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Full Length Research Paper

Stability analysis for phenological characteristics in chickpea

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This study aimed at determining the influence of genotype x environment interactions on phenological characteristics of chickpea. Field experiments were carried out on four different locations, in semi-arid conditions, in complete randomized blocks design with four replications from 2001 to 2002. Eleven certified and 3 indigenous varieties were used. Emergency date, first flowering period, flowering period and vegetation period were examined as phenological characteristics. For all characteristics, important changes, source of genotype x environment interactions, were determined at P<0.01. Stability analysis was carried out for all characteristics according to Finlay-Wilkinson and Eberhart-Russel models. Stable genotypes for each characteristic were found for two parameters.

Key words: Chickpea, stability analysis, phenological characteristics, Turkey.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the first cultivated crops, and originated in south eastern Turkey (Akcin, 1988). It is the second most important pulse crop with 11.2 million cultivated areas in the world (Anonymous, 2006). It is an important source of human and animal food and also plays an important role in the maintenance of soil fertility, particularly in the dry, rain-fed areas (Saxena, 1990; Katerji et al., 2001). Chickpea is grown usually as a rain-fed cool-weather crop or as a dry climate crop in semi-arid regions, with relative humidity of 21 to 41% as optimum for seed setting (Muehlbauer and Tulu, 1998). It fixates nitrogen with Rhizobium bacteria on roots (Akcin, 1988), and although known as long-day plant, flowers in every photoperiod (Smithson et al., 1985).

Plants do not look like each other, from the point of view of many characteristics. They show differences known as variation. Genotype (G) x environment (E) interactions leads to variations (Sehirali and Ozgen, 1988). New nominate varieties are tested in many environments due to changing their performance and adaptation ability. However, important G x E interactions decreases relationship between phenotype and genotype and also genetics improvements in breeding programmes (Comstok and Moll, 1963). In this situation, stability analysis is needed. Stability is defined as ability of a certain variety to maintain stable yield under changing environmental conditions (Yilmaz and Tugay, 1999).

Yates and Cohran (1938) reported that separation of important G x E interactions found in regression analysis into elements is needed as stability criteria. Afterwards, the same regression model was used by other authors to produce different stability criteria. For example, Finlay and Wilkinson (1963) used regression coefficient (b_i) of the linear regression of individual genotypic yield on the mean yield of all genotypes for each environment; while Eberhart and Russel (1966) used the variance of deviations (S^2d_i) from regression. The aim of this study was to determine the influence of G x E interactions on phenological characteristics of chickpea.

MATERIALS AND METHODS

A total of 11 chickpea certified cultivars (Aydin-92, Menemen-92, Akcin-91, Aziziye-94, Damla-89, Er-99, Uzunlu-99, Gokce, Kusmen-99, Izmir-92, and Sari-98) and 3 local varieties (indigenous variety, Konya, Ispanyol) have been used in the field experiments. Average temperature and relative humidity were higher in 2001, compared to 2002 and long term but total rainfall in 2001 was lower than that of 2002 and long term.

On the other hand, rainfall of all locations in 2002 was higher than that of 2001 and long term. Some characteristics of the soil in the experiment area were as follows: silt clay-loam in Pazar district, clay-loam in Zile and Gokhoyuk and loam in Tahtoba in 2001, clay in all locations (Pazar, Zile, Gokhoyuk and Tahtoba) in 2002 (Anonymous, 1990); unsalted in all locations (0.029 to 0.049%); pH alkaline (Anonymous, 2003); amount of organic matter in

Table 1. ANOVA, F values, significance levels.

Variation sources	Degree of freedom	Emergency date	Period of first flowering	Flowering period	Vegetation period
Year (Y)	1	25.080*	639.884**	464.581**	153.309**
Error $_1$	3				
Environment (E)	3	56.263**	243.115**	243.305**	4.296*
Y x E	3	36.139**	201.371**	11.197**	29.513**
Error $_2$	18				
Genotype (G)	13	35.008**	8.850**	8.759**	1.255
Y x G	13	2.868**	6.907**	5.753**	1.363
G x E	39	2.535**	3.057**	4.351**	1.969**
Y x E x G	39	2.267**	3.824**	4.820**	3.345**

