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Research article

STABILITY ANALYSIS FOR YIELD AND ITS ATTRIBUTING CHARACTERS IN LINSEED (*LINUM USITATISSIMUM* L.)

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ABSTRACT: Thirty diverse genotypes used to study their stable performance over three environmental conditions *viz*., rain fed, irrigated and late sown conditions, respectively for seed yield and its attributing characters. Significant genotype x environment interaction was observed for all the characters under study. Linear component of G x E interaction was also significant for almost all the characters except days to 50% flowering, number of primary branches per plant and harvest index. None of the genotypes showed stable performance for all the characters. The genotypes R-2510, R-2511, R-2516 were showed stable performance for three characters, R-2526, R-2527, J-23 stable for two characters and rest of the genotypes showed stable performance for one character over a range of environments under study.

Key words: Stability, yield and its attributing characters, linseed.

INTRODUCTION

Linseed is one of the oldest *rabi* oilseed crop. In Chhattisgarh linseed is mainly cultivated for its seed and oil. The low yield of linseed is characterized mainly due to lack of high yielding genotypes and further lack of response to better conditions and the instability in yield of linseed due to varying environments are also great concern. Stability in performance is most desirable character of a genotype to be released as a variety for wider adoption. So information on stability of linseed genotypes prior to their recommendation for cultivation is very necessary. Keeping this point in view the present investigation was carried out on 30 diverse linseed genotypes for stability analysis.

MATERIAL AND METHODS

The present investigation was conducted during *rabi* season of 2002-03 at Agricultural Research Farm, Department of Plant Breeding and Genetics, College of Agriculture, IGAU, Raipur (CG). The experimental material comprised 30 diverse linseed genotypes (Table 1) which were grown under three environmental conditions *viz*., rain fed, irrigated and late sown conditions, respectively. The experiment was raised in a randomized complete block design with three replications at each environment with 4 m x 1 m plot size. Recommended cultural practices were followed. The observations were recorded on days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of capsules per plant, number of seeds per capsule, plant weight, 1000 seed weight, harvest index and seed yield per plant. The analysis of variance was done based on the formula suggested by Panse and Sukhatme [4]. For stability analysis the data were analysed based on the formula suggested by Eberhart and Russell [1].

RESULTS AND DISCUSSION

Based on the results, the genotypes mean sum of squares and environment mean sum of squares (Table 2) were highly significant for almost all the characters under study. It revealed that there was considerable variation present amongst genotypes as well as environments. Genotype x Environment interaction was also showing significant for all the characters, indicating the genotypes interact strongly with the environments for all the eleven characters. The significant G x E interaction also indicated that the genotypes were suitable for applying stability parameters. E + (G x E) was significant for all the characters except number of primary branches per plant, number of secondary branches per plant, number of seeds per capsule and harvest index. It revealed that the varied response of genotypes to changing environments. Mean sum of squares for environment (linear) showed significant for all the characters except days to 50% flowering, number of primary branches for plant and harvest index, revealed that the real differences in the genotypes for regression over environmental means.

Significant differences for G x E (linear) were observed for all the characters except days to 50% flowering, number of primary branches per plant and harvest index revealed that the presence of responsiveness of genotypes for the characters. The mean sum of squares table revealed that the linear component of G x E was higher than the non-linear component of G x E, indicating that the performance of genotypes for seed yield could be produced across the environments. The similar results have been presented by Rai *et al*. [6], Verma and Mahto [7], Kavani *et al*. [2], Patil *et al*. [5], Singh *et al*. [8] and Kumari *et al*. [3]. According to Eberhart and Russell [1] model, b_i is considered as a measure of responsiveness and $\hat{s}^2d_i$ as a measure of stability. Based on these parameters a variety is said to be stable when it possesses high mean value, b_i equals to unity and the $\hat{s}^2d_i$ equals to zero for a normal range of environment. Based on these considerations the thirty genotypes have been classified into five categories excluding the significant b_i and mean square deviation values for all genotypes under study. For all characters environmental index showed positive for irrigated conditions revealing the favourable effect of the environment and negative for rain fed and late sown conditions. None of the genotypes (Table 3) showed stable performance for all the characters under study. The genotypes R-2510 and R-2511 stable for plant weight, 1000 seed weight and seed yield per plant, R-2516 stable for number of seeds per capsule, 1000 seed weight and seed yield per plant, R-2526 and J-23 stable for number of seeds per capsule and plant weight, R-2527 stable for 1000 seed weight and seed yield per plant, R-2502, R-2509, R-2513 stable for seed yield per plant, R-2505, R-2512, R-2522, R-2524 stable for 1000-seed weight, R-2503 stable for number of primary branches per plant, R-2508 stable for days to maturity and R-2530 showed stable performance for plant height over the three environmental conditions under study.

