

Genotype x Environment Interaction for Seed Yield and its Component Traits in Lentil

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Abstract: Thirty genetically diverse genotypes of lentil (*Lens culinaris* Medik.) were evaluated for genotype x environment (G x E) interaction for seed yield and its component traits during three consecutive years from 1997-98 to 1999-2000 at CCS Haryana Agricultural University, Hisar. Both linear and non-linear components of G x E interactions were found important for the expression of grain yield and related traits. Ten genotypes were found to be high yielders and stable for all the environments, whereas four and five genotypes were observed to be high yielding and stable for better and poor environments, respectively. Stability of genotypes with respect to grain yield plot⁻¹ in all the environments was imparted by the stability of different yield contributing traits.

Key words: *Lens culinaris*, environment, genotype, genotype x environment interaction, stability.

Lentil (*Lens culinaris* Medik.), second most important rabi pulse crop of our country, is generally grown under rainfed conditions after cotton and paddy. In India, it is grown on 1.1 mha area with 0.9 mt production and 818 kg ha⁻¹ productivity (FAO, 1999). Environmental conditions have always been a major constraint for stable lentil yield because G x E interaction has an important bearing on the breeding of improved varieties. The larger the interaction, the lesser is the chance of progress under selection. Under such circumstances, it is desirable to have stable genotypes for commercial exploitation over a wide range of environmental conditions. A few reports on genotype x environment interaction in lentil are available (Waldia *et al.*, 1988; Kumar and Bajpai, 1993; Sharma and Koranne, 1996) where only a limited number of genotypes have been explored. Therefore, in the present investigation, an attempt has been made to collect the information on the impact of

different environments on various lentil genotypes and also to know how important are these G x E interactions for seed yield and its attributes.

Materials and Methods

The experimental material, comprising 30 diverse genotypes of lentil (15 *microsperma* and 15 *macrosperma*), was grown on Dec. 16, Dec. 24 and Dec. 2 during rabi seasons of 1997-98, 1998-99 and 1999-2000, which constituted three different environments, i.e., E₁, E₂ and E₃, respectively, at CCS Haryana Agricultural University, Hisar. In E₂ and E₃ sowing was done after pre-sowing irrigation and there after crop was raised following normal cultural practices under rainfed conditions, whereas in E₁, pre-sowing irrigation was not applied. The crop received 27 mm rainfall each in February and March during E₁, and 30 mm in January during E₂, whereas

during E₃, there were no rains at all. During E₃, the temperature from sowing (December) to flowering (February) remained comparatively lower, whereas in the months of March and April, it (heat stress) was observed to be significantly lower in E₁. In different environments, all the genotypes were planted in a randomized block design with three replications in 4 m long three-row plots with a distance of 22.5 cm between rows and 5 cm between plants within rows. Equal number of plants were maintained in each plot and five competitive plants were taken at random from each plot to record the data on plant height, fruiting branches and pods plant⁻¹, 100-seed weight and seed yield plant⁻¹. The data on days to 50% flowering and seed yield plot⁻¹ were recorded on plot basis. The homogeneity of error variances was tested following Bartlett's test. The statistical analysis for G x E interaction was done according to the method proposed

by Eberhart and Russel (1966). The magnitude of linear and non-linear components of G x E interactions was worked out following Fripp and Caten (1971).

Results and Discussion

A perusal of the data in respect of range and mean for various characters under different environments revealed that E₁ was the best environment for fruiting branches, fruiting pods and seed yield plant⁻¹ and seed yield plot⁻¹ (Table 1). This was due to the favorable environmental conditions like timely and optimum rainfall in February and March, and lower temperature (heat stress) during grain filling and maturity (March and April). For days to 50% flowering (earliness, desirable), E₁ and E₂ were comparable and better than E₃. Overall, for majority of the important characters, E₂ and E₃ were the average and the poor environments, respectively.

