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ESTIMATION OF GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE IN F_4 PROGENIES FOR SHOOTFLY TOLERANCE AND GRAIN YIELD IN *RABI* SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH]

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Abstract

The present investigation entitled estimating genetic variability for grain yield and shootfly resistance components in F_4 population of *rabi* sorghum [*Sorghum bicolor* (L.) Moench]. The experimental material consists of 53 F_4 progenies with four checks (Parbhani Moti and Parbhani Jyoti for grain yield assessment and IS 18551 (Resistance Check) and DJ 6514 (Susceptible Check) for shootfly screening nursery). Analysis of variance showed significant genetic variability in the progenies for all traits under study. The lowest days required for maturity in progenies 1076-1 x RSF 19-3-38 (115 days) and highest in 1076-1 × RSF 19-3-08 (124 days). Panicle length was highest in progeny 1071-1 × RSF 16-3-22 (23.03 cm) and lowest in 1076-1 × RSF 12-4-15 (15.42 cm), whereas the panicle girth was highest in progeny 1076-1 × RSF 12-4-09 (14.87). The highest grain yield per plot was observed for 1071-1 × RSF 12-4-13 (1.51 kg). The progenies namely 1071-1 × RSF 12-4-20, 1071-1 × RSF 12-4-04 and 1071-1 × RSF 16-3-13 were recorded at par glossy score with resistant check IS 18551. The character seedling vigour showed at par score with resistant check IS 18551. The genotype viz., 1071-1 × RSF 12-4-08, 1071-1 × RSF 12-4-20, 1071-1 × RSF 12-4-05 and 1071-1 × RSF 16-3-07. Statically at par with resistant check IS 18551. High heritability accompanied with genetic advance recorded in the two traits *viz*., plant height and panicle weight. High heritability accompanied with genetic advance reported in non preference for oviposition I and II, trichome density at upper and lower leaves surface and deadherat I and II count at 21 DAE and 28 DAE (days after emergence).

Key words : Genetic advance, shootfly resistance, sorghum, variability.

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is an important staple food crop for more than 300 million people and feed for cattle in Asia and Africa. Among the cereals, sorghum ranks fifth in world production next to wheat, maize, rice and barley. India is major sorghum growing country in the world. In India, sorghum is cultivated in all three season *viz*., *kharif*, *rabi* and summer. According to Indian budget in 2011, the production of sorghum is expected to 6.7 million tonnes from an area of 9.1 million hectare with productivity 783 kg ha^{-1}. In *kharif* season the productivity was 1125 $kgha^{-1}$ whereas in that *rabi* season was 420 kg ha^{-1}. With a shift in our approach from substance agriculture to substance to profitable agriculture quantum jump in production has been noticed. It has become pertinent to stabilize yield of sorghum, through the utilization of high yielding hybrid and varieties. The release hybrid and varieties become popular in *kharif* season and help to increase average productivity. Very recently, more attention is being given for genetic improvement of *rabi* sorghum.

Insect pest is one of the major factor limiting sorghum production. About 32 per cent of actual crop produce is lost due to insect pest in India. About 150 insect species have been recorded on sorghum out of which 31 species are economically important in India 20 pest species have been recorded to infest sorghum (Reddy and Davis, 1979). Sorghum, shootfly (*Atherigona soccata* Rond.) is most

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important yield constraint in India. The losses due to this pest have been estimated to reach as high as 86 per cent of grain and 46 per cent of fodder yield. The crop loss of US $ 30 million per annum directly due to shootfly alone estimates. Although high yielding varieties and hybrids have been released in sorghum since the 1960s, several biotic and abiotic constraints have affected its productivity. One of the most biotic stress is the shootfly (*Atherigona socccata* Rond.) infestation. The insect attacks sorghum at seedling stage (1-4 week after emergence) and the peak infestation periods being late peach infestation periods being late sown *kharif* (rainy) and early sown *rabi* (post rainy). Levels of infestation may be upto 90-100 per cent (Usman, 1972). Shootfly control through adoption of chemical methods is not economically feasible for resource poor farmers of semi arid tropics (SAT) as the low crop value per acre includes use of insecticides for control of insects (Dhams, 1993). Hence, host plant resistance is supported to the realistic approach to minimize grain and fodder yield losses to insect pest. Advancing of sowing dates for *rabi* sorghum gives better yield and paves way for efficient the crop to higher shootfly incidence. As shootfly resistance is pre-requisite for *rabi* adoption exploiting that gene pool of resistant sources is preamble in a *rabi* breeding programme.

