Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(4): 3033-3037
Received: 25-05-2019
Accepted: 27-06-2019

Aarti Sharma
Department of Genetics and Plant Breeding, Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, India

Satyendra Kumar
Department of Genetics and Plant Breeding, Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, India

MP Chauhan
Department of Genetics and Plant Breeding, Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, India

Correspondence
Aarti Sharma
Department of Genetics and Plant Breeding, Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, India

Simple & joint scaling tests for yield and yield attributing traits in linseed (*Linum usitatissimum* L.)

Aarti Sharma, Satyendra Kumar and MP Chauhan

Abstract
Simple and joint scaling tests done on four crosses following generation mean analysis unveiled presence of epistatic interaction hence hints fitness of digenetic interaction model for all the eleven characters in the four crosses. Duplicate type of epistasis was detected for number of secondary branches per plant, number of capsules per plant, number of seeds per capsule, biological yield per plant, harvest index and 1000-seed weight in cross I; days to 50% flowering, days to maturity, number of capsules per plant, biological yield per plant, harvest index, 1000-seed weight and seed yield per plant in cross II; number of primary branches per plant, number of secondary branches per plant, number of capsules per plant, number of seeds per capsule, biological yield, harvest index, 1000-seed weight and seed yield per plant in cross III; days to maturity, plant height, number of secondary branches per plant, number of seeds per capsule, biological yield per plant and 1000-seed weight in cross IV. While complementary type of epistasis was observed for plant height and number of primary branches per plant in cross I; plant height, number of secondary branches per plant and number of seeds per capsule in cross II; days to maturity and plant height in cross III.

Keywords: Simple scaling test, Joint scaling test, linseed

Introduction
Linseed (*Linum usitassimum* L.) belongs to the family Linaceae is an annual herbaceous plant. Linseed is grown either for fiber or oil. Linseed is not much in domestic use but it has substantial use in pharmaceutical, cosmetics and lubricant industries (Amit J. Jhala and Linda M. Hall, 2010). Thus versatile uses of linseed make it an important agro-industrial crop. In breeding programme, it is essential to have an idea of the nature and magnitude of genetic variability and to explore full range of variability in population for complex traits like yield, plant breeders favors the inter-mating approaches to elevate population mean and genetic variability. The simple scaling tests (Mather, 1949; Hayman and Mather, 1955) [5, 3] and joint scaling test (Cavalli, 1952) [2] followed by generation mean analysis (Jinks and Jones, 1958) [4] provide more precise assessment of variability by studying gene action and effects. Therefore study of simple and joint scaling tests were done for 11 metric traits of four crosses of linseed which directly or indirectly influences yield of linseed crop.

Materials and Methods
Simple and joint scaling tests were calculated for each of the six generations (P_1, P_2, F_1, F_2, BC_1, BC_2,) of four cross families *viz.*, Cross I, NDL- 2004-05 X GS-234, Cross II, NDL-2004-05 X A-95 B, Cross III, NDL2004-05 X TL-27, Cross IV, NDL- 2004-05 X TL-11 by generation mean analysis. The experimental materials were evaluated during *Rabi* season of 2013-14 at the research farm of Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Faizabad UP, in a compact family block design with three replications. The estimation of simple scaling tests were done by using Mather (1949), Hayman and Mather (1955) [5, 3] four scaling tests, namely, A, B, C, and D which are. The significant deviation of any one or more of these four scales from zero indicates presence of epistasis. Further, joint scaling test of Cavalli (1952) [2] gives more general, convenient adoptable and informative approach of any kind of generation used in estimation of the genetic parameters and to test goodness of fit. The analysis of variance for Compact Family Block Design (Panse, V. G. and P. V. Sukhatme, 1954) [7] for eleven characters of four crosses was done separately. Significance of data was tested by 'F' test.

Experimental Results
Cross I (NDL 2004-05 x GS-234)
In cross I (Table 1) all the four scales (A, B, C and D) were found highly significant for all characters except for days to 50% flowering.

