The Pharma Innovation Journal 2023; 12(12): 1121-1124

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(12): 1121-1124

www.thepharmajournal.com
Received: 11-10-2023
Accepted: 22-11-2023

Gyan Pratap Singh Bhadouriya
Department of Genetics & Plant Breeding, ITM University, Gwalior, Madhya Pradesh, India

Narendra Singh Bhadouriya
Rajmata Vijayaraje Scandia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Corresponding Author:
Gyan Pratap Singh Bhadouriya
Department of Genetics & Plant Breeding, ITM University, Gwalior, Madhya Pradesh, India

Estimates of combining ability in spring-summer sorghum [*Sorghum bicolor* (L.) Moench] for yield and some morphological traits using line x tester analysis

Gyan Pratap Singh Bhadouriya and Narendra Singh Bhadouriya

Abstract
In *kharif*-2022 at crop research centre-1 of ITM University, Gwalior situated in gird agroclimatic zone of Madhya Pradesh, (India). Eight sorghum genotypes were crossed following line x tester mating design giving rise to 15 hybrids which were cultivated during spring-summer season 2023 at same place to estimate the combining ability. Hybrids were evaluated for yield and its allied characters namely Days to 50% flowering, Days to maturity, Plant height (cm), Number of leaves, Leaf length (cm), Leaf breadth (cm), Leaf area (cm^2) and 1000 seed weight (gm). For all the characters under study non additive gene action was predominant as σ^2 GCA/ σ^2 SCA ratio was less than unity. It was observed that line CSV 15 and tester RVJ 1862 were good combiners for grain yield per plant while JJ 1022 was a good combiner for plant height, crosses JJ 1022 x JJ 938 and SPV2376 x RVJ 1862 was found desirable for plant height. SPV 2688 x RVJ 1862 and SPV2376 x JJ 938 were found good for grain yield per plant.

Keywords: *Spring-summer sorghum*, line X tester, combining ability, hand emasculation

Introduction
Sorghum [*Sorghum bicolor* (L.) *Moench*; 2n = 2x = 20] is one of the important staple crops, it is a good substitute to fulfil the requirement of healthy staple food and fodder in dairy industry, sorghum is important crop in various aspects and should be worked on it provides food security to areas where water for agriculture is a deficit commodity. In present India ranks sixth for sorghum production in world with a total production of 4423 thousand tons on 4584 thousand ha of area with a productivity of 1.0 tons/ha (anonymous, 2022-2023). But also, the yield and grain quality of sorghum is decreasing in Bharat each passing year (FAOSTAT: http://www.fao.org/faostat). Sorghum is mainly grown as *Kharif* crop in northern parts of Bharat while as *Rabi* crops in southern parts, *kharif* sorghum is sown during time period of May-June in Gird region of Madhya Pradesh, Bharat (India). The minimum temperature requirement for germination is 7–10 °C. More than 80% of the seeds germinate at 15 °C. The optimum temperature requirement for growth and development is 27–30 °C. Growth and yields can be affected beyond 35 °C (Chadalavada *et al*., 2021) [5]. The author believes, Sorghum being a good climate resilient crop can be sown during March (pre monsoon), it can make us capable of obtaining two crops consecutively remarkably increasing the sorghum yields. The primary objective of the study was to evaluate the eight high yielding genotypes for their combining ability to set a premise for further breeding programmes. Combining ability analysis helps in identifying the parents, and these parents can be used for hybridization program in order to produce superior hybrids (Ingle *et al*., 2018) [8]. As a general rule, general combining ability (GCA) is the result of additive gene effects, while the specific combining ability (SCA) is the result of non-allelic interactions (Jinks, 1954; Ingle *et al*., 2018) [19, 8].