Several mechanism of resistant lines such as non preference for oviposition (components of which includes trichomes, glossiness and restricted leaf surface wetness), antibiosis and tolerance or recovery (Sharma and Nwanze, 1997). Some morphological characters such as toughness of leaf sheath (Singh and Jotwani, 1980), presence of irregularly shaped silica bodies in leaves (Narayana, 1975). The glossiness of leaves and presence of trichomes on lower surface of leaves (Maiti *et al*., 1980) also contributed for resistance. The present study was therefore planned to identify *rabi* adoptive progenies having yield potentiality and resistance to shootfly in *rabi* sorghum.

Materials and Methods

Isolines of PMS 20B genetic background differ from shootfly QTL introgression were crossed Iso restorer line differ from QTL of R 354 genetic background developed at RRS, Bijapur by emasculation and pollination programme. Developed F_1 were evaluated and heterotic F_1 for grain and shootfly tolerance advanced to F_2, F_3, F_4 by pedigree selection. The experimental material consists of 53 F_4 progenies with four checks (Parbhani Moti and Parbhani Jyoti for grain yield assessment and IS 18551 [Resistance Check and DJ 6514 (Susceptible Check) for shootfly screening nursery]. During season early *rabi* 2012, one set of entries was planted in randomized block design with two replication for estimation of grain yield and its associated traits (shootfly control condition) and one set of entries planted in shootfly screening nursery in randomized block design with two replication for estimation of shootfly resistance and its component traits (non control condition) at Sorghum Research Station, MKV, Parbhani (M.S.). The agronomic and plant protection measures were followed as and when required during the period of crop growth. One protected irrigation was given to the second set of planting. The yield and yield contributing traits like, Days to 50 per cent flowering, Days to maturity, Plant Height, Panicle length, Panicle girth, Panicle weight, 1000 seed weight/test weight, Fodder yield plot^{-1}, Grain yield plot^{-1} and all observations for shootfly resistance and components traits viz., Glossy score (1-5), Seedling vigour score (1-5), Ovipositon (%), Trichome density (No.s / microscopic field), Deadheart Incidence (%), Deadheart count-I (21 DAE), Dead heart count-II (28 DAE) were recorded from each genotypes at each replication and data was used to calculate mean, range and genetic variability parameters.

Results and Discussion

Plant breeding deals with the management of genetic variability present in a plant population. Their assessment in available germplasm is of immense importance for further crop improvement and identifies the superior progenies. It is therefore, necessary to study the nature and magnitude of genetic diversity systematically for its exploitation in genetic upgradation of biological population. Fifty three progenies along with four checks viz., IS-18551, DJ-6514, Parbhani Moti and Parbhani Jyoti were assessed to understand the nature and magnitude of variability for different quantitative characters of grain yield and shootfly resistance.

The analysis of variance for various associated traits of grain, fodder yield and shootfly resistance component traits recorded significant genotypic differences indicating presence of variability among the progenies selected for study (tables 1 and 2). Abundant genetic variability for different characters in sorghum was also reported by Ambekar (2000) and Date (2002). This gives more scope for selection of desirable plants.

On the basis of mean performance for yield and its components, the genotype *viz*., 1076-1 × RSF 19-3-18, 1071-1 × RSF16-3-02 and the thirty eight other progenies were recorded significant earliness than the standard check Parbhani Moti and Parbhani Jyoti. The progenies *viz*., 1076-1 × RSF 16-3-09, 1076-1 × RSF 12-4-10 and 1076-1 × RSF 16-3-06 were taller than all other genotype

Table 1 : ANOVA for F_4 progenies for yield and its attributing traits.

