African Journal of Agricultural Research Vol. 6(28), pp. 6119-6125, 26 November, 2011
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.1228
ISSN 1991-637X © 2011 Academic Journals

*Full Length Research Paper*

# Genotype × environment ınteraction and stability analysis of some Hungarian vetch (*Vicia pannonica* Crantz.) genotypes

**Nizam, I.[1]*, Cubuk, M. G.[2] and Moralar, E.[3]**

[1]Department of Field Crops, Faculty of Agriculture, Namık Kemal University, Tekirdag, Turkey.
[2]Silivri Pioneer Farmer Association, Silivri, Turkey .
[3]Agricultural Province Management, Tekirdag, Turkey.

Accepted 10 November, 2011

**The aim of this research was to determine genotype × environment interactions and stability parameters for forage and seed yield of some Hungarian vetch (*Vicia pannonica* Crantz.) genotypes. Seven Hungarian vetch genotypes were grown for forage and seed yield at three locations (Tekirdag, Kirklareli and Hayrabolu) in Trakya region of Turkey for two years (2002-2003 and 2003-2004 growing periods). The experiments were carried out as randomised complete block design with three replications. Genotype × environment interaction was investigated and the stabilities of genotypes were estimated by using regression coefficient ($b_i$) and deviation from regression ($S^2d$). Genotype × environment interaction was found to be statistically significant (P≤0.01) in herbage yield, dry matter yield and seed yield of Hungarian vetch genotypes. Stability analysis indicated that the most stable genotypes were 84.1 and 42.1 for dry matter yield and 47.2 for seed yield. Genotype 56.3 can be recommended for favourable conditions in Trakya Region for forage and seed production. However, genotype 47.1 was well adapted to unfavourable environments for forage production in the region.**

**Key words:** *Vicia pannonica* Crantz., Hungarian vetch, genotype × environment interaction, stability parameters.

## INTRODUCTION

Common vetch (*Vicia sativa* L.) has a greater yield potential than other vetch species, especially when autumn-sown. Winter killing has been a major problem for the Trakya region of Turkey; therefore, winter hardiness is one of the most important characteristics for successful vetch production in this region. Although Hungarian vetch (*Vicia pannonica* Crantz.) has a lower yield under favorable conditions than common vetch, it is a suitable vetch species for greater cold resistance, down to -19°C. Hungarian vetch can be used as a forage crop in a mixture of grains or alone, or dried and used as silage (Kendir, 1999; Klages, 1928).

*Corresponding author. E-mail: inizam@nku.edu.tr or ilkerniz@hotmail.com. Tel:+90 2822 93 14 42. Fax: +90 282 293 14 54.

The environmental factors that affect the performance of genotypes change depends on regions and years. Interaction between genotype and environment reduces the association between phenotypic and genotypic values. It might also cause poor performance of genotypes for selection from one environment to another (Sabanci, 1996; Bilgin and Korkut, 2000; Toker, 2004). The response of genotypes to different environments is defined as genotype × environment interaction (Beyene et al., 2011; Sabanci, 1997). Therefore, genotype × environment interactions is important in determining adaptation and stability of new genotypes (Sabanci, 1996). The development of stable vetch cultivars with good adaptation and high yield would greatly contribute to increased feed supply for livestock. Genotype × environment interaction was studied by several researchers in some vetch species (Sabanci, 1996; Berger et al., 2002; Albayrak et al., 2005; Firincioglu et al., 2009;

**Table 1.** Total rainfall (mm) data of three experimental sites.

| Months | Tekirdag | | | Kirklareli | | | Hayrabolu | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2002-2003 | 2003-2004 | Long term years | 2002-2003 | 2003-2004 | Long term years | 2002-2003 | 2003-2004 | Long term years |
| October | 35.7 | 105.4 | 56.5 | 39.4 | 96.8 | 51.68 | 36.1 | 117.9 | 74.7 |
| November | 76.1 | 19.8 | 72.9 | 95.0 | 13.2 | 71.04 | 128.0 | 20.5 | 63.8 |
| December | 83.3 | 61.9 | 87.4 | 83.8 | 45.8 | 74.62 | 31.6 | 49.5 | 67.9 |
| January | 95.8 | 148.3 | 56.5 | 130.8 | 67.8 | 70.10 | 68.6 | 39.8 | 47.8 |
| February | 105.8 | 37.2 | 51.4 | 58.0 | 6.6 | 51.90 | 79.2 | 41.0 | 44.0 |
| March | 20.1 | 62.4 | 56.4 | 10.3 | 36.2 | 47.51 | 17.6 | 51.4 | 49.3 |
| April | 75.8 | 30.5 | 44.4 | 78.3 | 13.4 | 44.72 | 79.4 | 51.3 | 46.3 |
| May | 5.6 | 26.8 | 39.1 | 31.9 | 40.2 | 51.68 | 46.3 | 58.6 | 48.5 |
| June | 9.8 | 106.3 | 35.3 | 21.1 | 109.6 | 45.39 | 0.0 | 56.9 | 47.0 |
| Total | 508.0 | 598.6 | 499.9 | 548.6 | 429.6 | 508.64 | 486.8 | 486.9 | 489.3 |