Materials and Methods
During *kharif*-2022 at the crop research centre-1 of ITM University Gwalior, located at 26º 08' 22.6" N latitude and 78º 11' 42.9" E longitude at a height of 211.5m above sea level. Which falls under gird agroclimatic zone of Madhya Pradesh, Bharat (India). five lines JJ 1022, SPV2376, IV 16-2, SPV 2688 and CSV 15 were hand emasculated and pollinated with three testers JJ 741, JJ 938 and RVJ 1862, following line x tester mating design giving rise to fifteen hybrids which were sown in randomized block design with two replications during spring-summer season of 2023.

Recommended set of cultural practices were followed for cultivation of the crop, data was collected from randomly selected five plants per replication for nine morphological characters namely Days to 50% flowering, Days to maturity, Plant height (cm), Number of leaves, Leaf length (cm), Leaf breadth (cm), Leaf area (cm^2), 1000 seed weight (gm) and Grain yield per plant (gm) which were subjected to line x tester analysis through method suggested by Arunachalam (1974) [2]. Statistical analysis was done using R studio package 'gpbstat'.

Results and Discussion

Analysis of Variance

Analysis of variance for combining ability as presented in table 1 revealed that for hybrids (Crosses), all the characters were significant at 1%, except for days to 50% flowering and number of leaves per plant which were significant at 5%. Lines were found significant for all characters except days to 50% flowering and number of leaves per plant while testers were found significant only for the grain yield per plant. For L x T all the characters were found significant except days to maturity and plant height, Significant L x T component suggested presence of high SCA among hybrids (Dar *et al*., 2017) [6]. It can be estimated that out of all character's grain yield per plant showed significant variance for crosses, lines, tester and line x tester components. It was also observed that means squares of lines were greater than testers for all characters except days to 50% flowering and grain yield per plant indicating greater diversity among testers for days to 50% flowering and grain yield per plant. σ^2 SCA was higher in magnitude than σ^2 GCA for all the characters under the study indicating the higher influence of non-additive gene action, similar results were observed by Prasuna *et al*., (2013) [2]. Totre *et al*., (2021) [18] observed such results for days to 50% flowering, 1000 seed weight and grain yield per plant. Dominance variance was found higher than additive variance for both F=0 and F=1 Totre *et al*., (2021) [18] observed similar results for grain yield per plant, since dominance variance is higher than additive variance it would be better to go for heterosis breeding in F2 generation. Presence of non-additive gene action was also confirmed by the ratio σ^2 GCA/ σ^2 SCA being lower than unity, similar results was observed by Rachman *et al*., (2022) [17] for plant height, days to 50% flowering, days to maturity and grain yield per plant.

General combining ability effects

Presence of highly significant GCA and SCA effects for most characters indicated the importance of both additive and non-additive genes in the expression of the traits (Suguna *et al*., 2021) [16]. As mentioned in Table 2, for Grain yield per plant, among lines only CSV 15 (33.17**) showed significant general combining ability in the desired direction, similar result was observed for CSV 15 by Jain and Patel (2014) [9] while IV 16–2 (-23.08*) showed negative significant GCA, among testers it was only RVJ 1862 (26.77**) with positive and significant GCA In sorghum, positive GCA effects is desirable for Grain yield per plant while for Days to 50% flowering and Days to maturity negative GCA effects are desirable (Kalpande *et al*., 2015) [10]. For Days to maturity CSV 15 (1.13**) showed the highest significant GCA in undesirable directio n followed by JJ 1022 (0.8*) while lines SPV 2376 (-0.7*) and IV 16–2 (-0.7*) showed the significant GCA in desirable direction. For plant height CSV 15 (12.03*) showed highest GCA in undesirable direction, Premalatha *et al*., (2006) [12] observed similar results for CSV 15, while JJ 1022 (-11.3*) showed significant GCA in desirable direction. For Leaf breadth lines SPV 2376 (2.29**), JJ 1022 (-2.74**) and IV 16-2 (-1.24*) showed significant GCA. Line SPV 2376 (-9.77**) showed significant GCA for Leaf length. Line JJ 1022 (-96.9**) showed significant GCA for Leaf area. Line IV 16-2 (-1.78**) showed significant GCA for 1000 seed weight.

