

Original Research Article

<https://doi.org/10.20546/ijcmas.2021.1002.139>

Estimation of Heterosis and Inbreeding Depression in Linseed (*Linum usitatissimum* L.) for Yield, its Attributing Traits and Oil Content

Sanjay Kumar¹, Sohan Ram², Ekhlague Ahmad^{3*}, Manigopa Chakraborty², Nutan Verma², Hem Chandra Lal⁴, Shanti Bhushan⁵, Yogendra Prasad², Kmleshwer kumar², Anuj Choudhary⁶, Radhey Shyam Singh¹ and Satish Chandra Narayan²

¹Department of Plant Breeding and Genetics, MBAC, Agwanpur, Saharsa, Bihar, India
²Department of Genetics and Plant Breeding, ⁴Department of Plant Pathology, BAU, Kanke, Ranchi, Jharkhand, India
³Zonal Research Station (BAU), Chianki, Palamau, Jharkhand, India
⁵Department of Plant Breeding and Genetics, VKSCOA, Dumraon, Bihar, India
⁶Department of Plant Breeding and Genetics, BPSAC, Purnia, Bihar, India

*Corresponding author

ABSTRACT

Keywords

Linseed, Heterosis, Inbreeding Depression, Yield

Article Info

Accepted:

10 January 2021

Available Online:

10 February 2021

An experiment was conducted at Zonal Research Station (BAU) Chianki, Palamu during 2017-18 to estimate the heterosis and inbreeding depression of six crosses in linseed for different characters. Significant and desirable heterosis over better parent was observed for days to 50% flowering, technical height, plant height, number of primary branches per plant, number of capsules per plant, number of seed per capsule, seed yield per plant and 1000-seed weight. The different crosses showed significant heterosis over check-I (Parvati) for days to 50% flowering, technical height, plant height, number of capsules per plant, seed yield per plant, 1000-seed weight and oil content. Similarly, heterosis over check-II (T-397) was also observed significant desirable direction for days to 50% flowering, technical height, number of seed per capsules, capsule diameter, seed yield per plant and 1000- seed weight and oil content in all crosses. Significant and desirable inbreeding depression was seen for days to maturity, technical height, plant height, number of primary branches, numbers of capsule per plant, number of seeds per capsule, capsule diameter, seed yield per plant, 1000-seed weight and oil content in different crosses.

Introduction

Linseed (*Linum usitatissimum* L.) is an important oilseed crop grown for both seed as well as fibre purposes. It is a self- pollinated diploid (2n=30) annual oil seed plant which belong to the family linaceae having 14

genera and over 200 species. The seed of linseed contain about 33-45 per cent oil. Omega-3 fatty acids lower levels of triglycerides in the blood, thereby reducing heart disease, and also show promise in the battle against inflammatory diseases such as rheumatoid arthritis. Linolenic acid (LA), an

Omega-6 essential fatty acid is also found in linseed. Linseed oil contains three times much Omega-3 fatty acid fatty than Omega-6 fatty acid¹. It is generally unsuitable for culinary purpose due to high linolenic acid content (47-58 per cent) but it is an excellent source for industrial purposes.

In self pollinated crops, it is well recognized that heterosis is very useful to increase productivity. The magnitude of heterosis provides a basis for genetic diversity and guideline to the choice of desirable parents for developing superior F₁ hybrids so as to exploit hybrid vigour and for building gene pool to be exploited in population improvement. Therefore, heterosis studies can provide the basis for the exploitation of valuable hybrid combinations in future breeding programs as earlier reported by Pali *et al.*, (2014a) and Reddy *et al.*,. Being such an important crop, the productivity is less and limited information are available. Thus, the present investigation was undertaken to measure the magnitude of heterosis in hybrids for seed yield and associated traits in linseed.

