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LINE X TESTER ANALYSIS IN LATHYRUS (*Lathyrus sativus* Linn.)

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ABSTRACT

The research work entitled "Line x Tester analysis in Lathyrus (*Lathyrus sativus* Linn.) was conducted during *rabi* 2021- 22 and 2022-23 at the experimental research farm of Agricultural Botany Section, College of Agriculture, Nagpur, where twenty F_1 crosses obtained by crossing two testers and ten lines in a line x tester fashion were used to study the general and specific combining ability of parents and crosses, respectively and selected good combiner parents and crosses for studying them in the next generation. These crosses were grown in randomized block design replicated thrice and observations on days to first flower, days to maturity, plant height (cm), number of branches plant^{-1}, number of seeds pod^{-1}, number of pods plant^{-1}, 100 seed weight (g), yield plant^{-1} (g) were recorded. The mean squares due to specific combining ability were highly significant for seed yield and its contributing characters in lathyrus. The predictability ratio ranged from 0.46 for number of days to maturity to 0.75 for number of branches plant^{-1}.

Considering GCA effects for most of the yield contributing traits, the line NLK-06 and tester Ratan were recorded as good general combiner for yield plant^{-1} and its contributing characters. The crosses NLK-06 X Ratan and BIOR-222 X Prateek showed significant negative SCA effect for seed yield and most of its contributing characters. These crosses can be forwarded to next generation for producing genotypes of inheritant superiority by intercrossing and following simple selection methods.

(Key words: Lathyrus, GCA, SCA, heterobeltiosis, combining ability)

INTRODUCTION

The *Lathyrus sativus* (L). (2n = 14) is an annual herb and an important pulse crop, rich in protein content (28%) next to soybean locally called as grass pea*, khesari dal, peavine* or *chanamatra*. It belongs to family Leguminosae, sub family Papilionoideae and genus Lathyrus with 130 species occurring all over the temperate region of Northern hemisphere and the higher altitude of tropical Africa. In India, besides the ornamental *Lathyrus odoratus*, the only other species cultivated is *Lathyrus sativus* which yield the *khesari dal.* The edible *Lathyrus sativus* originated in the West Central Asia, Mediterranean region and North India was its centre of domestication, where 3600 years old remains have been discovered. The important lathyrus growing states are Bihar, Jharkhand, Madhya Pradesh, Eastern Uttar Pradesh, Orissa, Gujarat, Maharashtra and Andhra Pradesh.

The plant is considered as a great boon against droughts, floods, hails and various pests. The plant is strong drought resistant. It is mostly sown in standing crop of paddy as a 'Utera' or 'Paira' crop in *rabi* season. Secondly, the main pulse crop *Tur* (Pigeonpea) is grown only on bunds, hence the production of *Tur* is not sufficient for fulfilling the requirements of these region. This gives the chance to lathyrus to serve as alternative pulse. Thirdly, the lathyrus plant type is considered to be strong drought resistant and grows luxuriantly without any cultivation input and lastly, this pulse is consumed in various forms like *chapatis, wadas* and curries and fed to cattle as green fodder and stover (dried chaff) since ancient times. Sharma and Padmanabham (1969) analyzed and reported that the protein quality of lathyrus is better than any other pulse. Chemical composition of *Lathyrus sativus* grain also shows the presence of minerals like Ca, Fe, P and vitamins like B1, B2 and niacin. It is also rich in carbohydrates (58.2%). But ban is imposed due to association with neurolathyrium a non-reversible neurological disorder in human and animals due to presence of neurotoxin (B-N- Oxalyl-L-α, P-diaminopropionic acid) β-ODAP in its seedlings and seeds. The traditional varieties of grass pea contain 0.5-2.5% β - ODAP (Kumar *et al*., 2011). Globally, the area under grass pea cultivation is estimated as 1.50 million ha, with annual production of 1.20 million tonnes. In India area under lathyrus is about 0.58 million hectares and the major area

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under lathyrus is in Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh and Maharashtra contributing about 4.5% total pulse production of the country. In Maharashtra it is cultivated in Bhandara, Chandrapur, Gadchiroli, Gondia and Nagpur districts of eastern Vidarbha (Anonymous, 2023).

