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Research Article

Evaluation of sorghum germplasm for genetic diversity using D^2 statistics

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Abstract
The D^2 statistics was applied to assess the diversity among 61 genotypes of sorghum. The analysis of variance revealed significant differences among the genotypes for all the characters under study. The genotypes were grouped into 15 clusters, where cluster I comprised maximum of 47 genotypes, while the rest of the clusters had one genotype each. Inter-cluster distance was maximum between the clusters XV and XIV followed by XV and IX which indicated that genotypes included in these clusters may give heterotic response and thus better segregants. Regarding genetic divergence of the genotypes, relative water content contributed major share followed by grain weight, panicle weight, days to 50% flowering, plant height and fodder weight.

Key words
Sorghum, genetic divergence and D^2 statistics

Introduction

Sorghum is one of the most important cereal crop grown in Africa, Asia, USA, Australia, and Latin America. Its importance after wheat, maize, rice and barley is because of its good adaptation to a wide range of ecological conditions, low input cultivation and diverse uses (Aruna *et al*., 2011). In India, it is third major cereal after rice and wheat and it is most important food crop grown under rainfed conditions. With the present water scarcity situation, sorghum cultivation is the heart of dryland agriculture and being C_4 plant it can utilize sunlight and water efficiently (Godbharle *et al*., 2010). As a drought tolerant crop, it allows farmers to use one third less water than similar crops such as corn. Sorghum crop exhibits considerable differences in plant traits, panicle and grain characteristics including physiological responses to selection and is highly influenced by environmental factors (Ezeaku *et al*., 1997).

The basis for genetic enhancement in any crop is systematic assessment of variability and genetic diversity available in the germplasm. The most widely used technique to assess the genetic diversity is Mahalanobis's D^2 statistic. In the present study, this technique has been applied to assess the diversity among 61 sorghum genotypes.

Materials and methods

The present field experiment on sorghum (*Sorghum bicolor* L. Moench) was conducted on the experimental farm at Sorghum Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.) during *rabi* 2013-14. The experiment was laid out in randomized block design with three replications. The experimental material was sown at 23rd October, 2013 with plot size of 1 row of 2 m length and spacing of 45 x 15 cm. The standard agronomic practices were followed throughout the period of crop growth. The observations were recorded on five randomly selected plants from each entry per replication for plant stand, days to 50 % flowering, seedling vigour, number of leaves, leaf length, leaf breadth, plant height, panicle length, panicle girth, chlorophyll content %, relative water content, 100 seed weight, panicle weight, shoot fly dead heart %, fodder weight and grain weight.

The data was subjected to statistical analysis. Wilk's criteria was used to test the significance of pooled differences in mean values for all the sixteen characters. Genetic diversity was studied using Mahalanobis's (1936) D^2 statistic and clustering of genotypes was done according to Tocher's method.

Results and discussion

Analysis of variance revealed the significant differences among genotypes for all characters under study. Based on D^2 statistics and Tocher's method 61 genotypes were grouped into 15 clusters with a variable number of entries revealing the presence of considerable amount of genetic diversity in the material (Table 1). The cluster I comprised of maximum number of 47 genotypes, while the rest of the clusters had one genotype each. The pattern of distribution of genotypes into various clusters was at random suggesting that the genetic diversity was not related to geographic diversity. Similar results were reported by Sameer Kumar *et al.* (2010) in genetic divergence studies in *rabi* sorghum.

Average intra and inter-cluster D^2 (Table 2) values among all genotypes revealed that the solitary clusters showed intra-cluster value of 0.00, while cluster I (3.28) showed maximum intra-cluster distance. The inter-cluster D^2 values ranged from

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2.76 to 7.21. Minimum inter-cluster D^2 values were observed between clusters IX and II indicating the close relationship among the genotypes included in these clusters. Maximum inter-cluster values were observed between the clusters XV and XIV followed by XV and IX which indicated that genotypes included in these clusters may give heterotic response followed with better segregants. These results are in conformity with Shivani and Sreelakshmi (2013).

