Elucidating Combining Ability through Line x Tester Analysis for Yield and its Contributing Traits in Isabgol [*Plantago ovata* (Forsk.)]

Mukesh Kumar Yadav[1]*, Amit Dadheech[2], Amit Kumar[3] and Deepak Meena[1]
[1]Research Scholar, Department of Genetics and Plant Breeding,
Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), India.
[2]Assistant Professor, Department of Genetics and Plant Breeding,
Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), India.
[3]Assistant Professor, M.B College of Agriculture, Tonk (Rajasthan), India.

(Corresponding author: Mukesh Kumar Yadav*)

ABSTRACT: In order to explore the genetic architecture of isabgol (*Plantago ovata* Forsk.) through combining ability studies, the present investigation was carried out using 45 crosses which were produced using fifteen lines and three testers in a Line x Tester mating design at experimental farm of Plant Breeding and Genetics, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan). The experimental material assessed in three environments: E1 (*Rabi*-2020-21, Instructional Farm, RCA, Udaipur), E2 (*Rabi*-2020-21, Krishi Vigyan Kendra, Badgaon) and E3 (*Rabi*-2020-21, Krishi Vigyan Kendra, Banswara) using a randomized block design with three replications in each environment. One of the important reasons for nearly stagnant yields of isabgol may be limited genetic improvement. This might have been due to a narrow genetic base and use of traditional breeding techniques with little or no understanding of the genetic architecture of the target populations. The good general combiner parental lines for seed yield per plant were L_1, L_5, L_{14} and L_{15}. SCA effects revealed that out of 45 crosses, 13 hybrids exhibited significant positive SCA effects for seed yield per plant on pooled basis. The crosses, $L_{10} \times T_3$, $L_{11} \times T_1$, $L_5 \times T_2$ and $L_1 \times T_3$ showed positive and significant SCA effects in all the environments and over the environments for seed yield per plant. Cross $L_{10} \times T_3$ showed highest positive and significant SCA effects in all the three environments as well as on pooled basis for seed yield and other yield attributing traits.

Keywords: Combining ability, Isabgol, Line x Tester and Environment.

INTRODUCTION

Isabgol (*Plantago ovata* Forsk.) is an important medicinal plant commercially cultivated in India and being exported in the world market. India holds monopoly in the trade of Isabgol seed and husk. It is a *Rabi* season crop, usually matures in 120 to 140 days after sowing. The seed husk, the seed epidermis having muco-polysaccharide layers are responsible for medicinal properties and are widely used against constipation, diarrhoea and intestinal irritation. The swelling property of the mucilaginous polysaccharide of husk is responsible for the medicinal property (Rohilla *et al*., 2012).

It is also known as "blond psyllium" belonging to the family plantaginaceae and genus *Plantago* (Kumar *et al*., 2014). It has narrow genetic base (Kaswan *et al*., 2013) on account of small genome size (621Mb) based on 4 (2n=2x=8) heterochromatin rich chromosomes, low chiasmata frequency and recombination index and

predominantly a cross-pollinated annual herb (Kour *et al*., 2016).

The seeds of *Plantago ovata* contains 17.4% protein, 6.7% fat, 24.6% fibre, 19.6% insoluble fibre, 5% soluble fibre and combustion dietary heat of 4.75% kcl/g. The One of the important reasons for nearly stagnant yields of isabgol may be limited genetic improvement. This might have been due to a narrow genetic base and use of traditional breeding techniques with little or no understanding of the genetic architecture of the target populations (Singh and Lal 2009).

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 (Hallauer, 1990). Combining ability is the relative ability of a genotype to transmit its desirable performance to its crosses. It is very important to screen out the parent materials for their genetic diversity and

combining ability. 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.

