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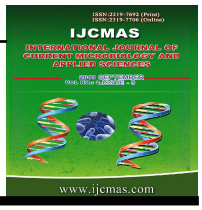

Original Research Article

Screening of Linseed Genotypes for Resistance against Budfly, *Alternaria* and Powdery mildew, Genetic parameters for Yield Components in Linseed (*Linum usitatissimum* L.)

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Keywords

Resistance; Budfly; *Alternaria*; Powdery mildew; Heritability; Genetic advance.

A B S T R A C T

In this study genotypes were screened on field conditions to evaluate genotypes for resistance to bud fly, *Alternaria* blight and powdery mildew. The results revealed that the pest and diseases for parents ranged from 11.39 (EC544) to 59.54 (ES44) and 5.34 (Neelum) to 17.68 (ES44) for budfly and *Alternaria* blight. Among the hybrids Padmini x Ayogi and PKVNL-260 X EC9825 were found to be resistant to budfly infestation and *Alternaria* infestation. PKVNL260, PKDL18, KL178, LCK8605, A125, Karthika x Ayogi, Padmini x Ayogi, PKVNL260 x ACC NO4/47 and Padmini x ACC NO4/47 were found to be resistant to powdery mildew under field conditions and therefore, have the potential to reduce the yield losses because of these diseases and pest in the field. The heredity and expected genetic advance estimates were high for number of primary branches, 1000 seed weight, seed yield per plant and budfly incidence. The traits with high heritability and high genetic advance may be subjected to mass or progeny or family selection or any selection scheme, aimed at exploiting additive (fixable) genetic variance, a widely adapted genotype can be developed, possessing good quality and high productivity.

Introduction

Linseed (*Linum usitatissimum* L.) is a conventional oilseed as well as a fiber crop. Linseed has numerous medicinal uses. Its fiber is used in the manufacturing of canvas, cloth, water resistant pipes, paper and strawboard. Linseed oil is used in the manufacturing of paints and varnish, oil cloth and linoleum (Hatim *et al*., 1994).

Linseed crop suffers from several diseases and insect pest in India. The significant yield losses occur in linseed due to budfly (*Dasyneura lini*) (20 to 97%), *Alternaria* blight (*Alternaria lini*) and powdery mildew (*Odium lini*) (up to 60 %), (Srivastava *et al.*, 1997). Leaf infection causes from 27 to 60 per cent. However,

bud infection can cause loss up to 90 per cent. The loss due to *Alternaria* from 28-60 per cent has been reported from Kanpur (Chauhan and Srivastava, 1975). Therefore, there is a need to develop varieties resistant to pests and diseases to stabilize the yield potentials of linseed varieties. Therefore, this research work helps in developing varieties resistant to pest and diseases to stabilize the yield potentials of linseed varieties. The manipulation of inherent potentials of plants in the form of resistant varieties is a cheap, viable and environment friendly alternative to reduce losses from biotic stress.

For increasing the genetic potentialities of any crop, heritable variability in parents is of primary importance for a successful breeding programme. The heritability (in narrow sense) is one of the most important selection parameter for measuring genetic relationship between parent and progeny, has been widely used in determining the degree to which a character may be transmitted from parent to off springs. However, heritability alone is not enough for making efficient selection in advanced generations unless accompanied by substantial amount of genetic advance. According to Hanson (1963), heritability and genetic advance are complementary aspects. Therefore, values of heritability can also be used for computing the expected genetic progress made possible through selection. Hence, the present paper reports the heritability and genetic advance for yield components.

Materials and Methods

The complete set of material under study consisting of 20 male parents (A95B, EC1392, EC1424, GS234, PKDL18, Ayogi, ES44, EC544, Eita, GS15, A125, LCK8605, LCK88062, JRF5, EC4168, EC9825, KL178, BR1, ACC NO- 4/47 and Neelum) and 3 female parents (Karthika, Padmini and PKVNL260) and 60 crosses were grown in randomized complete block design with two replications at college of Agriculture, AICRP, Nagpur during *rabi* 2010-11. The row to row spacing was 30 cm with single row plot. PKVNL-260 was grown on all sides of the block to avoid border effect. Recommended package of practices were followed to raise a good crop. The data were recorded on 5 randomly taken plants in each parent and 60 F_1s for seven quantitative traits *viz.*, days to 50% flowering, plant height, number of primary branches per plant, number of capsules per plant, days to maturity, 1000-seed weight and seed yield per plant.