Significance of one or more of the four scales of eleven characters suggested presence of non-allelic gene interactions and inadequacy of additive-dominance model. Significant chi-square values for, number of secondary branches per plant, number of capsules per plant, biological yield per plant and harvest index which indicated inadequacy of additive-dominance model or presence of epistasis. Non-significant chi-square value was found for days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of seeds per capsule, 1000-seed weight and seed yield per plant which revealed absence of epistasis and adequacy of additive-dominance model.

Table 1: Simple scaling tests of 11 metric traits of cross I (NDL2004-05 x GS-234)

Characters	A	B	C	D
Days to 50% flowering	-2.46** ±0.17	-0.70 ±0.60	-5.03** ±0.37	-0.93** ±0.31
Days to maturity	0.80** ±0.18	2.23** ±0.10	5.30** ±0.13	1.13** ±0.10
Plant height (cm)	-3.37** ±0.19	-3.40** ±0.12	-3.48** ±0.25	1.64** ±0.09
Number of primary branches per plant	-0.60** ±0.06	-1.33** ±0.60	-1.18** ±0.11	0.03 ±0.05
Number of secondary branches per plant	-1.10** ±0.10	-2.20** ±0.14	1.36** ±0.18	2.33** ±0.09
Number of capsules per plant	-3.13** ±0.14	-25.06** ±0.19	8.00** ±0.87	10.10** ±0.43
Number of seeds per capsule	-1.03** ±0.09	-1.23** ±0.12	0.73** ±0.25	1.50** ±0.11
Biological yield per plant (g)	0.62** ±0.10	-4.00** ±0.08	6.53** ±0.17	4.95** ±0.07
Harvest index (%)	-4.39** ±0.04	3.00** ±0.10	-19.9** ±0.06	-9.29** ±0.05
1000-seed weight (g)	0.58** ±0.06	-1.20** ±0.04	-0.37** ±0.07	0.12** ±0..04
Seed yield per plant (g)	-1.00** ±0.10	-1.17** ±0.05	-0.69** ±0.18	0.24** ±0.08

*,** Significant at 5% and 1% level of probability, respectively

Cross II (NDL 2004-05 x A- 95 B)

In cross II, table 2, all the four scales were found highly significant for days to 50% flowering, plant height, number of primary branches per plant, number of secondary branches per plant, number of capsules per plant, number of seeds per capsule, biological yield per plant, 1000-seed weight and seed yield per plant; A and C scales were significant for days to maturity; A, B and C scales were significant for harvest index. Thus, presence of non-allelic gene interaction and inadequacy of additive dominance model were revealed for eleven characters for which more than one scale was found significant. Significant chi-square values were observed for days to 50% flowering, days to maturity, number of primary branches per plant and 1000-seed weight, which indicated inadequacy of additive-dominance model or presence of epistasis. Non-significant chi-square value was found for plant height, number of secondary branches per plant, number of capsules per plant, number of seeds per capsule, biological yield per plant and harvest index, which revealed absence of epistasis and adequacy of additive-dominance model.

Table 2: Simple scaling tests of 11 metric traits in cross II (NDL2004-05 x A-95 B)

Characters	A	B	C	D
Days to 50% flowering	-2.27** ±0.12	-8.90** ±0.19	-3.96** ±0.28	3.60** ±0.15
Days to maturity	-1.00** ±0.17	-0.23 ±0.14	1.43** ±0.25	1.33** ±0.12
Plant height (cm)	-3.19** ±0.15	-1.93** ±0.14	-5.59** ±0.29	-0.23** ±0.08
Number of primary branches per plant	-0.96** ±0.08	-1.34** ±0.07	-3.30** ±0.12	-0.50** ±0.05
Number of secondary branches per plant	-2.03** ±0.15	-2.34** ±0.14	-2.96** ±0.25	0.70** ±0.07
Number of capsules per plant	-7.60** ±0.11	-1.80** ±0.20	-20.06** ±0.35	-5.33** ±0.17
Number of seeds per capsule	-1.23** ±0.09	-1.53** ±0.12	-4.36** ±0.07	-0.80** ±0.07
Biological yield per plant (g)	-1.04** ±0.09	-1.26** ±0.11	3.63** ±0.18	2.97** ±0.07
Harvest index (%)	-3.94** ±0.07	1.86** ±0.09	-1.95** ±015	0.06 ±0.07
1000-seed weight (g)	-1.56** ±0.06	-3.07** ±0.06	-0.31** ±0.09	2.16** ±0.05
Seed yield per plant (g)	-0.70** ±0.12	-0.72** ±0.10	1.26** ±0.17	1.38** ±0.09

