Annals of Plant and Soil Research 26(2): 317-322 (2024)
https://doi.org/10.47815/apsr.2024.10366

Evaluation of combining ablity in isabgol through line X tester analysis

MONIKA SHAHANI[1]*, AMIT DADHEECH[2], HEMLATA SHARMA[3] AND DEEPAK MEENA[1]

[1]Research Scholar, Department of Genetics and Plant Breeding, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), India

Received, January, 2024; Revised accepted, April, 2024

ABSTRACT

The present study was undertaken in three distinct environments (E1, E2, and E3) during the Rabi season of 2022-2023 in Rajasthan. The experimental set comprised of 70 genotypes, including 19 parents, 48 crosses, and 3 checks (Niharika, VI-3, GI-2), which were assessed using a randomized block design with three replications. The analysis of variance for combining ability revealed significant effects due to lines, testers, and line x tester interactions across all three environments, except for specific traits in certain environments. The parental lines L5, L10, and L7 demonstrated good general combining ability (GCA) effects across various traits. The specific combining ability (SCA) effects were diverse, with several crosses displaying consistently high effects, particularly for seed yield per plant, where crosses such as L11 x T3, L16 x T1, L6 x T2, L10 x T2, and L7 x T1 exhibited the highest estimates. Overall, the study provides valuable insights into the combining ability of Isabgol genotypes and their performance across different environments, contributing to the understanding of traits and potential breeding strategies.

Key words: Combining ability, Gene action, Genotypes, Isabgol

INTRODUCTION

Plantago ovata Forsk. commonly known as Isabgol a botanical gem cherished for its medicinal properties and versatile applications. The seeds hold medicinal significance, and the drug is primarily composed of the light rosy-white membranous covering of the seed which is known as husk (Rohilla. *et al.,* 2012). The seed husk is renowned for their cooling and demulcent properties, making them valuable in addressing inflammatory and biliary disorders in the digestive system (Beara *et al.,* 2010). They also help in alleviating rheumatic and gouty swellings, as well as for managing dysentery and intestinal irritation. In recent years, the demand of Isabgol has been increased in the western countries and it is traded in the major medicinal drug market of the world. India currently dominates the global production and export of Isabgol. However, the productivity of Isabgol falls significantly short of the required levels, preventing India from fully satisfying global demand. To maintain its monopoly in the export of this valuable foreign exchange-earning commodity, India must commit to intensive initiatives aimed at breeding high-yielding varieties characterized by husk with good swelling capacity. Combining ability studies constitute a pivotal component of crop breeding programs, serving as a systematic tool to assess the genetic potential of parental lines and their ability to yield superior progeny when subjected to hybridization. The combining ability studies provide useful information regarding the selection of suitable parents for effective hybridization programme and at the same time elucidates the nature and magnitude of gene action. Since, the nature of gene action varies with genetic architecture of population involved in hybridization, it is necessary to evaluate the parents for their combining ability.

MATERIALS AND METHOD

The experimental material comprised of 16 parental lines, 3 testers, 48 F_1 and three checks *viz*., VI-3, GI-2 and Niharika. The lines, testers and checks were obtained from AICRP M & AP, Udaipur. These 48 F1 were obtained by crossing 16 parental lines and 3 testers in Line × Tester mating design. These 19 parents (16 lines and 3 testers) along with 48 F_1 crosses and three checks were evaluated using a Randomized Block Design with three replications at three different locations (Instructional Farm, Rajasthan College of Agriculture, Udaipur, Agriculture Research Station, Banswara and Krishi Vigyan Kendra- Chittorgarh) during Rabi, 2022-2023 (Table 1). The method of random sampling was adopted for recording the observations of various characters in Isabgol.

[2]Assistant Professor, Department of Genetics and Plant Breeding, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), India, [3]Associate Professor, Department of Genetics and Plant Breeding, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), India, (Corresponding author: Monika Shahani monikashahani04@gmail.com)*

The observations for important morphological traits were recorded on randomly selected 'ten' plants excluding the border plants at both the extreme ends in each row. Replication wise collected data of 'ten' plants were averaged and resultant mean data were used further for statistical analysis. Only two observations *viz*., days to 50 per cent flowering and days to maturity were recorded on plot basis, whereas all the remaining observations were recorded on plant basis.