S. no.	Sources of variation	d.f.	Days to 50% flowering (days)	Days to maturity (days)	Plant height (cm)	Panicle length (cm)	Panicle girth (cm)	Panicle weight (g)	1000 seed weight (g)	Grain yield plot^{-1} (kg)	Fodder yield plot^{-1} (kg)
1.	Replication	1	0.0090	16.03	709.68	7.571	14.436	347.10	24.82	0.339	3.351
2.	Genotype	54	11.247**	11.23**	854.18**	5.807**	1.304**	212.57**	38.80**	0.106**	3.481**
3.	Error	54	2.898	3.591	76.511	1.427	0.379	18.66	16.32	0.0343	0.443

*, ** Significance at 5% and 1%, respectively.

Table 2 : ANOVA for F_4 progenies for shootfly resistance traits.

S. no.	Sources of variation	d.f.	Glossiness intensity 9 DAE (1-5)	Seedling vigour score (1-5)	Oviposition -I 14 DAE (%)	Oviposition -II 21 DAE (%)	Trichome density (upper 10 × field)	Trichome density (lower 10 × field)	Deadheart -I 21 DAE (%)	Deadheart -II 28 DAE (%)
1.	Replication	1	1.309	1.202	124.675	584.25	349.59	19.46	32.22	142.57
2.	Genotype	54	0.620**	0.696**	153.817**	172.28**	423.92**	1466.58**	117.698**	148.64**
3.	Error	54	0.068	0.100	36.82	69.43	284.41	71.13	11.437	28.62

*, ** Significance at 5% and 1%, respectively.

and check. Variation for plant height was reported by Wankhede *et al*. (1985) and Thorat *et al*. (2004). The maximum panicle length was found in genotype 1071-1 × RSF 16-3-22 (23.03), 1071-1 × RSF 16-3-06 (22.72). Four progenies *viz.* 1076-1 × RSF 12-4-09, 1071-1 × RSF 16-3-18, 1076-1 × RSF 16-3-10 and 1076-1 × RSF 12-4-12 recorded at par panicle girth with the checks Parbhani Moti and Parbhani Jyoti and progenies, 1071-1 × RSF 12-4-25 recorded highest panicle weight. Three progenies *viz*., 1071-1 × RSF 16-3-02, 1076-1 × RSF 12-4-14 and 1071-1 × RSF 12-4-25 recorded higher test weight over standard check. The progenies *viz*., 1071-1 × RSF 12-4-13 (1.51 kg), 1076-1 × RSF 12-4-10 (1.48), 1071-1 × RSF 12-4-21 (1.42), 1076-1 × RSF 16-3-30 (1.37), 1071-1 × RSF 12-4-06 (1.36), 1076-1 × RSF 12-4-12 (1.36), 1076-1 × RSF 19-3-16 (1.35) showed superior performance for grain yield over the standard check Parbhani Moti (1.28 kg) whereas, for fodder yield plot^{-1} the progenies *viz*., 1076-1 × RSF 12-4-09 (7.10 kg), 1071-1 × RSF 12-4-08 (6.85 kg), 1076-1 × RSF 16-3-09 (6.80), 1076-1 × RSF 12-4-15 (6.70) showed superior performance over standard check parbhani moti and Parbhani jyoti. Giriraj and Goud (1983), Nimbalkar *et al*. (1988) and Hemalata *et al*. (2006) also reported importance of panicle length, test weight in grain, fodder yield for sorghum improvement.

According to the mean performance data on Shootfly resistance and component traits, In present investigation the progenies namely 1071-1 × RSF 12-4-20, 1071-1 × RSF 12-4-04 and 1071-1 × RSF 16-3-13 recorded glossyscore, which is statistically at par with resistant check IS 18551. These progenies will be utilized in future breeding programme for shootfly resistance. Rapid growth of seedling may retard the first instar larvae from reaching the growth tip. In contrast slow growth due to poor seedling vigour low fertility or environmental stress increases shootfly damage (Taneja and Leushner, 1985). Shootfly resistant lines have rapid initial plant growth, greater seeding height and bardness. The relationship between vigour of the plant and its escape from shootfly attack was reported by (Karanjkuar *et al*., 1992). In the present study, the nine progenies *viz*., 1071-1 × RSF 12-4-08, 1071-1 × RSF 12-4-20, 1071-1 × RSF 12-4-05, 1071-1 × RSF 16-3-07, 1071-1 × RSF 16-3-08, 1071-1 × RSF 16-3-13 and 1071-1 × RSF 16-3-18, 1076-1 × RSF 19-3-01and 1076-1 × RSF 19-3-34 recorded seedling vigour score which was comparable with resistant check IS 18551. Statistically at par seedling vigour with resistant check IS 18551. The progenies *viz*., 1071-1 × RSF 12-4-13 (20.51), 1076-1 × RSF 19-3-22 (23.07), 1076-1 × RSF 19-3-25 (23.71) recorded less oviposition than the resistant check IS 18551.