Field screening

The intensity of disease in the field was estimated from five randomly selected plants in each genotype which were tagged with labels, at the flowering stage of the crop. On an average 60 leaves were selected at random from the selected plant and disease severity was recorded by visually examining each leaf for leaf area damage using pictorial key of Allen *et al*., (1983) in each relationship and the average was computed. The scale adopted to indicate the degree of resistance in linseed genotypes is furnished below (Table 3).

Individual plant was scored for budfly infection. In each plant buds infected by budfly (*Dasyneura lini*) were counted and percentage was taken from the total number of buds as follows.

$$\text{Budfly infestation (\%)} = \frac{\text{infected buds}}{\text{total number of buds}} \times 100$$

Infected buds by *Alternaria lini* were counted in each plant and percentage was taken from the total number of buds.

$$\text{Alternaria blight Infestation (\%)} = \frac{\text{infected buds}}{\text{total number of buds}} \times 100$$

Heritability (in narrow sense) and genetic advance was calculated as per Crumpacker and Allard, (1962) and Johson *et al*., (1955) respectively, and interpretation of results was done as per Robinson, (1966).

Results and Discussion

The analysis of variance for combining ability for different characters has been presented in Table 1. The variation between crosses was partitioned into different components representing the mean squares due to males, females and male x females interaction. Mean squares due to males, males x females were significant for all characters except days to 50% flowering, number of branches per plant, 1000 seed weight and *Alternaria* infestation, indicating considerable genetic variability for general combining ability among males and specific combining ability among crosses. Mean squares due to females were significant for all characters except days to 50% flowering, number of capsules per plant, 1000 seed weight and *Alternaria* blight infestation, indicating substantial genetic variability for general combining ability among females. The significant general combining ability and specific combining ability variation was also reported by Ratnaparkhi *et al*., (1998); Kusalkar (1999); Jadhav (2010).

Mean performance of parents and their crosses for morphological traits

Plant height (cm)

Plant height ranged from 29.70 cm (EC1424) to 60.00 cm (PKDL-18) among the parents. Among the crosses plant height ranged from 27.75 cm (Padmini x ACC N0- 4/47) to 58.90 cm (Kartika x EC4168), the tallest cross being Kartika x EC4168 (58.90 cm).

Number of capsules per plant

The best parent exhibiting this character was LCK 8605 (79.00) followed by GS15 (69.90), ES44 (53.45), ACC-No-4/47 (48.00), Padmini (47.60), Kartika (47.40) and EC9825 (42.08). Padmini x EC4168 (142.80) had the maximum number of capsules per plant. This was followed by PKV NL-260 x EC9825 (136.50), Padmini x GS234 (135.20), Kartika x EC4168 (134.60), PKV NL-260 x GS-15 (132.50), Kartika x Eita (126.40), Padmini x GS15 (122.30).

Days to maturity

Earliness is desirable character, it ranged from 96 to 117 days in case of parents. The parents which matured earlier were PKVNL260, A125, EC544 (96.00 days) followed by BRI (98.00 days), EC1392 (99.00 days), EC9825 (100.00 days), Padmini, GS234, Eita, Ayogi, EC4168 (102.00 days). The crosses which attained maturity earlier in 91 days were PKV NL260 x LCK 88062, Padmini x EC1424 and Padmini x EC 1392, followed by Padmini x LCK 8605, Padmini x Neelum,

Table.1 Analysis of Variance

Source of variation	DF	Mean squares								
		1	2	3	4	5	6	7	8	9
Crosses	59	6.10	58.91**	1201.42**	12.77	35.33**	45.01	2.61**	219.66**	72.35
Females	2	2.23	305.76**	120.61	48.59**	101.31**	36.52	3.03**	2425.36**	61.71
Males	19	10.05	77.71**	1608.11**	14.52	31.65*	46.89	4.03**	199.52**	69.82
Females x Males	38	4.33	36.52**	1054.96**	10.01	33.70*	44.52	1.88**	113.64**	74.18
Error	59	8.39	7.46	65.66	11.4	18.56	43.05	0.37	18.63	50.79
GCA vs SCA (Baker,1978)		0.83	0.93	0.76	0.88	0.83	0.74	0.85	0.96	0.74

*Siginificant at 5%, ** Siginificant at 1%

Note: 1. Days to 50% flowering 2. Plant height (cm) 3. Number of capsules per plant, 4. Number of branches per plant 5. Days to maturity 6. 1000 seed weight (g) 7. Seed yield per plant 8. Budfly incidence (%) and 9. *Alternaria* blight (%)

Kartika x Eita, Kartika x BR-1, Padmini x EC9825, PKV NL260 x GS15, Padmini x EC4168, (92.00, 92.00, 93.00, 93.00, 93.00, 94.00 and 94.00 days, respectively). The cross (Kartika x A95B) matured late in 112.00 days.