Table 1: Analysis of variance for stability analysis

Source	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches /plant	No. of secondary branches /plant	No. of capsules /plant	No. of seeds /capsule	Plant weight (g)	1000 seed weight (g)	Harvest index (%)	Seed yield (g)
Genotypes	29	72.55**	53.10**	61.00**	0.68**	10.53**	130.83**	0.66**	3.32**	2.59**	49.05**	0.44**
Environments	2	1.71	43.51**	618.25**	0.098	0.73	926.01**	0.95**	38.62**	5.42**	0.01	2.76**
G x E	58	17.47**	6.28**	10.45*	0.28	3.56*	43.38*	0.63	1.66	4.83*	29.91	0.18
E + (G x E)	60	16.95**	7.52**	26.47**	0.17	1.20	48.63**	0.23	1.77**	0.27**	17.31	0.17**
E (linear)	1	3.34	87.52**	1236.59**	0.19	1.46**	1852.03**	1.90**	77.24**	10.68**	0.02	5.52**
G x E (linear)	29	16.73	10.02**	10.90**	0.21	2.30**	35.47**	0.25**	0.96**	0.16**	4.35	0.15**
Pooled deviations	30	17.61**	2.44**	1.19	0.14*	0.12	1.24	0.05	0.04	0.04**	30.41**	0.01
Pooled error	174	1.24	1.31	7.65	0.18	2.58	31.42	0.42	1.09	0.03	16.85	0.09

*: Significant at 5% level; **: Significant at 1% level.

Table 2: Stability analysis for seed yield and yield components of 30 genotypes in linseed

