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STABILITY ANALYSIS FOR SEED YIELD IN LENTILS (*LENS CULINARIS* MEDIK.)

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Abstract

The development of genotypes, which can be adapted to a wide range of diversified environment, is the ultimate goal of plant breeders in a crop improvement program. In this study, linear regression were used to analyze the response to environmental conditions of lentil (Lens culinaris Medik) genotypes taking as independent variable (X) the average yield of all lentil genotypes in four experiences (two locations and two years). Yield stability was assessed by determining the coefficients of variation. Seven lentil genotypes were tested for seed yield in two locations of Southern Romania environmental conditions during 2008 and 2009 growing seasons. On the basis of the regression coefficient genotypes Idlib-1, Idlib-2, Idlib-3, Hurani and Kurdi had general adaptability to over environments and genotypes Idlib-4 and Oana were suitable for favorable environments. The result of coefficient of variation indicated that the same genotypes were more stable. Among these Idlib-3 genotype was superior for stability and adaptation.

INTRODUCTION

Lentil (*Lens culinaris* Medik.) is the fourth most important pulse (legume) crop in the world after bean (*Phaseolus vulgaris* L.), pea (*Pisum sativum* L.), and chickpea (*Cicer arietinum* L.). Four major lentil producing countries in decreasing order are Canada, India and Turkey (FAO, 2009). At present in Romania lentils are grown on the lower areas, the only lentil Romanian cultivar being Oana. Lentil and other grain legumes are important dietary constituents worldwide even though their overall production lags far behind that of the cereals. Yields per unit area are generally less than one-half those of the major cereal grains. There are several reasons why grain legume yields in general and those of lentil (*Lens culinaris* Medik.) in particular have lagged behind: relegation of these crops to poorer soils, minimal research efforts until very recently, and various abiotic and biological limitations. Phenotypic yield stability is a trait of special interest for plant breeders. Several methods can be used for measuring crop yield stability. Among them, regression analysis is an important biometrical method of measuring a genotype's response (production response) to varying environmental condition [2]. The present research work was undertaken with a view to studying genotype-environment interaction and to identify stable and high yielding genotypes with greater seed production under changing cultural environments.

MATERIAL AND METHODS

This study was carried out during 2008 and 2009 growing seasons in two different locations from Southern Romania. Seven lentil genotypes were evaluated for seed yield in the experimental fields through University of Agronomic Sciences and Veterinary Medicine, Bucharest and Moara Domneasca research station. The characteristics and the location of the experimental environments are given in table 1 and table 2. The experimental seed material was from ICARDA lentil breeding program and from USAMV Iasi. Their name, pedigree, origin and some features are given in table 3. Experiments were monofactoriale such comparative cultures and experimental design was randomized complete block with four replications. Each genotype was sown in 6 rows; 2 m length with 25 cm inter-row spacing. Harvesting was done by hand. Grain yield was obtained by extrapolating plot grain yields on a hectare basis (kg/ha).

Table 1

Climatic characteristics of the environments tested in Romania

Year	Climatic factor	Month				
		March	April	May	June	July
USAMV Bucharest						
2008	Mean temperature ^{0}C	9.36	13.58	17.27	22.18	23.39
	Sum rainfall, mm	46.1	76.6	71.8	79.7	105.0
2009	Mean temperature ^{0}C	5.98	12.82	18.64	23.97	24.30
	Sum rainfall, mm	41.7	18.5	42.6	74.6	58.4
Moara Domneasca						
2008	Mean temperature ^{0}C	8.9	13.3	17.4	22.2	23.4
	Sum rainfall, mm	26.4	63.2	73.4	29.9	52.5
2009	Mean temperature ^{0}C	6.4	11.9	16.8	21.6	24.1
	Sum rainfall, mm	29.0	24.6	45.9	78.5	59.8

Table 2

Soil conditions of the environments tested in Romania

Location	Soil conditions		
	Texture	**Type**	**pH**
USAMV Bucharest	Clay-Loam	Chromic Luvisol	Medium alkaline
Moara Domneasca	Clay-Loam	Chromic Luvisol	Medium acid

Response to environmental conditions of each genotype was determined by regression analysis taking as independent variable (X) the average yield of all lentil genotypes in four experiences (two locations and two years). Yield stability was characteriyed by determining the coefficients of variation (CV%), described by Francis and Kannenberg [3]. Keim and Kronstand [6], using regression analysis

suggested that a variety is adapted to adverse environmental conditions when b< 1 (regression slope subunitar) and "a" (constant regression) has positive values; adapted to favorable environmental conditions when b>1; widely adapted to different environmental conditions when b>1 and "a" has positive values.

Table 3

Characteristics of lentil genotypes used in the study

Genotype	Origin / Pedigree*	Maturity	Features
Idlib 1	Syria-ICARDA	Early	Lodging resistance
Idlib 2	Syria-ICARDA/ Single-plant selection from a Jordanian landrace, 74TA14	Early	Resistance to vascular wilt, semierect growth habit, lodging resistance
Idlib 3	Syria ICARDA /ILL 99♀Moroccan landrace x ILL5588♂ elite line from Jordanian landrace population	Early	Tolerant to drought, erect growth habit, resistance to vascular wilt, lodging resistance
Idlib 4	Syria-ICARDA / ILL5879♀ x ILL5714♂	Early	Erect growth habit, resistance to vascular wilt, lodging resistance
Hurani	Syria -ICARDA / local cultivar	Early	Susceptible to lodging
Kurdi	Syria- ICARDA / local cultivar	Late	Tolerant to drought, susceptible to lodging
Oana	USAMV Iasi Romania / Mutagenesis and selection from local landrace	Late	Resistance to vascular wilt, lodging resistance

*ICARDA - International Center for Agricultural Research in the Dry Areas, Allepo, Syria
USAMV - University of Agricultural Sciences and Veterinary Medicine, Iasi, Romania

RESULTS AND DISCUSSION

The average seed yield for 7 lentil genotypes tested across two locations over the two years are presented in table 4.