Number of branches per plant

Among the parents, number of branches per plant ranged from 2.50 to 7.15. High mean performance for this trait was recorded by GS-15 (7.15) followed by JRF5 (7.05) ES44 (6.95), LCK8605 (6.00), Neelum (6.00) and LCK-88062 (5.40) and low mean performance for this trait was recorded by BR1 (2.50). Among sixty crosses, number of branches per plant ranged from 4.70 (PKV NL-260 x BR-1) to 9.75 (Padmini x GS234). The crosses Padmini x LCK88062 (9.08), Padmini x EC4168 (9.00), Padmini x GS15 (8.90), Padmini x EC9825 (8.90) Padmini x ES44 (8.80), Kartika x EC9825 (8.15) and Padmini x KL178 (8.15) also showed high mean performance for this character.

Seed yield per plant (g)

Mean value for seed yield per plant ranged from 1.11g to 3.15g. The maximum yield was recorded by the parent LCK8605 (3.15 g), where as Neelum (1.11g) was the low yielding parent. High yielding crosses were Padmini x LCK8605 (6.04 g), PKV NL-260 x Eita (5.90) Kartika x LCK8605 (5.60), Padmini x GS15 (5.48 g), PKV NL-260 x A125 (5.32 g), PKV NL-260 x EC9825 (5.14 g), Kartika x Eita (5.14 g), Padmini x Ayogi (5.13 g), Kartika x ACC No-4/47 (5.16 g), Padmini X JRF5 (5.05 g) and Padmini x A125 (5.00 g),while the low yielding cross was observed to be PKV NL-260 x A95B (1.58g).

Screening of parents and F_1s for resistance against budfly (*Dasyneura lini*) infestation (%) *in vivo*

The parents exhibiting the greater degree of resistance to budfly were EC544 (11.39), Padmini (14.35), EC9825 (15.94), EC4168 (15.68), PKV NL-260 (16.29), JRF5 (16.64), A125 (17.47), while the parent ES-44 (59.54) exhibited more susceptibility to bud fly. Among the crosses bud fly damage ranged from 9.65% (Padmini x Ayogi) to 56.38% (Kartika x Neelum). The cross exhibiting greater amount of bud fly resistance was Padmini x Ayogi (9.65) followed by Padmini x EC4168 (9.77), Padmini x EC544 (11.63), Padmini x Neelum (12.55), PKV NL-260 x PKDL18 (13.75), Padmini x EC1392 (14.71), PKV NL-260 x LCK8605 (15.00), Padmini x PKDL18 (15.23), Padmini x Eita (15.79) and PKV NL-260 x KL178 (16.37).

Screening of parents and F_1s for resistance against *Alternaria* blight (*Alternaria lini*) infestation (%) *in vivo*

Alternaria blight incidence ranged from 5.34 to 17.68 among the parents. The parents that showed least infestation of *Alternaria* blight was Neelum (5.34), EC1392 (5.70), EC9825 (6.72) and KL178 (6.83). The crosses that showed the least infestation of altenaria blight was PKVNL-260 X EC9825 (5.08). The other crosses showing resistance to *Alternaria* blight were Padmini x EC1424 (5.15), Padmini x EC4168 (5.27), Kartika x EC9825 (5.56). Padmini x ACCNo-4/47 (23.87) was the most susceptible to *Alternaria* blight.

