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Stability Parameters in Lentil Genotypes

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Abstract: Total 20 lentil genotypes were examined for assessment stability in different environments for grain yield in Southeastern Anatolia of Turkey. Genotypes and genotypes x environments interactions were significant for grain yield. The regression coefficient, deviations of the regression coefficients, coefficient of variation, ecovalence and stability variance were computed for genotypes. Genotypes FLIP2011-26L, ILL10975 and Firat 87 with a high stability (b) and high grain yield would be adapted to a wide range of growing conditions in a given production area with above average yield. The stability variance (σ2i) revealed that the lentil genotypes Kafkas, Cagil and FLIP2009-55L had the smallest variance across the environments, while the genotype Firat 87 had the largest stability variance (σ2i).

Keywords: Adaptability; genotype; lentil; Lens culinaris; stability.

Mercimek Genotiplerinde Stabilite Parametreleri

Öz : Araştırmada, 20 mercimek genotipi Güneydoğu Anadolu Bölgesi'nde farklı çevre koşullarında tane verimi stabilitesi yönünden incelenmiştir. Tane verimi yönünden genotipler ve genotip x çevre interaksiyonları önemli bulunmuştur. Genotiplerin regresyon katsayısı, regresyon katsayısı sapmaları, varyasyon katsayısı, ekovalans varyansı ve stabilite varyansı hesaplanmıştır. FLIP2011-26L, ILL10975 ve Firat 87 genotipleri yüksek stabilite (b) ve yüksek tane verimine sahip olup, belirtilen üretim alanında, ortalamanın üzerinde verimle çok farklı yetiştirme koşullarına adapte olduğu belirlenmiştir. Kafkas, Cagil ve FLIP2009-55L genotiplerinin stabilite varyansı ($\sigma^2 i$), çevre açısından en düşük değere sahip olurken, Firat 87 genotipi en yüksek değeri verdiği belirlenmiştir.

Anahtar kelimeler: Adaptasyon; genotip; mercimek; *Lens culinaris*; stabilite.

1. Introduction

Red lentil (*Lens culinaris* Medic.) (winter grown lentils with red cotyledon color) is important grain legume crop of Southeastern Anatolia of Turkey, and it is widely grown in rotation with winter cereals. Lentil production exhibits fluctuation mainly due to cultivation of low yielding and environment sensitive genotypes [1]. Yadav et al. [2] reported that mega environments help to identify the most suitable lentil cultivars that can be recommended for areas within the mega-environment in either one or more test locations. The significances among the environments indicate that their locations can be used as testing stations for different environments while significant differences among genotypes reveals the differential response of genotypes to different environments. The genotypes used in this study have been high or low yielding in previous years in

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only one location, but their performances in different environments are very important to recommend as a new variety for region. Plant breeders have used the stability to introduce a genotype that indicates a relatively constant yield, independent of environmental conditions [3]. Several models for the statistical measurement of the stability have been proposed by researches [4-7], but researchers reported that single method could not adequately explain cultivar performance across environments [8]. Finlay and Wilkinson [4] used the coefficient of regression (*b*) as a stability parameter, they reported the regression coefficients can be used to describe the response of different cultivars to environments. The coefficient of variation [7] is used to select cultivars that have both high yield and low variance (a small among-environment variance). Wricke's ecovalance [5] suggested using genotype environment interactions for each genotype as a stability measure. Shukla [9] used stability variance of genotypes for determining stability of a genotype. Some genotypes of lentil for their yield stability under different environments and different the stability parameters were evaluated in this present study.

2. Materials and Methods

This research was conducted in Southeast Anatolia of Turkey on lentil genotypes. Experiment was conducted in Diyarbakir (altitude: 674 m), Silvan (altitude: 840 m), Hazro (altitude: 1050 m) and Kiziltepe (altitude: 498 m) of Southeast Anatolia of Turkey. Meteorological data of experimental areas were given in Table 1.