The cluster means and contribution of each trait towards divergence are presented in (Table 3). The data revealed considerable differences among the clusters for most of the characters studied. Cluster X recorded the highest mean for leaf length, chlorophyll content and grain weight, whereas cluster IV recorded the highest mean for plant height and leaf breadth and the lowest mean for seedling vigour and cluster VIII recorded the highest mean for panicle weight. Cluster XIV recorded the lowest mean for days to 50 per cent flowering and Shoot fly dead heart per cent.

Among the 16 characters studied relative water content contributed the most (17.76 %) to the genetic divergence of the genotypes followed by grain weight (16.23 %), panicle weight (14.97 %), days to 50% flowering (9.84 %), plant height (8.80 %) and fodder weight (6.34 %). However, plant stand indicated narrow range of diversity among the genotypes under study.

The data on inter-cluster distances were used to select genetically diverse and agronomically superior genotypes. The genotypes exceptionally good with one or more characters were seemed to be desirable. Inter-crossing of divergent groups would lead to greater opportunity for crossing over, which releases hidden potential variability by disrupting the undesirable linkages (Thoday, 1960). The progeny derived from such diverse crosses are expected to have wide spectrum of genetic variability, providing a greater scope for isolating transgressive segregants in advanced generations.

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Table 1. Distribution of sorghum genotypes in fifteen different clusters

Cluster No.	Name of genotypes	No. of genotypes
Cluster I	IS 22040, IS10876, IS 6154, IS 22291, IS 21425, IS 10978, Gcp_Sb_0510, IS 2179, IS 25910, IS 20665, IS 20700, IS 10234, IS 29496, IS 29375, IS 2367, IS 19053, IS 6973, IS 25596, IS 14446, IS 5867, SSM 379, IS 3971, IS 303, IS 20713, E 36-1, IS 9911, IS 29569, IS 25442, Gcp_Sb_0659, IS 13, IS 1127, IS 9713, E 36-1, IS 20763, SSM 547, IS 9586, IS 19026, IS 22325, IS 4027, IS 3121, IS 29472, IS 2398, IS 2430, IS 6193, IS 32050, IS 4821, IS 20724	47
Cluster II	SSM 1370	1
Cluster III	IS 31693	1
Cluster IV	IS 27	1
Cluster V	IS 2807	1
Cluster VI	IS 29409	1
Cluster VII	IS 9713	1
Cluster VIII	IS 15526	1
Cluster IX	Parbhani Moti	1
Cluster X	SSM 501	1
Cluster XI	IS 30441	1
Cluster XII	IS 18922	1
Cluster XIII	IS 8348	1
Cluster XIV	IS 30619	1
Cluster XV	IS 4027	1

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Table 2. Average intra and inter cluster distances (D^2) for fifteen clusters of *rabi* sorghum germplasm

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
I	3.28	3.95	3.84	3.94	3.93	4.09	3.73	4.18	4.64	4.18	3.89	4.13	4.20	4.71	4.77
II		0.00	4.39	4.61	2.87	3.27	3.69	4.25	2.76	5.46	3.67	4.65	2.92	3.26	5.83
III			0.00	4.56	4.71	4.30	5.04	5.00	5.19	4.75	3.52	3.82	5.16	4.83	4.21
IV				0.00	3.33	3.62	2.90	5.23	5.25	3.29	4.72	5.15	4.24	5.23	5.16
V					0.00	2.85	2.91	4.47	4.26	4.54	4.12	5.29	3.37	4.60	5.47
VI						0.00	3.23	5.23	3.97	4.41	4.03	4.86	3.44	4.92	5.17
VII							0.00	5.10	4.72	4.07	4.91	4.93	3.01	4.53	5.56
VIII								0.00	4.65	5.00	3.88	4.95	5.39	5.43	6.09
IX									0.00	5.60	4.24	5.41	4.23	3.77	7.04
X										0.00	4.60	5.95	5.39	5.85	4.99
XI											0.00	5.16	5.33	4.42	5.84
XII												0.00	5.12	4.90	5.19
XIII													0.00	4.89	5.20
XIV														0.00	7.21
XV															0.00