Screening of parents and F_1s for resistance against powdery mildew (*Oidium lini*) *in vivo*

Each plant was scored visually in the field and plants were rated in 0-5 scale as showed in Table 3. Based on visual score of disease incidence the mean score was determined (Anonymous, 2004). Powdery mildew score ranged from 0 (free) to 5 (highly susceptibile). It was observed that female parent PKV NL-260 and male parents PKDL-18, KL178, LCK 8605 and A125 were resistant to powdery mildew. Neelum showed high susceptibility to powdery mildew. Among sixty crosses, eight crosses exhibited free reaction to powdery mildew *viz.*, Kartika x Ayogi, Kartika x EC4168, Kartika x EC9825, PKVNL-260 x EC4168, PKVNL 260 x Ayogi, Padmini x Ayogi, PKVNL 260 x ACCNo-4/47 and Padmini x ACCNo-4/47. Eight crosses fall under resistant group here Kartika x EC1424, Kartika x KL178, PKV NL – 260 x A-125, PKV NL-260 x ES44, PKV NL-260 x JRF5, PKVNL260 x BR1, Padmini x A95B and Padmini x JRF5. Twenty three crosses were categorized as moderately resistant *viz*., Kartika x A95B, Kartika x A125, Kartika x Eita, Kartika x EC1392, Kartika x PKDL-18, Kartika x JRF5, Kartika x B1, Kakrtika x ACC No. 447, PKVNL-260 x GS15, PKV NL-260 x EC1392, PKV NL260 x KL178, PKV NL260 x PKDL18, PKV NL260 x EC544, Padmini x EC1424, Padmini x GS-234, Padmini x A125, Padmini x EC1392, Padmini x PKDL18, Padmini x EC9825, Padmini x EC544, Padmini x BR1, Padmini x KL178, and Padmini x GS15. Seventeen crosses were belonging to moderately susceptible group *viz.*, Kartika x GS234, Kartika x GS15, Kartika x EC544, Kartika x LCK8605, Kartika x LCK88062, PKV NL260 x A95B, PKV NL260 x GS234, PKV NL260 x Eita, PKV NL260 x EC9825, LCK88062, NL260 x LCK8608, PKV NL-260 x LCK88062, PKVNL-260 x Neelum, Padmini x Eita, Padmini x ES44, Padmini x EC4168, Padmini x LCK 8605 and Padmini x LCK-88062.

Table.2 Mean performance of parents and their crosses

Characters	I	II	III	IV	V	VI	VII	VIII	IX	X
Females										
A	69.00	45.50	47.40	5.00	103.00	5.29	1.85	37.82	6.84	MR
B	58.00	41.60	40.20	3.20	96.00	6.18	2.19	16.29	13.58	R
C	59.50	39.00	47.60	4.10	102.00	6.63	1.98	14.35	10.92	MR
Males										
1. A-95-B	68.50	52.20	32.30	3.60	111.00	4.58	1.59	26.57	10.95	MS
2. EC14-24	62.50	29.70	35.20	5.10	99.00	4.55	1.24	36.87	9.91	MS
3. GS-234	62.00	44.15	28.80	4.05	102.00	6.73	1.22	23.09	17.18	MR
4. A-125	61.50	46.95	39.35	3.50	96.00	6.07	1.67	17.47	14.79	R
5. Eita	62.00	43.30	26.90	4.00	102.00	5.79	1.60	23.94	15.64	MR
6. GS-15	67.00	44.60	69.90	7.15	106.00	5.46	2.73	33.98	15.50	MR
7. EC1392	60.50	49.45	26.00	3.50	99.00	8.39	1.17	24.47	5.70	MR
8.PKDL-18	67.50	60.00	32.50	3.90	107.00	6.43	1.34	34.68	13.71	MS
9.Ayogi	61.00	40.05	37.20	4.90	102.00	7.75	2.05	24.89	9.27	R
10.ES-44	66.50	48.40	53.45	6.95	107.00	5.50	1.79	59.54	17.68	MR
11.EC4168	63.00	51.10	37.90	4.30	102.00	4.28	1.59	15.60	10.27	F
12. EC9825	58.50	47.15	42.08	3.60	100.00	6.08	1.81	15.94	6.72	MS
13. EC544	58.00	44.60	33.12	4.07	96.00	5.99	1.46	11.39	12.74	MS
14. KL-178	68.00	42.93	36.60	4.93	107.00	5.74	1.33	35.17	6.83	R
15. JRF-5	70.50	53.00	40.20	7.05	115.00	4.31	1.20	16.64	10.60	MS
16. LCK-8605	62.50	44.80	79.00	6.00	117.00	5.83	3.15	24.17	9.90	R
17. BR-1	62.00	40.10	24.60	2.50	98.00	6.94	1.32	20.46	15.18	S
18.ACC NO4-47	69.50	41.05	48.00	4.05	108.00	6.19	2.05	41.07	16.02	F
19.LCK-88062	67.00	40.65	25.10	5.40	106.00	8.01	1.14	39.29	13.39	MR
20.Neelum	64.00	42.45	40.10	6.00	105.00	4.02	1.11	28.43	5.34	HS
Crosses										
A X 1	60.50	44.45	88.10	6.70	112.00	6.59	2.56	47.90	6.73	MR
A X 2	58.00	42.95	109.10	8.00	96.00	6.55	2.83	30.53	7.48	R
A X 3	59.00	51.90	62.40	5.80	96.00	4.66	2.26	41.33	9.93	MS
A X 4	59.00	47.10	58.60	6.00	97.00	6.43	2.82	27.40	11.57	MR
A x 5	58.00	39.98	126.40	7.28	93.00	6.50	5.14	34.16	10.43	MR
A X 6	59.00	49.20	69.05	5.65	97.00	7.28	3.00	36.39	14.06	MS
A x 7	62.00	45.90	74.00	7.40	97.00	7.49	3.79	30.93	7.67	MR
A X 8	59.00	52.80	73.50	5.70	99.00	6.44	3.47	37.11	11.39	MR
A X 9	60.00	40.80	73.30	4.70	96.00	8.77	2.94	21.30	10.92	F
A X 10	61.00	44.00	87.10	6.60	98.00	5.52	3.03	43.37	11.54	S
A X 11	61.00	58.90	134.60	7.85	100.00	6.52	4.64	40.56	11.85	F
A X 12	58.00	45.15	91.80	8.15	100.00	7.98	2.63	31.53	5.56	F
A X 13	57.50	49.35	78.60	6.80	103.00	6.67	3.47	31.10	8.71	MS
A X 14	62.00	44.30	72.05	6.75	95.00	6.26	3.05	46.84	8.46	R
A X 15	61.50	49.65	106.40	5.10	103.00	5.73	3.87	20.12	7.47	MR
A X 16	58.50	47.85	107.20	5.50	103.00	5.81	5.60	27.80	13.33	MS
A X 17	58.50	42.05	95.60	7.30	93.00	7.18	3.47	31.43	15.69	MR

