ORIGINAL PAPER

STABILITY PARAMETERS IN LENTIL

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ABSTRACT

Fourteen lentil genotypes were tested for grain yield in Southeastern Anatolia ecological conditions, over our consecutive years to classify these cultivars for yield stability. Seed yield ranged from 1.903 t/ha to 1.367 t/ha. RM76, RM601 and RM152 showed regression coefficient above 1.00, but RM76 among these lines was consistently produced the highest yields. The unstable cultivars, RM601 and RM152 had the highest S^2 values and high C.V. for grain yield.

Keywords: Lentil, Lens culinaris Medik., Yield, Stability Parameters

INTRODUCTION

Red lentil (winter grown lentils with red cotyledon colour) is important grain legume crop of Southeastern Anatolia of Turkey, and it is widely grown in rotation with winter cereals. However, its production exhibits fluctuation mainly due to cultivation of low yielding and environment sensitive genotypes. A genotype is considered to be adaptive or stable one if it has a high mean yield but a low degree of fluctuation in yielding ability when grown over diverse environments [1]. Therefore, emphasis should be put on the identification of genotypes, which could perform better irrespective of small changes in environment. Several methods can be used for measuring crop yield stability. Among them, the most popular and widely used is the linear regression analysis as proposed by Eberhart and Russell [3]. Thus, this study was aimed on grain yield of 14 promising lentil lines to find out ones with comparatively better and consistent grain yield in differential growing conditions.

MATERIALS AND METHODS

This study was carried out during 2002, 2003, 2004 and 2005 years in Southeastern Anatolia of Turkey. The experimental location has mild climate with rainy winters and dry hot summers. The soil were clay loam with a pH of 7.9 and 2.03% organic matter. Climatic data related to experimental area are summarized in Table 1. According to Table 1, the weather from February to May over four years was rainy, and the rainfall, particularly in 2003 and 2004 growing seasons, was more than the long-term average. Overall rainfall during the entire growing season (to 95% physiological maturity) was about 300 mm for each year.

The experimental material consisted of eleven lentil genotypes (Regional Material) isolated from Southeastern Anatolia lentil populations, and three standard cultivars (ST) which were previously breed for the region and used as check varieties. Experimental design was randomized complete block with four replications. Seeds were sown by seed drill 6 row plots of 4 m length, with 20 cm between the rows and 2.5 cm between plants. Sowings were performed Nov.14, 2001, Jan.5, 2002, Nov.21, 2003, and Dec.5, 2004. Standard agro-technique measures were used during lentil grows.

The data used were obtained from one location and four years. The variance analysis combined over four environments [10]. Location effects were considered as random variables while the genotype effects were treated as fixed. Different stability parameters were used. The method of Eberhart and Russell [3] employs the regression

Table 1 Precipitation (mm), Temperature (^{0}C) and Humidity (%) distribution during crop seasons at Diyarbakir, Turkey

Years	Months	Jan.	Feb.	March	April	May	June	Nov.	Dec.
Long term average	P.	74.6	68.4	66.2	73.5	40.8	7.20	54.6	71.4
	T.	1.60	3.60	8.30	13.9	19.3	25.9	9.80	4.10
	H.	77.0	73.0	66.0	63.0	56.0	36.0	68.0	77.0
2001	P.	14.9	72.4	126.1	54.0	86.9	0.00	52.3	131.7
	T.	4.00	5.00	11.4	14.3	16.7	26.7	7.00	5.10
	H.	68.0	66.0	69.0	64.0	60.1	26.0	61.0	82.0
2002	P.	31.2	46.1	73.0	65.0	34.9	1.30	36.6	74.1
	T.	0.70	5.60	9.40	12.2	17.9	26.3	10.2	11.3
	H.	77.0	58.0	64.0	69.4	48.8	29.7	55.3	71.0
2003	P.	68.4	151.8	80.7	80.6	54.0	26.9	62.5	87.9
	T.	4.00	2.5.0	6.50	13.4	20.4	26.4	8.80	8.70
	H.	78.0	75.8	64.5	66.1	45.0	24.5	67.7	76.1
2004	P.	85.1	93.4	9.30	54.9	97.0	16.0	123.1	4.70
	T.	3.30	2.70	9.60	12.8	18.0	26.4	8.20	1.40
	H.	81.9	79.6	5.40	49.6	54.0	23.3	69.4	59.9
2005	P.	58.7	46.8	58.4	36.8	26.5	-	-	-
	T.	2.30	3.00	8.40	14.1	19.6	-	-	-
	H.	66.0	61.7	53.3	51.9	-	-	-	-