Orak and Nizam, 2009; Yücel et al., 2009). The researchers reported that genotype x environment interactions were statistically significantly different for forage and seed yield of *Vicia* species.

The aim of this study was to evaluate genotype × environment interactions and stability parameters for forage and seed yield of some Hungarian vetch genotypes in Trakya Region of Turkey.

## MATERIALS AND METHODS

Seven Hungarian vetch genotypes (42.1, 47.1, 47.2, 56.3, 84.1, Hungarian vetch population and Egebeyazi) were used as genetic material. The Hungarian vetch genotypes were developed by the Agricultural Faculty of Namik Kemal University, Tekirdag, Turkey. Egebeyazi was used as control variety.

The experiments were conducted at 3 locations with different climate and soil characteristics in Trakya region of Turkey during two consecutive growing years (2002-2003 and 2003-2004). The locations were Tekirdag/Center (40°59'N, 27°34' E; 19 m), Kirklareli/Center (41°41' N, 27°12' E; 171 m), and Tekirdag/Hayrabolu (41°15' N, 27°08' E; 35 m).

Trakya region is a peninsula, and the central part of Trakya region is under the effect of continental climate, along with Mediterranean climate and Black Sea climate. In the region, summer was dry and hot while winter was chilly and rainy. The average temperatures for the two growing periods were 10.77 and 11.11°C, 9.83 and 10.17°C and 9.37 and 9.62°C in Tekirdag, Hayrabolu and Kirklareli, respectively. Precipitation in the same order was 508.0 and 598.6 mm, 486.8 and 486.9 mm, and 548.6 and 429.6 mm during the 2002-2003 and 2003-2004 growing periods, respectively (Table 1 and 2). The average relative humidity for the two years was 78% in Tekirdag and Hayrabolu. But, the average relative humudity in Kirklareli during the 2002-2003 growing period was 77%, and 83% during 2003-2004 growing period.

Soil of the experiment field at Tekirdag location was clay loam structure with organic matter content of 1.42%, which was considered to be low, and pH was neutral (7.0). Soils for Hayrabolu and Kirklareli locations were clay and light alkaline, with low organic matter (1.5 and 1.62%, respectively) in both locations. Phosphorus was moderate and potassium was at a high level in all locations.

At each location, the field experiment was arranged in a randomised complete block design with three replications. Sowing dates at the three locations were 20-22 October in 2002, 25-26 October in 2003. Sowing was done by hand with a seed rate of 8 kg $da^{-1}$. Each experimental plot consisted of 4 rows, each 5 m long and with 30 cm spaces between two rows.

In this research, data for herbage yield, dry matter yield and seed yield were recorded for each experimental plot. Forage harvest was made when the first pod formed. Dry matter yield was calculated after drying a sample of 500 g forage in an oven at 78°C for 48 h. Seed harvest was made after the grain filling period when 4 or 5 pods turned brown on the plant.

Data from this research were evaluated statistically using MSTAT version 3.00/EM statistical computer package software. After the combined variance analysis, the homogeneity of variance was tested with Bartlett Chi-square method and variance was found as homogeneous. The two stability parameters calculated were the regression coefficient ($b_i$) and deviation from regression ($S^2d$). A stable genotype is above the general average yield. Regression coefficient of a stable genotype is equal to 1, and deviation from regression is 0 or close to 0. Those genotypes with regression coefficient >1 would be more adapted to favourable environmental conditions, those with regression coefficient <1 would be adapted to unfavourable environmental conditions (Finlay and Wilkinson, 1963; Eberthart and Russel, 1966). Confidence limits were determined with a probability of 1%. These were determined using Confidence limits= $\overline{X}$ ± t.Sx.

