PHENOTYPIC STABILITY OF YIELD AND ITS COMPONENT TRAITS IN LENTIL (*LENS CULINARIS* MEDIK)

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Abstracts: Thirty genotypes of lentil were evaluated under four diverse environments for stability analysis for yield and its related traits. Pooled analysis of variance for all the eleven characters indicated significant differences among the genotypes and environments. The linear component was observed to be significant for all the characters suggesting that the prediction of performance of genotypes were possible across the environments. Genotype L-4676 and L-4594 were observed to be desirable and stable for seed yield as well as other characters like number of primary and secondary branches/plant, plant height, 100 seed weight and biological yield. Further, the genotype L-415 was having high yield, S^2d_i=0 and b>1 indicating that this genotype would perform better in favourable environmental conditions.

Keywords: Lentil, G × E interaction, Phenotypic stability, Seed yield

INTRODUCTION

The effects of genotype and environment on phenotype may not be always independent. The phenotypic response to change in environment is not same for all genotypes, the consequences of variation in phenotype depend upon the environment. Since G×E interaction has masking effect on genotype (Comstock and Moll, 1963) hence these interactions are of considerable importance to plant breeders in identifying the genotypes suitable for favourable location/ environment and assumes importance for potential expression of characters under interest. Evaluation of genotypes over several years appears to improve genotypic evaluation and it would enable characterization of each genotype for intra-location variance to evaluate the non-predictable part of the GE interactions, due to annual effects (Lin and Binns, 1988). The importance of G×E interactions is recognized well and these are known to be heritable and statistical techniques are available to estimate them. The main efforts of geneticists are to reduce them or to scale them out. The genotypes adjusting their phenotypic state in response to environment so that they are able to give their maximum yield or near maximum economic returns are called "well buffered" genotype (Allard and Hansche, 1964). Hence present investigation was carried out utilizing 30 genotypes over four diverse environments to assess the stability of seed yield and its component traits in lentil.

MATERIAL AND METHOD

The present experiment was conducted during two years (2004-05 and 2005-06) with early and late sowing under rainfed condition. The thirty genotypes procured from Division of Genetics, IARI, New Delhi, were grown in randomized block design with three replications under four environments. Each entry was sown in single row of 3 m length with a distance of 25 cm and 10 cm between rows and plants, respectively. In each replication the observations were recorded on five randomly selected plants in each plot on eleven characters days to days to 50% anthesis, days of maturity, number of primary branches, number of secondary branches, number of pods per plant, plant height (cm), number of seeds per pod, biological yield per plant (g), seed yield per plant (g), 100-seed weight (g) and harvest index (%). Plot means were subjected to stability analysis as per model given by Eberhart and Russell (1966).

RESULT AND DISCUSSION

Pooled analysis of variance for all the 11 characters studied, indicated that highly significant differences exist among the genotypes and environments (Table 1). Kumar and Bajpai (1993), Solanki (2001), El-Saied and Afiah (2004), Dehghani *et al.* (2008), Sabaghnia *et al.* (2012) and Abo-Hegazy *et al.* (2013) also recorded highly significant variances amongst the genotypes and environments for all the characters studied.

The results of the present study clearly indicated that the linear component of G×E interaction played an important role in the expression of days to anthesis, number of secondary branches, number of pods per plant, plant height, number of seeds per pod, biological yield, grain yield and 100-seed weight. The non-linear components of genotype × environment (G×E) interaction were significant only for days to maturity and harvest index. For days to anthesis, number of secondary branches, number of pods per plant, plant height, seeds per pod, biological yield per plant, seed yield per plant and 100-seed weight, the linear component was more important than that of non-linear one suggesting thereby that major portion of G×E interaction was attributable to linear components in respect to these traits. The significant variance due to environment (linear) indicated differences among environmental conditions under study. Kumar *et al.* (2005) revealed that most of the genotypes exhibited predictable linear type of genotype × environment interaction in terms of mean performance and response to changing environment for the traits.

Eberhart and Russell (1966) suggested that both linear sensitivity coefficient (b_i) and non-linear sensitivity coefficient (S^2d_i) should be considered in assessing the phenotypic stability of a genotype and considered three stability parameters viz., mean performance ($\overline{X}$), regression coefficient (b_i) and deviation from regression (S^2d_i). Based on stability parameters the genotypes L-396, L-416 and L-4661 were found to be stable and desirable for days to anthesis (Table 2). Mean number of days taken to maturity ranged from 125.0 days (L-4677) to 156.0 days (L-381) over environment with a general mean of 142.91 days. The genotypes L-4661 and L-4620 with low mean, unit regression (b_i) and non-significant (S^2d_i) were identified as desirable and stable for days to maturity (Table 2).