Materials and Methods

The basic materials for the present investigation comprised of the parents (P₁ and P₂), the F₁s and F₂s of each of the six crosses viz., Himalshi-2 x SLS-61, Himalshi-2 x BAU-13-1, Himalshi-2 x Meera, Mukta x SLS-61, Mukta x BAU-13-1 and Mukta x Meera. The experiment was carried out at the experimental area of the Zonal Research Station (BAU) Chianki, Palamu, during *Rabi* 2017-18. The non-segregating generations (Parents, F₁s and Checks) were grown in 3 rows, the segregating F₂ generations were grown in 10 rows and F₃s were grown in 20 rows. The observations were recorded from 10 randomly selected plants from P₁, P₂, F₁s and check, 20 plants from F₂s and F₃s from each plot for eleven yield attributing

characters. Standard heterosis over check varieties (Parvati and T-397) was calculated as per formula of Meredith *et al.*, (1972), heterobeltiosis was calculated following the method Fonseca S. and Patterson (1968) and mid-parent heterosis (relative heterosis) was founded out by the process suggested by Turner (1953). The cause of decrease in fitness and vigour *i.e.* inbreeding depression was estimated in per cent with the help of F₁ and F₂ populations of the each six crosses.

Results and Discussion

Estimates of heterosis depicted in Table 1 revealed that none of the cross exhibited significant heterosis for all the characters under study over mid parent, better parent and check varieties. The degree and direction of heterotic response varied not only from character to character but also from cross to cross also. Significant and desirable heterosis over mid parent was observed in only one cross (Mukta x Meera) for each days to 50% flowering and technical height, one cross *i.e.* Mukta x SLS-61 for plant height, two crosses (Himalshi-2 x SLS-61 and Himalshi-2 x BAU-13-1) each for number of primary branches per plant, (Himalshi-2 x SLS-61 and Mukta x BAU-13-1) for number of capsules per plant, and crosses (Himalshi-2 x BAU-13-1 and Himalshi x Meera) for number of seeds per capsule, one cross (Himalshi-2 x Meera) for capsule diameter, two crosses (Himalshi-2 x SLS-61 and Himalshi-2 x Meera) for seed yield per plant and one cross (Mukta x BAU-13-1) for 1000-seed weight and (Himalshi-2 x Meera) for oil content. Heterosis over better parent was observed significant in desirable direction for only one cross (Mukta x Meera) for days to 50% flowering, technical height, cross (Mukta x SLS-61) for plant height, cross (Himalshi-2 x BAU-13-1) for number of primary branches per plant, cross (Mukta x BAU-13-1) for number of capsule per plant, cross (Himalshi-2 x Meera) for number of seed

per capsule, cross (Himalsi-2 x SLS-61) for seed yield per plant and cross (Mukta x BAU-13-1) for 1000 seed weight. Heterosis over check variety-1 (Parvati) was found significant desirable in all crosses for days to 50% flowering, two crosses (Himalsi-2 x BAU-13-1 and Himalsi-2 x Meera) for Days to maturity, one cross (Mukta x Meera) for technical height, two crosses (Mukta x SLS-61 and Mukta x BAU-13-1) for plant height, one cross (Mukta x BAU-13-1) for number of capsules per plant, five crosses (Himalshi-2 x SLS-61, Himalsi-2 x BAU-13-1, Himalshi-2 x Meera, Mukta x SLS-61 and Mukta x Meera) for seed yield per plant, four crosses (Himalsi-2 x BAU-13-1, Mukta x SLS-61, Mukta x BAU-13-1 and Mukta x Meera) for 1000-seed weight and all crosses for oil content. Heterosis over check variety-2 (T-397) was observed significant in desirable direction for all six crosses for different traits. The cross Mukta x Meera showed heterotic for technical height with the value of -22.56 per cent, four crosses (Himalsi-2 x SLS-61, Himalsi-2 x BAU-13-1, Himalshi-2 x Meera and Mukta x SLS-61) for number of seed per capsules, one cross (Himalshi-2 x Meera) for capsule diameter, five crosses (Himalsi-2 x SLS-61, Himalsi-2 x BAU-13-1, Himalshi-2 x Meera, Mukta x SLS-61 and Mukta x Meera) for seed yield per plant and four crosses (Himalsi-2 x BAU-13-1, Mukta x SLS-61, Mukta x BAU-13-1 and Mukta x Meera) for test weight and one cross (Mukta x BAU-13-1) for oil content. The result of previous workers are also in agreement of our findings for days to 50% flowering, seed yield per plant and plant height (Kiran *et al.*, 2012), for number of primary branches per plant, number of capsules per plant, 1000-seed weight, seed yield per plant, plant height and number of seeds per capsule (Kumar *et al.*, 2013), for seed yield per plant, days to 50% flowering, number of capsules per plant, and oil content (Pali and Mehta, 2014a), for plant height, days to 50% flowering, number of