MATERIALS AND METHODS

The experimental material comprised of ten lines *viz.,* BIOR-222, NLK-42, BIOR-208, NLK-48, NLK-37, NLK-06, NLK-38, NLK-67, IC120469, NLK-73 and two testers *viz.,* Prateek (check) and Ratan (check). During *rabi* 2021-22, ten lines were crossed with two testers in line × tester mating design to produce 20 crosses. In *rabi* 2022-23, 20 crosses (F_1's) were grown in RBD design in three replications with the spacing of 45 cm × 15 cm accommodating 10 plants in each row. The recommended practices were followed to raise good crop. The analysis of variance was performed to test the significance of differences between the genotypes (parents and crosses) for all the characters as per the methodology suggested by Panse and Sukhatme (1954). The combining ability analysis was carried out by the methodology of Kempthorne (1957) with fixed effect model.

RESULTS AND DISCUSSION

Combining ability analysis is one of the most powerful analytic tool to decipher the genetic architecture of quantitative traits. The concept of combining ability was enunciated by Sprague and Tatum (1942) in maize crop. Concept of general and specific combining ability in relation to diallel crossing system was explained by Griffing (1956). The mean squares of genotypes were highly significant for eight characters studied i.e. days to first flower, days to maturity, plant height, number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 100 seed weight (g) and yield plant^{-1}. This indicated the presence of sufficient variability in the material used for this study which allows the exploitation of the material for further analysis. Similar to this result Sawant *et al.* (2011), Sayyad *et al*. (2017) and Jambulkar *et al*. (2021) also reported significant mean squares for genotypes in lathyrus.

Among the crosses the range for yield plant^{-1} varied from 12.53 g to 23.20 g. The cross BIOR-222 × Ratan (23.20 g) exhibited highest yield plant^{-1} followed by NLK-37 × Ratan (22.23 g), NLK-06 × Prateek (21.23 g) and BIOR-208 × Ratan (20.97 g). While it was minimum in cross NLK- 48 × Prateek (12.53 g) followed by NLK- 67 × Prateek (12.73 g), IC-120469 × Ratan (13.10 g) and NLK- 38 × Ratan (13.23 g).

On basis of *per se* performance studied for yield and yield contributing characters among twenty crosses, the cross NLK-06 × Ratan was identified as the top ranking cross as it recorded yield plant^{-1} (19.33 g), number of pods plant^{-1} (96.44), days to first flower (60.33), days to maturity (121.73) and plant height (63.86 cm) followed by cross BIOR-222 × Prateek which produced yield plant^{-1} (19.20 g), number of pods plant^{-1} (85.47), days to first flower (55.33), days to maturity (119.40) and plant height (63.86 cm). These two crosses were identified as potential crosses for selecting superior segregant in future generation on the basis of *per se* performance of crosses. Anyhow, according to Allard (1960) *per se* performance of crosses gives only some indication of their usefulness in selecting potential crosses but their long-term potentiality was not known. Hence, selection of superior parents which has the potential to produce superior cross combination and identifying the cross combination on the basis of combining ability will give required information as compared to information obtained from *per se* performance of crosses.

Line × tester analysis of twenty crosses obtained by crossing ten lines with two testers was carried out and the total variance due to crosses was partitioned into portions attributable to lines, testers, lines × testers and error sources. The components of variances attributable to lines and testers were used as a measure of general combining ability effects and the variance due to interaction between lines and testers was used as a measure of specific combining ability effects. Mean squares due to lines were significant for all the characters. Mean squares due to testers were significant for all the characters studied except days to maturity, number of branches plant^{-1}, 100 seeds weight. The mean squares due to lines for all characters i.e. days to first flower, days to maturity, plant height (cm), number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 100 seed weight and yield plant^{-1} were higher in magnitude than those due to testers, indicating large diversity among the lines than in testers for these characters. The mean squares due to line × tester were significant for all the characters under study.

The predictability ratios ranged from 0.46 (days to maturity) to 0.75 (number of branches plant^{-1}). The fixed effect model adopted in this study does not provide estimates of variance components and thus it was not possible to know precisely the relative importance of additive and dominance components in the control of different characters. However, in this model an idea about the relative importance of GCA and SCA in determining progeny performance can be obtained by calculating the general predictability ratio on the basis of GCA and SCA mean squares (Baker, 1978). Predictability ratio was found to be less than 0.50 for characters days to maturity (0.46), days to first flower (0.48) and predictability ratio was more than 0.50 for other characters i.e. number of pod plant^{1} (0.55), 100 seed weight (0.62), number of seed pod^{-1} (0.67), plant height (0.68), yield plant^{-1} (0.73) and number of branches plant^{-1} (0.75). The predictability ratio was closer to 0.5 which indicated the additive as well as non-additive genetic component are equally responsible for the development of these characters.