*: Significant at P<0.05; **: Significant at P<0.01.

experiment fields was change from 1.25 to 2.66% in two years. In the first year, amounts of organic matter in the experimental fields of Pazar and Tahtoba were middle and others were low (Hizalan and Unal, 1956; Helson and Sommers, 1982). At each location (Tahtaoba-Tokat, Pazar-Tokat, Zile-Tokat, Gokhoyuk-Amasya), field experiments were designed in a factorial randomized complete block with four replications in 2001 to 2002. Each genotype was sown in 6 rows of 5 m length in each replicate and planted with 10 cm intra-row spacing, whereas inter-row distance was kept at 40 cm. Plot size was 12.0 m^2 (5.0 m x 0.40 m x 6 rows). The experiments were planted at rate of around 50 seeds in each row. There was no distance among the genotypes. Genotypes, in the head and the end of the blocks, were sown seven rows. Observations were obtained from four rows in the middle of each plot. The plots were formed by 4 m long rows, spaced at 0.40 m. The useful area (6.4 m^2) was formed by the four rows after being trimmed 0.50 m from the ends. N-P fertilizer, 27 kg/ha N and 69 kg/ha P_2O_5, was uniformly applied to the soil before sowing. Sowings were made on 26 March (Pazar), 27 March (Gokhoyuk), 28 March (Zile) and 29 March (Tahtaoba) in 2001; 18 March (Gokhoyuk), 19 March (Pazar), 7 April (Zile), and 12 April (Tahtaoba) in 2002.

In the study, observations related to emergency date, first flowering period, flowering period and vegetation period were determined according to Akcin (1988). A combined three-factor analysis of variance was performed on data collected for all locations and years via the statistical model (Goncalves et al., 2003). For characteristics having significant genotype by environment variance, stability parameters (b_i and S^2d_i) were calculated. According to the regression model, a stable genotype is one with a high mean yield, $b_i = 1$, $S^2d_i = 0$ or $S^2d_i \sim 0$ (Finlay-Wilkinson, 1963; Eberhart-Russell, 1966).

RESULTS AND DISCUSSION

In the study, genotype by environment interactions were found significant (P<0.01) for all characteristics (Table 1). Being significant G x E interactions resulted in making decision easily about performance of each genotype in terms of each characteristic. Singh and Bejiga (1990), Bozoglu and Gulumser (2000) and Mart (2000) explained similar findings with the earlier mentioned statement. Averages and confidence interval of phenological characteristics of chickpea varieties were given in Table 2. Findings are as follows: average of emergency dates (24.9 to 27.0 days), first flowering period (43.1 to 45.7 days), flowering periods (18.5 to 22.6 days) and vegetation period (127.9 to 130.4 days). Stability parameters for phenological characteristics of chickpea varieties were given in Table 3. Regression coefficients and mean square deviations from regression for emergency date ranged 0.93 to 1.06, and 0.3 to 4.9, respectively. Varieties 3, 4, 8, 9 and 11 are within confidence interval calculated for the regression coefficients. Averages of varieties, regression coefficients and mean square deviations from regression are taken into consideration, stable varieties are 1, 2, 5, 6, 12, 13 and 14 according to Finlay-Wilkinson (1963); 5, 13 and 14 according to Eberhart-Russel (1966). Soil temperature and humidity are important factors for germination (Saxena and Singh, 1985).

Regression coefficients and mean square deviations from regression coefficients for first flowering period ranged 0.73 to 1.18, and 1.0 to 4.3, respectively. All varieties, except for variety 7, 9 and 11, are within confidence interval calculated for the regression coefficients. Stable varieties are 1, 3, 4, 5, 8, 12 and 13 according to Finlay-Wilkinson (1963); 3 and 6 according to Eberhart-Russel (1966). Flowering dates change depending on photoperiod and temperature in chickpea (Saxena and Singh, 1985). In addition, high relative humidity and temperature delay flowering (Singh et al., 1993). Regression coefficients and mean square deviations from regression coefficients for flowering period ranged 0.72 to 1.12, and 1.6 to 10.4, respectively. All varieties, except for variety 3, 5, 11 and 12, are within confidence interval calculated for the regression coefficients. Stable varieties are 1, 4, 7, 8, 10, 13 and 14 according to Finlay-Wilkinson (1963); 6, 13 and 14 according to Eberhart-Russel (1966).