The genotypes L-415, L-4674, L-4676, L-4618, L-381, L-4594, L-4598, L-4147, L-4596, L-414, L-4661 and L-417 for number of primary branches; L-4676, L-4618, L-381, L-4598, L-4147, L-414, L-4661 and L-4677 for number of secondary branches; L-396, L-381, L-4594, L-4147, L-414, L-4597and L-310 for plant height showed high mean performance, b=1 and S^2d_i=0 indicating stable performance over environments. Further, the genotypes L-415, L-396, L-308, L-386, L-4672, L-4598, L-4147, L-4596, L414, L-4597 and L-471 for seeds/pod and L-4674, L-4676, L-4618, L-381, L-4148, L-4596, L-414, L-4661, L-417 and L-4620 for 100-seed weight showed high mean performance, b=1 and S^2d_i=0 indicating stable performance over environments.

The genotype L-395 for seed yield and L-307, L-4595, L-4674, L-396, L-309, L-386, L4620 and L-310 for biological yield showed below mean performance, unit regression coefficient and non-significant S^2d_i (Table 2). This indicated that the performance of these genotypes can be improved by adopting suitable management practices and can also used as one of the parents along with high mean performance and wider adaptation. Further, the genotype L-415 was observed to be high yielding and stable but their corresponding bi value were significantly than greater unity. This showed that this genotype would perform better in favourable conditions and hence could be recommended for cultivation in high fertility areas and management practices. Furthermore, genotypes L-4676 and L-4594 had mean seed yield greater than population mean and was stable (S^2d_i=0) but their b_i values were significantly lower than unity (b_i <1). It indicated that these genotypes would perform better in poor environmental conditions and hence these genotypes can be used as a donor parent to breed a suitable genotype for poor environment (Table 2).

The results of the present study indicated that none of the genotype studied was found superior for all the characters in all the environments. The stable genotypes identified could be used as parents in future breeding programme for developing suitable genotypes with wider adaptability. Dehghani *et al.* (2008) recommended that yield and stability of performance should be considered simultaneously to exploit the useful effect of GE interactions and to make genotype selection more precise and refined. Further Abo-Hegazy *et al.* (2013) also concluded in lentil breeding programs, which the performance of genotypes under each location should be evaluated firstly and those reliable ones will be tested for stability across various environmental conditions prior to recommendations.

Table1. Joint regression analysis for seed yield and its components in lentil (Eberhart and Russell, 1966)

Source of variation	d.f.	**Mean squares**										
		Days of anthesis	**Days to maturity**	**Primary branches**	**Secondary branches**	**No. of pods per plant**	**Plant height (cm)**	**No. of Seeds per pod**	**Biological yield (g)**	**Seed yield (g)**	**100-seed weight (g)**	**Harvest index (%)**
Genotype (G)	29	1349.97**	236.38**	0.56**	1.78**	815.03**	34.44**	0.096**	90.32**	10.09**	4.79**	1.59
Environment (E)	3	175.29**	187.79**	0.42**	1.77**	143.96**	52.01**	0.059**	81.86**	9.12**	0.90**	8.78**
G × E	87	4.96	7.25**	0.03	0.08	10.88	1.89	0.004	1.95	0.17	0.03	1.07*
E + G × E	90	10.63	13.27**	0.04	0.14	15.31	3.57	0.006	4.62	0.46	0.06**	1.33**
E (linear)	1	525.39**	563.88**	1.26**	5.30**	432.22**	156.03**	0.177**	243.58**	27.37**	2.71**	26.29**
G × E (linear)	29	8.00**	2.14	0.03	0.12*	16.03*	3.42*	0.007**	2.87**	0.29**	0.05**	0.86
Pooled deviation	60	3.01	9.47**	0.2	0.06	8.02	1.09	0.002	1.44	0.11	0.02**	1.14**
Pooled error	232	11.99	3.81	0.10	0.37	60.80	7.78	0.010	7.69	0.79	0.03	0.72

*,** = significant at P = 0.05 and P = 0.01 levels, respectively.