MATERIAL AND METHODS

The experimental0 material comprised 15 parental lines, 3 testers, 45 F_1 and two checks *viz.,* VI-1 and Niharika. The lines, testers and checks were obtained from AICRP M & AP, Udaipur. These 45 F_1 were obtained by crossing 15 parental lines and 3 testers in Line × Tester mating design. These 18 parents (15 lines and 3 testers) along with 45 F_1 crosses and two checks were evaluated using a Randomized Block Design with three replications at three different locations (Instructional Farm, Rajasthan College of Agriculture-

Udaipur, Krishi Vigyan Kendra- Badgaon and Krishi Vigyan Kendra- Banswara) during *Rabi,* 2020-2021 (Table 1).

The method of random sampling was adopted for recording the observations of various characters in isabgol. 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 75 per cent 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.

Sr. No.	Symbol / Code	Inbred Lines	Source
1	L_1	UI-1	AICRP M &AP Udaipur
2	L_2	UI-2	AICRP M &AP, Udaipur
3	L_3	UI-6	AICRP M &AP, Udaipur
4	L_4	UI-7	AICRP M & AP, Udaipur
5	L_5	UI-10	AICRP M & AP, Udaipur
6	L_6	UI-11	AICRP M & AP, Udaipur
7	L_7	UI-16	AICRP M & AP, Udaipur
8	L_8	UI-25	AICRP M & AP, Udaipur
9	L_9	UI-29	AICRP M & AP, Udaipur
10	L_{10}	UI-62	AICRP M & AP, Udaipur
11	L_{11}	UI-121	AICRP M & AP, Udaipur
12	L_{12}	UI-130	AICRP M & AP, Udaipur
13	L_{13}	HI-1	AICRP M & AP, Udaipur
14	L_{14}	HI-8	AICRP M & AP, Udaipur
15	L_{15}	HI-9	AICRP M & AP, Udaipur
16	T_1	UI-2-1	AICRP M & AP, Udaipur
17	T_2	UI-3	AICRP M & AP, Udaipur
18	T_3	UI-124	AICRP M & AP, Udaipur
19	C_1	VI-1	AICRP M & AP, Udaipur
20	C_2	Niharika	AICRP M & AP, Udaipur

Statistics: 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).

RESULT AND DISCUSSION

The analysis of variance for combining ability revealed significant differences between crosses for all the characters in all the three environments. Significant mean squares due to lines and testers indicated that lines and testers contributed significantly to the GCA effects. Similarly, significant mean squares due to lines x testers indicated that hybrids contributed significantly to SCA effects.

The results on pooled basis revealed that mean squares due to lines, testers and lines x testers were significant for all traits except plant height in all the environments, seed yield and biological yield in E1, 1000 seed weight in E3 and harvest index in E2 due to testers.

Parents were classified as good, average and poor combiners on the basis of their GCA effects (Table 2). Parents with desirable and significant GCA effects were considered good combiners while parents showing non-significant estimates but in desirable direction were classified as average combiners. Poor combiners possess undesirable GCA effects. The estimates of GCA effects for yield and yield contributing characters revealed that good general combiner inbred lines for seed yield per plant were L_1, L_5, L_{14} and $L_{15.}$

Table 2: Classification of parents based on general combining ability (GCA) effects for various traits over the environments.

Sr. No.	Parents / Traits	T1	T2	T3	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
1	Days to 50 per cent flowering	G	P	P	P	G	A	P	P	P	G	A	A	G	P	P	G	G	G
2	Days to 75 per cent maturity	G	G	G	A	A	P	P	P	P	P	G	P	G	A	P	A	G	G
3	Plant height (cm)	P	P	A	A	P	P	P	P	P	G	P	G	P	A	G	G	G	A
4	Number of branches per plant	P	G	G	P	P	P	P	P	P	G	P	G	G	G	G	G	A	P
5	Number of effective spikes per plant	G	A	G	P	P	A	G	G	A	G	G	P	G	P	G	G	G	P
6	Spike length (cm)	G	P	G	P	P	G	P	P	P	G	A	G	A	G	G	A	P	P
7	Length of peduncle (cm)	P	P	G	P	P	P	P	P	P	G	A	P	G	P	G	P	G	G
8	Length of leaves per plant (cm)	P	P	G	P	G	G	A	P	A	P	P	G	A	P	P	A	P	G
9	1000 Seed weight (g)	P	P	G	P	G	A	P	A	P	P	G	G	A	P	P	A	P	G
10	Number of leaves per plant	P	A	G	A	P	P	A	G	P	P	P	G	P	P	G	P	G	G
11	Number of florets per spike	P	P	G	G	G	P	P	P	P	P	A	P	G	P	P	A	G	A
12	Seed yield per plant (g)	P	A	A	P	P	G	G	G	G	P	P	P	G	G	G	P	P	P
13	Biological yield per plant (g)	P	P	G	G	G	G	A	A	P	P	G	P	A	P	P	P	A	A
14	Harvest index (%)	P	P	G	P	P	P	P	G	P	G	G	G	G	P	P	P	G	G
15	Husk yield per plant (g)	A	A	P	G	P	G	P	P	P	P	P	P	P	P	P	P	G	P