*, ** Significant at 5% and 1% level of probability, respectively

Cross III (NDL 2004-05x TL- 27)

It is obvious from Table 3, that all the scales (A, B, C, and D) were significant for days to maturity, plant height, number of primary branches per plant, number of capsules per plant, biological yield per plant, harvest index and seed yield per plant; A, C and D scale were found significant for days to 50% flowering and number of secondary branches per plant; A, B and C scales were significant for number of seeds per capsule; A and D scales were significant for 1000-seed weight. Significance of one or more of the four scales for eleven characters revealed the existence of epistatic interactions and inadequacy of additive-dominance model. Significant values of chi-square were observed for days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of capsules per plant, biological yield per plant, harvest index and seed yield per plant which indicated the presence of epistasis and hence inadequacy of additive-dominance model. Days to 50% flowering, number of seeds per capsule, 1000-seed weight and oil content had non-significant chi-square values, which indicated adequacy of additive-dominance model i.e. absence of epistasis.

Table 3: Simple scaling tests of 11 metric traits in cross III (NDL2004-05 x TL-27)

Characters	A	B	C	D
Days to 50% flowering	-0.86* ±0.34	0.03 ±0.34	-2.70** ±0.24	-0.93** ±0.24
Days to maturity	-2.86** ±0.25	-2.26 0.14±	2.20** ±0.36	3.66** ±0.15
Plant height (cm)	-6.33** ±0.11	0.95** ±0.05	-5.86** ±0.14	-0.24** ±0.01
Number of primary branches per plant	-108** ±0.06	-0.76** ±0.02	-1.71 ±0.09	0.06* ±0.03
Number of secondary branches per plant	-1.36** ±0.08	-0.16 ±0.08	0.66** ±0.13	1.10** ±0.07
Number of capsules per plant	-28.83** ±0.08	-13.20** ±0.08	-31.84** ±0.24	5.10** ±0.10
Number of seeds per capsule	-0.60** ±0.09	-1.03** ±0.09	-1.50** ±0.17	0.67 ±0.03
Biological yield per plant (g)	-0.69** ±0.11	-1.42** ±0.10	1.71** ±0.34	1.91** ±0.14
Harvest index (%)	-2.78** ±0.03	-4.76** ±0.04	-15.64** ±0.13	-4.04** ±0.06
1000-seed weight (g)	-0.49** ±0.17	0.50 ±0.10	0.16 ±0.19	0.30** ±0.10
Seed yield per plant (g)	-1.38** ±0.04	-10.40** ±0.03	-1.91** ±0.07	0.25** ±0.03

*, ** Significant at 5% and 1% level of probability, respectively

Cross IV (NDL 2004-05 x TL-11)

In Table 4, all the four scales were found highly significant for days to maturity, plant height, number of secondary branches per plant, number of capsules per plant, number of seeds per capsule, biological yield per plant, harvest index and 1000-seed weight; A, B and D scales were found significant for days to 50% flowering; A, B and C scales were found significant for number of primary branches per plant and seed yield per plant. Significant chi-square values were observed for days to 50% flowering, days to maturity, plant height, number of secondary branches per plant, number of capsules per plant, biological yield per plant, harvest index and 1000-seed weight, while non-significant chi-square values were observed for number of primary branches per plant, number of seeds per capsule and seed yield per plant. Significant values of chi-square indicated the presence of epistasis and hence found inadequacy of additive-dominance model, while non-significant chi-square values, indicated adequacy of additive-dominance model i.e. absence of epistasis. In scaling test estimation, deviation from zero revealed that epistasis had a predominant role in expression of most of the characters. Simple and joint tests indicated presence of epistatic interaction and fitness of digenetic interaction model for all the eleven characters in the four crosses. Out of 44 cases covering characters of 4 crosses for which presence of epistasis was observed in all the four crosses. Both simple and joint scaling tests led to similar inferences in respect of presence or absence of epistasis in majority of cases for the eleven characters of four crosses. The presence of epistasis by simple scaling tests with absence of epistasis by joint scaling test was observed in 17 cases.