Specific combining ability effects

Out of fifteen crosses SPV 2688 x RVJ 1862 (45.9*) showed highest desirable significant SCA for grain yield per plant followed by SPV2376 x JJ 938 (36.82*). For days to 50% flowering there were no significant combiners however crosses CSV 15 x RVJ 1862 (-8.6**) and JJ 1022 x JJ 741(-6.3*) was significant in desirable direction. SCA for JJ 1022 x JJ 938 (-20.1*) and SPV2376 x RVJ 1862 (-18.53*) was found significant for plant height in desirable direction. Crosses SPV 2688 x JJ 741(2**), CSV 15 x RVJ 1862 (1.62**) and IV 16-2 x JJ 938 (1.38*) showed significant desirable SCA for 1000 seed weight.

Table 1: Analysis of variance for combining ability of nine morphological characters in sorghum and estimates of genetic components

Source	df	Days to 50% flowering	Days to maturity	Plant height	Number of leaves	Leaf length	Leaf breadth	Leaf area	1000 seed weight	Grain yield per plant
Replication	1	45.63	1.63	1.2	0.83	1	0.1	183.77	0.2	392.41
Crosses	14	35.01*	2.34**	444.03**	1.98*	188.15**	12.40**	22960.10**	4.89**	3104.53**
Lines	4	8.38	4.78**	584.45**	2.08	201.96*	23.61**	27030.25*	8.74**	3662.48**
Testers	2	10.8	1.3	94.03	0.13	120.51	1.86	4216.53	0.86	5393.00**
Line X Tester	8	54.38**	1.38	461.32	2.38*	198.15**	9.43**	25612.48**	3.97**	2253.43*
Error	14	10.49	0.56	105.84	0.69	43.58	1.81	5906.87	0.58	493.37
Genetic components										
σ^2 GCA		-1.03	0.05	-0.92	-0.02	-0.53	0.16	-140.61	0.05	45.13
σ^2 SCA		9.76	0.83	139.5	0.47	66.39	4.48	6898.07	1.84	1517.8
σ^2 GCA/ σ^2 SCA		-0.105	0.060	-0.006	-0.042	-0.008	0.036	-0.020	0.027	0.030
σ^2 A (F=0)		-4.11	0.2	-3.67	-0.09	-2.12	0.63	-562.44	0.19	180.53
σ^2 A (F=1)		-2.05	0.1	-1.83	-0.04	-1.06	0.31	-281.22	0.1	90.27
σ^2 D (F=0)		43.89	0.82	355.48	1.69	154.57	7.61	19705.61	3.39	1760.1
σ^2 D (F=1)		21.95	0.41	177.74	0.85	77.29	3.81	9852.8	1.69	880.04

*, ** significant at 5% and 1% level, respectively

Table 2: GCA effects of parents and SCA effects in hybrids for nine morphological characters in sorghum