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

The maximum significant GCA effects in positive direction were exhibited by line L_{14} for number of effective spikes per plant and husk yield per plant. The line L_{15} exhibited maximum significant GCA effects in positive direction for number of branches per plant, spike length, 1000-seed weight, number of florets per spike, biological yield per plant and for harvest index. For maturity related traits, inbred lines L_2, L_7, L_{10}, L_{13}, L_{14} and L_{15} were good general combiners for day to 50 per cent flowering and lines L_8, L_{10} L_{14} and L_{15} for days to 75 per cent maturity. Among three testers, the maximum

significant GCA effects in positive direction were exhibited by tester parent T_2 for seed yield per plant. For other yield contributing traits, tester parent T_1 was considered good general combiner for number of branches per plant, spike length, length of leaves, husk yield per plant, the tester parent T_2 for number of leaves per plant, the tester parent T_3 for length of peduncle, length of leaves, 1000-seed weight. For maturity related traits, tester T_1 for days to 50 per cent flowering and days to 75 per cent maturity and tester T_2 for days to 75 per cent maturity was good general combiner. The high general combining ability effects were due to additive gene effects and additive x additive gene effects (Griffing, 1956 and Sprague, 1966).

A perusal of SCA effects among hybrids revealed that maximum magnitude of positive SCA effects for seed yield per plant were exhibited by cross $L_{10} \times T_3$ in E1 (41.60), E2, E3 and as well as over the environment. 13 crosses showed significantly superior SCA effects in which the crosses $L_{11} \times T_1$, $L_5 \times T_2$ and $L_1 \times T_3$ showed positive significant SCA effects in all the three environments as well as over the environments.

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

Sr. No.	Traits / Crosses	Days to 50 % flowering	Days to 75 % maturity	Plant height (cm)	No. of branches per plant	No. of effective spikes per plant	Spike length (cm)	Length of peduncle (cm)	Length of leaves (cm)	1000 Seed weight (g)
1	L₁ x T₁	**	**			**		**	**	
2	L₂ x T₁								**	**
3	L₃ x T₁									
4	L₄ x T₁									
5	L₅ x T₁				**	**	**	**		
6	L₆ x T₁			*			**			**
7	L₇ x T₁									
8	L₈ x T₁	**		*	**	**			*	
9	L₉ x T₁				**					
10	L₁₀ x T₁					**		**	**	
11	L₁₁ x T₁					**	**	**		
12	L₁₂ x T₁		**	**			**		**	**
13	L₁₃ x T₁		**			**	**	**		**
14	L₁₄ x T₁							*		**
15	L₁₅ x T₁	*		*		**		**		**
16	L₁ x T₂						**			
17	L₂ x T₂	**		**		**		**		**
18	L₃ x T₂	**		*		**				
19	L₄ x T₂					**	*	**		
20	L₅ x T₂							*		**
21	L₆ x T₂							**		
22	L₇ x T₂	**								**
23	L₈ x T₂						**	**		**
24	L₉ x T₂					**	*			
25	L₁₀ x T₂					**			**	
26	L₁₁ x T₂									
27	L₁₂ x T₂	**								**
28	L₁₃ x T₂		**						**	
29	L₁₄ x T₂			**	**	**	**	**	*	**
30	L₁₅ x T₂	**	**		**		**			
31	L₁ x T₃				*					
32	L₂ x T₃						**			
33	L₃ x T₃						*	**	**	**
34	L₄ x T₃		*	**			**			
35	L₅ x T₃			*	**	*	**	*	*	
36	L₆ x T₃						**			
37	L₇ x T₃		**			**	**	**		
38	L₈ x T₃					**		*		
39	L₉ x T₃	**	**	**	**	**	**	**	*	
40	L₁₀ x T₃	**	**					**	**	**
41	L₁₁ x T₃						**			
42	L₁₂ x T₃						**			
43	L₁₃ x T₃	**			**					**
44	L₁₄ x T₃			**	**	**	**	**	*	**
45	L₁₅ x T₃				**	**		**		**