P: Precipitation, T: Temperature, H: Humidity of individual means on the environmental index, which is defined as the mean of all genotypes grown in that environment. The regression coefficient (b) and the deviation from the regression (S^2d) are the parameters of stability. Significance of b's were investigated by t-test. Furthermore, other stability parameters were considered such as ecovalence (Wi), environmental variance (S^2), and coefficient of variation. Ecovalence (Wi), measures contribution to genotype x environment interaction of each genotype, and was described by Wrick [11]. Environmental variance (S^2), estimate the variance of each genotype over all environments [7]. Coefficient of variation (C.V.) was described by Francis and Kannenberg [5].

RESULTS AND DISCUSSION

The variance analysis combined over four environments (years), and data from variance analysis of stability were given in Table 2. Results of the combined analysis of variance for grain yield indicate that the genotype x year (G×Y) interaction effects were statistically significant (Table 2). This demonstrates the presence of genotype and environmental differences governing the expression of this trait and the significant contribution of G×Y interactions in influencing genotype performance. Partitioning of interaction effects using Eberhart and Russell's [3] regeneration method showed that year (Linear) and G×Y (Linear) effects were non significant for yield. However, the deviation from the regression (S^2d) was significant. Variance of deviation from the regression is more important than genotype x environment interaction in stability [9].

Table 2 Pooled analysis of variance for grain yield in lentil

Source of Variance	DF	MS
Genotype	13	0.18196**
Year	3	122.4694**
Year x Genotype	39	1.1917**
Genotype (linear)	13	0.1011 ^{ns}
Year+(y x g) (linear)	42	0.24274
Year (linear)	1	7.225515
Year x Genotype (linear)	13	0.02113 ^{ns}
Pooled Deviations	28	13.47554*
Error	156	0.635

*, ** Significantly different at p = 0.05 and p = 0.01 levels respectively

The lentil genotypes evaluated revealed by different rankings at the different years. This showed that the performance of the genotypes and their superiority was dependent on environment. The highest yield was given by RM76 with mean over years of 1.903 t/ha followed by ST1 1.768 t/ha (Table 3). The lowest yield was observed on RM601 (1.367 t/ha). ST2 as standard variety was produced mean over years grain yield of 1.529 t/ha.

The stability results were generally argued on the basis of seed yield ranking and stability parameters. According

Table 3 Ranking of lentil genotypes at four years

Genotypes	2002	2003	2004	2005
ST1	10	8	6	3
RM76	1	3	2	1
RM498	12	11	7	13
ST2	14	4	13	6
RM711	11	5	12	11
RM479	7	1	11	2
RM500	3	2	1	14
RM760	9	7	9	8
RM34	2	10	14	5
RM152	5	12	5	9
ST3	4	6	4	4
RM601	13	14	3	12
RM499	6	9	10	7
RM201	8	13	8	10
CV	26	19	14	16.
Environment Mean	1,713	1,021	2,005	1,6598
Environment index	0,113	-0,579	0,405	0,0599

to the techniques followed by Finlay and Wilkinson [4], who defined varieties with general adaptability as those with average stability (bi = 1.0) when associated with high mean yield over tested environment. Eberhart and Russell [3] proposed that an ideal population of genotype is one which has the highest yield over a broad range of environments, a regression coefficient (b) value of 1.0 and deviation mean square of zero.