Table 3. Cluster means for sixteen characters in *rabi* sorghum

Cluster No.	Plant stand	Days to 50 % flowering	Seedling vigour	Number of leaves	Leaf length (cm)	Leaf breadth (cm)	Plant height (cm)	Panicle length (cm)	Panicle girth (cm)	Chlorophyll content%	Relative water content%	100 seed weight (g)	Panicle weight (g)	Shoot fly dead heart %	Fodder weight (g)	Grain weight (g)
I	24.47	74.38	3.11	7.07	54.82	4.90	165.35	16.40	14.71	51.09	64.59	2.64	48.89	64.00	274.43	62.85
II	22.00	64.33	3.67	6.67	51.19	5.03	138.33	18.30	13.73	49.90	83.72	2.15	53.00	57.57	219.33	60.00
III	25.00	76.33	4.00	6.00	49.41	3.85	137.67	14.63	12.83	40.39	64.77	2.98	45.00	87.63	211.33	48.00
IV	21.33	69.33	2.67	7.67	61.23	5.56	232.00	16.20	13.00	54.78	69.65	2.05	38.33	68.82	221.33	51.33
V	17.67	70.67	2.67	6.67	56.63	5.50	208.67	19.30	13.33	54.69	82.41	2.91	52.00	70.07	222.00	55.67
VI	20.33	74.33	2.67	6.67	50.63	4.54	215.00	14.97	13.57	38.99	81.88	2.28	48.67	52.29	156.67	67.67
VII	22.00	67.67	3.33	8.33	56.37	4.97	211.33	18.87	15.20	54.13	82.39	2.92	45.00	56.01	307.00	63.67
VIII	25.00	69.67	3.67	7.00	62.17	4.27	163.67	18.53	13.03	55.87	58.35	2.82	59.00	56.51	144.00	81.00
IX	30.67	62.67	2.33	6.00	59.33	5.20	125.00	13.83	14.23	45.79	83.96	2.05	52.00	48.33	166.70	64.00
X	24.67	78.67	2.67	7.33	64.06	4.89	186.67	14.33	14.83	57.19	66.65	3.01	38.67	74.42	127.00	88.00
XI	21.67	69.33	3.00	6.33	49.97	5.36	121.33	16.43	12.23	41.73	60.69	3.20	48.00	73.13	185.67	87.00
XII	25.00	70.67	4.33	6.33	43.23	3.94	189.33	16.07	16.67	45.81	57.90	2.26	54.33	53.11	194.67	33.00
XIII	20.67	69.67	3.67	7.67	58.69	5.03	184.67	12.97	14.84	50.45	88.44	1.74	52.33	56.06	330.33	59.00
XIV	19.00	57.33	3.33	6.33	52.85	5.14	96.00	18.50	15.53	51.12	76.76	3.00	44.00	48.05	171.76	39.67
XV	23.33	98.00	5.00	7.00	54.97	4.67	197.67	15.20	14.13	52.20	63.99	2.08	49.33	70.30	280.33	56.00

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Table 4. Percentage contribution of different characters towards genetic divergence in *rabi* sorghum

S. No.	Characters	Percentage contribution
1	Plant stand	0.77
2	Days to 50% flowering	9.84
3	Seedling vigour	1.80
4	Number of leaves	1.69
5	Leaf length (cm)	2.95
6	Leaf breadth (cm)	1.86
7	Plant height (cm)	8.80
8	Panicle length (cm)	3.93
9	Panicle girth (cm)	4.81
10	Chlorophyll content %	1.42
11	Relative water content	17.76
12	100 seed weight (g)	2.90
13	Panicle weight (g)	14.97
14	Shoot fly dead heart %	3.93
15	Fodder weight (g)	6.34
16	Grain weight (g)	16.23