Table 3. Continued…

Sr. No.	Traits / Crosses	No. of leaves per plant	Number of florets per spike	Seed yield (g)	Biological yield (g)	Harvest index (%)	Husk yield per plant (g)
1	L₁ x T₁	**					
2	L₂ x T₁		**				
3	L₃ x T₁						**
4	L₄ x T₁		**			**	**
5	L₅ x T₁	**			**		
6	L₆ x T₁				**		**
7	L₇ x T₁						**
8	L₈ x T₁	**		**			*
9	L₉ x T₁						
10	L₁₀ x T₁		*	**			
11	L₁₁ x T₁		*			**	
12	L₁₂ x T₁	*					**
13	L₁₃ x T₁			**			
14	L₁₄ x T₁		*				
15	L₁₅ x T₁		**			**	
16	L₁ x T₂		**				**
17	L₂ x T₂			**	**	*	**
18	L₃ x T₂						
19	L₄ x T₂				**		
20	L₅ x T₂		**	**		**	**
21	L₆ x T₂						
22	L₇ x T₂	**		**			
23	L₈ x T₂				**	**	
24	L₉ x T₂		*		**	**	
25	L₁₀ x T₂						**
26	L₁₁ x T₂	*	**				**
27	L₁₂ x T₂					**	
28	L₁₃ x T₂	**					**
29	L₁₄ x T₂	**			**	**	
30	L₁₅ x T₂						**
31	L₁ x T₃	**					
32	L₂ x T₃		**		**	**	
33	L₃ x T₃					**	
34	L₄ x T₃			**	**		
35	L₅ x T₃	**	**	**	**	**	**
36	L₆ x T₃	**			**		**
37	L₇ x T₃	**			**		
38	L₈ x T₃	*				*	
39	L₉ x T₃	**	**	**	**	**	**
40	L₁₀ x T₃	**				**	
41	L₁₁ x T₃				**		
42	L₁₂ x T₃						
43	L₁₃ x T₃						**
44	L₁₄ x T₃	**	**	**	**	**	**
45	L₁₅ x T₃	**				**	

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

On pooled basis, the maximum positive SCA effects were exhibited by cross L_9 x T_3 for plant height, cross L_{10} x T_3 for number of branches per plant, husk yield per plant and 1000-seed weight, cross L_4 x T_2 for number of effective spikes per plant and spike length, cross L_5 x T_3 for length of peduncle, cross L_2 x T_2 for length of leaves, cross L_9 x T_2 for number of leaves per plant, cross L_1 x T_3 for number of florets per spike and biological yield per plant, cross L_{13} x T_3 for harvest index.

For maturity related traits, cross T_9 x T_3 showed maximum negative significant SCA effects for days to 50 per cent flowering and days to 75 per cent maturity, respectively (Table 3). 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 (2018a) and Singh and Saxena (2019) in isabgol. In the present investigation, crosses with significant high SCA effects for different traits were found from either poor or average (or both) general combiner parents. The combination of desirable genes from the parents for the corresponding traits might have resulted in high SCA effects. It is also observed that many of these hybrids with high SCA effects were from either average x average or good x average general combiner parents. Hence, it is evident that the parents with either good GCA or poor GCA would have greater probability to have good complimentarily with other parents. 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.