The importance of trichome on the under surface of leaves has been reported by several workers (Gibson and Maiti, 1983 and Taneja Lauchner, 1985). Trichomes were major factors, but not only factor involved in resistance, density of trichomes per unit area of leaf lamina surface is genetically controlled but presence of

Table 3 : Estimation of variability, heritability and genetic advance for grain yield and its component traits of F_4 progenies of sorghum.

S. no.	Character	Range		Mean	Variance		GCV(%)	PCV(%)	h^2(%)	GA(%)	GAM(%)
		Min.	Max.		σg^2	σp^2					
1.	Days to 50% flowering (days)	74	84	79	4.175	7.065	2.57	3.35	59.09	3.22	4.06
2.	Days to maturity (days)	115	124	120	3.82	7.41	1.62	2.26	51.55	2.85	2.36
3.	Plant height (cm)	151.70	248.40	193.55	388.83	465.34	10.18	11.14	83.56	36.88	19.05
4.	Panicle length (cm)	15.42	23.03	18.92	2.18	3.61	7.81	10.05	60.51	2.35	12.42
5.	Panicle girth (cm)	10.99	15.25	13.06	0.46	0.84	5.20	7.02	54.96	1.02	7.81
6.	Panicle weight (g)	38.60	93.30	68.31	96.55	115.61	14.38	15.74	83.51	18.38	26.90
7.	1000-seed weight (g)	25.25	44.25	32.81	11.24	27.56	10.21	16.00	40.78	4.32	13.16
8.	Grain yield plot^{-1} (kg)	0.60	1.52	1.10	0.036	0.070	17.24	24.05	51.42	0.27	24.26
9.	Fodder yield plot^{-1} (kg)	2.80	7.60	4.85	3.03	3.48	35.93	38.46	87.24	3.34	68.86

σg^2 = Genotypic variance; σp^2 = Phenotypic variance
GCV = Genotypic coefficient of variability; PCV = Phenotypic coefficient of variability
h^2 = Heritability (b.s.); GA = Genetic advance
GAM = Genetic advance as percent of mean

Table 4 : Estimation of variability, heritability and genetic advance for shootfly resistance and its component traits of F_4 progenies of sorghum.

S. no.	Character	Range		Mean	Variance		GCV(%)	PCV(%)	h^2(%)	GA(%)	GAM(%)
		Min.	Max.		σg^2	σp^2					
1.	Glossiness intensity at 9 DAE	1.00	5.00	2.30	0.027	0.344	22.84	25.50	80.23	0.96	41.73
2.	Seedling vigour score (14 DAE)	1.00	4.25	2.09	0.298	0.398	26.11	30.18	74.87	0.96	46.01
3.	Oviposition-I 14 DAE (%)	20.51	53.18	38.73	58.49	95.31	19.78	25.50	61.36	12.26	31.65
4.	Oviposition-II 21 DAE (%)	27.20	72.10	52.78	51.42	120.85	13.58	20.82	42.54	9.50	17.99
5.	Trichome density (upper) 10x field	0.00	231.90	118.75	1919.29	2203.70	36.85	39.48	87.09	84.13	70.76
6.	Trichome density (lower) 10x field	0.00	122.65	58.01	697.72	768.85	45.39	47.65	90.74	51.39	88.31
7.	Deadheart-I 21 DAE (%)	11.90	49.23	28.91	53.17	64.60	25.22	27.80	82.30	13.56	46.90
8.	Deadheart-II 28 DAE (%)	25	80.18	44.92	60.01	88.63	17.24	20.95	67.70	11.63	25.89