Table 4: Simple scaling tests of 11 metric traits in cross IV (NDL2004-05 x TL-11)

Characters	A	B	C	D
Days to 50% flowering	0.30* ±0.15	-1.10** ±0.19	-0.13 ±0.15	0.33** ±0.11
Days to maturity	-2.20** ±0.20	-1.23** ±0.20	1.36** ±0.41	2.40** ±0.13
Plant height (cm)	-0.34** ±0.07	0.81** ±0.09	-0.84** ±0.10	-0.66** ±0.04
Number of primary branches per plant	-0.67** ±0.03	-0.93** ±0.04	-1.36** ±0.12	0.10 ±0.05
Number of secondary branches per plant	0.50** ±0.14	-0.26** ±0.06	-1.83** ±0.13	-1.03** ±0.07

Number of capsules per plant	-8.60** ±0.30	-3.03** ±0.48	-15.56** ±0.67	-1.96** ±0.28
Number of seeds per capsule	-1.10** ±0.04	-1.26** ±0.68	-1.96** ±0.14	0.20** ±0.06
Biological yield per plant (g)	-0.16* ±0.06	0.45** ±0.16	-1.96** ±0.10	-1.13** ±0.08
Harvest index (%)	-4.83** ±0.09	-7.82** ±0.10	-4.49** ±0.17	4.08** ±0.02
1000-seed weight (g)	-0.41** ±0.04	-0.91** ±0.04	0.41** ±0.68	0.87** ±0.04
Seed yield per plant (g)	-0.63** ±0.10	-0.94** ±0.08	-1.57** ±0.13	0.00 ±0.05

*, ** Significant at 5% and 1% level of probability, respectively

Table 5: Joint scaling test for 11 characters in cross I-IV

Characters	Chi-square values			
	Cross I	**Cross II**	**Cross III**	**Cross IV**
Days to 50% flowering	1.170	57.542**	4.385	3.969*
Days to maturity	3.797	16.326**	6.301*	20.609**
Plant height (cm)	0.030	0.04	12.597**	88.443**
Number of primary branches per plant	0.325	15.573**	3.929*	3.459
Number of secondary branches per plant	42.663**	5.206	112.078**	26.382**
Number of capsules per plant	38.09**	6.225*	22.945**	25.591**
Number of seeds per capsule	0.974	0.001	3.647	0.636
Biological yield per plant (g)	30.445**	2.925	116.112**	14.397**
Harvest index (%)	27.927**	0.889	14.395**	68.951**
1000-seed weight (g)	8.577*	42.824**	2.084	6.913*
Seed yield per plant (g)	7.967*	0.995	42.275**	0.000