## RESULTS AND DISCUSSION

Results of analysis of variance for herbage yield, dry matter yield and seed yield of Hungarian vetch genotypes are given in Table 3.

**Table 2.** The mean temperature ($^oC$) data of three experimental sites.

| Months | Tekirdag | | | Kirklareli | | | Hayrabolu | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2002-2003 | 2003-2004 | Long term years | 2002-2003 | 2003-2004 | Long term years | 2002-2003 | 2003-2004 | Long term years |
| October | 16.1 | 16.0 | 15.1 | 13.9 | 13.6 | 13.7 | 12.5 | 16.0 | 19.3 |
| November | 12.8 | 10.6 | 10.3 | 10.6 | 8.6 | 9.5 | 12.5 | 10.0 | 15.2 |
| December | 5.6 | 6.4 | 6.9 | 2.8 | 3.9 | 5.1 | 2.5 | 4.5 | 4.9 |
| January | 7.1 | 4.0 | 4.9 | 4.6 | 2.1 | 2.2 | 6.5 | 3.5 | 4.0 |
| February | 1.1 | 5.7 | 5.2 | -1.0 | 3.6 | 4.1 | 1.5 | 3.0 | 4.5 |
| March | 4.5 | 8.3 | 7.2 | 3.5 | 7.4 | 6.6 | 4.5 | 9.0 | 7.6 |
| April | 8.8 | 12.0 | 11.9 | 9.0 | 11.6 | 11.5 | 9.0 | 9.5 | 7.6 |
| May | 17.9 | 16.0 | 16.5 | 18.4 | 15.4 | 16.0 | 17.5 | 15.0 | 16.2 |
| June | 23.0 | 21.0 | 21.1 | 22.5 | 20.4 | 21.2 | 22.0 | 21.0 | 21.1 |
| Average | 10.77 | 11.11 | 11.01 | 9.37 | 9.62 | 9.99 | 9.83 | 10.17 | 11.16 |

**Table 3.** Analysis of variance for herbage, dry matter yield, and seed yield for seven Hungarian vetch genotypes tested over three locations.

| variation source | df | Herbage yield | | Dry matter yield | | Seed yield | |
|---|---|---|---|---|---|---|---|
| | | Mean square | F value | Mean square | F value | Mean square | F value |
| Year (Y) | 1 | 51351874.560 | 12.124ns | 13127307.667 | 47.474* | 2634669.841 | 67.735* |
| Location (L) | 2 | 291792128.965 | 106.679** | 24754589.055 | 188.871** | 2053715.867 | 95.245** |
| Y x L | 2 | 1076137367.990 | 393.433** | 76732182.322 | 585.446** | 65789.016 | 3.051* |
| Genotype (G) | 6 | 24190894.617 | 8.844** | 647721.950 | 4.942** | 179659.382 | 8.332** |
| G x Y | 6 | 9157046.335 | 3.348** | 393550.513 | 3.003** | 147640.233 | 6.847** |
| G x L | 12 | 9834194.422 | 3.595** | 661147.769 | 5.044** | 120509.345 | 5.589** |
| G x Y x L | 12 | 8723329.813 | 3.189** | 517299.060 | 3.947** | 69675.488 | 3.231** |
| Error | 80 | 2735246.610 | | 131066.151 | | 21562.348 | |
| General | 125 | 27629390.967 | | 1983218.142 | | 103405.481 | |
| CV (%) | | 39.8327 | | 44.9846 | | 50.6427 | |

*: P < 0.05 at significance; **: P < 0.01 at significance, ns: not significant.

Differences between the genotypes and environments were statistically found at P<0.01 for herbage, dry matter, and seed yield. Genotype x environment interactions were also significant (P<0.01) for this study (Table 3). Since genotype × environment interactions were significant, stability analysis was performed and values using 2 different stability parameters were estimated. Estimates of stability parameters ($b_i$ and $S^2d$) and mean values of yields for herbage yield (kg/ha), dry matter yield (kg/ha), and seed yield (kg/ha) of Hungarian vetch genotypes are shown in Table 4.

