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Research Article

Genetics of qualitative traits in linseed (*Linum usitatissimum* L.)

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Abstract
The genetics of inheritance of traits and their nature is important for selection of proper breeding strategy for the improvement of valuable traits of interest in linseed. The inheritance pattern of qualitative traits was studied in F_2 generation for a cross between RLC-95 x Indira alsi-32 and Surabhi x RLC-92. Their gene interaction ratios were worked out using chi-square test. The chi-square ratio of 3:1 was obtained for flower colour, growth habit and dehiscence for both the crosses representing the typical monohybrid ratio and that for shape of corolla and anther colour for both the crosses was 9:3:4 reflecting the presence of supplementary gene action for these characters. A chi-square ratio of 9:6:1 was obtained for flower aestivation for both the crosses signifying polymeric gene action. The chi-square ratio had a difference among both the populations for capsule size showing a ratio of 9:6:1 for first population derived from the cross RLC-95 x Indira alsi-32 indicating polymeric gene action and a ratio of 1:2:1 for second population derived from the cross Surabhi x RLC-92. Flower venation showed a ratio of 9:3:4 for first population (RLC-95 x Indira alsi-32) indicating supplementary gene action and a ratio of 12:3:1 for second population (Surabhi x RLC-92) indicating masking gene action.

Key words
Linseed, genetics, gene action, chi-square

Introduction

Linseed (*Linum usitatissimum* L.) 2n = 30, is an important oilseed crop that belongs to the genus *Linum* of the family Linaceae. It is also called flax or flaxseed. The crop is predominantly self pollinated, but out crossing (less than 2%) occasionally results from insect activity (Dilman, 1928).

The productivity of linseed can be increased upto 20-25% by good quality seed production of improved varieties. To develop new improved varieties of linseed the genetics of inheritance of traits and their nature is important for selection of proper breeding strategy for the improvement of valuable traits of interest in linseed. The different types of gene interactions were identified in various agronomic qualitative traits in linseed.

Material and Methods

The experimental materials used in the research work obtained from AICRP on linseed, Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidhyalaya, Raipur which comprised of 200 plants of F_2 population each of the two crosses *viz.,* RLC-95 x Indira alsi 32 and Surabhi x RLC-92.

The experiment was laid out at the Research cum Instructional Farm, College of Agriculture, IGKV, Raipur during *Rabi* 2014-15. The 200 F_2 single plant selection entries were sown in one row each of 3 m length with spacing of 30 cm between rows and 10 cm approximately between the plants. The recommended packages of practices were followed for raising a healthy crop. Eight characters under this study includes flower colour, growth habit, flower aestivation, shape of corolla, flower venation, anther colour, capsule size and capsule dehiscence.

Results and Discussion

The qualitative traits are the classical Mendelian traits of kinds like colour, form, structure, *etc.* governed by one or a few major genes. A qualitative trait is expressed qualitatively, which means that the phenotype falls into different categories. These categories do not necessarily have a certain order. Each qualitative trait may be under genetic control of two or many alleles of a single gene with little or no environmental modifications to obscure the gene effects. The organisms possessing qualitative traits have distinct (separate) or discrete phenotypic classes and are said to exhibit discontinuous variations. Traits of this type are termed highly heritable. Not much work has been reported in the past regarding such gene action study for qualitative traits in linseed or similar crops. The inheritance pattern of qualitative traits of linseed with a cross of RLC-95 x Indira alsi-32 and Surabhi x RLC-92 are presented and discussed in traits as under.

Genetics of flower colour in Linseed: In the present experiment linseed variety RLC-95 and Surabhi had white flowers, while variety Indira alsi-32 and RLC-92 had blue flowers. Segregation pattern of flower colour (blue and white) was studied in F_2 population of two crosses listed in table 1. Calculated value of chi-square was being less than table value, indicated fitness of monohybrid ratio (3:1). Results further showed that blue flower colour is dominant in nature and is governed by a single dominant gene (Sood *et al.,* 2012).

Genetics of plant growth habit: In a similar way, 200 F_2 segregating population of linseed was studied for plant growth habit in the two crosses presented in the following table 2. Results showed that calculated value of chi-square being less than table value, indicated fitness of monohybrid ratio (3:1) which observed that semi-erect growth habit is dominant in nature than erect habit and is governed by a single dominant gene in the given crosses.

Genetics of flower aestivation: In case of flower aestivation the **s**egregation pattern was studied in 200 F_2 plants of each of the two crosses as listed in table 3. Result showed that the calculated value of chi-square being less than table value, indicated fitness of null hypothesis in the ratio 9:6:1 which showed that flower aestivation in the given crosses is governed by polymeric gene action.