Regression coefficients and mean square deviations from regression coefficients for vegetation period, ranged from 0.60 to 1.28, and 4.5 to 22.5, respectively. All varieties are within confidence interval calculated for the

Table 2. Averages of chickpea genotypes phenological characteristics.

	Genotypes	Averages ($\overline{X}$)			
		Emergency date (day)	First flowering period (day)	Flowering period (day)	Vegetation period (day)
1	Aydin–92	25.5	43.9	21.5	128.7
2	Menemen–92	25.9	45.8	19.8	129.6
3	Akcin–91	25.5	44.7	21.0	129.0
4	Aziziye–94	24.9	44.6	20.3	128.9
5	Damla–89	26.3	43.8	20.9	129.3
6	Er–99	25.8	42.9	21.8	127.9
7	Uzunlu–99	27.0	44.9	20.1	130.4
8	Gokce	25.7	43.1	21.7	128.8
9	Kusmen–99	26.8	45.3	18.5	128.3
10	Izmir–92	24.7	45.7	21.3	128.3
11	Sari–98	26.1	44.7	20.3	129.7
12	Indigenous Variety	26.3	43.4	22.6	128.8
13	Ispanyol	25.9	44.2	21.3	130.2
14	Konya	26.1	43.0	21.5	127.9
Average		25.9	44.3	20.9	129.0
Confidence Interval		25.4< $\overline{X}$ <26.4	43.0< $\overline{X}$ <45.6	20.1< $\overline{X}$ <21.7	126.9< $\overline{X}$ <131.1

Table 3. Stability parameters for phenological characteristics of chickpea genotypes.

	Genotypes	Emergency date (day)		First flowering period (day)		Flowering period (day)		Vegetation period (day)	
		(bi)	(S^2d)	(bi)	(S^2d)	(bi)	(S^2d)	(bi)	(S^2d)
1	Aydin–92	1.02	1.1	1.00	3.9	0.95	6.1	0.81	12.9
2	Menemen–92	1.01	1.6	0.91	2.6	1.09	4.1	1.00	6.7
3	Akcin–91	0.94	0.8	0.96	1.6	1.10	2.8	0.94	22.5
4	Aziziye–94	1.04	2.1	1.06	3.0	1.00	3.0	0.94	8.7
5	Damla–89	1.01	0.8	1.05	1.6	0.85	10.4	0.84	6.3
6	Er–99	1.02	0.2	1.05	1.0	1.02	2.1	0.60	17.4
7	Uzunlu–99	1.01	4.9	0.73	1.8	1.07	7.5	1.12	9.1
8	Gokce	0.93	0.5	1.07	4.3	1.07	2.9	1.28	4.5
9	Kusmen–99	1.06	1.9	1.18	3.5	1.06	7.9	1.12	6.5
10	Izmir–92	1.00	1.9	1.01	2.9	1.03	4.9	1.19	5.6
11	Sari–98	0.95	1.0	0.86	2.0	1.12	1.8	1.21	11.5
12	Indigenous variety	1.02	2.4	1.03	6.8	0.72	5.8	1.08	5.9
13	Ispanyol	1.02	0.3	1.04	3.1	0.98	2.6	1.14	6.9
14	Konya	0.98	0.6	1.05	2.2	0.93	1.6	0.72	13.8
Average		1,00		1.00		1.00		0.99	
Confidence Interval		0.97<bi<1.03		0.91<bi<1.09		0.91<bi <1.09		0.83<bi<1.15	

regression coefficients. Stable varieties are 2, 3, 4, 5, 7, 9, 12 and 13 according to Finlay-Wilkinson (1963); 2, 5 and 9 according to Eberhart-Russel (1966).

Conclusion

To sum up, there were significant effects of G x E interactions on phenological characteristics of chickpea. According to two parameters, stable varieties are: 5, 13 and 14 for emergency dates; 3 for period of first flowering; 13 and 14 for flowering period; 2, 5 and 9 for vegetation period. In the light of these findings, it can be said that:

i) G x E interactions have effects on variations of

phenological characteristics;
ii) There are stable genotypes for these characteristics.

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