capsules per plant, 1000-seed weight and seed yield per plant (Reddy *et al.*, 2013c) and for both days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of capsules per plant, number of seeds per capsule and seed yield per plant (Ahmad *et al.*, 2018 and Sharma *et al.*, 2018). While considering the significant and useful heterosis over mid parent, better parent and economic parent, the best cross was Himalsi-2 x SLS-61 for seed yield per plant. It was also found that increase in seed yield in these crosses were mostly due to desirable heterotic response of important component traits like primary branches per plant, number of capsules per plant, number of seeds per capsule, capsule diameter and test weight. Linseed workers like Ahmad *et al.*, (2018), Sharma *et al.*, (2018), Reddy *et al.*, (2013c) and Singh *et al.*, (2014) have also reported the contribution of these components to the heterosis for seed yield per plant..

Inbreeding depression in F₂ generation was estimated for all the characters under study. The result indicated that three crosses (Himalshi-2 x Meera, Mukta x SLS-61 and Mukta x Meera) for days to maturity, five crosses (Himalsi-2 x SLS-61, Himalsi-2 x BAU-13-1, Himalsi-2 x Meera, Mukta x SLS-61 and Mukta x BAU-13-1) for technical height, one cross (Himalsi-2 x BAU-13-1) for plant height, four crosses (Himalsi-2 x SLS-61, Himalsi-2 x BAU-13-1, Mukta x SLS-61 and Mukta x Meera) for number of primary branches per plant, three crosses (Himalsi-2 x SLS-61, Mukta x SLS-61 and Mukta x BAU-13-1) for number of capsules per plant, four crosses (Himalsi-2 x SLS-61, Himalshi-2 x BAU-13-1, Himalsi-2 x Meera, Mukta x SLS-61) for number of seeds per capsule, three crosses (Himalsi-2 x BAU-13-1, Himalsi-2 x Meera and Mukta x Meera) for capsule diameter, four crosses (Himalsi-2 x SLS-61, Himalshi-2 x BAU-13-1, Mukta x SLS-61 and Mukta x Meera) for seed yield per plant, two

crosses (Himalshi-2 x BAU-13-1 and Mukta x Bau-13-1) for 1000-seed weight and one cross (Himalshi-2 x BAU-13-1) for oil content revealed significant positive inbreeding depression indicating deterioration in their performance in next generation. It might be due to lack of accumulation of desirable genes responsible for dominance effect or may be due to tight linkage of desirable genes or due to phenomenon of fixing of heterozygosity. Such crosses could prove useful in diallel selective mating system (Tonde *et al.*, 2016). Our results are also in conformity for seed yield per plant with earlier workers Srivastava

et al., (2003) and Swarnkar *et al.*, (2003) for days to 50% flowering, number of primary branches per plant, days to maturity and 1000-seed weight (Kiran and Kanojia, 2014), for days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of capsules per plant, number of seeds per capsule and seed yield per plant (Sharma *et al.*, 2018), for days to 50% flowering, plant height, number of primary branches per plant, number of capsules per plant and 1000-seed weight (Ahmad *et al.*, 2018).