Genetics of Flower: Shape of corolla: Two hundred plants from F_2 population of two crosses listed below were studied for Flower: Shape of corolla as presented in the table 4. Results showed that calculated value of chi-square being less than table value, indicated fitness of null hypothesis in the ratio 9:3:4 which reflect that flower: shape of corolla in the given crosses is governed by Supplementary gene action (Sood *et. al.* 2009).

Genetics of venation colour: Segregation pattern of venation colour was studied in F_2 population of two crosses are presented in table 5. Result showed that the calculated value of chi-square being less than table value, indicated fitness of null hypothesis in the ratio 9:3:4 in Cross 1 (RLC-95 x IA-32) and 12:3:1 in Cross 2 (Surabhi x RLC-92). Result showed that Venation colour in Cross 1 (RLC-95 x IA-32) is governed by supplementary gene action and the venation colour in Cross 2 (Surabhi x RLC-92) is governed by masking gene action.

Genetics of Anther colour: In case of anther colour the **s**egregation pattern was studied in 200 F_2 plants of each of the two crosses as presented in table 6. In case of anther colour, calculated value of chi-square being less than table value, indicated fitness of null hypothesis in the ratio 9:3:4 which showed that supplementary gene action governs anther colour in the given crosses

Genetics of capsule size: In table 7, segregation pattern of capsule size was studied in F_2 population for 200 plants of the two crosses. In case of capsule size in linseed the value of chi-square being less than table value, indicated fitness of null hypothesis in the ratio 9:6:1 in Cross no.1 (RLC-95 x IA-32) and 1:2:1 in Cross no.2 (Surabhi x RLC-92). Result showed that capsule size in Cross no.1 (RLC-95 x IA-32) is governed by polymeric gene action and the capsule size in Cross no.2 (Surabhi x RLC-92) is governed by single dominant gene.

Genetics of capsule dehiscence: The F_2 population consisting of 200 plants from the two crosses were studied for capsule dehiscence and the results presented in table 8. Result showed that the calculated value of chi-square being less than table value indicating fitness of monohybrid ratio (3:1) for capsule dehiscence. Further it can be seen here that non-dehiscent type capsule is dominant in nature over semi-dehiscent type and is governed by a single dominant gene.

Conclusion

The inheritance of qualitative traits in F_2 segregating generation of a cross between RLC-95 x Indira alsi-32 and Surabhi x RLC-92, the chi-square ratio of 3:1 was obtained for flower colour, growth habit and dehiscence for both the crosses representing the typical monohybrid ratio. A chi-square ratio of 9:3:4 was obtained for shape of corolla and anther colour for both the crosses reflecting the presence of supplementary gene action. In case of flower aestivation, chi-square ratio of 9:6:1 was obtained for both the crosses signifying polymeric gene action. The chi-square ratio had a difference among both the populations for capsule size showing a ratio of 9:6:1 for first population derived from the cross RLC-95 x Indira alsi-32 -32 indicating polymeric gene action and a ratio of 1:2:1 for second population derived from the cross Surabhi x RLC-92 indicating incomplete dominance. Similarly for flower venation, a ratio of 9:3:4 was found for first population derived from the cross RLC-95 x Indira alsi-32 indicating supplementary gene action and a ratio of 12:3:1 for second population derived from the cross Surabhi x RLC-92 indicating masking gene action.

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Table 1. Fitness of monohybrid ratio for flower colour in F_2 populations of two crosses

Flower Colour	Observed Frequency (O)	Ratio	Expected Frequency (E)	(O-E)=d	d^2	$\chi^2 = d^2/E$
RLC-95 x IA-32						
Blue	148	3	150	-2	4	0.03
White	52	1	50	2	4	0.08
Total	200	4	200	0		0.11
Surabhi x RLC-92						
Blue	158	3	150	8	64	0.43
White	42	1	50	-8	64	1.28
Total	200	4	200	0		1.71

Table value of chi-square (χ^2 = 3.84) at 5% level of significance at 1 degree of freedom

Table 2. Fitness of monohybrid ratio for growth habit in F_2 populations of two crosses

Growth habit	Observed Frequency (O)	Ratio	Expected Frequency (E)	(O-E)=d	d^2	$\chi^2 = d^2/E$
RLC-95 x IA-32						
Semi Erect	160	3	150	10	100	0.67
Erect	40	1	50	-10	100	2.00
Total	200	4		0		2.67
Surabhi x RLC-92						
Semi Erect	156	3	150	6	36	0.24
Erect	44	1	50	-6	36	0.72
Total	200	4		0		0.96

Table value of chi-square (χ^2 = 3.84) at 5% level of significance at 1 degree of freedom

Table 3. Fitness of di-hybrid ratio for flower aestivation in F_2 populations of two crosses