Table 1. Meteorological data of experiment areas

	Average temperature (°C)				Average humidity (%)				Total precipitation (mm)			
	Hazro	**Silvan**	**D.bakir**	**K.tepe**	**Hazro**	**Silvan**	**D.bakir**	**K.tepe**	**Hazro**	**Silvan**	**D.bakir**	**K.tepe**
2015												
January	2.8	3.6	2.0	5.2	74.4	85.5	92	64.1	138.4	95.8	66.6	60.0
February	5.0	6.4	5.0	6.7	77.2	79.7	92.5	66.8	113.8	92.5	65.8	111.0
March	7.9	9.3	7.6	10.1	69.7	72.6	86.2	57.9	154.7	117.5	122.2	149.9
April	11.7	13.3	12.1	14.5	67.1	68.1	79.7	51.0	82.8	66.0	42.4	46.3
May	19.0	20.5	18.9	22.5	47.9	48.4	59.2	33.4	14.5	23.8	28.5	49.7
June	25.4	27.3	25.6	28.5	29.3	27.2	36.4	24.2	6.9	4.60	3.4	3.7
Nov.	10.6	11.1	9.5		54.2	62.5	62.7		22.7	13.7	9.0	
Dec.	5.3	5.9	3.8		53.3	61.0	61.6		33.8	22.2	23.2	
2016												
January	1.3	2.4	1.1	5.3	82.2	90.1	82.5	74.1	73.4	71.3	79.2	143.4
February	7.3	8.9	7.9	11.1	72.9	75.4	75.2	67.3	74.6	76.2	62.2	68.8
March	9.0	10.5	9.7	12.0	67.6	64.7	70	66.2	60.8	134.0	39.6	86.4
April	15.4	19.9	15.7	17.5	50.4	51.2	59.9	58.3	40.0	52.3	18	38.5
May	18.2	27.4	19.9	21.0	49	51.3	56.1	53.0	45.1	52.1	38.2	21.4
June	25.1	32.2	26.8	29.1	31.4	28.6	35.1	26.5	19.2	6.0	4.2	0.0

Source: Turkish State, Meteorological Service/Ankara

Fifteen lentil genotypes (Lentil International Drought Tolerance Nursery, Lentil International Elite Nursery-Drought Tolerance Nursery from ICARDA and local genotypes) and five lentil cultivars (Firat 87, Kafkas, Cagil, Sakar and Ozbek) were used. Experiments were carried out separately in a randomized complete block design with four replications, and six rows at 4 m length, in row spacing 20 cm and with a seed rating 300 seed m^{-2}. Sowings were performed November 20 in Diyarbakir, November 21 in Hazro and November 22 in Kiziltepe in 2016 growing season. Plots were fertilized with 30 kg N ha^{-1} of and 50 kg P_2O_5 ha^{-1} in planting. Experiment was designed randomized complete block design with four replications. The harvested plot size was 3.2 m^2, and plots were harvested by hand at end of May.

- Stability parameters

The regression coefficient (*bi*) was computed according to Finlay and Wilkinson [4] for the estimated to measure the stability and adaptability. The deviations of the regression coefficients Eberhart and Russell [6] generalized this concept by calculating from unity. According to this model, regression coefficients approximating one coupled with (S^2d) of zero indicate average stability. When this is associated with high mean yield, genotypes have general adaptability and when associated with low mean yield, genotypes are poorly adapted to all environments. Ecovalence (W^2i) as suggested by Wricke [5] was computed to further describe stability. The GE interaction effect for genotype i, squared and summed across all environments, is the stability measure for genotype i. A low ecovalence (W^2i) value indicates high relative stability. An unbiased estimate using stability variance ($\sigma^2 i$) of genotypes was determined according to Shukla [9]. The stability was measured by combining use of coefficient of variation (*CVi*) and mean yield [7].

3. Results and Discussions

Variance analysis was performed for each environment, genotypes and genotypes x environments interactions were significant for grain yield in lentil.

Grain yield ranks were given in Table 2. Mean grain yield ranged from 1435 kg ha-1 in BM848 to 2096 kg ha-1 in Sakar. Sakar were identified as top genotypes in three environments in the top five ranks. Although Firat 87 has good performance in Southeast Anatolia of Turkey, it has not showed good performance at Kiziltepe and Diyarbakir due to *Fusarium oxysproium*. Regression co-efficient (bi) values ranged from -0.4 in FLIP2010-103L to 2.7 in FLIP2010-19L (Table 3). Ten genotypes, those having a b value less than one, were found to have high yield stability and responded less to year x location effects. Other ten genotypes had a low yield stability index as indicated by a b value significantly greater than one. These hybrids had a greater response to environmental effects.

Table 2. Grain yield rank over environments in lentil genotypes

No	Genotypes	Diyarbakir	Hazro	Kiziltepe	Silvan
1	**FLIP2011-26L**	2	12	6	9
2	**ILL 3375**	4	10	10	18
3	**BM798**	16	16	19	10
4	**BM848**	19	18	18	11
5	**FLIP2009-50L**	6	8	1	7
6	**FLIP2010-19L**	11	3	4	5
7	**FLIP2009-55L**	1	7	15	17
8	**ILL10975**	3	2	11	8
9	**FLIP2010-94L**	14	9	7	12
10	**FLIP2011-61L**	20	20	14	14
11	**FLIP2010-82L**	8	17	17	20
12	**FLIP2011-55L**	12	14	16	16
13	**FLIP2011-56L**	7	19	13	19
14	**FLIP2010-103L**	17	6	3	15
15	**FLIP2011-49L**	5	13	2	13
16	**Kafkas**	9	4	9	4
17	**Sakar**	10	5	5	2
18	**Ozbek**	15	11	12	3
19	**Cagil**	13	15	8	6
20	**Firat 87**	18	1	20	1

Genotypes FLIP2011-26L, ILL10975 and Firat 87 with a high stability and high grain yield would be adapted to a wide range of growing conditions in a given production area with above average yield. Genotypes FLIP2011-26L is medium early maturing trait, can be escape from the cold damage occurred in March, and tolerant to drought. Firat 87 is late maturing, resistant to cold damage and drought, has been cultivated almost everywhere in the region for 20 years for high and stable yield. Although variety Firat 87 is defined as resistant to *Fusarium*, it suffered from disease in 2016 year in two locations. Temperatures are often higher than optimum for lentil in May and rainfall is more sporadic in southeast Anatolia, and lentil producers sometimes can't predict the environment, so genotypes with high b values can be selected to reduce risk. Genotype FLIP2011-61L with below average yields demonstrated a tendency to perform poorly in unfavorable environments [6, 10].