Table 1. Range (R) and mean (M) performance of different characters under three rainfed environments in lentil

Character	Parameter	Environment		
		E ₁	E ₂	E ₃
Days to 50% flowering	R	77.00-81.00	76.67-83.33	78.00-93.33
	M	79.26±0.60	79.27±0.52	89.20±0.59
Plant height (cm)	R	32.33-44.00	29.00-45.00	35.00-60.67
	M	38.03±1.87	36.31±2.30	43.49±1.50
Fruiting branches plant ⁻¹	R	6.57-14.77	5.43-9.47	5.70-9.80
	M	8.75±0.96	7.43±0.75	7.68±0.35
Fruiting pods plant ⁻¹	R	56.67-106.00	34.67-88.33	35.66-70.66
	M	77.42±9.40	64.25±7.50	57.47±3.68
100-seed weight (g)	R	1.43-2.77	1.43-2.73	1.50-2.83
	M	1.98±0.09	1.92±0.08	2.02±0.06
Seed yield plant ⁻¹ (g)	R	1.50-2.63	1.10-3.47	0.90-3.10
	M	2.23±0.25	1.95±0.23	1.75±0.08
Seed yield plot ⁻¹ (kg)	R	0.273-0.793	0.257-0.763	0.203-0.720
	M	0.586±0.030	0.559±0.026	0.519±0.028

E₁, E₂ and E₃ are better, stable and poor environments, respectively.

The pooled analysis of variance for stability revealed significant differences among genotypes for all the characters studied (Table 2). Significant differences were also observed among all the environments, which suggested that the choice of different years was effective in

would be reliable. However, the variances due to G x E (L) for 100-seed weight, fruiting branches and seed yield plant⁻¹ were found significant when tested against pooled error. This indicated the importance of both linear and non-linear components of G x E interactions.

Table 2. Analysis of variance (mean squares) for stability of different characters in lentil

Source of variation	df	Days to 50% flowering	Plant height (cm)	Fruiting branches plant ⁻¹	Fruiting pods plant ⁻¹	100-seed weight	Seed yield plant ⁻¹	Seed yield plot ⁻¹
Genotypes	29	7.124 ⁺⁺	18.508 ⁺⁺	2.107 ^{**}	166.725 ⁺	0.626 ⁺⁺	0.528 ⁺⁺	53.235 ⁺⁺
Env. + Genotype x Env.	60	39.935 ⁺⁺	28.996 ⁺⁺	1.969 ^{**}	224.457 ⁺⁺	0.018 ^{**}	0.155 ⁺	3.372 ⁺⁺
Environment (L)	1	1975.632 ⁺⁺	842.496 ⁺⁺	29.357 ⁺⁺	6170.802 ⁺⁺	0.145 ⁺⁺	3.569 ⁺⁺	68.221 ⁺⁺
Genotype x Env. (L)	29	13.150 ⁺⁺	23.280 ⁺⁺	1.421 ^{**}	152.796 ⁺	0.011 ^{**}	0.110 ^{**}	3.706 ⁺⁺
Pooled deviation	30	1.303 ^{**}	7.406 ^{**}	1.586 ^{**}	95.517 ^{**}	0.021 ^{**}	0.085 ^{**}	0.888 ^{**}
Pooled error	174	0.162	1.839	0.268	26.311	0.003	0.021	0.390

** P = 0.01 against pooled error

+ and ++ P = 0.05 and 0.01 against pooled deviation, respectively.

providing diverse environments for testing (Sharma and Koranne, 1996; Godawat and Choudhary, 1996). The significant E + (G x E) interaction for all the traits revealed instability and fluctuation in their expression with changed environment. The variances due to pooled deviation were significant for all the characters, suggesting that the prediction of performance based on regression analysis for all the traits may not be reliable (Khapre *et al.*, 1996). The variances due to G x E (L) were significant against pooled deviation for days to 50% flowering, plant height, fruiting pods plant⁻¹ and seed yield plot⁻¹ which indicated that the prediction of performance for these traits

The computation of linear and non-linear components of G x E interaction for different traits (Table 3) revealed that days to 50% flowering, plant height, fruiting pods and seed yield plant⁻¹ and seed yield plot⁻¹ exhibited 62.21, 79.39, 64.63, 58.15 and 86.95% G x E interaction of linear type, respectively. Therefore, prediction of G x E interaction for these traits was possible. The preponderance of linear type of G x E interaction for majority of the characters and non-linear type for a few characters as observed in the present investigation is in agreement with a number of earlier reports (Waldia *et al.*, 1988; Khapre *et al.*, 1996; Dua, 1998; Kumar, 1998).