Table 2. Estimates of stability parameters in 30 genotypes

Genotypes	Days to anthesis			Days to maturity			Primary branches			Secondary branches		
	$\overline{X}$	b_i	S^2d	$\overline{X}$	b_i	S^2d	$\overline{X}$	b_i	S^2d	$\overline{X}$	b_i	S^2d
L-415	65.25	0.36^{**}	-3.66	143.75	0.97	6.21^{+}	4.23	1.01	0.00	6.83	0.22^{**}	-0.11
L-307	102.92	0.93	-3.98	142.25	1.72	7.15^{+}	3.80	1.26	-0.03	7.38	0.79	-0.12
L-4595	98.17	0.69	10.26	144.75	0.73	0.14	3.92	1.26	-0.01	7.04	0.38	-0.08
L-4674	80.58	2.46^{**}	-1.02	151.33	0.96	0.35	4.28	1.49	-0.02	7.27	0.93	-0.11
L-396	63.00	0.73	-3.48	143.92	0.86	7.23^{+}	4.13	1.16	-0.03	6.68	0.46	-0.10
L-308	103.67	0.99	-1.85	144.83	0.67	0.37	4.04	-0.34	0.14	7.00	-1.42^{*}	0.15
L-306	103.33	0.65	-3.13	148.33	1.15	3.55	3.86	0.38	-0.03	7.62	-0.33	-0.03
L-309	103.67	1.56	15.36	147.92	1.34	25.90^{++}	4.04	-0.82	0.17^{+}	6.67	0.80	-0.10
L-4676	97.17	0.35^{**}	-3.23	148.83	0.59	12.82^{++}	4.23	0.49	-0.03	8.23	0.56	-0.09
L-4618	90.67	1.40	0.27	145.75	0.33^{**}	-0.91	4.26	1.32	-0.01	7.74	1.51	-0.12
L-4671	73.42	0.16^{*}	-0.97	149.17	0.71	2.25	3.43	0.57	-0.02	6.90	0.87	-0.12
L-395	104.08	0.79	-3.78	146.58	0.86	2.10	3.57	0.29	-0.03	6.62	0.96	-0.12
L-386	96.92	1.21	-0.47	149.83	0.91	22.57^{++}	4.44	0.04^{**}	-0.03	8.63	0.36^{*}	-0.11
L-381	103.33	0.67^{**}	-3.22	150.50	1.30	81.01^{++}	4.39	0.36	-0.02	8.55	1.05	-0.05
L-4594	94.33	1.73^{**}	-2.86	147.58	0.52	34.83^{++}	4.26	0.54	-0.03	7.63	0.95	-0.11
L-4672	85.42	0.50	-3.66	148.92	1.05	7.50^{+}	3.52	0.28	-0.03	6.48	1.26	-0.06
L-4148	103.75	0.85	-3.23	143.92	1.47^{**}	-0.81	4.13	0.30	-0.02	7.25	0.63	-0.02
L-4598	94.83	0.78	-0.11	142.83	1.62	1.92	4.50	0.51	-0.02	8.02	0.73	-0.11
L-32225	61.75	0.61^{*}	-3.48	126.00	1.26^{**}	-1.10	4.11	1.49	-0.03	7.68	0.26^{**}	-0.12
L-4147	104.58	0.79	-3.76	143.83	1.22	-0.10	4.41	0.98	-0.01	8.44	2.05	-0.01
L-4596	104.50	0.76	-3.14	144.33	1.02	-0.73	4.48	1.80	0.06	7.90	1.78^{**}	-0.11
L-414	94.92	1.94^{**}	-2.65	144.17	0.99	0.77	5.13	1.25	-0.03	8.67	1.91	-0.04
L-412	49.42	2.36^{**}	-2.78	126.00	1.36^{**}	-1.16	4.11	3.18^{**}	-0.02	7.95	1.76^{**}	-0.12
L-4597	73.58	1.39^{**}	-3.66	145.58	0.39^{**}	-0.81	4.57	0.39^{*}	-0.03	7.62	2.96	0.63^{+}
L-416	82.08	1.14	13.76	145.83	0.73	2.91	4.28	3.35^{*}	0.04	7.23	1.77	-0.08
L-4661	61.92	0.50	-1.79	127.42	1.02	4.95	4.44	1.64	0.00	7.95	1.58	-0.02
L-417	62.42	0.44^{**}	-3.95	144.75	0.88	-1.18	4.64	1.31	-0.03	8.40	2.06^{**}	-0.10
L-4677	44.75	0.35^{*}	-2.68	127.50	1.27	16.07^{++}	4.88	2.32^{**}	-0.02	8.66	1.22	-0.05
L-4620	71.33	0.01^{*}	-0.33	127.25	1.14	5.89	3.91	1.03	-0.02	7.12	0.80	-0.11
L-310	90.00	2.92^{**}	-2.51	143.75	0.97	6.21^{+}	4.12	1.15	-0.02	7.35	1.12	-0.11
Pop Mean S.E. of Mean	85.53 1.00	1.00 0.41		142.91 1.78	0.99 0.71		4.204 0.01	0.99 0.82		7.58 0.15	1.00 0.62	