S.No.	Genotypes	Seed yield per plant (g)			Days to 50% flowering			Days to maturity			Plant height (cm)			No.of.pri.branches/plant		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_I	Mean	b_i	S^2d_I	Mean	b_i	S^2d_i
1	R-2501	1.33	-0.97**	-0.03	45.18	9.51	3.11	102.73	-1.43*	5.19	46.01	1.13	-1.93	4.06	8.07	0.28
2	R-2502	1.79	0.91	-0.03	52.24	0.56	2.31	104.49	1.32	-0.38	46.09	0.54*	-2.41	3.90	-6.12	0.34
3	R-2503	1.46	0.32**	-0.03	56.80	3.18	0.33	103.27	2.94	0.94	44.42	1.34	-2.55	4.04	1.28	-0.06
4	R-2505	2.04	0.52	-0.03	46.89	-0.83	-0.40	98.58	-2.48**	0.50	44.02	0.99	-0.89	4.64	-1.82	0.06
5	R-2506	1.76	0.39	-0.03	53.93	-0.97	0.08	100.67	-2.74**	8.77	50.49	0.95	-2.55	3.40	4.15	-0.06
6	R-2508	2.28	0.60	-0.02	45.38	-0.37	-0.41	112.47	1.08	-0.30	40.58	-0.04**	-2.54	3.81	-5.58	-0.01
7	R-2509	1.77	1.08	-0.02	45.51	0.56	0.42	104.00	-0.36	1.67	41.20	0.95	6.83	3.09	-0.52	-0.05
8	R-2510	1.81	0.80	-0.03	49.27	22.38	53.27**	109.73	3.25	2.01	43.87	1.56	-2.35	4.48	-9.63*	0.72*
9	R-2511	1.81	1.01	-0.03	52.00	-12.70	24.39**	106.31	-0.03	1.41	47.94	0.45**	-2.55	3.20	6.64	0.03
10	R-2512	2.60	2.26	0.01	52.58	-14.11	21.93**	109.27	1.92	-0.33	50.12	0.54*	-1.74	3.44	5.06	-0.05
11	R-2513	1.81	0.97	0.00	50.40	15.47	31.85**	109.73	1.99	-0.10	53.69	0.53**	-2.17	3.91	-4.26	-0.05
12	R-2514	1.64	1.56	-0.03	55.87	8.62	8.66**	109.40	3.32	11.32**	43.41	0.98	-2.49	4.27	-2.31	-0.04
13	R-2515	1.59	-0.06**	-0.02	52.40	4.15	-0.40	107.61	2.21	0.99	44.88	1.63	-2.27	3.41	-1.11	-0.04
14	R-2516	1.73	1.12	-0.03	50.73	-12.62	26.91**	112.27	4.40	5.33	44.67	1.68	-0.92	3.28	1.84	-0.01
15	R-2518	1.09	1.42	-0.03	50.71	39.12	182.97**	117.71	0.80	2.03	57.09	2.30	1.52	3.79	7.14	0.21
16	R-2522	1.29	1.04	-0.03	60.64	-24.88**	81.99	105.96	0.70	0.50	47.56	1.28	-2.46	3.19	7.75	0.15
17	R-2523	2.34	2.20	-0.03	44.89	5.73	-0.15	104.84	1.18	-0.41	48.46	1.05	-2.50	3.59	-2.45	-0.03
18	R-2524	1.90	1.85	0.04	44.31	6.14	1.44	104.48	-0.65	5.26*	45.21	0.90	-1.85	3.61	0.21	-0.06
19	R-2525	1.65	0.56	-0.03	46.44	-2.83	0.78	102.44	1.89	0.58	48.00	0.55*	-2.55	3.46	-3.37	-0.01
20	R-2526	1.50	-0.88**	-0.03	54.16	-11.48	16.06**	104.42	1.75	5.42*	57.82	1.09	-2.51	3.78	-5.36	0.07
21	R-2527	1.66	0.80	-0.03	54.33	-4.24	2.85	104.60	-0.04	0.10	45.27	1.01	-2.46	4.13	-9.27*	0.26
22	R-2528	1.36	0.77	-0.03	49.60	9.92	6.97*	105.87	-0.06	-0.41	46.53	0.00**	-2.55	2.66	2.95	-0.06
23	R-2529	1.13	0.41*	-0.03	47.87	-3.41	3.84	106.98	0.93	0.84	45.14	1.34	4.30	3.00	3.25	-0.02
24	R-2530	1.08	0.73	-0.03	62.87	13.65	16.60**	115.84	3.87	2.83	53.66	1.36	-0.22	3.30	-1.17	-0.01
25	LMH-62	1.31	0.68	-0.03	47.63	6.80	7.10**	110.49	3.11	0.69	47.16	0.85	-2.31	3.37	1.47	-0.06
26	J-23	2.14	3.53	0.01	55.20	-0.85	2.23	107.98	2.05	-0.16	47.64	1.02	-1.04	3.84	5.77	0.04
27	T-397	1.56	1.98	-0.03	46.73	-5.69	1.43	109.31	1.74	-0.40	37.46	0.57*	-2.49	4.03	4.25	-0.02
28	RLC-29	1.34	1.28	0.01	57.78	-9.78	9.66 **	104.69	-1.72**	-0.35	43.77	0.55*	-1.83	3.27	-1.85	-0.05
29	R-552	1.11	1.77	-0.03	54.22	-1.57	-0.39	104.27	-0.08	-0.44	42.39	1.83	0.13	3.28	11.55	0.21
30	Kiran	1.29	1.86	-0.02	57.80	-9.05	10.64**	107.22	-1.46**	6.98**	46.52	1.07	-1.21	2.78	13.50	0.75*
Population mean		1.64			51.48			106.92			46.67			3.60		

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

Contd….

