 8.51 (NDF) to 170.45 (leaf: stem ratio). These values were showing higher magnitude for dry matter yield per plant 105.43, green fodder yield per plant 88.12, number of leaves per plant 61.33 and stem girth 56.58 Whereas, number of tillers per plant 44.59, dry matter content 43.22 and leaf width 31.84 showed moderate expected genetic advance. The remaining traits exhibited low expected genetic advance.

Table 4: The estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), Heritability (%), expected genetic advance and expected genetic advance as percentage of mean for various characters in sorghum

Sl. No.	Source	GCV	PCV	Heritability (%)	GA	GA(%)
1.	Days to 50 per cent flowering	11.79	11.84	99.2	14.82	24.18
2.	Plant height (cm) at 50 per cent flowering	13.11	14.23	84.8	54.90	24.86
3.	Number of tillers plant^{-1}	23.45	25.57	84.1	1.03	44.59
4.	Leaf: Stem ratio	83.08	83.45	99.1	0.75	170.45
5.	Number of leaves plant^{-1}	30.60	31.47	94.5	7.39	61.33
6.	Leaf length (cm)	11.59	12.62	84.4	16.04	21.93
7.	Leaf width (cm)	18.72	22.69	68.0	1.56	31.84
8.	Stem girth	29.11	31.11	87.6	0.43	56.58
9.	Green fodder yield plant^{-1} (gm)	43.08	43.39	98.6	110.86	88.12
10.	Dry matter content (%)	22.34	23.79	88.2	12.46	43.22
11	Dry matter yield plant^{-1} (gm)	51.65	52.13	98.1	38.63	105.43
12	Crude protein content (%)	9.35	10.07	86.3	1.42	17.75
13	HCN content (ppm)	19.96	23.61	71.5	29.25	34.77
14	NDF content (%)	6.72	10.94	37.8	6.47	8.51
15	Crude fibre content (%)	22.89	23.62	93.9	11.99	45.68

The conclusion that can be reached from the present investigation was carried out to estimate magnitude of genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance as percentage of mean were recorded high for characters like leaf: stem ratio, number of leaves plant^{-1}, green fodder yield plant^{-1}, stem girth and dry matter yield plant^{-1}. Therefore, more emphasis should be laid on these component traits during selection for further improvement of green forage yield. . From the preceding results it can be also concluded that different sorghum varieties have different capability of performing in agro-climatic conditions of Gujarat.

REFERENCES :

Allard, R.W. (1960): *Principles of Plant Breeding*. John Willey and Sons. Inc., New York. pp: 85-95.

Anonymous (2010-11): Website < *http://www.agricoop.nic.in* > *All-India production of milk, eggs and wool from 1985-86 to 2010-11*.

Burton, G.W. (1952): Quantitative inheritance in grasses. *Proc. 6th Int. Grassland Cong*. **1**: 273-283.

Durrishahwar, M., Noor, H., Rehman, Ihteramullah, I.A., Shah, F., Ali, S.M.A. Shah and N. Mehmood. (2012): Characterization of sorghum germplasm for various morphological and fodder yield parameters. *Afr. J. Biotechnol*. **11 :**11952-11959.

Fisher, R. A. and Yates, F. (1943): *Statistical table for biological, agricultural and medical research*. Oliver and Byod Edinburgh, 6th ed. pp. 63

Ghasemi, A., M.H. Karim and Ghasemi, M. M. (2012): Green fodder yield performance of different varieties of sorghum grown in an arid region. *Int. J. Agri. Crop Sci.* **4 :** 839-43.

Hazel, L. N.; Baker, M. L. and Reinmiller, C. F. (1943): Genetic and environmental correlations between the growth rates of pigs at different ages. *J. Animal Sci.* **2**: 118.

Jain, S.K. and Patel P.R., (2012): Genetic variability in land races of forage sorghum [*Sorghum bicolor* (L.) Moench] collected from different geographical origin of India. *Int. J. Agri. Sci*. **4 :** 182-85.

Johnson, H. W., Robinson H. F., and R. E. Comstock, (1955): Estimates of genetic and environmental variability in soyabean. *Agron. J.,* **47** : 314-18.

Panse, V. G. and Sukhatme, P. V. (1978): *Statistical Methods for Agricultural Workers*. 3rd edn., ICAR, New Delhi, p.347

Singh, J., Ranwah, B.R., Chaudhary, L., Lal,C., Dagla, M.C. and Kumar V., (2013): Evaluation for genetic variability, correlation and path coefficient analysis in mutant population of forage (*Sorghum bicolor* L.). *Bioscan* **8 :** 1471-76.

Tonapi , V. A., Patil, J. V., Dayakar Rao, B., M. Elangovan, B. Venkatesh Bhat, and K. V. Raghavendra Rao, (2011): *Sorghum : Vision 2030*. Directorate of Sorghum Research, Rajendranagar, Hyderabad (AP), India. pp. 38.