Table 3. Magnitude (%) of linear and non-linear components of $G \times E$ interaction for six characters in lentil

Character	Linear component	Non-linear component
Days to 50% flowering	62.21	37.79
Plant height	79.39	20.61
Fruiting branches plant ⁻¹	46.66	53.34
Fruiting pods plant ⁻¹	64.63	35.37
100-seed weight	31.06	68.94
Seed yield plant ⁻¹	58.15	41.85
Seed yield plot ⁻¹	86.95	13.05

Information on relative stability of different yield components is essential to understand diverse mechanisms contributing to yield stability. An assessment of the stability parameters of individual genotypes (Table 4) revealed that the fruiting branches and seed yield plant⁻¹ were the most stable characters as 22 out of 30 genotypes were found stable for these characters, followed by fruiting pods plant⁻¹ (16), 100-seed weight (15), plant height and seed yield plot⁻¹ (14), whereas days to 50% flowering (4) was the most unstable character. Stability of days to 50% flowering is influenced to a great extent by the prevailing environmental conditions, e.g., low temperature during crop growth delays flowering. During E₃, the temperature from sowing (December) to flowering (February) remained low due to which the flowering was delayed, whereas higher temperature during the same period in case of E₁ and E₂ resulted in early flowering.

A comparative analysis of the classification of different genotypes on the basis of three stability parameters, viz., X_i , b_i and S^2d_i (Table 5) revealed that 10 genotypes (LH96-11, LH96-29, LH97-16, LH97-17, LH97-19, LH97-21, LH97-25,

LH97-27, LH97-35, and PL 4) were stable for seed yield plot⁻¹ and could be grown over a wide range of environments after multilocation testing in coordinated trials ($X_i \geq X_{..}$, $b_i = 1$, $S^2d_i = 0$). Majority of these genotypes exhibited additional stable performance for seed yield plant⁻¹ (all, except PL 4), pods plant⁻¹ (all, except PL 4, LH96-11 and LH97-21), branches plant⁻¹ (all, except LH97-16, LH97-19, LH97-25 and LH97-35), plant height (all, except LH97-17, LH97-19, LH97-27 and LH97-35) and 100 seed weight (LH97-16, LH97-19 and LH97-21). Four genotypes, viz., LH97-1, LH97-32, LH84-8 and L4076 were found suitable for superior environment ($b_i > 1$). The genotype, LH97-1 was found to be the best as it showed additional high and stable performance for seed yield plant⁻¹, 100-seed weight, branches plant⁻¹ and days to flowering. Five genotypes namely, LH97-3, LH97-10, LH97-47, LH97-53 and LH89-48 showed better performance and stability under poor environment ($b_i < 1$) for seed yield plot⁻¹. LH 97-53 showed additional stability for days to flowering and plant height, and LH 97-3 for days to flowering and 100-seed weight. This indicated that the stability of various component traits might be responsible for observed stability of seed yield. Patel *et*

Table 4. Distribution of various genotypes of lentil on the basis of two stability parameters for six characters

Character	Predictable		Unpredictable	
	G x E absent both bi and S ² di non-significant	G x E present only bi significant	G x E present both bi and S ² di significant	G x E present only S ² di significant
Days to 50% flowering	4	18	2	6
Plant height	14	12	1	3
Fruiting branches plant ⁻¹	22	5	-	3
Fruiting pods plant ⁻¹	16	11	-	3
100-seed weight	15	10	-	5
Seed yield plant ⁻¹	22	5	-	3
Seed yield plot ⁻¹	14	15	-	1

al. (1998) and Kumar (1998) also arrived at similar conclusion regarding the stability of seed yield. Therefore, the chances for selection of stable genotypes could be strengthened by selection for stability of individual yield components.

Among the yield components, the highest number of high and stable performing genotypes were observed for fruiting branches plant⁻¹ (22), followed by fruiting pods plant⁻¹ (21), plant height (19) and 100-seed weight (12), whereas for days to 50% flowering, 14 genotypes were found to be stable and better in performance. Out of 22 stable genotypes for fruiting branches plant⁻¹, 18 genotypes were ideal for all environments, whereas three and one were found most suitable for better and poor environments, respectively. Similarly, for fruiting pods plant⁻¹, thirteen, five and three; for plant height, nine, three and seven and for 100-seed weight, five, two and five genotypes were found ideal for all, better and poor environments, respectively. For days to 50% flowering,

two genotypes LH 97-34 and LH 97-39 were observed to be ideal for all the environments, whereas six genotypes each were found responsive to favorable and poor environments.