Table 1: Details of Inbred lines, testers and checks

S.N.	Symbol / Code	Inbred Lines
1	L_1	UI-3-1
2	L_2	UI-4
3	L_3	UI-8
4	L_4	UI-17
5	L_5	UI-81
6	L_6	UI-80
7	L_7	UI-96
8	L_8	UI-97
9	L_9	UI-123
10	L_{10}	UI-125
11	L_{11}	UI-158
12	L_{12}	UI-427
13	L_{13}	HI-2
14	L_{14}	UI-6-1
15	L_{15}	DPO-6
16	L_{16}	MIB-122
17	T_1	UI-2-1
18	T_2	UI-3
19	T_3	UI-124
20	$Check_1$	Niharika
21	$Check_2$	VI-3
22	$Check_3$	GI-2

The data was subjected to ANOVA following the standard procedures. Analysis of variance (ANOVA) for all treatments was carried out by the method Panse and Sukhatme, (1985) and combining ability analysis and test of significance of different genotypes was based on the procedure suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

The mean sum of squares due to lines, testers, and line x tester were found to be significant for all the characters in all the three environments with the exception of testers for days to maturity in E2, number of spikes per plant in E1 and E3, length of peduncle in E1 and E2, length of leaves in E1, number of spikelets per spike in all the three environments, biological yield in E1 and total soluble sugar in E1 and E2 environments. Significant mean squares due to lines and testers indicated that lines and testers played a significant role in the general combining effects. Similar to lines x testers, significant mean squares indicated a significant contribution of crosses for specific combining (SCA) effects. On pooled basis, mean squares due to lines, testers and lines x testers were also found to be significant for all the traits except length of peduncle, husk recovery content due to tester. Parents were categorized into high (good), medium (average), and low (poor) combiners based on their General Combining Ability (GCA) effects, as outlined in Table 2.

Table 2: Classification of parents on the basis of general combining ability effects for various characters over the environments

Parents / Traits	T1	T2	T3	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16
Days to 50 per cent flowering	P	G	A	G	G	P	P	P	G	P	P	P	P	P	A	G	P	P	A
Days to maturity	P	A	A	G	G	P	G	P	G	P	P	P	G	P	G	G	P	P	P
Plant height (cm)	G	P	P	P	A	P	P	G	A	P	P	A	G	G	G	P	A	A	P
Number of tillers per plant	P	G	A	A	G	P	P	G	P	A	P	P	A	G	P	P	A	P	G
Number of spikes per plant	P	A	A	P	P	A	A	G	P	A	G	P	G	P	P	G	A	G	P
Spike length (cm)	P	G	A	P	G	P	P	G	P	G	P	P	P	P	P	G	G	G	P
Length of peduncle (cm)	P	A	G	P	P	P	A	G	P	P	A	P	A	P	G	P	A	G	A
Length of leaves (cm)	G	P	P	P	A	G	P	G	G	P	P	P	P	G	G	G	G	G	P
Number of leaves per plant	G	G	P	P	G	P	P	G	P	G	G	G	G	P	G	A	A	G	P
Number of spikelets per spike	A	A	P	P	P	P	P	G	P	G	P	G	P	A	G	P	G	A	P
1000 Seed weight (g)	P	G	A	G	A	P	P	G	A	A	G	P	P	A	P	A	G	G	G
Seed yield per plant (g)	A	G	P	P	A	A	A	A	G	G	P	P	G	P	P	P	P	A	P
Biological yield per plant (g)	A	G	P	P	A	G	P	A	A	G	P	P	G	A	P	P	P	P	G
Harvest index (%)	G	A	P	G	P	P	G	A	A	G	P	P	G	P	P	P	P	A	G
Swelling factor (cc/g)	P	G	P	P	P	P	P	G	P	G	P	P	A	P	G	P	G	G	A
Husk recovery content (%)	P	P	G	P	P	P	P	P	G	G	G	P	P	G	P	G	P	P	P
Husk yield per plant (g)	A	G	P	P	A	A	P	A	G	G	P	P	G	A	P	P	P	P	G
Crude fiber (%)	A	P	G	P	G	G	G	G	G	G	P	P	G	P	P	G	P	G	P
Total soluble sugar (mg/g)	A	P	A	P	P	G	G	G	P	G	G	G	G	G	G	P	G	G	G

