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RESEARCH ARTICLE

GENETIC ANALYSIS OF SEED YIELD AND ITS COMPONENTS IN LINSEED (LINUM USITATISSIMUM L.) UNDER LATE SOWN CONDITIONS IN THE NORTH CENTRAL PLATEAU ZONE OF ODISHA IN INDIA

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ABSTRACT

Five lines, three testers and their 15 F_1s were grown under late sown conditions. The line × tester analysis of Kempthorne (1957) was employed to estimate additive genetic variance (σ^2_A), dominance genetic variance (σ^2_D), degree of dominance ($[\sigma^2_D/\sigma^2_A]^{1/2}$), heritability in narrow sense ($H_{(ns)}$) and standard heterosis (d_{iii}) over standard variety '*Padmini*' for plant height (cm), number of primary branches per plant, number of capsules per plant, number of seeds per capsule,1000-seed weight (g) and seed yield per plant (g). All the characters were controlled by a preponderance of non-additive gene action. Low estimates of $H_{(ns)}$ were observed for all the characters except number of primary branches per plant and number of seeds per capsule which had negative heritability. OL 1-3×Kiran, OL 2-3×Padmini, OL 18-4×Padmini and OL 22-1×Padmini had significantly high d_{iii} for number of capsules per plant and low d_{iii} for 1000-seed weight as well as high d_{iii} for seed yield per plant. The hybrids having significant positive standard heterosis (d_{iii}) can be effectively used for isolating transgressive segregants which will increase the frequency of desirable genes for seed yield component traits

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INTRODUCTION

Linseed (*Linum usitatissimum* L., 2n= 30, X = 15) belongs to the order Malpighiales, the family Linaceae and the tribe Lineae. It is the second most important *rabi* (winter) oilseed crop and stands next to rapeseed-mustard in area and production in India. But, the national average productivity of linseed is quite low. As per FAOSTAT (2014), India ranks 4th among world's linseed producing countries. However, in terms of productivity, India (392 kg/ha) is far below than Switzerland (2647 kg/ha), Tunisia (2633 kg/ha), U.K. (2600 kg/ha), France (2121 kg/ha) and New Zealand (1853 kg/ha). In India, during 2013-14 linseed was grown in an area of 292.1 thousand hectares with annual production of 141.2 thousand tonnes and productivity of 484 kg/ha. Out of 15 linseed growing states, the major are Madhya Pradesh (110.4 thousand ha), Maharashtra (31.0 thousand ha), Chhattisgarh (26.2 thousand ha), Uttar Pradesh (26.0 thousand ha), Jharkhand (25.5 thousand ha), Odisha (22.9 thousand ha) and Bihar (18.7 thousand ha). In Odisha, the annual production is 11 thousand tonnes with productivity of 478 kg/ha (Anonymous, 2015a, b).

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The North Central Plateau Zone of Odisha comprising the districts of Mayurbhanj and Keonjhar contributes to about 50.6 % of the total linseed area of the state of Odisha (Anonymous, 2015b). However, a significant number of farmers are forced to sow linseed one month late due to excess moisture in the field. Seed setting is highly affected due to higher temperature during later phase of growth decreasing seed yield significantly (Dash *et al*., 2011). Hence, there is urgent need to increase the productivity by breaking the present yield barrier and developing hybrids with high yield potential. The best hybrids for seed yield and its components can be achieved through evaluation of the promising lines and their cross combinations. So, the present study was undertaken to measure the magnitude of heterosis in hybrids over standard check '*Padmini*' under late sown conditions.

MATERIALS AND METHODS

The experiment comprised of five lines (OL 1-3, OL 2-3, OL 4-1, OL 18-4 and OL 22-1), three testers (Kiran, Padmini and OLC 10) and their 15 F_1s. The crosses along with lines and testers were grown one month late during November in randomized complete block design with two replications at the Regional Research and Technology Transfer Sub-station of OUAT at Jashipur, Mayurbhanj, Odisha (latitude : 21° 57' N,

longitude : 86° 06' E, altitude : 400 m above mean sea level, annual rainfall : 1475 mm, soil : red lateritic, sandy loam and acidic). Each genotype was sown in a single row of 1 m length with a spacing of 30 cm ×10 cm between and within the row respectively. The sowing depth was 2-3cm. Recommended package of practices was followed to raise a good crop. Five randomly selected competitive plants from each row were used to record the biometric observations of plant height (cm), number of primary branches per plant, number of capsules per plant, number of seeds per capsule and seed yield per plant (g). But 1000-seed weight (g) was recorded on whole row basis. The line×tester analysis of Kempthorne (1957) was carried out using SPAR 2 software of ICAR-Indian Agricultural Statistics Research Institute, New Delhi. The estimates of additive genetic variance (σ^2_A), dominance genetic variance (σ^2_D), degree of dominance ($[\sigma^2_D/\sigma^2_A]^{1/2}$) , heritability in narrow sense ($H_{(ns)}$) and standard heterosis (d_{iii}) over standard variety '*Padmini*' were calculated following Singh and Chaudhary (1985), Nadarajan and Gunasekaran(2005), and Thirugnanakumar *et al*. (2012). Standard heterosis (d_{iii}) was classified as low (less than 10 %), moderate (10-20 %) and high (more than 20 %).