S.No.	Genotypes	No.of sec.branches/plant			No. of capsules/plant			No. of seeds/capsule			Plant weight (g)			1000 seed weight (g)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
1	R-2501	10.36	19.16	-0.41	46.64	1.92	-10.25	6.60	-0.56	-0.14	5.41	1.10	-0.36	6.08	0.34	-0.01
2	R-2502	9.78	-4.11**	-0.62	40.36	0.37**	-10.48	7.77	-3.52	-0.08	5.64	0.47**	-0.36	6.30	0.65	0.08
3	R-2503	13.62	-1.51	-0.86	32.73	0.80	-8.82	7.82	-0.21	-0.14	5.27	0.65**	-0.35	7.31	1.90	0.09
4	R-2505	12.81	-1.03	-0.59	43.50	1.29	-9.77	7.46	3.51	-0.13	6.09	0.29**	-0.35	7.27	1.41	0.04
5	R-2506	9.61	-5.56**	-0.79	35.51	0.18**	-8.19	8.23	1.49	-0.14	5.60	0.18**	-0.34	5.41	0.52	0.03
6	R-2508	12.10	-5.98**	-0.81	47.03	-0.01**	-10.01	8.09	4.94	-0.11	6.64	0.67*	0.34	6.45	2.64	0.11
7	R-2509	9.04	2.28	-0.85	40.86	1.68	-1.94	7.52	1.15	-0.08	4.87	0.35**	-0.37	6.00	2.02	0.00
8	R-2510	14.47	-12.50**	-0.19	33.51	0.19**	-10.47	6.96	2.72	-0.03	6.80	1.29	-0.35	7.68	1.41	0.00
9	R-2511	10.68	4.37	-0.86	34.23	1.28	-5.35	6.69	3.03	-0.35	6.13	1.07	0.02	6.99	1.24	0.00
10	R-2512	12.26	2.66	-0.77	44.81	1.97	-10.29	7.30	1.46	-0.12	8.22	1.76	-0.26	8.94	1.38	0.00
11	R-2513	11.70	-8.28**	-0.75	40.20	0.50**	-10.47	7.72	0.18	-0.13	6.97	0.73*	-0.37	5.44	1.28	-0.01
12	R-2514	11.32	-0.80	-0.83	28.33	0.49**	-10.47	7.51	2.07	-0.09	5.24	0.76	-0.36	6.75	1.54	0.02
13	R-2515	10.00	-4.66**	-0.85	28.07	-0.12**	-9.50	7.54	-0.54	-0.13	5.11	0.18**	-0.36	6.54	0.47	-0.01
14	R-2516	8.99	8.85	-0.69	33.49	1.65	-9.78	8.24	0.92	-0.14	5.63	1.98	-0.18	6.73	1.27	0.00
15	R-2518	9.29	10.83	-0.86	27.08	1.33	-10.23	7.13	-2.04**	-0.08	4.69	1.32	-0.36	6.09	0.55	-0.01
16	R-2522	8.29	12.06	-0.63	30.62	1.58	-10.17	7.42	2.60	-0.11	4.93	1.24	-0.28	6.62	0.99	0.02
17	R-2523	11.06	-2.46**	-0.60	49.91	2.73	-8.56	7.90	2.28	-0.12	7.22	2.00	-0.34	6.19	0.55	-0.01
18	R-2524	9.32	2.18	-0.85	36.30	1.47	-8.04	7.78	3.97	-0.13	6.06	1.73	-0.26	6.48	1.41	0.03
19	R-2525	8.86	-1.86	-0.86	32.02	0.37**	-10.15	8.08	-2.14**	-0.08	4.48	-0.18**	-0.35	6.11	2.06	0.00
20	R-2526	9.91	-9.62**	-0.69	34.62	-0.36**	-10.35	7.93	1.11	-0.12	6.93	0.94	-0.33	6.34	-0.36**	0.00
21	R-2527	9.53	-2.57**	-0.84	32.52	0.68*	-10.07	8.14	4.23	-0.12	5.20	0.76	-0.37	6.99	1.28	0.02
22	R-2528	8.83	5.98	-0.74	33.19	0.20**	-9.86	8.20	0.63	-0.14	4.33	0.67**	-0.36	5.49	0.90	-0.01
23	R-2529	7.86	2.04	-0.86	28.16	0.89	-10.43	8.28	6.84	-0.11	4.18	0.80	-0.34	5.23	0.96	-0.01
24	R-2530	7.84	9.45	-0.85	26.62	0.36**	-9.35	7.82	-0.62	0.06	4.31	1.03	-0.37	6.23	1.06	-0.01
25	LMH-62	7.37	5.74	-0.66	29.11	1.24	-10.27	7.39	-1.63**	0.10	6.32	1.40	-0.36	8.20	1.09	0.12
26	J-23	8.01	-1.27	-0.84	38.18	2.27	-7.94	8.29	1.49	-0.14	7.11	1.27	-0.34	6.64	0.22*	0.11
27	T-397	9.82	3.78	-0.84	33.18	1.66	-9.80	8.00	-0.40	-0.14	5.78	2.47	-0.36	6.62	0.85	0.30
28	RLC-29	9.37	-2.32*	-0.79	30.00	1.33	-7.80	7.26	-0.13	-0.13	4.72	0.46**	-0.36	5.64	0.20*	0.06
29	R-552	6.62	-0.06	-0.83	25.73	1.01	-8.08	8.34	-0.18	-0.13	4.16	1.06	-0.37	4.91	0.24*	0.04
30	Kiran	7.88	5.17	-0.46	30.20	1.05	-9.94	7.71	-2.75**	0.00	4.58	1.56	-0.35	4.49	-0.04**	-0.01
Population mean		9.89			34.89			7.70			5.62			6.41		