Because between the two locations tested are not large pedoclimatic differences, the significant influence on production occurred due to different climatic conditions in the two years of experimentation 2008, 2009.

Coefficients of variation values were higher in 2009 year when drought stress was severe compared with 2008 year, in both experimental locations.

In 2008 year the highest yield 1280 kg/ha were obtained from genotype Idlib-4 at USAMV Bucharest, while the lowest was 870 kg/ha from genotype Hurani at Moara Domneasca.

The best production results in dry conditions of 2009 year were recorded by Idlib-3 and the lowest by Romanian cultivar Oana. This could be explained by the fact that the Idlib-3 genotype is resistant to drought and Oana genotype has a late maturity. Stability parameters estimates for seed yield in 7 lentil genotypes are presented in

Table 5. Examining the linear regression lines it is found that for Idlib-1 and Hurani lentil genotypes correlated distribution of seed yield in four experiments compared to average genotypes, is discribed by a linear regression with slope (b) less than 1, which highlights a lack of response to environmental changes for yield. However, the results indicate seed yield of these 2 genotypes were lower than that of mean (Table 5).

Table 4

Seeds yield in 7 lentils genotypes - UASVM Bucharest, Moara Domneasca (2008, 2009)

No.	Genotype	Seed Yield (kg/ha)			
		USAMV Bucharest		Moara Domneasca	
		2008	2009	2008	2009
1	**Idlib-1**	1045	920	990	910
2	**Idlib-2**	1123	1007	1009	986
3	**Idlib-3**	1150	1125	1100	1008
4	**Idlib-4**	1280	1010	1150	997
5	**Hurani**	910	815	870	790
6	**Kurdi**	1115	982	1100	954
7	**Oana**	1147	785	1000	733
	Mean	**1110**	**949,14**	**1031**	**911.14**
	CV%	**10.09**	**12.43**	**9.11**	**14.48**

The genotypes with regression slope (b) less than 1, giving average stability, resisting fluctuations with good yields were Idlib-2, Idlib-3 and Kurdi (Table 5).

Table 5

Estimates of stability parameters for seed yield in 7 lentil genotypes

Genotype	Mean yield, kg/ha	Diff. to environments mean yield, kg/ha	Regression stability parameters			
			b	a	r^2	CV %
Idlib-1	966.25	- 34.07	0.711	254.6	0.987	6.56
Idlib-2	1031.25*	30.93	0.622	408.5	0.790	6.12
Idlib-3	1095.75***	95.52	0.527	568.5	0.567	5.65
Idlib-4	1109.25***	108.93	1.489	-380.7	0.980	11.99
Hurani	846.25	-129.07	0.608	237.1	0.995	9.60
Kurdi	1037.75**	37.43	0.879	158	0.912	7.86
Oana	916.25	-84.07	2.163	-1248	0.992	20.99
Mean	1000.32					9.75

LSD 5%= 27.44; LSD 1% = 36.12; LSD 0.1% = 46.06

The genotypes Idlib-4 and Oana had regression coefficients higher than 1, which indicates a very strong reaction of these genotypes to environmental conditions, so a lower yield stability. Idlib-4 lentil genotype recorded the highest gain of yield

(108.93 kg/ha) which shows the tendency of this genotype to achieve high yields in favorable growing conditions. Oana Romanian lentil genotype showed higher production normal growing conditions.

In addition to above mentioned stability parameters, genotypes indicating low coefficients of variation (CV) are also considered stable [5]. Low CV values were shown by Idlib-1, Idlib-2, Idlib-3, Hurani and Kurdi, confirming their high stability. The unstable cultivars, Idlib-4 and Oana had the highest CV values for seed yield (Table 4.)

According to Freeman [4] one of the main reasons for growing genotypes over a wide range of environments is to estimate their stability and adaptability.

The use of two stability parameters may be valuable for some purposes.

For a long time, most breeders used the term stability to characterize a genotype which always showed a constant yield, under variable environmental conditions. This idea of stability agrees with the concept of homeostasis widely used in quantitative genetics and may be considered as a biological (static) concept of stability [1]. Biological stability is not acceptable to most plant breeders, who prefer an agronomic concept of stability.

In this concept of stability, it is not necessary for the genotypic response to environmental conditions to be equal for all genotypes. Both 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. Genotype Idlib-3 can be recommended as the most stable genotype with regard to both stability and yield.

Genotypes Idlib - 4 and Oana can be recomanded as the most performed genotypes with regard the yield in favorable growing conditions.

CONCLUSIONS

1. In terms of yield stability, expressed as regression coefficient and coefficient of variation, Syrian genotypes Idlib-3, Idlib-2, Idlib-1, Kurdi and Hurani showed highest degree of adaptation to environmental conditions in four experiments, so a good production stability.
2. Genotypes Oana and Idlib-4 recorded values of the coefficients of variation much higher than the average and regression coefficients higher than 1, suggesting a stronger response of these genotypes to environmental conditions, so a lower stability of yield.
3. The average yield reporting to yield obtained in the most favorable conditions could find that genotype Idlib-4 made on average the highest yield during testing period. The biggest loss of seed yield in unfavorable condition compared with the average, has been registered at Oana genotype.

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