J. Soils and Crops 32 (1) 180-183, June 2022

ISSN 0971-2836 (Print)
ISSN 2582-2756 (Online)

ESTIMATION OF HETEROSIS FOR YIELD AND YIELD CONTRIBUTING TRAITS IN LINSEED (*Linum usitasissimum* L.)

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ABSTRACT

Forty five F_1 crosses of linseed (*Linum usitasissimum* L.).were obtained by half diallel mating design using ten parents and F_1 hybrids along with parents during *rabi* 2019-20 and were evaluated to estimate the useful heterosis of crosses for seed yield and yield contributing characters. The parents and crosses were grown in randomized block design replicated twice at Research field of AICRP (Linseed and Mustard), College of Agriculture, Nagpur during *rabi* 2020-21 and observations were taken on days to 50 % flowering, days to maturity, plant height (cm), number of branches plant^{-1}, number of capsules plant^{-1}, 1000 seed weight (g) and seed yield plant^{-1} (g).The crosses NL 142 x PKV NL 260, Neela x Tiara, Tiara x EC 99001, Padmini x Neelum and Padmini x PKV NL 260had high mean performance and exhibited significant standard heterosis over the superior check for number of branches plant^{-1}, number of capsules plant^{-1}, seed yield plant^{-1} and 1000 seed weight. These crosses were identified as superior crosses, which can be utilized for heterosis breeding.

(Key words: Linseed, heterosis, useful heterosis, yield and yield contributing characters).

INTRODUCTION

Linseed (*Linum usitatissimum* L.) is an annual self pollinated diploid (2x=2n=30) oilseed crop belonging to linaceae family, it is mainly cultivated for fibre (Flax fibre) and seed oil (Linseed) or both (dual purpose linseed). Linseed is an important industrial and edible oil and fibre producing crop.

Due to its versatile use there is a high demand of linseed by various industries but still the production is very low as per its demand, due to lack of high yielding varieties. To overcome the problem of poor yield levels on linseed, development of high yielding varieties becomes the top priority, thus the study on heterosis is useful in deciding the direction and prospects of future improvement programme, which might be more promising than the conventional breeding programme.

MATERIALS AND METHODS

The experimental material comprising of ten parents *viz.,* NL 115, NL 142, NL 165, NL 367, Padmini, Neelum, Neela, Tiara, EC 99001 and PKV NL 260 crossed in half diallel fashion to obtain 45 crosses during *rabi* 2019-20. These 45 crosses along with 10 parents were grown in Randomized Block Design in two replications with the spacing of 30 cm x 5 cm during *rabi* 2020-21 at farm of AICRP on linseed and mustard, College of Agriculture, Nagpur. Five plants were taken randomly from each plot for recording the observations. Observations were recorded for seven quantitative characters *viz.,*plant height (cm), number of branches plant^{-1}, number of capsules plant^{-1},days to 50% flowering (on plot basis), days to maturity (on plot basis), seed yield plant^{-1} (g) and 1000 seed weight.

RESULTS AND DISCUSSION

The analysis of variance for heterosis was estimated for days to 50 % flowering, days to maturity, plant height (cm), number of branches plant^{-1}, number of capsules plant^{-1}, 1000 seed weight and seed yield plant^{-1} and data are presented in Table 1. The mean squares due to genotypes, parents, crosses and parents vs. crosses were significant for all the seven characters under study except for days to 50 % flowering and 1000 seed weight for parents vs crosses. In accordance with these results, Dhirhi *et al.* (2018) and Kumar *et al.* (2018) had reported significant mean squares for parents, crosses and parents vs. crosses for the various characters studied in linseed. The heterotic effect for days to 50 % flowering and 1000 seed weight was not estimated as its respective mean sum of squares due to parent vs. crosses was non significant.

It was observed that (Table 2) fourty three crosses showed negative standard heterosis over the check PKV NL 260 for plant height. Maximum negative useful heterosis for plant height were recorded by Neelum x PKV NL 260 (-60.71%) followed by Padmini × Neela (-59.58%) and Padmini × Tiara (-56.38%).Three crosses showed positive significant useful heterosis for number of branches plant^{-1}were NL 142 x EC

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Table 1. Analysis of variance for heterosis

Source of variation	d.f	Plant height	No. of branches plant^{-1}	No. of capsules plant^{-1}	Days to 50 % flowering	Seed yield plant^{-1} (g)	1000 seed weight (g)
Replication	1	55.77	2.25	1505.88	1120.00	1.23	3.71
Genotypes	54	608.70**	4.51**	1452.69**	73.09**	2.32**	4.90**
Parents	9	714.19**	10.73**	529.06**	182.25**	2.14**	3.30**
Crosses	44	270.71**	2.50**	1629.65**	52.37**	2.38**	5.32**
Parents vs. Crosses	1	14531.04**	36.87**	1979.33**	2.40	2.30**	1.11
Error	54	55.77	2.25	1505.88	2.54	0.34	0.32

Note : * Significant at 5% level, ** Significant at 1% level.