Flower aestivation	Observed Frequency (O)	Ratio	Expected Frequency (E)	(O-E)=d	d^2	$\chi^2 = d^2/E$
RLC-95 x IA-32						
Semi-twisted	129	9	112.5	16.5	272.25	2.42
Twisted	8	1	12.5	-4.5	20.25	1.62
Valvate	63	6	75.0	-12.0	144	1.92
Total	200	16				5.96
Surabhi x RLC-92						
Semi-twisted	125	9	112.5	12.5	156.25	1.39
Twisted	12	1	12.5	-0.5	0.25	0.02
Valvate	63	6	75.0	-12.0	144	1.92
Total	200	16				3.33

Table value of chi-square (χ^2 = 5.99) at 5% level of significance on 2 degree of freedom

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Table 4. Fitness of di-hybrid ratio for flower: Shape of corolla in F_2 populations of two crosses

Flower: Shape of corolla	Observed Frequency (O)	Ratio	Expected Frequency (E)	(O-E)=d	d^2	$\chi^2 = d^2/E$
RLC-95 x IA-32						
Funnel	121	9	112.5	8.5	72.25	0.64
Disc	36	3	37.5	-1.5	2.25	0.06
Star	43	4	50.0	-7.0	49.00	0.98
Total	200	16				1.68
Surabhi x RLC-92						
Funnel	126	9	112.5	13.5	182.25	1.62
Disc	37	3	37.5	-0.5	0.25	0.01
Star	37	4	50.0	-13.0	169.00	3.38
Total	200	16				5.01

Table value of chi-square (χ^2 = 5.99) at 5% level of significance on 2 degree of freedom

Table 5. Fitness of di-hybrid ratio for venation colour in F_2 populations of two crosses

Venation colour	Observed Frequency (O)	Ratio	Expected Frequency (E)	(O-E)=d	d^2	$\chi^2 = d^2/E$
RLC-95 x IA-32						
Violet	121	9	112.5	8.5	72.25	0.64
White	27	3	37.5	-10.5	110.25	2.94
Light violet	52	4	50.0	2.0	4.00	0.08
Total	200	16				3.66
Surabhi x RLC-92						
Violet	142	12	150.0	-8.0	64.00	0.43
White	42	3	37.5	4.5	20.25	0.54
Light violet	16	1	12.5	3.5	12.25	0.98
Total	200	16				1.95

Table value of chi-square (χ^2 = 5.99) at 5% level of significance on 2 degree of freedom

Table 6. Fitness of di-hybrid ratio for anther colour in F_2 populations of two crosses

Anther colour	Observed Frequency (O)	Ratio	Expected Frequency (E)	(O-E)=d	d^2	$\chi^2 = d^2/E$
RLC-95 x IA-32						
Grey	115	9	112.5	2.5	6.25	0.06
Blue	33	3	37.5	-4.5	20.25	0.54
Cream	52	4	50.0	2.0	4.00	0.08
Total	200	16				0.68
Surabhi x RLC-92						
Grey	118	9	112.5	5.5	30.25	0.27
Cream	38	3	37.5	0.5	0.25	0.01
Blue	44	4	50.0	-6.0	36.00	0.72
Total	200	16				1.00

Table value of chi-square (χ^2 = 5.99) at 5% level of significance on 2 degree of freedom

Table 7. Fitness of di-hybrid ratio for capsule size in F_2 populations of two crosses

Capsule size	Observed Frequency (O)	Ratio	Expected Frequency (E)	(O-E)=d	d^2	$\chi^2 = d^2/E$
RLC-95 x IA-32						
Bold	117	9	112.5	4.5	20.25	0.18
Medium	66	6	75.0	-9.0	81.00	1.08
Small	17	1	12.5	4.5	20.25	1.62
Total	200	16				2.88
Surabhi x RLC-92						
Bold	59	1	50.0	9.0	81.00	1.62
Medium	90	2	100.0	-10.0	100.00	1.00
Small	51	1	50.0	1.0	1.00	0.02
Total	200	4				2.64

Table value of chi-square (χ^2 = 5.99) at 5% level of significance on 2 degree of freedom

Table 8. Fitness of monohybrid ratio for capsule type in F_2 populations of two crosses

Capsule type	Observed Frequency (O)	Ratio	Expected Frequency (E)	(O-E)=d	d^2	$\chi^2 = d^2/E$
RLC-95 x IA-32						
Non-dehiscent	153	3	150	3	9	0.06
Semi-dehiscent	47	1	50	-3	9	0.18
Total	200	4		0		0.24
Surabhi x RLC-92						
Non-dehiscent	143	3	150	-7	49	0.33
Semi-dehiscent	57	1	50	7	49	0.98
Total	200	4		0		1.31

Table value of chi-square (χ^2 = 3.84) at 5% level of significance on 1 degree of freedom