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

S.No.	Genotypes	Harvest index (%)		
		Mean	b_i	S^2d_i
1	R-2501	26.52	111.90	256.55**
2	R-2502	31.53	-54.06	-0.47
3	R-2503	28.06	-8.21	5.53
4	R-2505	33.62	47.84	-3.75
5	R-2506	31.24	-42.44	-5.08
6	R-2508	34.52	95.50	-4.87
7	R-2509	36.62	-113.52	11.32
8	R-2510	27.09	-9.258	8.43
9	R-2511	29.77	-95.23	1.86
10	R-2512	31.56	-34.59	-4.21
11	R-2513	25.72	-59.58	-5.67
12	R-2514	31.29	12.54	20.92
13	R-2515	31.91	40.58	-5.53
14	R-2516	33.90	42.87	49.13
15	R-2518	22.82	27.82	5.16
16	R-2522	26.39	-57.45	0.48
17	R-2523	32.80	51.44	-5.53
18	R-2524	32.00	-85.13	-0.76
19	R-2525	37.00	-45.16	58.58
20	R-2526	22.22	112.55	89.49**
21	R-2527	32.74	-46.77	-5.55
22	R-2528	32.30	19.31	-5.40
23	R-2529	27.50	-4.79	16.50
24	R-2530	25.66	-2.24	3.88
25	LMH-62	21.52	20.93	0.67
26	J-23	29.47	-184.22	123.30**
27	T-397	26.43	53.26	-5.49
28	RLC-29	28.47	147.44	70.99*
29	R-552	25.48	8.07	67.84*
30	Kiran	27.93	52.12	5.50
Population mean		29.47		

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

The genotypes which are showing stable performance for particular characters are useful for further breeding programmes and also used for commercial consumption. Some genotypes (Table 3) showed their performance under favourable environments only, which were having high mean value, $b_i > 1$ and some genotypes suit for poor environments, which showed high mean value with $b_i < 1$. The genotypes which are showing low mean value and $b_i > 1$ and low mean value with $b_i < 1$ are poor for all the environmental conditions and further improvement of these characters are difficult.

Table 3 : Classification of genotypes for various characters based on stability parameters

S.No.	Genotypes	A	B	C	D	E	F	G	H	I	J	K
1.	R-2501	4	5	4	2	2	2	5	4	5	4	5
2.	R-2502	3	4	5	3	5	3	3	3	5	3	1
3.	R-2503	2	4	4	1	3	5	3	5	2	5	5
4.	R-2505	5	5	5	3	3	2	4	3	1	2	3
5.	R-2506	3	5	3	4	5	3	2	5	5	3	3
6.	R-2508	5	1	5	3	3	3	2	3	2	2	3
7.	R-2509	5	5	5	5	4	2	4	5	4	3	1
8.	R-2510	4	2	4	3	3	5	4	1	1	5	1
9.	R-2511	3	5	3	4	2	4	4	1	1	3	1
10.	R-2512	3	2	3	4	2	2	4	2	1	3	2
11.	R-2513	4	2	3	3	3	3	3	3	4	5	1
12.	R-2514	2	2	5	3	3	5	4	5	2	2	2
13.	R-2515	2	2	4	5	3	5	5	5	3	2	5
14.	R-2516	5	2	4	4	4	4	1	2	1	2	1
15.	R-2518	4	3	2	2	4	4	5	4	5	4	4
16.	R-2522	3	5	2	4	4	4	4	4	1	5	4
17.	R-2523	4	4	2	5	3	2	2	2	5	2	2
18.	R-2524	4	5	5	3	4	2	2	2	1	3	2
19.	R-2525	5	4	3	5	5	5	3	5	4	3	3
20.	R-2526	3	4	2	3	3	5	1	1	5	4	5
21.	R-2527	3	5	4	3	5	5	2	5	1	3	1
22.	R-2528	4	5	5	4	4	5	3	5	5	2	5
23.	R-2529	5	3	4	4	4	5	2	5	5	5	5
24.	R-2530	2	2	1	5	4	5	3	4	4	5	5
25.	LMH-62	4	2	5	4	4	4	5	2	2	4	5
26.	J-23	3	2	2	2	5	2	1	1	3	3	2
27.	T-397	5	2	5	2	4	4	3	2	3	4	4
28.	RLC-29	3	5	5	5	5	4	5	5	5	4	4
29.	R-552	3	5	4	4	5	4	3	4	5	4	4
30.	Kiran	3	3	4	4	4	4	3	4	5	4	4

A= Days to 50 % flowering; B= Days to maturity; C= Plant height; D= Number of primary branches per plant; E= Number of secondary branches per plant; F= Number of capsules per plant; G= Number of seeds per capsule; H= Plant weight; I= 1000 seed weight; J= Harvest index and K= Seed yield per plant.

Classification:
1 = Genotypes stable over all the environments;
2 = Genotypes desirable for favourable environments;
3 = Genotypes desirable for poor environments;
4 = Genotypes with low mean, bi>1 and
5= Genotypes poor for all the environments.

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