Good (G)=Desirable significant (+ or -) GCA effect, Average (A)=Desirable non-significant (+ or -) GCA effect, Poor (P)=Undesirable significant (+ or -) GCA effect

Parents with desirable and significant GCA effects were considered good combiners while parents showing nonsignificant estimates but in desirable direction were classified as average combiners. Poor combiners possess undesirable GCA effects. Among all the lines, these two lines L7, L10 were found to exhibit significant GCA effects in desirable direction within all three environments. The parental lines L7, L10 were found as promising general combiners for majority of the yield contributing and seed quality traits. The parental lines L7 exhibited good general combining ability for spike length, number of leaves per plant, number of spikelets per spike, biological yield per plant, harvest index swelling factor, husk recovery content, crude fiber, total soluble sugar while the parental lines L10 exhibited good general combining ability for days to maturity, plant height, number of spikes per plant, number of leaves per plant, biological yield per plant, harvest index, crude fiber, total soluble sugar. Among all the three testers studied in this investigation it was found that the tester T2 exhibited good general combining for majority of the yield contributing and seed quality traits along with the seed yield per plant.

Table 3: Significant specific combining ability (SCA) effect estimates of crosses in desirable directions for various traits over the environments

Traits / Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of tillers /plant	No. of spikes/plant	Spike length (cm)	Length of peduncle (cm)	Length of leaves (cm)	Number of leaves
L_1 x T_1								**	
L_2 x T_1	**	*					**		**
L_3 x T_1							**		**
L_4 x T_1									**
L_5 x T_1	*								
L_6 x T_1	**	**		**			*		*
L_7 x T_1			*	**	**	**			
L_8 x T_1			**			*			
L_9 x T_1			*			**			
L_{10} x T_1									
L_{11} x T_1				**		*			
L_{12} x T_1						**			
L_{13} x T_1	**	*							
L_{14} x T_1			*	**	**	**	**	**	**
L_{15} x T_1					**			**	
L_{16} x T_1									
L_1 x T_2									
L_2 x T_2									
L_3 x T_2				**		**			
L_4 x T_2					**	**		**	
L_5 x T_2			*		**	**	**	*	
L_6 x T_2									**
L_7 x T_2									*
L_8 x T_2				**	**	*			
L_9 x T_2	**	*	**					**	
L_{10} x T_2	**	**							**
L_{11} x T_2					*				
L_{12} x T_2							**		
L_{13} x T_2				**			**	**	*
L_{14} x T_2									*
L_{15} x T_2			**	**	**	**	**	*	**
L_{16} x T_2									
L_1 x T_3			**	**	**	**			**
L_2 x T_3					**	**			
L_3 x T_3					**				
L_4 x T_3	**	**							
L_5 x T_3				**	*	**	*	**	**
L_6 x T_3						**			
L_7 x T_3	**	*							**
L_8 x T_3								**	**
L_9 x T_3									*
L_{10} x T_3			**	**	**	**	**	**	
L_{11} x T_3								**	**
L_{12} x T_3					*			**	
L_{13} x T_3			**		**	**			
L_{14} x T_3									
L_{15} x T_3									
L_{16} x T_3	*		**			**			

Table 4: Four promising crosses identified on the basis of per *se* performance along with GCA and SCA effects for seed yield per plant on the pooled basis