Table.1 Estimates of heterosis (MP, BP and Checks) and inbreeding depression in per cent for different yield attributing traits in linseed

Characters and heterosis		Cross combinations						CD 5%	CD 1%
		Himalshi-2 x SLS-61	Himalshi-2 x BAU-13-1	Himalshi-2 x Meera	Mukta x SLS-61	Mukta x BAU-13-1	Mukta x Meera		
Days to 50% flowering	MP	2.67	-0.78	-0.78	1.07	-3.38	-4.44*	2.35	3.14
	BP	0.52	-1.55	-1.04	-1.05	-4.12	-4.69*	2.72	3.63
	C1	-11.93**	-12.39**	-12.84**	-13.30**	-14.68**	-16.06**	2.72	3.63
	C2	-13.12**	-13.57**	-14.03**	-14.48**	-15.84**	-17.19**	2.72	3.63
	ID	-12.50**	-15.18**	-11.57**	-17.98**	-8.60**	-12.56**	2.72	3.63
Days to maturity	MP	4.64**	2.26	-0.54	4.46**	3.71**	6.74**	3.29	4.39
	BP	3.40*	1.59	-1.07	1.74	0.50	2.23	3.80	5.06
	C1	-2.71	-5.42**	-9.11**	0.99	-0.25	1.48	3.80	5.06
	C2	6.47**	3.50*	-0.54	10.51**	9.16**	11.05**	3.80	5.06
	ID	-4.05**	-3.90**	0.81**	4.39**	-0.24**	3.39**	3.80	5.06
Technical height (cm)	MP	4.26	11.32	17.86**	-3.58	44.10**	-19.21**	3.56	4.76
	BP	3.38	-3.65	16.0*	-6.12	26.71**	-19.48**	4.12	5.49
	C1	3.27	-5.37	14.01*	-6.22	19.91**	-23.30**	4.12	5.49
	C2	4.26	-4.47	15.11**	-5.32	21.05**	-22.56**	4.12	5.49
	ID	1.63**	0.44**	9.42**	3.50**	13.17**	-47.23**	4.12	5.49
Plant height (cm)	MP	0.98	5.34	-2.75	-12.26*	4.01	0.05	7.05	9.40
	BP	0.10	0.51	-2.75	-16.08*	3.37	-5.10	8.14	10.86
	C1	-6.74	-6.36	-9.40	-23.17**	-12.54*	-11.59	8.14	10.86
	C2	10.59	11.04	7.43	-8.90	3.72	4.84	8.14	10.86
	ID	-10.99**	5.27**	-1.88**	-8.77**	-5.75**	-4.08**	8.14	10.86
Number of primary branches per plant	MP	28.48*	36.13**	14.03	21.11	-2.91	-4.24	1.52	1.76
	BP	12.77	34.02**	-25.20**	0.00	-8.26	-11.02	1.52	2.03
	C1	-9.40	11.11	-18.80	-6.84	-14.53	-3.42	1.52	2.03
	C2	-26.90**	-10.34	-34.48**	-24.83**	-31.03**	-22.07**	1.52	2.03
	ID	30.18**	18.46**	-8.42**	22.93**	-28.00**	8.85**	1.52	2.03

*, ** --Significant at 5% and 1% level of significance respectively. MP = mid parent, BP = better parent, C1= check 1, C2= check2 and ID = inbreeding depression

contd.....