4. Conclusion

Nine genotypes, having a low yield stability but above average yields, are responsive to the positive effects of good management and favorable environmental [6]. The means of these nine genotypes were compared to the average yield, and it was observed that the difference between genotypes Ozbek, FLIP2010-94L and FLIP2010-103L and average yield was less than other genotypes Kafkas, Sakar, FLIP2011-49L, FLIP2009-50L and FLIP2009-55L.

Table 3. Stability parameters over four environments in lentil

No	Genotypes	Yield kg ha^{-1}	b	δij^2	s^2i	CVi	W^2i	σ^2i
1	**FLIP2011-26L**	2011	1.2	91437	311625	27.76	108660	19.5
2	**ILL 3375**	1762	1.4	230177	529877	41.31	261853	46.9
3	**BM798**	1499	1.5	262279	606322	51.95	306730	55.0
4	**BM848**	1446	1.1	227334	412353	44.41	228883	41.0
5	**FLIP2009-50L**	2076	0.2	110985	117101	16.48	210917	37.8
6	**FLIP2010-19L**	1750	2.7	70723	1185422	62.22	529819	94.9
7	**FLIP2009-55L**	2092	0.5	34448	72675	12.89	80099	14.3
8	**ILL10975**	2012	1.4	54921	354621	29.60	90434	16.2
9	**FLIP2010-94L**	1855	0.3	7043	20805	7.78	84157	15.1
10	**FLIP2011-61L**	1435	0.4	87969	112434	23.37	144123	25.8
11	**FLIP2010-82L**	1463	2.4	49096	929846	65.91	347601	62.3
12	**FLIP2011-55L**	1558	2.1	46544	720869	54.50	225285	40.4
13	**FLIP2011-56L**	1533	1.7	229527	671431	53.45	295153	52.9
14	**FLIP2010-103L**	1800	-0.4	198944	223409	26.26	492553	88.2
15	**FLIP2011-49L**	1971	0.3	308234	321996	28.79	374655	67.1
16	**Kafkas**	2030	0.8	4200	102061	15.74	21265	3.8
17	**Sakar**	2096	0.4	51989	76455	13.19	119214	21.4
18	**Ozbek**	1851	0.6	257801	312848	30.22	295845	53.0
19	**Cagil**	1892	0.6	32734	87781	15.66	74591	13.4
20	**Firat 87**	1836	1.1	91437	1614406	69.20	1435104	257.1
	Mean	1798						

Mean: Mean grain yield; bi: Regression coefficient (Finlay and Wilkinson, [4]); CVi: Coefficient of variation (Francis and Kannenberg, [7]); s^2i: Genotypic variance; *W^2i: Wricke's* ecovalence (Wricke, [5]); σ^2i: Stability variance (Shukla, [9]); δij^2: Deviation from the regression (Eberhard and Russel, [6])

Although variety Sakar and Kafkas have good yield performance, Kafkas has been unfavored by growers due to late maturing, also Sakar is a very earlier genotype and high yielding, but it is sensitive to cold at beginning March. When stability parameters separately evaluated (Table 3); Wricke's [5] stability parameter W^2i, Kafkas, Cagil, FLIP2009-55L, ILL10975 and FLIP2010-94L with lower ecovalance (W^2i) were considered to be stable. The stability variance (σ^2i) revealed that the genotypes Kafkas, Cagil, and FLIP2009-55L had the smallest variance across the environments, while the genotype Firat 87 had the largest σ^2i. Kafkas, Cagil, and FLIP2009-55L were stable, while the Firat 87 was unstable. FLIP2010-94L and FLIP2009-55L according to Francis and Kannenberg [7] stability parameter (*CVi*) were stable genotypes, and these genotypes had a low *CVi* and high yield. Kafkas had lower stability variance ($\sigma^2 i$:3.8), Wricke's ecovalence ($W^2 i$:21265) and deviation from the regression (δij^2:4200) than other genotypes, and this genotype had high stability (low *b* value). FLIP2010-94L with low b and high yield had a low stability variance ($\sigma^2 i$:15.1), coefficient of variation (*CVi*: 7.78) and deviation from the regression (δij^2:7043). These results indicated that some lentil genotypes were more sensitive to the small changes in environment while others were more stable. These findings agree with other researchers [11-14].

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