S.No.	Traits Crosses	No. of spikelets per spike	1000 Seed weight (g)	Seed yield per plant	Biological yield per plant (g)	Harvest index (%)	Swelling factor (cc/g)	Husk recovery content (%)	Husk yield per plant (g)	Crude fiber (%)	Total soluble sugar (mg/g)
1	L_1 x T_1										
2	L_2 x T_1			**		**		*	**	**	
3	L_3 x T_1		**								
4	L_4 x T_1							**		**	
5	L_5 x T_1										
6	L_6 x T_1							**			*
7	L_7 x T_1	**		**					**	**	
8	L_8 x T_1									**	
9	L_9 x T_1	*									
10	L_{10} x T_1			**					**	**	
11	L_{11} x T_1	**	*				**				
12	L_{12} x T_1	**	**					**		**	
13	L_{13} x T_1	**	**				*				**
14	L_{14} x T_1	**	**				*	**			**
15	L_{15} x T_1							*			
16	L_{16} x T_1			**	**	*		**	**	**	
17	L_1 x T_2				*					**	**
18	L_2 x T_2	**									
19	L_3 x T_2	**		*	*			**	**		
20	L_4 x T_2	**	**			**					
21	L_5 x T_2	*	**					**			
22	L_6 x T_2		**	**		**		**	**	**	
23	L_7 x T_2	*	**								
24	L_8 x T_2										
25	L_9 x T_2							**		**	**
26	L_{10} x T_2			**				**	**		
27	L_{11} x T_2										
28	L_{12} x T_2						**			**	**
29	L_{13} x T_2			*	**				**	**	
30	L_{14} x T_2		**		*		**			**	
31	L_{15} x T_2	**	**				**				**
32	L_{16} x T_2	**								**	
33	L_1 x T_3	**				*		*	*		
34	L_2 x T_3		**				*				
35	L_3 x T_3									**	
36	L_4 x T_3										
37	L_5 x T_3	**	**		**		**		**	**	
38	L_6 x T_3						*				
39	L_7 x T_3				**			**	**	**	*
40	L_8 x T_3		*	**				**		**	*
41	L_9 x T_3	*				**					
42	L_{10} x T_3	**	**				**				**
43	L_{11} x T_3		**	**	**	*		**	**	**	**
44	L_{12} x T_3	*				*					
45	L_{13} x T_3							**	*	**	*
46	L_{14} x T_3							**		**	
47	L_{15} x T_3										
48	L_{16} x T_3						**				

(, ** significant at 0.05 and 0.01 probability level, respectively)*

A perusal of SCA effects among hybrids revealed that maximum magnitude of positive SCA effects for seed yield per plant were displayed by the cross L11 x T3 followed by L16 x T1, L6 x T2, L10 x T2, L7 x T1. The crosses L15 x T1, L6 x T2, L11 x T3 possessed positive and significant values for SCA effects across the all three environments as well as over the environments. For husk yield per plant, the highest magnitudes of positive and significant SCA effects displayed by the crosses were L11 x T3 followed by L10 x T1, L7 x T3 on the pooled basis. For other yield and seed quality attributing traits the highest magnitude of positive and significant SCA effects displayed by L10 x T3 for1000-seed weight, L15 x T2 for number of spikes per plant and L14 x T1 for spike length, L10 x T3 for length of peduncle and total soluble sugar, L15 x T1 for length of leaves, L3 x T1 for number of leaves per plant, cross L15 x T1 for husk per cent, L13 x T1 for number of spikelets per spike, L5 x T3 for biological yield per plant, L9 x T3 for harvest index. For quality traits, maximum magnitudes of positive SCA effects by cross L12 x T2 for swelling factor and L11 x T3 for crude fiber while L8 x T3 for husk recovery content. Similar findings for identification of superior hybrids based on SCA effects for seed yield and its components were also reported by Ardelean *et al*. (2006) in foxglove, Singh and Lal (2009), Sarkar and Lal (2018) and Singh and Saxena (2019) in Isabgol. In the present investigation, crosses with significant high SCA effects for different traits were found involving all kinds of combinations, viz., High × High, High × Low, Low × High, and Low × Low general combiners. Among 48 crosses, the four promising crosses that L7 x T1, L10 x T1, L10 x T2, L6 x T2 exhibited the high per se performance as well positive significant SCA effects for seed yield per plant and as well as husk yield per plant on the pooled basis. Ahmad *et al*. (2017) and Yadav *et al*. (2023) also reported similar findings The Cross L7 x T1 and L10 x T1 were obtained by crossing between parents with good x poor GCA effects whereas, crosses L10 x T2 and L6 x T2 were obtained by crossing between good x good GCA effect parents for seed yield per plant. High SCA effects resulting from crosses where both parents are good general combiners (i.e., good GCA × good GCA) may be ascribed to additive × additive gene action. The high SCA effects derived from crosses including good × poor general combiner parents may be attributed to favourable additive effects of the good general combiner parent and epistatic effects of poor general combiner, which fulfils the favourable plant attribute Dey *et al.,* (2014). Venkateshwarlu and Singh (1982) suggested that cross combinations which involved G x A and G x P general combiners and having higher heterosis values beside higher per se performance suggested the possibility of exploiting these crosses for yield improvement through heterosis breeding.