*, ** Significant at 5% and 1% level of probability, respectively

Conclusion

In case of simple scaling tests, significance of one or more of the four scales tests (A, B, C and D) for a character in a cross indicated presence of epistasis and inadequacy of additive-dominance model. In case of joint scaling test, the significant or highly significant chi-square values indicated the presence of epistasis and inadequacy of additive-dominance model. The results of simple and joint scaling tests in respect of eleven characters of four crosses are summarized in Table 6. For days to 50% flowering, simple as well as joint scaling tests detected presence of epistasis in cross II and IV. In cross I and III epistasis was shown only by simple scaling test. For days to maturity, simple as well as joint scaling tests detected presence of epistasis in crosses II, III and IV. In cross I epistasis was detected by only simple scaling test. Presence of non-allelic interactions for plant height was shown in cross III and IV by simple and joint scaling tests. In cross I and II showed epistasis only by simple scaling test. For number of primary branches per plant, simple scaling test revealed presence of epistasis in cross I and IV. Simple as well as joint scaling tests detected presence of epistasis in cross II and III. The simple as well as joint scaling tests indicated presence of epistasis for number of secondary branches per plant in cross I, III and IV. Only simple scaling tests showed presence of epistasis in cross II. For number of capsules per plant, both type of scaling tests indicated presence of epistasis in all the crosses I, II, III and IV. In case of number of seeds per capsule, only simple scaling test revealed presence of non-allelic interactions in all the four crosses I, II, III and IV. In case of biological yield per plant, consistent existence of non-allelic gene interactions was recorded by simple as well as joint scaling tests in cross I, III and IV. In cross II only simple scaling tests detected presence of epistasis. For harvest index, only simple scaling test detected presence of epistasis in cross II. Simple as well as joint scaling test showed presence of epistasis in cross I, III and IV. In case of 1000-seed weight, cross I, II and IV showed presence of epistasis by both simple as well as joint scaling tests. Cross III showed presence of epistasis by only by simple scaling test. For seed yield per plant, simple as well as joint scaling revealed presence of epistasis in cross I and III. In cross II and IV presence of epistasis was revealed only by simple scaling test. Significance of epistasis was detected by either one or both types of scaling tests in majority of crosses for all the eleven characters of linseed. Out of 44 cases, covering eleven characters of four crosses for which presence of epistasis was studied, in some cases absence of epistasis was also showed by one of the two scaling tests. Days to 50% flowering, days to maturity, plant height and number of primary branches per plant in cross I; plant height, number of secondary branches per plant, number of seeds per capsule, biological yield per plant, harvest index and seed yield per plant in cross II; days to 50% flowering, number of seeds per capsule and 1000-seed weight in cross III; number of primary branches per plant, number of seeds per capsule and seed yield per plant, showed absence of epistasis by joint scaling test in cross IV. Simple scaling test on other hand showed epistasis for all traits under study in all the four crosses. In 27 of 44 cases presence of epistasis was verified by both the tests. In 17 out of 44 cases, presence of epistasis was only detected by joint scaling test. Importance of epistasis in inheritance of yield cand yield attributing traits in linseed has been reported by the previous workers *viz.*, Narain *et al.*, (2009) and Rashid and Shrivastva, (2011) [6, 8].

Table 6: Summary of results of simple and joint scaling tests for eleven traits in cross I-IV

Characters	Cross I		Cross II		Cross III		Cross IV	
	S	J	S	J	S	J	S	J
Days to 50% flowering	E	-	E	E	E	-	E	E
Days to maturity	E	-	E	E	E	E	E	E
Plant height (cm)	E	-	-	-	E	E	E	E
Number of primary branches per plant	E	-	E	E	E	E	E	-
Number of secondary branches per plant	E	E	-	-	E	E	E	E
Number of capsules per plant	E	E	E	E	E	E	E	E
Number of seeds per capsule	E	-	-	-	E	-	E	-
Biological yield per plant (g)	E	E	-	-	E	E	E	E
Harvest index (%)	E	E	-	-	E	E	E	E
1000-seed weight (g)	E	E	E	E	E	-	E	E
Seed yield per plant (g)	E	E	-	-	E	E	E	-

S = Simple scaling test, J = Joint scaling test
E = Presence of epistasis, - = Absence of epistasis

References

1. Amit J, Jhala, Linda M Hall. Current Uses and Future Applications. Australian journal of basic and applied Sciences. 2010; 4(9):4304-4312.
2. Cavalli LL. An analysis of linkage in quantitative inheritance, In: Quantitative inheritance (ECR Rieve and CH Waddington *et al*., eds.) London, 1952, 135-144p.
3. Hayman BI, Mather K. The description of genetic interactions in continuous variation. Biometrics. 1955; 11:69-82.
4. Jinks JL, Jones RM. Estimation of the components of heterosis. Genetics. 1958; 43:31-34.
5. Mather K. Biometrical Genetics. The study of continuous variation. Methuen and Co. Ltd., London, 1949.
6. Narain V, Srivastv RL, Singh PK, Singh Mahak. Genetics of yield and its attributes in linseed (*Linum usitatissimum* L.). J. Oilseeds. Res. 2009; 26(special issues):159-163.
7. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. Indian Counc. Agr. Res. New Delhi, 1954, 361p
8. Rashid, Srivastava. Genetics of yield and its attributes in linseed (*Linum usittissimum* L.). Agric. & Bio. Res. 2011; 27(2):122-126.