Table 2.Mean, Useful heterosis over PKVNL-260 (H2)

Sr. No.	Crosses	Plant height (cm)		Number of branches plant^{-1}		Number of capsules plant^{-1}		Days to maturity		Seed yield plant^{-1} (g)		1000 seed weight (g)	
		Mean	**H2**	**Mean**	**H2**	**Mean**	**H2**	**Mean**	**H2**	**Mean**	**H2**	**Mean**	**H2**
1	NL 115 ×NL 165	42.62	-32.44	5.87	-15.70	98.95**	69.15**	94.00**	-17.54	3.05	44.10	6.67**	-10.40
2	NL 115× NL 142	58.87	-6.69	4.75	-3.32	179.06**	206.08**	102.00	-10.52	2.84	33.96	7.25**	2.68
3	NL 115× NL 367	30.50**	-51.66	3.25	4.74	59.50	1.70	110.50	-3.72	1.64	-15.43	7.90**	6.74
4	NL 115× Padmini	66.75	5.78	6.91**	-10.65	88.93**	52.01**	96.50**	-17.16	3.10	34.58	7.07**	-5.17
5	NL 115×Neelum	36.12**	-42.74	6.47**	-8.11	72.66	24.21**	102.00	-10.86	1.58	-32.35	7.87**	5.38
6	NL 115× Neela	37.29**	-40.90	5.20	0.00	90.70**	55.05**	105.50	-8.81	1.67	-14.33	7.62**	2.47
7	NL 115× tiara	62.8	-0.47	4.85	-4.91	68.60	17.26	106.50	-7.35	2.86	47.17	6.95**	-6.35
8	NL 115× EC 99001	39.37**	-37.59	4.79	-3.21	126.37**	116.02**	105.50	-8.06	3.48	81.17*	5.25	-28.85
9	NL 115× PKV NL 260	37.25**	-40.96	4.12	-5.70	51.28	-12.33	107.50	-6.10	1.61	-17.47	6.97**	-6.83
10	NL 165 × NL142	43.80	-30.58	4.62	-4.93	79.96	36.69**	106.00	-7.58	3.44	38.07*	6.52**	-17.62
11	NL 165 ×NL 367	58.50	-7.29	4.16	-10.76	78.48	34.17**	99.50	-13.49	3.54	88.03*	8.22	11.11
12	NL 165×Padmini	45.75	-27.49	5.75	-6.28	57.09	-2.40	104.50	-8.96	3.15	30.15	8.07**	9.58
13	NL 165× Neelum	36.50**	-42.15	6.00	-5.38	63.58	8.68	105.50	-8.54	3.58	41.36*	5.24	-26.87
14	NL 165× Neela	40.6**	-35.65	3.6	-2.24	83.45	42.64**	109.00	-4.78	2.70	18.47	5.375	-25.70
15	NL 165× Tiara	35.40**	-43.89	4.30	-7.59	39.47	-32.57	103.50	-9.95	1.56	-15.59	5.22	-42.46
16	NL 165×EC99001	54.30	-13.94	5.16	-3.14	64.86	10.87	108	-5.50	1.75	-13.39	5.45	-37.21
17	NL 165× NL260	51.80	-17.90	4.32	-9.21	52.22	-10.72	103.50	-10.14	1.35	-49.26	3.22	-80.86
18	NL 142 ×NL 367	40.66	-35.55	4.70	5.71	92.34**	57.85**	111.00	-2.78	3.26	65.32	4.22	-59.17
19	NL 142×Padmini	59.87	-5.11	6.37**	-1.39	55.79	-4.62	106.50	-7.25	3.43	97.24*	5.27	-67.44
20	NL 142×Neelum	47.37	-24.92	5.12	-1.35	79.50	35.89**	109.50	-4.05	2.39	8.52	2.92	-107.10
21	NL 142×Neela	31.87**	-49.48	3.87	0.48	53.75	-8.11	105.50	-7.98	0.68	-41.72	1.92	-104.74
22	NL 142×tiara	50.50	-19.96	4.16	-1.79	68.66	17.37	110.00	-3.65	0.94	-48.96	2.92	-154.70
23	NL 142×EC99001	32.62**	-48.29	7.20**	-2.29	78.50	34.18**	106.50	-7.11	3.12	145.82	3.07	-227.27
24	NL 142×PKVNL260	33.00**	-47.70	4.00	-1.75	95.66**	63.53**	112.00	-1.82	3.76**	174.32**	4.15	-112.82
25	NL 367×Padmini	32.12**	-49.08	7.12**	-0.93	76.07	30.03**	107.00	-6.57	2.60	15.65	7.55**	3.25

(contd.)