RESULTS AND DISCUSSION

The dominance genetic variances were greater than the additive ones for all the six characters. These results are corroborated by the degree of dominance ($[\sigma^2_D/\sigma^2_A]^{1/2}$) that takes values greater than unity (Table1). Therefore, it appeared that the inheritance of all the characters studied was controlled by a preponderance of non-additive gene action as reported by earlier workers (Tak, 1996; Patel *et al*, 1997; Mahto and Rahman, 1998; Kumar *et al*., 2000; Bhateria *et al*., 2001; Bhateria *et al*., 2006; Reddy *et al*., 2013; and Kumar and Paul, 2015). Such type of gene action clearly indicated that selection of superior plants in terms of seed yield, plant height, number of primary branches, number of capsules, number of seed and 1000-seed weight should be postponed to later generations. Selection efficiency is related to heritability. In this study, low estimates of narrow sense heritability ($H_{(ns)}$) were observed for all the characters except number of primary branches per plant and number of seeds per capsule which had negative heritability indicating that selection is not effective in these two cases.

Table 1. Estimates of genetic parameters in linseed

Characters	σ^2_A	σ^2_D	$[\sigma^2_D/\sigma^2_A]^{1/2}$	$H_{(ns)}$
Plant height (cm)	3.316	14.544	2.094	7.784
Nos. of primary branches/plant	-0.022	0.680	-5.560	-2.005
No. of capsules/plant	30.366	1007.352	5.760	2.589
No. of seeds/capsule	-0.030	0.295	-3.136	-3.645
1000- seed weight (g)	0.002	0.909	21.319	0.219
Seed yield/plant (g)	0.024	1.803	8.667	1.108

NB: σ^2_A = Additive genetic variance, σ^2_D = Dominance genetic variance, $[\sigma^2_D/\sigma^2_A]^{1/2}$ = Mean degree of dominance, $H_{(ns)}$ = Heritability (narrow sense)

Table 2. Percentage of heterosis over standard check '*Padmini*' in linseed

Crosses	Plant height (cm)	No. of primary branches/plant	No. of capsules/plant	No. of seeds/capsule	1000- seed weight (g)	Seed yield/plant (g)
OL 1-3 × Kiran	8.66	-32.00**	54.15**	-19.77**	5.45**	47.80**
OL 2-3 × Kiran	25.37**	-36.00**	41.81**	-9.60**	-7.93**	50.00**
OL 4-1 × Kiran	26.49**	8.00**	12.75	-12.99**	-11.38**	-3.01**
OL 18-4 × Kiran	28.48**	-1.33	40.41**	-19.21**	-5.79**	63.08**
OL 22-1 × Kiran	15.24**	-29.33**	-8.34	-11.86**	11.03**	-3.59**
OL 1-3 × Padmini	14.98**	-49.33**	11.40	-6.78**	11.17**	29.17**
OL 2-3 × Padmini	13.59*	2.67**	44.04**	-3.95**	1.24**	29.75**
OL 4-1 × Padmini	14.55**	-25.33**	-23.21	6.78**	-7.93**	-23.26**
OL 18-4 × Padmini	23.12**	-26.67**	37.72**	-2.26**	4.69**	20.14**
OL 22-1 × Padmini	6.84	14.67**	40.36**	-6.21**	3.10**	56.13**
OL 1-3 × OLC 10	17.84**	-12.00**	53.01**	-22.60**	-14.21**	8.68**
OL 2-3 × OLC 10	9.35	-25.33**	-11.50	-6.21**	-30.28**	-17.25**
OL 4-1 × OLC 10	21.99**	-4.00**	-0.67	-14.69**	-14.48**	4.75**
OL 18-4 × OLC 10	16.10**	-25.33**	-9.59	-20.90**	2.14**	-25.93**
OL 22-1 × OLC 10	2.60	-30.67**	34.82**	-23.16**	-2.00**	2.08**
SE (m) ±	4.98	0.66	11.63	0.75	0.03	0.58