Genotypes	No. of Pods per plant			Plant height			No. of Seeds per pod			Biological yield		
	$\overline{X}$	b_i	S^2d	$\overline{X}$	b_i	S^2d	$\overline{X}$	b_i	S^2d	$\overline{X}$	b_i	S^2d
L-415	79.82	1.10	8.12	27.95	0.60	-2.08	1.73	1.14	0.00	24.23	2.11	4.54
L-307	52.63	0.46	-19.06	26.35	0.78	-1.88	1.33	0.00	0.00	17.08	0.43	-1.79
L-4595	82.12	1.03	-18.86	28.72	0.91	-2.22	1.66	1.96	0.00	18.06	1.01	-1.47
L-4674	55.73	1.21	-17.62	30.99	0.78	-2.40	1.67	0.74	0.00	18.16	1.26	-1.44
L-396	89.91	1.42	3.55	36.25	1.08	-2.52	1.80	0.30	0.00	19.32	0.76	-1.74
L-308	85.76	0.50^{**}	-19.92	31.17	0.84	-2.12	1.82	-0.36	0.00	18.64	0.55^{**}	-2.34
L-306	80.74	0.62^{**}	-20.13	31.54	0.56	-1.99	1.53	2.28	0.00	16.92	0.54^{**}	-2.54
L-309	70.13	0.07	27.08	31.57	1.55^{**}	-2.36	1.33	0.63	0.00	20.74	0.91	1.36
L-4676	81.22	0.52^{*}	-19.75	32.02	0.26^{**}	-2.29	1.44	0.19	0.00	22.56	0.29^{**}	-2.36
L-4618	83.77	0.79	-19.63	31.14	0.67	-1.77	1.62	1.63	0.00	21.91	1.13	-2.43
L-4671	59.42	-1.70^{*}	1.95	31.87	0.80	-1.63	1.56	2.31	0.00	12.35	-0.01^{**}	-1.51
L-395	54.12	0.57^{*}	-	27.30	0.62^{**}	-2.51	1.73	-0.39^{*}	0.00	10.91	0.63^{**}	-

			19.70									2.40
L-386	95.37	-0.18	-12.38	33.07	0.27**	-2.29	1.76	1.61	0.00	20.28	0.49	-1.67
L-381	96.47	0.88	-19.92	33.19	1.03	-2.53	1.52	0.11	0.00	24.84	1.15	-2.04
L-4594	100.50	0.77	-18.34	34.83	0.23	-1.54	1.49	0.32	0.00	22.24	1.32	-1.88
L-4672	64.03	0.32	-11.76	28.35	0.02	-1.04	1.83	1.32	0.00	9.73	0.12**	-2.10
L-4148	87.73	0.51	-18.10	35.29	0.29**	-2.23	1.51	0.68	0.00	23.82	1.02	-2.12
L-4598	97.03	0.57	-17.01	35.67	0.27**	-2.41	1.87	0.90	0.00	26.15	0.82	-1.99
L-32225	87.37	0.69	-19.26	30.82	1.47**	-2.44	1.62	1.33	0.00	18.56	0.57**	-2.53
L-4147	96.29	0.89	-16.98	35.83	0.63	-2.24	1.86	1.92	0.00	24.77	0.89	-1.35
L-4596	73.17	1.16	-19.70	32.54	-0.30	1.41	1.77	-0.09	0.00	21.71	1.14	-2.27
L-414	93.46	0.74	-18.52	36.33	1.06	-2.03	1.81	-0.20	0.00	28.30	1.02	-1.26
L-412	96.24	3.62*	-1.63	37.77	2.03**	-2.51	1.54	4.33**	0.01	20.33	2.41*	0.89
L-4597	86.41	1.08	-16.80	34.03	2.95	4.61	1.72	0.87	0.00	22.72	1.52	-1.55
L-416	87.35	1.37	-17.12	33.93	1.84*	-2.04	1.65	1.09	0.00	21.70	1.98**	-2.05
L-4661	94.91	1.42**	-20.14	30.62	2.49	3.12	1.47	0.57	0.00	23.12	1.14	-0.84
L-417	95.32	2.11**	-19.92	32.03	1.17	-2.51	1.88	-0.17	0.00	28.71	0.40	-1.20
L-4677	92.72	4.28*	0.53	33.07	2.98*	0.64	1.77	-0.39*	0.00	30.00	1.64	4.95
L-4620	64.23	2.00*	-16.71	28.62	1.57	-1.50	1.57	2.28	0.00	19.21	1.97	0.98
L-310	90.30	1.18	10.19	35.30	0.55	-1.46	1.73	3.06*	0.00	19.17	0.77	-1.43
Pop Mean **S.E. of Mean**	82.46 1.63	0.99 0.75		32.27 0.61	1.00 0.46		1.65 0.03	.99 0.71		20.87 0.69	1.00 0.42	