A X 18	59.00	44.65	109.70	6.40	99.00	6.75	5.10	26.4	11.87	MR
A X 19	60.50	43.50	94.50	8.75	100.00	6.72	2.77	44.69	13.08	MS
A X 20	60.50	43.68	116.80	6.95	102.00	5.62	2.29	56.38	10.62	HS
B X 1	60.00	40.60	57.80	7.20	100.00	7.40	1.57	31.23	11.01	MS
B X 2	60.50	32.40	90.40	5.40	98.00	7.79	2.91	39.88	11.33	S
B X 3	61.00	40.30	73.08	5.73	98.00	7.53	2.14	25.57	13.18	MS
B X 4	59.50	44.45	91.90	6.20	97.00	7.95	5.32	21.70	10.73	R
B x 5	59.00	47.50	120.90	7.20	97.00	6.31	5.90	24.60	9.14	MS
B X 6	56.50	45.80	132.50	5.70	94.00	7.65	4.61	18.97	11.01	MR
B x 7	63.00	41.45	63.50	6.45	103.00	6.40	2.00	22.89	9.21	MR
B X 8	62.00	52.50	114.30	7.15	95.00	6.76	4.09	13.75	8.47	MR
B X 9	58.00	33.75	66.00	4.95	99.00	6.11	3.05	27.15	10.38	F
B X 10	60.50	49.05	106.50	6.30	97.00	6.38	3.86	20.30	11.77	R
B X 11	59.50	42.80	113.60	8.00	95.00	6.86	2.93	25.82	8.41	F
B X 12	60.50	40.90	136.50	7.40	95.00	7.27	5.14	21.19	5.08	MS
B X 13	58.50	48.20	78.50	4.90	95.00	6.16	3.17	21.29	13.49	MR
B X 14	61.50	47.12	104.90	5.80	98.00	6.83	4.48	16.37	9.86	MR
B X 15	61.00	42.30	95.50	5.80	97.00	6.47	3.75	18.89	9.90	R
B X 16	58.50	41.30	92.00	5.50	95.00	6.84	4.06	15.00	11.43	MR
B X 17	60.00	34.08	74.65	4.70	95.00	8.06	2.67	31.99	8.35	R
B X 18	61.00	43.90	88.00	5.38	99.00	7.04	3.36	26.09	7.82	F
B X 19	60.00	44.50	40.20	7.50	91.00	8.64	1.58	41.18	12.50	MS
B X 20	59.00	43.15	84.60	6.40	101.00	6.16	2.19	38.75	6.30	MS
C X 1	59.00	37.80	84.80	7.10	102.00	6.69	2.57	29.35	9.95	R
C X2	56.00	35.15	112.50	7.70	91.00	6.57	4.13	19.00	5.15	MR
C X 3	56.50	44.10	135.20	9.75	99.00	6.98	4.38	24.39	11.88	MR
C X 4	57.00	41.25	109.60	7.30	101.00	6.10	5.00	18.01	11.13	MR
C x 5	61.00	39.50	105.60	7.80	95.00	6.58	3.78	15.79	10.55	MR
C X 6	56.50	40.05	122.30	8.90	95.00	7.58	5.48	18.04	10.71	MR
C x 7	59.00	42.55	75.60	5.90	91.00	6.88	3.43	14.71	12.33	MR
C X 8	59.00	43.98	81.48	6.93	96.00	5.41	3.54	15.23	9.20	MR
C X 9	60.00	41.85	113.40	7.50	98.00	8.23	5.13	9.65	8.56	F
C X 10	59.50	47.20	102.40	8.80	98.00	6.32	4.48	18.75	10.09	MS
C X 11	60.00	42.45	142.80	9.00	94.00	6.57	4.68	9.77	5.27	MS
C X 12	61.50	33.25	89.50	8.90	93.00	7.26	2.95	17.86	7.28	MR
C X 13	61.50	43.70	92.00	7.15	97.00	7.19	3.93	11.63	10.78	MR
C X 14	63.50	43.90	88.00	8.15	97.00	5.15	3.48	24.38	10.86	MR
C X 15	61.50	42.45	104.70	6.95	96.00	6.39	5.05	25.02	5.60	R
C X 16	58.00	48.75	113.20	5.50	92.00	6.78	6.04	28.11	17.77	MS
C X 17	60.50	40.20	62.90	5.10	96.00	7.88	2.80	26.85	7.94	MR
C X 18	58.00	27.75	31.00	5.25	99.00	6.54	1.69	31.02	23.87	F
C X 19	63.50	40.60	76.67	9.08	103.00	6.96	2.60	36.87	11.24	MS
C X 20	57.00	35.50	61.40	5.20	92.00	4.14	2.16	12.55	8.21	HS
S.E. (m) ±	2.04	1.84	4.83	0.32	2.94	0.23	0.39	2.88	1.11	
C.D. 5%	5.74	5.19	13.60	0.89	8.27	0.66	1.11	8.10	3.11	
C.V%	4.75	5.97	8.76	7.24	4.20	5.06	18.31	15.09	14.67	