The estimates of GCA effects among the lines and testers showed wide variation in level of significance for various characters. Among the lines, it was reported that line BIOR-222 and NLK-06 were found to be good combiner. BIOR-222 exhibited highly significant positive GCA effect

Table 1. Mean performance of parents and their crosses for various characters

Sr. No.	Genotypes	Days to First flower	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of Pods plant^{-1}	Number of seeds pod^{-1} (g)	100 seed weight (g)	Yield plant^{-1} (g)
	Lines								
1	BIOR-222	51.33	123.53	72.13	6.20	74.53	2.80	9.00	20.00
2	NLK-42	50.53	128.60	63.87	6.87	86.28	3.07	8.10	16.10
3	BIOR-208	51.13	125.67	61.30	7.00	86.71	2.93	8.57	12.80
4	NLK-48	55.07	125.00	68.70	6.40	88.56	2.83	8.70	17.80
5	NLK-37	50.53	125.27	68.80	6.47	73.94	2.90	9.10	19.80
6	NLK-06	58.60	122.47	55.27	6.47	74.33	2.90	9.20	21.73
7	NLK-38	48.07	122.87	70.00	7.67	81.75	2.37	9.03	17.10
8	NLK-67	57.33	123.00	65.67	6.67	58.56	2.80	7.27	20.37
9	IC120469	52.07	122.33	66.93	7.1	63.92	2.77	8.55	13.77
10	NLK-73	45.60	124.40	54.30	6.73	66.33	3.20	9.07	17.77
	Tester								
11	Prateek (check)	58.47	126.13	65.27	5.93	68.68	2.43	7.83	15.33
12	Ratan (check)	52.00	122.33	58.20	6.93	82.10	2.73	9.47	18.20
	crosses								
13	BIOR-222 × Prateek	55.13	119.40	72.00	5.07	85.47	3.03	8.30	19.20
14	BIOR-222 × Ratan	50.13	125.93	63.87	7.20	113.37	3.00	9.67	23.20
15	NLK-42 × Prateek	56.67	124.27	51.07	5.53	99.25	3.03	9.20	12.99
16	NLK-42 × Ratan	51.87	121.47	61.30	6.11	42.33	1.93	8.53	13.36
17	BIOR-208 × Prateek	53.13	121.67	54.33	6.27	49.55	2.63	9.03	13.97
18	BIOR-208 × Ratan	52.73	121.07	68.70	6.87	57.42	3.03	8.73	20.97
19	NLK-48 × Prateek	54.67	122.13	76.33	6.07	67.25	2.87	9.37	12.53
20	NLK-48 × Ratan	47.67	128.27	56.00	6.47	32.33	2.97	10.13	14.50
21	NLK-37 × Prateek	47.07	120.00	55.53	6.73	47.00	2.03	8.57	15.10
22	NLK-37 × Ratan	55.07	121.40	61.67	5.57	86.14	3.37	9.07	22.23
23	NLK-06 × Prateek	55.33	123.93	51.47	8.27	32.33	2.40	8.23	21.23
24	NLK-06 × Ratan	60.33	121.73	63.87	6.47	96.44	2.67	8.27	19.33
25	NLK-38 × Prateek	58.60	125.53	48.00	5.23	62.89	2.07	9.07	15.40
26	NLK-38 × Ratan	51.13	124.00	66.00	4.67	87.01	2.40	9.97	13.23
27	NLK-67 × Prateek	47.80	120.60	53.13	4.73	61.32	2.07	8.73	12.73
28	NLK-67 × Ratan	60.30	125.07	57.40	5.33	71.95	2.40	6.74	19.00
29	IC120469 × Prateek	60.27	128.27	58.00	5.27	69.95	2.30	9.83	15.23
30	IC120469 × Ratan	58.33	121.73	74.93	5.13	45.14	2.37	9.33	13.10
31	NLK-73 × Prateek	45.67	120.47	57.80	6.47	47.00	2.70	8.80	16.83
32	NLK-73 × Ratan	62.40	117.40	54.13	6.00	86.14	2.53	9.80	15.63
	Mean	**53.78**	**123.28**	**61.63**	**6.24**	**71.65**	**2.68**	**8.84**	**16.88**
	S E (m)±	**1.26**	**1.06**	**3.44**	**0.35**	**5.47**	**0.11**	**0.46**	**1.23**
	C D 5%	**3.57**	**3.00**	**9.73**	**0.99**	**15.48**	**0.32**	**1.29**	**3.49**