Based on result of the regression analysis, the genotypes RM201, ST3 and RM760 were classified as highly stable over environments because their regression coefficient was close to unity (b=1) (Table 4).

Table 4 Estimates of stability parameters for grain yield in lentil

Gen.	Rank on yield	Yield kg/ha	b	Rank	S^2d	Rank	S^2	Rank	CV	Wi	Rank
RM76	1	1.903**	1.224	10	0.1372*	8	0.3038	11	28.9	0.163	7
ST1	2	1.768**	0.904	4	0.0049	1	0.1424	4	21.3	0.009	1
RM500	3	1.745	1.137	7	0.3162**	11	0.3280	12	32.8	0.326	10
RM479	4	1.737	0.708	13	0.0677	6	0.1088	2	18.9	0.111	5
RM152	5	1.697	1.342	14	0.0778	7	0.3358	13	34.1	0.138	6
RM760	6	1.633	1.035	3	0.0342	4	0.1956	5	27.0	0.034	3
RM34	7	1.614	0.785	9	0.5558**	14	0.2913	9	33.4	0.579**	14
RM711	8	1.563	0.880	6	0.0165	2	0.1388	3	23.8	0.023	2
ST2	9	1.529	0.712	12	0.0272	3	0.0962	1	20.2	0.070	4
RM498	10	1.528	1.102	5	0.0447	5	0.2240	7	30.9	0.501	12
ST3	11	1.525	1.033	2	0.3389**	12	0.2965	10	35.7	0.339	11
RM499	12	1.419**	0.856	8	0.2739**	9	0.2175	6	32.8	0.284	8
RM201	13	1.369**	1.007	1	0.2893**	10	0.2708	8	38.0	0.289	9
RM601	14	1.367**	1.273	11	0.5105**	13	0.4488	14	49.0	0.549**	13
Mean		1.599									

*, ** Significantly different at p = 0.05 and p = 0.01 levels respectively

According to the ranking and mean yield the genotypes RM201and ST3 were all poorly adapted across the test environments, but RM760 had better yield and thus had better general adaptability and had resistance to fluctuating environmental conditions.

The highest yielder, RM76 had higher regression coefficient than the other genotype. This might come from higher yield value than other genotypes.

The genotypes with coefficients below 1, giving average stability, resisting fluctuations with good yields were ST1 and RM711. The genotypes RM479 and RM34 had regression coefficients significantly less than 1, which indicates their below average adaptability and lack of response to environmental changes for grain yield, with relatively small fluctuation in performance between poor and good environments.

The deviation column in Table 4 showed the genotypes ST1 and RM711 to be the most stable. Taking the ranking of yield into consideration, RM711 would be the most stable with RM760 second best if general stability is important. ST2 had good S^2di value, but had a small bi value. These results indicated that some genotypes were more sensitive to the small changes in environment while others were more stable. These findings agree with other researchers [2, 4, and 6].

In addition to above mentioned stability parameters, genotypes indicating low environmental variances (S^2) and low coefficients of variation (CV) are also considered stable [7]. Low CV values and environmental variances were shown by ST2, RM479, RM711 and ST1, confirming their high stability. In addition, it was indicated that grain yield of these genotypes were higher than that of mean. The unstable cultivars, RM601 and RM152 had the highest S^2 values and high C.V. for grain yield.

Wricke's [11] ecovalence is an alternative method that is frequently used to determine stability of genotypes based on the G x E interaction effects. It indicates the contribution of each genotype to the G x E interaction. The cultivars with the lowest ecovalence contributed the least to the G x E interaction and are therefore more stable. The genotypes like ST1 (0.009) and RM760 (0.034) were showed good stability and correlation to the mean yield. The least stable RM601 (0.549) showed no similarity to mean yield ranking. RM711 (0.023) and ST2 (0.070) had the best stability but had poor yield ranking and were therefore not well adapted to the test environments.

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