26	NL 367×Neelum	31.62**	-49.88	6.12	-3.60	121.08**	106.98**	107.00	-6.25	3.03	24.28	5.17	-54.82
27	NL367×Neela	49.37	-21.75	5.75	4.37	63.29	8.19	107.50	-6.07	3.64	58.36*	8.30**	11.26
28	NL 367× Tiara	34.87**	-44.73	3.70	-0.89	58.91	0.71	111.00	-2.80	2.83	23.52	7.29**	-3.00
29	NL 367× EC99001	37.3**	-40.88	2.2	-2.75	59.475	1.66	106.00	-7.44	2.59	12.99	7.25**	-2.41
30	NL 367× PKVNL260	27.75**	-56.02	4.37	-14.47	74.72	27.73*	97.50	-14.86	3.41	45.57*	5.92	-20.90
31	Padmini×Neelum	51.62	-18.18	4.87	-13.51	110.54**	88.96**	96.00**	-16.98	5.66	136.71**	7.20**	-3.45
32	Padmini×Neela	25.50**	-59.58	4.25	-2.31	42.00	-28.20	105.50	-8.72	3.68	45.99**	7.00**	-7.59
33	Padmini× Tiara	25.62**	-59.38	3.62	-1.34	61.54	5.19	110.50	-3.65	1.58	-9.53	7.22**	-3.13
34	Padmini× EC99001	27.33**	-56.68	4.41	-4.13	51.08	-12.68	104.50	-8.33	1.05	-50.28	4.47	-39.93
35	Padmini× PKVNL260	35.87**	-43.15	2.62	-16.23	84.50	44.44**	95.50**	-16.23	4.24**	100.12**	4.40	-40.94
36	Neelum×Neela	45.25	-28.29	4.75	-14.86	31.12	-46.79	94.50**	-17.11	0.64	-69.52	3.90	-47.62
37	Neelum× Tiara	45.75	-27.50	5.87	-11.61	72.37	23.72	99.00	-13.16	1.65	-22.17	4.30	-42.28
38	Neelum× EC99001	33.16**	-47.44	5.20	-8.56	68.95	17.88	101.50	-10.96	2.01	-5.09	5.35	-28.19
39	Neelum× PKVNL260	24.79**	-60.71	5.83	-13.16	68.70	17.45	99.00	-13.16	1.72	-18.65	7.15**	-4.03
40	Neela× Tiara	44.00	-30.27	4.37	-13.39	59.87	2.35	97.00	-14.91	3.82**	80.42**	6.15	-17.45
41	Neela× EC99001	48.00	-23.93	5.62	-12.84	22.50	-61.54	95.00**	-16.67	2.77	30.90	6.17	-17.11
42	Neela× PKVNL260	60.62	-3.92	4.37	-17.54	90.70**	55.06**	94.00**	-17.54	0.68	-67.57	5.41	-27.35
43	Tiara× EC99001	68.75	8.95	4.00	-13.39	86.83	48.43**	97.00	-14.91	3.96**	87.15**	7.33**	-1.61
44	Tiara× PKVNL260	53.53	-15.08	4.08	-12.72	123.87**	111.75**	99.50	-12.72	2.61	23.27	5.41	-27.35
45	EC99001× PKVNL260	50.69	-44.70	3.62	-9.65	128.02**	93.04**	103.00	-11.28	3.07	27.90	5.47	-33.33
	Mean	48.25	-32.66	5.08	-6.27	74.34	29.94	104.22	-9.24	2.56	23.25	5.91	-334.51
	S E (m) ±	**2.73**	**3.86**	**0.39**	**0.55**	**4.98**	**7.04**	**2.60**	**3.67**	**0.41**	**0.58**	**0.41**	**0.57**
	C D 5%	**8.13**	**11.32**	**1.16**	**1.63**	**14.84**	**20.97**	**7.74**	**10.93**	**1.22**	**1.72**	**1.22**	**1.69**
	C V %	**8.01**	**7.76**	**10.87**	**1.11**	**9.46**	**14.11**	**3.52**	**9.81**	**21.72**	**1.17**	**9.70**	**1.15**