Note: A= Karthika, B= NL-260, C= Padmini. 1. Days to 50% flowering 2. Plant height (cm) 3. Number of capsules per plant 4. Number of branches per plant 5. Days to maturity 6. 1000 seed weight (g) 7. Seed yield per plant 8. Budfly incidence (%) and 9. *Alternaria* blight (%) and 10. Powdery mildew

Table.3 Scale adapted to indicate degree of resistance against powdery mildew

	Score	Bud infection	Susceptiblity	Disease reaction
0	=	0%	Immune	Free
1	=	0-10%	Resistant	R
2	=	10.1-25%	Medium resistant	MR
3	=	25.1-50%	Medium Susceptible	MS
4	=	50.1-75%	Susceptible	S
5	=	Above 75%	Highly susceptible	HS

Table.4 Estimation of heritability, genetic advance, mean and genetic advance as percent of mean for nine characters in linseed (*Linum usitatissimum* L.)

Character	Heritability (h^2) narrow sense	Genetic advance	Grand mean	Genetic advance as per cent of mean
Days to 50% flowering	8.86	0.20	60.83	0.32
Plant height (cm)	51.56	5.30	43.72	12.12
No of primary branches	66.68	1.40	6.17	22.69
No of capsule per plant	21.88	5.00	78.08	6.41
Days to maturity	19.00	1.53	98.92	1.54
1000 seed weight (g)	68.30	1.02	4.52	22.56
Seed yield per plant	61.83	0.65	3.05	21.31
Budfly incidence (%)	66.16	17.52	26.97	64.96
Alternaria blight incidence(%)	11.14	0.71	10.66	6.66

Only two crosses were grouped as susceptible to powdery mildew *viz.*, Kartika x ES44, PKVNL-260 x EC1424. Two crosses *viz.*, Padmini x Neelum and Kartika x Neelum were categorized as highly susceptable. These promising parents and crosses may be utilized in linseed breeding programme on the basis of per se performance.