On the basis of above criteria, out of 45 crosses, four promising crosses *viz.,* L_{15} x T_1, L_{14} x T_1, L_{15} x T_2 and L_5 x T_2 were selected with higher *per se* performance along with high GCA and SCA effects for seed yield and yield contributing traits over the environments (Table 4). Ahmad *et al.* (2017) and Divya *et al.* (2022) also reported similar findings.

Table 4: Four promising crosses identified on the basis of highest *per se* performance along with significantly positive useful heterosis as well as GCA and SCA effects for seed yield per plant and husk yield per plant on pooled basis.

Sr. No.	Crosses	Seed yield per plant (g)			Husk yield per plant (g)		
		Mean value (g)	SCA effects	GCA effects	Mean value (%)	SCA effects	GCA effects
1	L_{15} x T_1	6.41	0.55**	1.19** x 0.10* H H	1.94	0.34**	0.40** x 0.03** H H
2	L_{14} x T_1	6.38	0.79**	0.91** x 0.10* H H	1.75	0.13**	0.42** x 0.03** H H
3	L_{15} x T_2	6.29	0.41*	1.19** x 0.12** H H	1.64	0.06	0.40** x 0.02 H L
4	L_5 x T_2	5.88	0.90*	0.29** x 0.12** H H	1.62	0.33**	0.10** x 0.02 H L

(*, ** significant at 0.05 and 0.01 probability level, respectively)
(# best check *i.e.*, Niharika for seed yield and VI-1 for husk yield, on pooled basis)
(GCA effect of parents *i.e.*, H: high, L: low

CONCLUSION

The crosses, L_{10} × T_3, L_{11} × T_1, L_5 × T_2 and L_1 × T_3 showed positive and significant SCA effects in all the environments and over the environments for seed yield per plant. Cross L_{10} × T_3 showed highest positive and significant SCA effects in all the three environments as well as on pooled basis for seed yield and other yield attributing traits. However, due to non-significant economic heterosis and low *per se* performance for seed yield, the hybrid cannot be selected only on the basis of significant SCA without high *per se* as a result, high *per se* performance and significant economic heterosis, as well as a good GCA of parents, should be used to select promising hybrids.

REFERENCES

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 and 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.

Divya, S., Geetha, K., Kumar, R. S., Kumari, A. N. and Sharavanan, P. T. (2022). Elucidating combining ability, gene action and heterosis for yield and yield contributing traits in finger millet (*Eleusine coracana* L. Gaertn). *Electronic Journal of Plant Breeding*, *13*(2), 663-669.

Griffing, B. A. (1956). Generalized treatment of the use of diallel crosses, in quantitative inheritance heredity. *Australian Journal of Biological Sciences*, *10*, 31–50.

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

Kaswan, V., Joshi, A. and Maloo, S. R. (2013). Genetic studies on divergence and quantitative characterization of plant isabgol (*Plantago ovata* Forsk.). *Research on Crops*, *14*(2), 585-591.

Kempthorne, O. (1957). An introduction to genetic statistics. John Wiley and Sons, Inc., 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.

Kumar, M., Fougat, R. S., Sharma, A. K., Kulkarni, K., Mistry, J. G., Sakure, A. A. and Kumar, S. (2014). Phenotypic and molecular characterization of selected species of *Plantago* with emphasis on *Plantago ovate*. *Australian Journal of Crop Science*, *8*(12), 1639.

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. (2018a). 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.

How to cite this article: Mukesh Kumar Yadav, Amit Dadheech, Amit Kumar and Deepak Meena (2023). Elucidating Combining Ability through Line x Tester Analysis for Yield and its Contributing Traits in Isabgol [*Plantago ovata* (Forsk.)]. *Biological Forum – An International Journal, 15*(10): 14-20.