Characters and heterosis		Cross combinations						CD at 5%	CD at 1%
		Himalshi-2 x SLS-61	Himalshi-2 x BAU-13-1	Himalshi-2 x Meera	Mukta x SLS-61	Mukta x BAU-13-1	Mukta x Meera		
Number of Capsules per plant	MP	24.28*	-7.57	7.21	14.56	37.10**	-21.02	48.09	64.15
	BP	10.87	-15.87	-1.97	4.90	28.19*	-25.80*	55.53	74.07
	C1	16.67	-11.47	3.16	4.11	27.22*	-26.37*	55.53	74.07
	C2	13.29	-14.03	0.18	1.09	23.54	-28.50*	55.53	74.07
	ID	24.47**	-9.06**	-22.37**	27.98**	22.08**	-86.16**	55.53	74.07
Number of Seeds per capsule	MP	8.33	14.29**	14.55**	-3.79	-8.40	-29.10**	0.69	0.92
	BP	0.00	6.25	14.55**	-5.22	-10.45	-35.45**	0.79	1.06
	C1	0.00	4.62	-3.08	-2.31	-7.69	-33.46**	0.79	1.06
	C2	18.18**	23.64**	14.55**	15.45**	9.09	-21.36**	0.79	1.06
	ID	10.38**	9.55**	3.17**	6.29**	-5.00**	-26.01**	0.79	1.06
Capsule diameter (mm)	MP	-0.19	8.45	13.93**	-8.89*	2.86	-0.52	0.56	0.75
	BP	-4.33	4.08	6.80	-13.04**	-1.94	-2.87	0.65	0.87
	C1	-8.74	-0.97	6.80	-8.74	2.91	1.94	0.65	0.87
	C2	-3.09	5.15	13.40*	-3.09	9.28	8.25	0.65	0.87
	ID	-17.53**	0.34**	1.95**	-12.39**	-1.88**	4.95**	0.65	0.87
Seed yield per plant (g)	MP	70.20**	25.29	24.03*	-3.67	-23.47**	-6.41	2.25	3.00
	BP	52.39**	20.62	13.82	-9.73	-37.25**	-14.48	2.59	3.46
	C1	169.31**	68.55**	90.40**	82.47**	26.83	72.87**	2.59	3.46
	C2	183.88**	77.66**	100.70**	92.34**	33.69	82.22**	1.06	1.42
	ID	15.15**	2.08**	-6.19**	25.45**	-40.02**	23.57**	1.27	1.70
1000-seed weight(g)	MP	-4.88	11.11	-9.30	5.62	25.00**	-5.38	0.92	1.22
	BP	-15.22*	0.00	-22.00**	-2.17	22.22**	-12.00	1.06	1.41
	C1	14.71	32.35**	14.71	38.24**	61.76**	29.41**	1.06	1.41
	C2	11.43	28.57**	11.43	34.29**	57.14**	25.71**	1.06	1.41
	ID	-20.51**	8.88**	-7.43**	-8.51**	0.00**	-18.18**	1.06	1.41
Oil%	MP	-5.40**	-8.92**	7.28**	-2.63	-6.79**	-1.14	0.92	1.23
	BP	-16.06**	-24.46**	-4.77	-4.22	-15.06**	-2.70	1.06	1.42
	C1	7.20**	13.44**	21.50**	22.32**	27.57**	24.13**	1.06	1.42
	C2	-11.07**	-5.89**	0.79	1.47	5.83**	2.97	1.06	1.42
	ID	-1.56**	20.59**	-1.86**	-19.19**	-1.98**	-22.77**	1.06	1.42

*, ** --Significant at 5% and 1% level of significance respectively. MP = mid parent, BP = better parent, C1= check 1, C2= check2 and ID = inbreeding depression

Thus the crosses showing significant economic heterosis in some crosses associated with high degree of inbreeding depression, in such hybrids significant heterosis in F₁ and high degree of inbreeding depression in F₂ could be attributed to high magnitude of non-additive gene effects. In contrast, the other heterotic crosses having high economic heterosis showed negative inbreeding depression, indicating the presence of additive gene effects. These crosses may be utilized

following pedigree method for the selection of transgressive segregants in advanced generation.

As regard the choice of most efficient breeding procedure, considering the importance of both additive and non-additive gene effects, it is imperative to plan for most effective utilization of intra and inter-allelic interactions and accumulation of favourable additive gene effects for greater amelioration.

In conclusion all the six crosses under investigation depicted significant positive heterosis for yield and oil content over check variety Parvati while Himalshi-2 x SLS-61 showed minimum inbreeding depression among these crosses. The segregant of this cross might be advance for selection or to be use in breeding programme.

Acknowledgement

We are thankful to the Department of Genetics and Plant Breeding, Birsa Agriculture University, Kanke, Ranchi for providing all necessary facilities and support during the course of investigation.