	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)	1000 seed weight (gm)	Grain yield per plant (gm)
Lines									
JJ 1022	0.6	0.8*	-11.3*	-0.67	-0.85	-2.74**	-96.9**	-0.28	-12.67
SPV 2376	0.77	-0.7*	8.53	0	-9.77**	2.29**	-1.53	0.13	-16.67
IV 16-2	-0.4	-0.7*	-3.8	-0.5	3.32	-1.24*	-27.15	-1.78**	-23.08*
SPV 2688	0.93	-0.53	-5.47	0.5	2.98	0.93	60.97	1.55	19.25
CSV 15	-1.9	1.13**	12.03*	0.67	4.32	0.76	64.6	0.38	33.17**
S.E.	1.32	0.31	4.2	0.34	2.69	0.55	31.37	0.31	9.07
C.D.	2.83	0.66	9	0.73	5.78	1.18	67.29	0.67	19.45
Testers									
JJ 741	-1.2	-0.3	2.87	-0.07	-3.97	0.49	-21.24	-0.33	-14.78
JJ 938	0.6	-0.1	-3.23	-0.07	2.48	-0.27	19.75	0.12	-11.98
RVJ 1862	0.6	0.4	0.37	0.13	1.48	-0.22	1.48	0.22	26.77**
S.E.	1.02	0.24	3.25	0.26	2.09	0.43	24.3	0.24	7.02
C.D.	2.2	0.51	6.98	0.56	4.48	0.91	52.13	0.52	15.06
Crosses									
JJ 1022 x JJ 741	-6.3	-0.2	-1.2	0.57	5.3	-0.33	31.61	0.58	10.12
JJ 1022 x JJ 938	-1.1	-0.9	-20.1	-0.43	-12.65	-0.06	-70.5	0.38	-1.68
JJ 1022 x RVJ 1862	7.4	1.1	21.3	-0.13	7.35	0.39	38.88	-0.97	-8.43
SPV2376 x JJ 741	1.53	0.3	8.97	0.9	-14.03	0.99	-89.07	-0.58	-15.63
SPV2376 x JJ 938	-1.27	0.1	9.57	-0.6	2.77	-2.09	-44.75	-0.03	36.82
SPV2376 x RVJ 1862	-0.27	-0.4	-18.53	-0.3	11.27	1.11	133.82	0.67	-21.18
IV 16-2 x JJ 741	-0.8	-0.7	3.8	0.4	5.63	-1.33	-1.01	-0.67	8.78
IV 16-2 x JJ 938	0.4	1.1	-5.1	0.4	-8.2	-1.06	-60.75	1.38	27.48
IV 16-2 x RVJ 1862	0.4	-0.4	1.3	-0.8	-4.82	2.39	61.76	-0.72	-36.27
SPV 2688 x JJ 741	0.87	0.13	-2.03	-2.1	2.97	2	98.36	2	-7.55
SPV 2688 x JJ 938	-1.93	-0.57	-0.93	0.9	4.52	1.27	65.62	-1.45	-38.35
SPV 2688 x RVJ 1862	1.07	0.43	2.97	1.2	-7.48	-3.27	-163.99	-0.55	45.9
CSV 15 x JJ 741	4.7	0.47	-9.53	0.23	0.13	-1.33	-39.89	-1.33	4.28
CSV 15 x JJ 938	3.9	0.27	16.57	-0.27	6.18	1.94	110.37	-0.28	-24.27
CSV 15 x RVJ 1862	-8.6	-0.73	-7.03	0.03	-6.32	-0.61	-70.49	1.62	19.98
S.E.	2.29	0.53	7.27	0.59	4.67	0.95	54.34	0.54	15.7
C.D.	4.91	1.14	15.6	1.26	10.01	2.04	116.56	1.16	33.68

*, ** significant at 5% and 1% level, respectively

Conclusion

The GCA effect is considered as the intrinsic genetic value of the parent for a trait, which is due to additive gene effects and it is fixable (Simmonds 1979; Suguna *et al*., 2021) [20, 16]. It can be concluded from the study that most of the characters were under the influence of non-additive gene action therefore heterosis breeding is more useful crosses SPV 2376 x JJ 938 and SPV 2688 x RVJ 1862 can be used for making good yielding varieties for the spring summer season in gird region therefore intensive study of F2 population is recommended it can also be concluded that except line IV 16-2 all the lines were somewhat good combiners but CSV 15 showed similar results as a parent in the following study as observed by Premalatha *et al*., (2006) [12] and Jain and Patel (2014) [9] while in tester RVJ 1862 was a good combiner for grain yield per plant.

Conflict of interest

Authors declare no conflict of interest

Authors Contribution

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Gyan Pratap Singh Bhadauria and Narendra Singh Bhadauria.

Acknowledgment

With profound respect I wish to express my sincere gratitude to Dr. Usha Saxena and Dr. Mukesh Saxena from collage of agriculture Indore for arrangement of sorghum genotypes.