Table 2. Analysis of variance for combining ability

Sources of variation	D.F.	Mean sum of squares							
		Days to first flower	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Number of seeds Pod^{-1}	100 seed weight (g)	Yield plant^{-1} (g)
Lines	9	41.85**	23.91**	151.61*	4.11**	1,500.86**	0.48**	2.31**	29.57**
Testers	1	36.85**	0.62	322.10**	0.02	968.11**	0.50**	0.18	67.62**
Lines × Testers	9	109.70**	27.9**	221.46**	1.30*	1,986.37**	0.48**	1.52*	35.79**
Error	38	2.96	3.24	27.77	0.54	94.80	0.04	0.56	5.07
GCA vs. SCA		0.48	0.46	0.68	0.75	0.55	0.67	0.62	0.73

*, ** = Significance at 5% and 1% level of significance

Table 3. GCA effect of parents and SCA effects of crosses

Sr. No.	Genotypes	Days to First flower	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of Pods plant^{-1}	Number of seeds pod^{-1} (g)	100 seed weight (g)	Yield plant^{-1} (g)
	GCA								
1	BIOR-222	-1.58*	2.27**	7.85**	0.09	26.54**	0.42**	0.02	2.62**
2	NLK-42	0.05	0.13	-3.90	0.22	1.49	-0.43**	-0.10	-2.91**
3	BIOR-208	-1.28	-1.37	1.43	0.52	-15.82**	0.24*	-0.09	1.38
4	NLK-48	-3.05**	2.47**	6.08**	0.36	-19.52**	0.32**	0.78*	-2.57**
5	NLK-37	-3.15**	-2.03**	-3.08	-0.08	7.30	0.10	-0.15	2.58**
6	NLK-06	3.61**	0.27	6.38**	1.66**	26.02**	-0.03	-0.72*	2.65**
7	NLK-38	0.65	2.03**	-1.48	-1.10**	5.65	0.00	0.55	-1.77*
8	NLK-67	-0.15	0.10	-4.82*	-1.01**	-2.67	-0.37**	-1.23**	-0.22
9	IC120469	5.08**	-0.07	-4.35*	-0.85**	-11.76**	-0.27**	0.62*	-1.92**
10	NLK-73	-0.18	-3.80**	-4.12*	0.19	-2.73	0.02	0.33	0.15
	S.E.(lines)	**0.631**	**0.698**	**2.041**	**0.285**	**3.771**	**0.085**	**0.290**	**0.672**
	Tester								
11	Prateek (check)	-0.78**	-0.11	-2.32	0.01	4.02**	0.09	-0.06	-1.06**
12	Ratan (check)	0.78**	0.11	2.32	-0.01	-4.02**	-0.09	0.06	1.06**
	S.E.(tester)	**0.210**	**0.233**	**0.680**	**0.095**	**1.257**	**0.028**	**0.097**	**0.291**
	SCA								
13	BIOR-222 × Prateek	3.28**	-3.16**	-6.38**	-1.07**	-13.51**	-0.08	-0.63*	-3.44**
14	BIOR-222 × Ratan	-3.28**	3.16**	6.38**	1.07**	13.51**	0.08	0.63*	3.44**
15	NLK-42 × Prateek	3.18**	1.51*	-2.80	0.26	32.48**	0.14	0.39	0.88
16	NLK-42 × Ratan	-3.18**	-1.51*	2.80	-0.26	-32.48**	-0.14	-0.39	-0.88
17	BIOR-208 × Prateek	0.98	0.41	-4.87**	-0.31	0.08	-0.29**	0.21	-2.44**
18	BIOR-208 × Ratan	-0.98	-0.41	4.87**	0.31	-0.08	0.29**	-0.21	2.44**
19	NLK-48 × Prateek	4.28**	-2.96**	12.48**	0.33	21.48**	-0.14	-0.33	0.08
20	NLK-48 × Ratan	-4.28**	2.96**	-12.48**	-0.33	-21.48**	0.14	0.33	-0.08
21	NLK-37 × Prateek	-3.21**	-3.16**	-6.68**	-0.04	-15.55**	0.58**	-0.20	-2.51**
22	NLK-37 × Ratan	3.21**	3.16**	6.68**	0.04	15.55**	-0.58**	0.20	2.51**
23	NLK-06 × Prateek	-1.71*	3.37**	6.15**	0.56	25.76**	0.38**	0.04	3.56**
24	NLK-06 × Ratan	1.71*	-3.37**	-6.15**	-0.56	-25.76**	-0.38**	-0.04	-3.56**
25	NLK-38 × Prateek	4.51**	0.87	-0.75	0.28	-8.05*	-0.19*	-0.40	2.15**
26	NLK-38 × Ratan	-4.51**	-0.87	0.75	-0.28	8.05*	0.19*	0.40	-2.15**
27	NLK-67 × Prateek	-5.48**	-2.13**	0.18	-0.31	-1.30	-0.26**	1.05*	-2.07**
28	NLK-67 × Ratan	5.48**	2.13**	-0.18	0.31	1.30	0.26**	-1.05*	2.07**
29	IC120469 × Prateek	1.758**	1.04	-1.95	0.06	16.43**	-0.13	0.31	2.13**
30	IC120469 × Ratan	-1.75**	-1.04	1.95	-0.06	-16.43**	0.13	-0.31	-2.13**
31	NLK-73 × Prateek	-7.58**	1.64*	4.15	0.23	-6.30**	-0.01	-0.45	1.66*
32	NLK-73 × Ratan	7.58**	-1.64*	-4.15	-0.23	6.30**	0.01	0.45	-1.66*
	S E(crosses)	**0.631**	**0.698**	**2.041**	**0.285**	**3.771**	**0.085**	**0.290**	**0.672**