References

- Ahmad, Ekhlaque., Ansari, A. M., Paul, A., Bhushan, S., Singh, M. K., Nazrussalam and Singh, D. N. 2018. Studies of heterosis and inbreeding depression for seed yield and its components in linseed (*Linum usitatissimum* L.). *Multilogic in Science*, VIII (A): 147-150.
- Fonseca, S. and Patterson, F. 1968. Hybrid vigour in seven parent diallel crosses in common winter wheat (*Triticum aestivum* L.). *Crop Sci.* 8: 85-95.
- Kiran; Sood, V. K. and Bhatneria, S. 2012. Detection of genetic components of variation for yield, fibre and quality traits in flax (*Linum usitatissimum* L.). *J. Agric. Sci.* 4 (10): 224- 231.
- Kiran and Kanojia, R.K. 2014. Heterosis and inbreeding depression in linseed (*Linum usitatissimum* L.), *New Agriculturist.* 25(2): 185–188.
- Kumar, S., Kumar, R., Singh, M. P., Kumar S., Singh, S., Kumar, S. and Jeet, R. 2013. Effect of heterosis and inbreeding depression in linseed (*Linum usitatissimum* L.), *Progressive Res.* 8: 438- 441.
- Meredith, W.R., Bridge, R.R.1972. Heterosis and gene action in cotton, (*Gossypium hirsutum*). *Crop Sci.*12: 304-310.
- Pali, V. and Mehta, N.2014a. Combining ability and heterosis for seed yield and it's attributes in linseed (*Linum usitatissimum* L.). *The Bioscan.* 9(2): 701-706.
- Reddy, M.P., Arsul, B.T., Shaik, N.R. and Maheshwari, J.J. 2013. Estimation of heterosis for some trait in linseed (*Linum usitatissimum* L.), *J. Agri and Vet. Sci.* 2(5): 11-17.
- Reddy, M.P., Reddy, B.R., Arsul, B.T. and Maheshwari, J. J. 2013c. Character association and path coefficient studies in linseed. *Int. J. Curr. Microbiol. App. Sci.* 2(9): 250-254.
- Sharma, A., Srivastava, A. and Chauhan, M.,P.2018. Heterosis and Inbreeding Depression in Linseed (*Linum usitatissimum* L.). *Int. J. Curr. Microbiol. App. Sci.* 7(2): 554-559.
- Sharma, R., Tiwari, S. K, Singh, P. and Ramakant. 2005. Heterobeltiosis and inbreeding depression in linseed. *Agriculture Science Digest.* 25(1):35-37.
- Singh, V. K., Verma, P. N., Sharma, V., Verma, I. K., Paswan, S. K. and Chauhan, M. P. 2014. Estimation of heterosis for yield and its contributing attributes in linseed (*Linum usitatissimum* L.). *The Ecoscan.* 6(Spl.): 81-84.
- Srivastava, R. L., Swarnkar, S. K., Kerkhi S. A., Dubey, S. D. and Malik, Y. P. 2003. Heterosis and inbreeding depression in linseed under salt affected soil, *ISOR National Seminar: stress management in oilseeds*, Jan, 28-30.Rajendranagar, Hyderabad.
- Swarnkar, S. K., Singh, P., Srivastava, R. L. and Singh, P. 2003. Combining ability analysis in linseed (*Linum usitatissimum* L.), *Progressive Agriculture.* 1(2): 103-106.

Tonde, N. G., Kale, V. S., Nagre, P. K. and Lajurkar, V. G. 2016. Heterosis and inbreeding depression studies in okra *Abelmoschus esculentus* (L.) Moench. *The Bioscan*. 11(3): 1979-1984.

Turner, J. M. 1953. A study of heterosis in upland cotton II. Combining ability and inbreeding effects. *Agron. J.* 43: 487-490.

How to cite this article:

Sanjay Kumar, Sohan Ram, Ekhlauque Ahmad, Manigopa Chakraborty, Nutan Verma, Hem Chandra Lal, Shanti Bhushan, Yogendra Prasad, Kmlshwer kumar, Anuj Choudhary, Radhey Shyam Singh and Satish Chandra Narayan. 2021. Estimation of Heterosis and Inbreeding Depression in Linseed (*Linum usitatissimum* L.) for Yield, its Attributing Traits and Oil Content. *Int.J.Curr.Microbiol.App.Sci.* 10(02): 1185-1191.
doi: <https://doi.org/10.20546/ijcmas.2021.1002.139>