From the results discussed above, it could be concluded that four genotypes (LH97-1, LH97-32, LH84-8 and L4076) for better and five genotypes (LH97-3, LH97-10, LH97-47, LH97-53 and LH89-48) for poor environment were found most suitable, whereas the genotypes LH96-11, LH96-29, LH97-35, PL 4, LH97-16, LH97-19, LH97-21, LH97-17, LH97-25 and LH97-27 with high seed yield and other desirable traits across the environments, if found suitable after multilocation testing in coordinated trials, could be recommended for general cultivation. The cultivation of these genotypes will help in stabilizing the grain yield in different environments. Besides, these high-yielding and stable genotypes can serve as useful parents in the breeding program for the improvement of grain yield and its attributes.

Table 5. Distribution of different genotypes of lentil on the basis of three stability parameters

Stability parameters	Days to 50% flowering	Plant height (cm)	Fruiting branches plant ⁻¹	Fruiting pods plant ⁻¹	100-seed weight (g)	Seed yield g plant ⁻¹	Seed yield kg plot ⁻¹
A=($X_i \geq X_{..}$, $b > 1$, $S^2_{di} = 0$)	LH95-12,	LH97-35	LH97-47,	LH97-34,	LH97-1,	LH97-1	LH97-1
	LH97-27,	LH96-36	LH97-1,	PL406,	LH97-25		LH97-32
	LH97-21,	LH97-19	LH97-39	PL4,			LH84-8
	LH97-1,			LH97-29			L4076
	LH84-8,		LH97-21				
	LH97-25						
B=($X_i \geq X_{..}$, $b_i = 1$, $S^2_{di} = 0$)	LH97-34	LH96-29,	LH96-29,	LH96-29,	LH97-15,	LH96-29,	LH96-29,
	LH97-39	LH97-47,	LH97-33,	LH97-35,	LH97-16,	LH97-10,	LH97-35,
		LH97-3,	LH97-38,	LH97-12,	LH97-21,	LH97-34,	LH96-11,
		LH96-11,	LH95-12,	LH97-38,	LH97-19,	LH97-53,	LH97-27,
		LH97-16,	LH97-38,	LH97-53,	L4076	LH97-47,	LH97-16,
		LH97-21,	LH97-53,	LH97-47,		LH97-32,	LH97-21,
		LH97-25,	LH89-48,	L9-12,		LH97-3,	LH97-19,
		LH82-6,	L-9-12,	LH97-32,		LH96-11,	LH97-25,
		PL4	PL4,	LH97-27,		LH97-27,	LH97-17,
			LH97-32,	LH97-16,		LH97-16,	PL4
			LH97-21,	LH97-19,		LH97-21,	
			LH96-11,	LH97-25,		LH84-8,	
			LH97-27,	LH97-17		LH97-19,	
		LH97-21,			LH97-25,		
		LH84-8,			LH97-17		
		LH82-6,					
		LH97-17,					
		L4076					
C=($X_i \geq X_{..}$, $b_i < 1$, $S^2_{di} = 0$)	LH97-33,	LH97-53,	LH97-15	LH84-8,	LH97-3,	-	LH97-10,
	LH96-29,	LH97-32,		LH97-39,	LH96-11,		LH97-53,
	LH97-53,	LH97-27,		L4076	LH97-27,		LH97-3,
	LH97-32,	LH97-27,			LH84-8,		LH89-48,
	PL4	LH84-8,			LH82-6		LH97-47
	LH97-39,						
	LH97-17,						
	L4076						

Note: For days to 50% flowering, A = ($X_i \leq X_{..}$, $b < 1$, $S^2_{di} = 0$); B = ($X_i \leq X_{..}$, $b = 1$, $S^2_{di} = 0$); C = ($X_i \leq X_{..}$, $b > 1$, $S^2_{di} = 0$).

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