σg^2 = Genotypic variance; σp^2 = Phenotypic variance
GCV = Genotypic coefficient of variability; PCV = Phenotypic coefficient of variability
h^2 = Heritability (b.s.); GA = Genetic advance
GAM = Genetic advance as percent of mean

trichomes probable is more important for increasing to shootfly resistance (Gibson and Maiti, 1983). The progenies *viz*., 1076-1 × RSF 12-4-04 (122.65), 1076-1 × RSF 12-4-13 (96.55) at lower surface of leaves and 1076-1 × RSF 12-4-04 (178.55), 1071-1 × RSF 12-4-21 (176.30), 1076-1 × RSF 16-3-30 (174.35) at upper surface of leaves recorded at par comparable trichome density with resistant check IS 18551. In the present study, the progenies *viz*., 1071-1 × RSF 12-4-25, (11.90), 1071-1 × RSF 12-4-13 (13.36), at 21 DAE and 1071-1 × RSF 12-4-10 (25.00), 1076-1 × RSF 16-3-03 (29.53), 1071-1 × RSF 12-4-13 (31.13), 1076-1 × RSF 19-3-32 (34.05), 1076-1 × RSF 19-3-22 (35.16), 1076-1 × RSF 12-4-20 (36.11) at 28 DAE recorded significant lowest deadheart than the resistant check IS 18551. Similar results also reported by Mote *et al*. (1983), Kumar *et al*. (2000), Shekharappa (2007).

Presence of genetic variability is an important pre-requiste in any crop improvement programme. Breeder has to quantify the fixable and non fixable component of variation for further crop improvement. Selection will be effective when the character is controlled by additive gene action. Hence, for successful crop improvement programme, the knowledge of genetic variability, heritability and genetic advance is of prime importance and hence the present study was undertaken to acquire the knowledge of these genetic parameter in selected advanced lines of *rabi* sorghum. The selection under field condition may be strongly influenced by environmental factors affecting progress in improvement programme.

In the present study, estimation of variability, heritability and genetic advance for grain yield, shootfly resistance and its components (tables 3 and 4) depicted that genotypic coefficient of variation estimate was lower than phenotypic coefficient of variation for all the characters. Although, the phenotypic coefficient of variation was greater than genotypic coefficient of variation, the differences between them were of lower magnitude. The character studied in present investigation is under genetic controlled but influenced by environment.

Higher magnitude of genotypic and phenotypic coefficient of variation were observed for plant height, panicle weight, test weight, grain yield plot^{-1} and fodder yield plot^{-1} indicating more variability and scope for selection in improvement of this character. Similar results were reported by Nayen Duy *et al*. (1998), Nimbalkar (1988) for grain yield, Asthana *et al*. (1995) for fodder yield, Negash *et al*. (2005), Singh *et al*. (1980b), for the plant height, panicle weight, Singh *et al*. (1980b), Prabhakar (2001) for the test weight and grain yield. The low genotypic and phenotypic coefficient of variability was observed for days to 50% flowering. These were same results reported by Nimbalkar *et al*. (1988).

Higher estimates of genotypic and phenotypic coefficient of variation were observed for glossiness, seedling vigour, non preference oviposition, trichome density at lower and upper surface and deadheart incidence. Similar results were reported by Borikar *et al*. (1982b) and Paul *et al*. (1984).

High heritability indicates the effectiveness of selection based on phenotypic performance but does not necessary mean and high genetic gain for particular character. Consideration of both heritability and genetic advance is more important for predicting effectiveness of selection than heritability alone. The characters plant height and panicle weight expressed high estimates of heritability accompanied with genetic advance and thus selection for this character in present study material would be more effective for desired genetic improvement. Kumar and Singh (1986) reported similar results for plant height and Patel *et al*. (1980b) for panicle weight.

The character non preference oviposition, trichome density at upper and lower leaves surface and deadheart incidence expressed the high heritability accompanied with high genetic advance. Therefore, the selection for these characters in present study MAS F_4 material would be more effective for desired genetic improvement. Similar results were reported by Paul *et al*. (1984) for deadheart incidence, Hallali *et al*. (1985) for non preference ovipsotion, trichome density and deadheart incidence.

Conclusion

In the present investigation, among the test F_4 progenies few progenies exhibited high per se mean for grain yield and associated traits and shootfly tolerance component traits. Those promising progenies for both (grain yield and shootfly tolerance) will be better source of advance breeding lines and will be utilized for development of improved cultivars having high grain and fodder yield and shootfly tolerance or parental lines in development of hybrids with shootfly tolerance.

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