CONCLUSION

The crosses, L7 x T1, L10 x T1, L10 x T2, L6 x T2 showed positive and significant SCA effects over the environments for seed yield per plant and husk yield per plant. The cross combinations exhibited significantly positive SCA effects and the parents involved in these cross combinations showed positive and significant GCA effects which indicated the presence of both additive and non-additive gene action in the manifestation of heterosis. These crosses may be advanced for isolation of homozygous inbred lines for use in breeding programmes or may be used as single cross hybrids after evaluation in multilocation trials. Alternatively, the population constituted from these inbreds is supposed to get sufficient improvement through recurrent and reciprocal recurrent selections which utilize both GCA and SCA variances.

REFRENCES

Ahmad, E., Akhtar, M., Badoni, S. and Jaiswal, J. P. (2017) Combining ability studies for seed yield related attributes and quality parameters in bread wheat (*Triticum aestivum* L.). *Journal of Genetics Genomics Plant Breeding*, **1**:21-27.

Ardelean, M., Costea, A. M. and Cordea, M. 2006. Breeding foxglove (Digitalis sp.) for ornamental and/or medical purposes. Bulletin of university of agricultural sciences and veterinary medicine. Cluj-Napoca. Horticulture, 63: 22-31.

Beara, I. N., Orcic, D. Z., Lesjak, M. M., Mimica-Dukić, N.M., Pekovic, B. A., and Popovic, M.R. (2010) Liquid chromatography /tandem mass spectrometry study of anti-inflammatory activity of Plantain (*Plantago* L.) species. *Journal of pharmaceutical and biomedical analysis*, **52**(5): 701-706.

Dey, S. S., Singh, N., Bhatia, R., Parkash, C., and Chandel, C. (2014) Genetic combining ability and heterosis for important vitamins and antioxidant pigments in cauliflower (*Brassica* *oleracea* var. *botrytis* L.). *Euphytica*, 195:169-181.

Griffing, B. (1956) Concept of general and specific combining ability in relation to diallel crossing systems. *Australian journal of biological sciences,* 9(4): 463-493.

Hallauer, A. R. (1990). Methods used in developing maize inbreds. *Maydica*, 35, 1-16.

Jain, D. K., and Jain, S. K. (2018) Induce mutation breeding for downy mildew tolerance in Isabgol (*Plantago ovata* Forsk.), **7**(5): 33-40.

Kempthorne, O. (1957) An introduction to genetical statistics. *John Willey and Sons In company*, New York. pp. 323-331.

Kour, B., Kotwal, S., Dhar, M. K. and Kaul, S. (2016) Genetic diversity analysis in *Plantago ovata* and some of its wild allies using RAPD markers. *Russian Agricultural Sciences*, **42**(1): 37-41.

Panse, V. G. and Sukhatme, P. V. (1967) Statistical Methods for Agricultural Workers 2nd ed. I.C.A.R. New Delhi, 381.

Rohilla, A. K., Kumar, M., Sindhu, A. and Boora, K. S. (2012) Genetic diversity analysis of the medicinal herb *Plantago ovata* (Forsk.). *African Journal of Biotechnology*, **11**(86): 15206-15213.

Sarkar, S. and Lal, R. K. (2018) Genetics, inheritance pattern and genotype selection in Isabgol (*Plantago ovata* Forsk). *International Journal of Genetic Science*, **1**: 68-79.

Singh, N. and Lal, R. K. (2009) Genetics of quantitative and qualitative traits of Isabgol (*Plantago ovata*). *Genetics and Molecular Research,* **8**(3): 939-950.

Singh, S. and Saxena, A. K. (2019) Study of genetical components determining vegetative, flowering and seed parameters in dogflower (*Antirrhinum majus* L.). *International Journal of Advances in Agricultural Science and Technology*, **6**(7): 96-105.

Sprague, G. F. and Tatum, L. A. (1942) General verses specific combining ability in single crosses of corn. *Journal of American Society of Agronomy*, **34**: 923- 932.

Venkateshwarlu, S. and Singh, R. B. (1982) Combining ability in pigeon pea. *Indian Journal of Genetics*, 42:11-14.

Yadav, M., Dadheech, A. Kumar, A., Meena, D. (2023)Elucidating Combining Ability through Line x Tester Analysis for Yield and its Contributing Traits in Isabgol (*Plantago ovata* Forsk.). *Biological Forum*, **15**(10):14-20.