Table 3. Crosses selected for heterosis breeding on the basis of mean performance and useful heterosis over check PKV NL 260 for yield

Cross	Mean performance for seed yield plant^{-1}(g)	Useful heterosis over check PKV NL 260 for seed yield plant^{-1}(g)	Heterosis superior over the check for other characters
Neela x Tiara	3.82**	80.42**	PH, NOB, NOC, 1000SW, SY
Tiara x EC 99001	3.96**	87.15**	PH, NOB, NOC, 1000SW, SY
Padmini x Neelum	5.66**	136.71**	DM, NOB, NOC, 1000SW, SY
NL 142 x PKV NL 260	3.76**	174.32**	NOB, NOC, 1000SW, SY
Padmini x PKV NL 260	4.24**	100..12**	NOB, NOC, 1000SW, SY

** = Significant at 1 % level. *= Significant at 5 % level

DM- Days to maturity, PH- Plant height (cm), NOB - Number of branches plant^{-1}, NOC- Number of capsules plant^{-1}, SY – Seed yield plant^{-1} and TSW- Thousand seed weight (g)

99001 (31.06%), NL 367 X Padmini (29.54%) and NL 115 x Padmini (25.75%).Twenty two crosses showed positive significant useful heterosis for number of capsules plant^{-1} which ranged from 206.08% (NL 115 x NL 142) to 24.11% (NL 115 x Neelum). Highest positive significant heterosis for number of capsules plant^{-1}were recorded by crosses *viz.,* NL 115 x NL 142 (206.08%), NL 115 X EC 99001 (116.02%), Tiara x PKV NL 260 (111.75%) and NL 367 x Neelum (106.98%).All crosses, showed negative useful heterosis for days to maturity, while none of the crosses showed useful heterosis in positive direction. The crosses NL 115 x NL 165 and Neela x PKV NL 260 (-17.54%) showed the highest useful heterosis for days to maturity.Thirteen crosses showed positive significant useful heterosis for seed yield plant^{-1} which ranged from 174.32% (NL 142 x PKV NL 260) to 41.36% (NL 165 x Neelum). Maximum significant useful heterosis for seed yield plant^{-1} was recorded by cross NL 142 x PKV NL 260 (174.32%). Heterosis for various characters (plant height, number of branches plant^{-1}, number of capsules plant^{-1}, days to 50 % flowering, days to maturity, seed yield plant^{-1} and 1000 seed weight) in linseed had also been reported by Sharma *et al*. (2018), Kumar *et al*. (2019) and Mahto *et al*. (2020).

Effective utilization of heterosis to develop high yielding hybrids is one of the most important objectives of linseed breeding. Considering the high mean performance, significant useful heterosis over check PKV NL 260 in desirable direction five potential crosses were identified for their exploitation from 45 crosses and data are given in Table 3. The hybrid NL 142 x PKV NL 260 was identified as best hybrid as it was significantly superior over PKV NL 260 for seed yield plant^{-1}, number of branches plant^{-1}, number of capsules plant^{-1} and 1000 seed weight followed by Neela x Tiara, Tiara x EC 99001, Padmini x Neelum and Padmini x PKV NL 260 for their exploitation in heterosis breeding. High mean performance for various characters (plant height, number of branches plant^{-1}, number of capsules plant^{-1}, days to 50 % flowering, days to maturity, seed yield plant^{-1} and 1000 seed weight) in linseed had also been reported by Jadhav *et al*. (2011) and Ghige *et al*. (2021).It was also found that increase in seed yield in these crosses were mostly due to heterotic response of important component like number of branches plant^{-1}, number of capsules plant^{-1}, seed yield plant^{-1}, 1000 seed weight.

The crosses NL 142 × PKV NL 260, Padmini × Neelum and Padmini × PKV NL 260 showed maximum significant positive heterosis over standard check PKV NL 260 for number of branches plant^{-1}, number of capsules plant^{-1}, seed yield^{-1}and 1000 seed weight. Considering high mean performance, significant useful heterosis in desirable direction five potential crosses *viz.,*Neela x Tiara, Tiara x EC 99001, NL 142 x PKV NL 260, Padmini x Neelum and Padmini x PKV NL 260 were identified for their exploitation in heterosis breeding.

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Rec. on 25.07.2021 & Acc. on 10.08.2021