Table 4. Potential crosses identified on the basis of mean performance, GCA effect of parents and SCA effect of crosses for yield and other traits

Sr. No.	Crosses	Characters	Mean	SCA effects	GCA effects
				P1	P2
1	**NLK-06 × Ratan**	Yield	19.33	-3.56**	2.64**	-1.06*
		NOP	96.44	-25.76**	26.02**	-4.01**
		NOS	2.67	0.38**	-0.03	-0.09
		Height	63.87	-6.15**	6.38**	2.31
		DTM	121.73	-3.37**	0.27	-0.11
2	**BIOR-222 × Prateek**	Yield	19.20	-3.44**	2.62**	1.06**
		NOB	5.07	-1.07**	0.09	0.01
		NOP	85.47	-13.51**	26.54**	4.02**
		100 SW	8.30	-0.63	0.02	-0.06
		Height	58.00	-6.15**	7.85**	-2.32
		DTM	119.40	-3.16**	-2.03**	0.11

Note: DTM = Days to maturity (days), NOB = Number of branches per plant^{-1}, NOP = Number of Pods plant^{-1}, NOSPP = Number of seeds Pod^{-1} DT1stF = Days to first flower (days), Yield = Yield plant^{-1} (g), 100SW = 100 seed weight.

for days to maturity, plant height, number of seeds pod^{-1} and yield plant^{-1}. NLK-06 also exhibited highly significant positive GCA effect for days to first flower, plant height, number of branches plant^{-1}, number of pods plant^{-1} and yield plant^{-1}.

Promising crosses and their selected *per se* performance are given in Table 4. Among the twenty crosses studied, the cross NLK-06 × Ratan showed negative significant SCA effect for yield plant^{-1}, number of pods plant^{-1}, days to maturity, number of seed pod^{-1} and plant height. Similarly, the same cross was significantly superior over the best check for yield plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1} and days to maturity. The GCA effect involved in the cross possessed high × high GCA effect for yield plant^{-1}, medium × high for number of pods plant^{-1}, medium × medium days to maturity, low × low for number of seeds pod^{-1} and high × medium for plant height.

The cross BIOR-222 x Prateek showed significant negative SCA effect for yield plant^{-1}, number of pods plant^{-1}, days to maturity, number of branches and plant height. Same cross was significantly superior over the best check for yield plant^{-1} and number of pods plant^{-1}. The GCA effect of parents involved in the cross possessed high × low for yield plant^{-1}, high × low for number of pods plant^{-1}, low × low for days to maturity and low × low for number of branches plant^{-1} and high × medium for plant height.

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