The per se performance of crosses give only indication of usefulness in selecting potential crosses but their long term potentialities are not known. Hence, selection of superior parents which has potential to produce superior cross combination and identifying best cross combination on the basis of combining ability which give required information in the absence of knowledge of genetic base of continuously varying characters.

Heritability (in narrow sense), genetic advance and genetic advance as per cent of mean for all the five characters under study have been worked out and results were presented in Table 1. The results revealed that value of heritability was highest for 1000 seed weight (68.30) followed by number of primary branches

(66.68), budfly incidence (66.16), seed yield per plant (61.83), plant height (51.56), number of capsule per plant (21.88), days to maturity (19.00), *Alternaria* blight incidence (11.14), and days to 50% flowering (8.86). As per classification heritability was high (>60%) for 1000 seed weight, number of primary branches, budfly incidence, seed yield per plant, medium (>30-60) for Plant height (cm), No of primary branches and low (<30) for days to 50% flowering, number of capsule per plant, *Alternaria* blight incidence (%) and days to maturity. Similar results were found by Tewari and Nalini, (1999) and Kumar *et al*., (2012). High heritability for 1000 seed weight, number of primary branches, budfly incidence, seed yield per plant indicated that portion of total variability was due to additive gene action. However, heritability is a property not only of a character but also of the population and environmental circumstances to which the individuals are exposed. Hence, recent trend lays more emphasis on the evaluation of genetic advance besides heritability. The order to ascertain the relative merit of different attributes, genetic advance in per cent of mean was also estimated for nine characters (Table 4).

The genetic advance in a trait is a product of the heritability and selection differential expressed in terms of phenotypic standard deviation of the trait concerned. For comparison of the different attributes, it is better to express it as a percentage of mean. Heritability values in conjunction with selection differential are more effective as they indicate the expected genetic gain resulting from selection. In view of Hanson (1963), heritability and genetic advance are two complementary concepts. GA ranged from 0.32 per cent for days to 50% flowering to 64.96 per cent for budfly incidence (%). Genetic advance was high (>20%) for budfly incidence (62.96), number of primary branches (22.69), 1000 seed weight (22.56) and seed yield per plant (21.31). Genetic advance was moderate (10-20%) for plant height (12.12) and low (<10%) for *Alternaria* blight incidence (6.66), number of capsules per plant (6.41), days to maturity (1.54) and days to 50% flowering (0.32). The estimates of heritability alone fail to indicate the response to selection (Johnson *et al*., 1955). Therefore, the heritability estimates appear to be more meaningful when accompanied by estimates of genetic advance. High heritability (>60%) combined with high genetic advance (>20%) was observed for budfly incidence, number of primary branches, 1000 seed weight and seed yield per plant. High genetic advance coupled with high heritability indicating that additive gene action is involved in the inheritance of these characters and thus, simple direct selection based on phenotypic performance of these traits would be more effective. These results are in agreement with those of Ramakant *et al*., (2005); Rai *et al*., (2000; Yadav and Gupta (1999).

The results revealed that the pest and diseases for parents ranged from11.39 (EC544) to 59.54 (ES44) and 5.34 (Neelum) to 17.68 (ES44) for bud fly and *Alternaria* blight. Among the hybrids Padmini x Ayogi and PKVNL-260 X EC9825 were found to be resistant to budfly infestation and *Alternaria* infestation. PKVNL260, PKDL18, KL178, LCK8605, A125, Karthika x Ayogi, Padmini x Ayogi, PKVNL260 x ACC NO4/47 and Padmini x ACC NO4/47 were found to be resistant to powdery mildew. Heredity and expected genetic advance

estimates were high for number of primary branches, 1000 seed weight, seed yield per plant and budfly incidence. High genetic advance coupled with high heritability indicating that additive gene action is involved in the inheritance of these characters and thus, simple direct selection based on phenotypic performance of these traits would be more effective.

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