*, ** significant at 5% and 1% level, respectively

Table 3. List of crosses showing significant positive heterosis over standard check '*Padmini*' in linseed

Characters	Crosses
Plant height (cm)	OL 2-3 × Kiran, OL 4-1 × Kiran, OL 18-4 × Kiran, OL 22-1 × Kiran, OL 1-3 × Padmini, OL 2-3 × Padmini, OL 4-1 × Padmini, OL 18-4 × Padmini, OL 1-3 × OLC 10, OL 4-1 × OLC 10, OL 18-4 × OLC 10 (11)
Nos. of primary branches/plant	OL 4-1 × Kiran, OL 2-3 × Padmini, OL 22-1 × Padmini (3)
No. of capsules/plant	OL 1-3 × Kiran, OL 2-3 × Kiran, OL 18-4 × Kiran, OL 2-3 × Padmini, OL 18-4 × Padmini , OL 22-1 × Padmini, OL 1-3 × OLC 10, OL 22-1 × OLC 10 (8)
No. of seeds/capsule	OL 4-1 × Padmini (1)
1000- seed weight (g)	OL 1-3 × Kiran, OL 22-1 × Kiran, OL 1-3 × Padmini, OL 2-3 × Padmini, OL 18-4 × Padmini, OL 22-1 × Padmini, OL 18-4 × OLC 10 (7)
Seed yield/plant (g)	OL 1-3 × Kiran, OL 2-3 × Kiran, OL 18-4 × Kiran, OL 1-3 × Padmini, OL 2-3 × Padmini, OL 18-4 × Padmini, OL 22-1 × Padmini, OL 1-3 × OLC 10, OL 4-1 × OLC 10, OL 22-1 × OLC 10 (10)

The ovary of linseed flower is pentalocular initially, later on each locule dividing into two by development of pseudo-septum (false septum). This results in 10-chamber capsule. There are two ovules per locule initially, after development of false septum only one ovule per locule. So, the upper limit for number of seeds is 10 per capsule. Hence, $H_{(ns)}$ for number of seeds per capsule is negative and its selection is ineffective as it cannot go beyond 10 seeds per capsule. The percentage of standard heterosis (d_{iii}) for seed yield and its component characters is presented in Table 2. None of the 15 hybrids had positive significant d_{iii} for all the characters. All the hybrids showed highly significant negative d_{iii} for number of seeds per capsule except OL 4-1×Padmini. Similarly, all the hybrids exhibited significant negative d_{iii} for number of primary branches per plant except OL 4-1×Kiran, OL 2-3×Padmini and OL 22-1×Padmini. Significant positive d_{iii} was expressed for plant height by all the crosses except OL 1-3×Kiran, OL 22-1×Padmini, OL 2-3×OLC 10 and OL 22-1×OLC 10. For improvement of seed yield, the selection criteria should be more 'days to 50% flowering' and higher 'number of capsules per plant' with moderate '1000-seed weight' under late sown conditions in the north central plateau zone of Odisha (Dash *et al*., 2016). OL 1-3×Kiran, OL 2-3×Padmini, OL 18-4×Padmini and OL 22-1×Padmini had significantly high d_{iii} for number of capsules per plant and low d_{iii} for 1000-seed weight as well as high d_{iii} for seed yield per plant. Earlier workers reported significant heterosis for number of capsules per plant (Patil and Chopde, 1983; Singh *et al.,* 1983; Sakhare,1990; Mishra and Rai, 1993; Saraswat *et al.,* 1993; Reddy *et al.,* 2013; Kumar and Paul, 2015), 1000-seed weight (Swarnkar *et al.*2005; Srivastava *et al.*2007; Reddy *et al.,* 2013; Kumar and Paul, 2015) and seed yield per plant (Kansal and Gupta, 1981; Dakhore *et al.,* 1987; Rao *et al.,* 1987; Saraswat *et al.,*1993; Foster *et al.,* 1998; Kurt and Evans, 1998; Rede,1999; Reddy *et al.,* 2013; Kumar and Paul, 2015).

The present investigation indicated that all the characters studied were controlled by a preponderance of non-additive gene action. Low heritability was observed for four characters and negative heritability for two characters. The hybrid OL 22-1×Padmini registered significant positive heterosis for seed yield per plant along with significant positive heterosis of yield contributing traits of number capsules per plant and 1000-seed weight. Hybrids exhibiting significant positive standard heterosis (d_{iii}) for different traits are presented in Table 3. Hence, the hybrids having significant positive standard heterosis (d_{iii}) can be effectively used for isolating transgressive segregants which will increase the frequency of desirable genes for seed yield component traits.

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