Genotypes	**Seed yield**			**100-seed weight**			**Harvest index**		
	$\overline{X}$	b_i	S^2d	$\overline{X}$	b_i	S^2d	$\overline{X}$	b_i	S^2d
L-415	7.84	2.51**	0.20	5.63	3.70**	0.00	32.27	0.99	0.23
L-307	5.53	0.57	-0.20	7.88	1.92**	-0.01	32.40	0.91	0.62
L-4595	5.83	1.21	-0.21	4.26	0.70	-0.01	32.25	0.45	0.13
L-4674	5.83	1.11	-0.21	6.28	0.68	0.02	32.17	1.49	0.46
L-396	6.25	0.58*	-0.23	3.87	0.50	0.00	32.44	1.81	0.03
L-308	5.93	0.37*	-0.18	3.78	0.79	-0.01	31.84	2.06	0.59
L-306	5.49	0.86	-0.21	4.43	0.70	-0.01	32.39	-1.27	2.29^{++}
L-309	6.48	0.63*	-0.25	7.01	2.39	0.36^{++}	31.53	4.30	2.74^{++}
L-4676	7.20	0.50**	-0.23	6.16	0.37	-0.01	31.90	0.78	-0.02
L-4618	7.07	1.18	-0.21	5.16	0.85	-0.01	32.27	1.42	0.27
L-4671	3.88	-0.07**	-0.17	4.21	0.42	-0.01	31.44	0.40**	-0.23
L-395	3.37	0.39	-0.26	3.60	0.57	0.01	31.01	0.65	1.75^{++}
L-386	6.59	0.72	-0.23	3.94	0.97	0.00	32.50	0.72	0.67
L-381	8.07	0.92	-0.22	5.49	1.60	0.00	32.52	0.70	0.74
L-4594	7.47	0.68**	-0.26	4.99	0.68	0.00	33.80	0.38	6.16^{++}
L-4672	3.13	0.18**	-0.24	2.68	0.25**	-0.01	32.29	1.56	0.23
L-4148	7.68	1.05	-0.21	5.82	1.77	0.01	32.25	0.90	-0.15
L-4598	8.56	0.96	-0.26	4.73	0.78	-0.01	32.73	0.40	0.53
L-32225	5.90	0.53**	-0.24	4.17	0.15	-0.01	31.83	-0.22	0.29

L-4147	8.24	1.07	-0.03	4.63	0.79	0.01	33.27	0.46	0.64
L-4596	7.09	1.11	-0.26	5.49	1.25	0.01	32.73	1.32	0.62
L-414	9.16	1.31	-0.24	5.43	1.28	0.01	32.36	0.24	0.54
L-412	6.48	1.96	-0.03	4.36	0.58	0.04	32.09	2.32	0.60
L-4597	7.30	1.36	-0.22	4.91	1.68	0.01	32.15	1.54	-0.01
L-416	6.87	1.65	-0.26	4.75	1.81	0.03	31.75	-0.10	0.67
L-4661	7.50	1.07	-0.13	5.35	0.65	-0.01	32.49	0.23	0.54
L-417	9.28	0.86	-0.09	5.20	0.50	0.00	32.32	0.55	0.60
L-4677	9.97	2.08	0.44	6.07	0.35**	-0.01	33.22	1.40	0.73
L-4620	6.36	1.49	0.06	6.29	0.75	-0.01	33.34	2.07	1.47+
L-310	6.48	1.18	-0.09	4.22	0.54*	-0.01	33.76	1.59	3.32++
Pop Mean	6.76	1.00		5.03	0.99		32.38	1.00	
S.E. of Mean	0.19	0.34		0.09	0.53		0.62	1.14	

*, ** = significantly deviating from unity at P = 0.05 at P = 0.01 level, respectively.
+, ++ = significantly deviating from zero at P = 0.05 and P = 0.01 level, respectively.

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