Funding declaration

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Abrha SW, Zeleke HZ, Gissa DW. Line x tester analysis of maize inbred lines for grain yield and yield related traits. Asian J Plant Sci Res. 2013;3(5):12-19.
2. Arunachalam V. The fallacy behind the use of modified line x tester design. Indian J Genet Plant Breed. 1974;34:280-287.
3. Baker RJ. Issues in diallel analysis. Crop Sci. 1978;18:533-536.
4. Ch PR, Aruna C, Jabeen F, Suguna M. Studies on Heterosis and Combining ability for Yield Components in Grain Sorghum [*Sorghum bicolor* (L.) Moench]. Madras Agric J. 2013;101(Jan-Mar):1.
5. Chadalavada K, Kumari BR, Kumar TS. Sorghum mitigates climate variability and change on crop yield and quality. Planta. 2021;253(5):113.
6. Dar ZA, Lone AA, Khuroo NS, Ali G, Abidi I, Ahangar MA, *et al*. Line x Tester Analysis in Maize (*Zea mays* L.) for Various Morpho-Agronomic Traits under Temperate Conditions. Int. J Curr Microbiol App Sci. 2017;6(7):1430-1437.

7. Elangovan M, Bahadure DM. Combining ability of new parental lines for flowering, maturity and grain yield in Rabi sorghum. Electron J Plant Breed. 2013;4(3):1214-1218.
8. Ingle KP, Gahukar SJ, Khelurkar VC, Ghorade RB, Kalpande VV, Jadhav PV, *et al*. Heterosis and combining ability for grain yield trait in rabi sorghum [*Sorghum bicolor* (L.) Moench] using line x tester mating design. Int. J Curr Microbiol Appl. Sci. 2018;1(6):1925-1934.
9. Jain SK, Patel PR. Combining ability and heterosis for grain yield, fodder yield and other agronomic traits in sorghum (*Sorghum bicolor* L. Moench). Electron J Plant Breed. 2014;5(2):152-157.
10. Kalpande VV, Sakhare BA, Ghorade RB, Lad AP, Kahate NS. Potential parents for grain yield and early maturity in *rabi* sorghum. Plant Arch. 2015;15(1):127-129.
11. Kempthorne O. An introduction to genetic statistics. London: John Willey and Sons; c1957. p. 208-221.
12. Premalatha N, Kumaravadivel N, Veerabadhiran P. Heterosis and combining ability for grain yield and its components in sorghum [*Sorghum bicolor* (L.) Moench]. Indian J Genet Plant Breed. 2006;66(02):123-126.
13. Rokade RC, Kusalkar DV, Thakre DS, Parde NS. Promising parents for grain yield and early maturity in *rabi* sorghum (*Sorghum bicolor* L. Moench). J Pharmacogn Phytochem. 2020;9(1):2102-2103.
14. Sandeep RG, Rao MG, Ramesh S, Chikkalingaiah C, Shivanna H. Parental combining ability as a good predictor of productive crosses in sweet sorghum [*Sorghum bicolor* (L.) Moench]. J Appl. Nat Sci. 2010;2(2):245-250.
15. Singh RK, Chaudhary BD. Biometrical methods in quantitative genetic analysis; c1977.
16. Suguna M, Aruna C, Deepika C, Ratnavathi CV, Tonapi VA. Genetic analysis of semolina recovery and associated traits-A step towards breeding for specific end uses in sorghum (*Sorghum bicolor* (L.) Moench). J Cereal Sci. 2021;100:103226.
17. Rachman F, Trikoesoemaningtyas T, Wirnas D, Reflinur R. Estimation of genetic parameters and heterosis through line× tester crosses of national sorghum varieties and local Indonesian cultivars. Biodiversitas J Biol. Divers, 2022, 23(3).
18. Totre AS, Jadhav AS, Parihar NN, Shinde MS, Kute NS, Dalvi US, Patil VR. Combining ability studies in post rainy sorghum by using the line x tester analysis. Pharma Innovation. 2021;10(7):1197-1205.
19. Jinks JL. The analysis of continuous variation in a diallel cross of Nicotiana rustica varieties. Genetics. 1954;39(6):767.
20. Simmonds NW. Principles of crop improvement. Principles of crop improvement; c1979.