## Herbage yield

The genotype × environment interaction was highly statistically significant (P<0.01) for herbage yield of Hungarian vetch genotypes (Table 3). In this study, values for regression coefficient ($b_i$)

**Table 4.** Stability parameters for herbage, dry matter and seed yields (kg ha$^{-1}$) of some Hungarian vetch genotypes.

| Genotypes | Herbage yield | | | Dry matter yield | | | Seed yield | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ (kg ha$^{-1}$) | $b_i$ | $S^2d$ | $\bar{X}$ (kg ha$^{-1}$) | $b_i$ | $S^2d$ | $\bar{X}$ (kg ha$^{-1}$) | $b_i$ | $S^2d$ |
| Egebeyazi | 12388.67d | 1.04 * | 3049042.3** | 2884.69 c | 1.01 ** | 99782.7** | 764.5 a | 1.39 $^{ns}$ | 44367.2** |
| 56.3 | 14902.71 a | 1.09 $^{ns}$ | 8298199.4* | 3378.89 a | 1.18 ** | 128039.3* | 756.8 a | 1.52** | 76163.0** |
| 47.2 | 12192.90 d | 0.97** | 2735624.3** | 2957.13 bc | 0.92** | 225500.5** | 692.79 a | 1.07$^{ns}$ | 1571.2** |
| 47.1 | 14386.78 ab | 0.85** | 1854317.2** | 3304.86 a | 0.88** | 229649.1** | 547.08 b | 0.80** | 21797.8** |
| 42.1 | 12767.59 cd | 1.05** | 2566386.8 $^{ns}$ | 3227.52 a | 0.94** | 230814.3 $^{ns}$ | 537.12 b | 0.58 $^{ns}$ | 11032.3** |
| Population | 11951.91 d | 0.92** | 253733.9* | 2983.20 bc | 1.13** | 165044.9 $^{ns}$ | 572.21 b | 0.77** | 37592.9** |
| 84.1 | 13782.12 bc | 1.09** | 2762518.7** | 3177.58 ab | 0.94** | 103448.3** | 574.29 b | 0.87** | 13014.3** |
| Mean | 13196.10 | 1.001 | | 3130.55 | 1.000 | | 634.97 | 1.000 | |
| LSD (% 5) | 1097.059 | | | 240.147 | | | 97.405 | | |
| Confidence limits | | $\bar{X}$± 245.17 | | | $\bar{X}$± 53.66 | | | $\bar{X}$± 21.77 | |

($\bar{X}$): Mean, ($b_i$): regression coefficient, ($S^2d$): deviation from regression.

ranged from 0.85 to 1.09 for herbage yield (Table 4). Genotype 47.2 with $b_i$<1 and low herbage yield adapted poorly to unfavourable environments (Figure 1). The genotypes 56.3 and 84.1 with regression coefficient higher than 1 ($b_i$>1) had high yield performance and adapted to a high potential environment. Genotype 47.1 with $b_i$<1 and high herbage yield was considered a genotype adapting better to unfavourable yield conditions. Genotype 42.1 with $b_i$>1 and low yield adapted to special environments for herbage yield (Figure 1).

## Dry matter yield

Analysis of variance revealed that genotype × environment interaction was statistically significant (P<0.01) for dry matter yield (Table 3). Similarly, Yucel et al. (2009) found significant genotype × environment interaction in some vetch species for dry matter yield. Table 4 shows that the regression coefficient ($b_i$) ranged from 0.88 to 1.18 for dry matter yield. Egebeyazı could be considered widely adapted with regression coefficient for dry matter yield $b_i$ values equal to 1 and small deviation from regression ($S^2d$). However, the genotype had below average performance for dry matter yield (Table 3). So, the genotype was poorly adapted for all environments in the region (Figure 2). In contrast, genotype 56.3 with $b_i$>1 and high yield was regarded as sensitive to environment changes for dry matter yield. The genotype can be recommended for cultivation under favourable conditions. Genotype 47.1 with $b_i$<1 and high herbage yield was determined as adapting better in unfavourable environments. However, genotype 47.2 having $b_i$<1 and low dry matter yield adapted poorly to unfavourable environmental conditions. Genotypes 42.1 and 84.1 were determined to be the most stable genotypes with $b_i$ values equal to 1 and a small deviation from regression for dry matter yield (Figure 2).

## Seed yield

The genotype x environment interaction was statistically highly significant (P<0.01) for seed yield (Table 3). Similar results were reported by other researchers (Sabanci, 1996; Albayrak et al., 2005; Acikgöz et al., 2009; Orak and Nizam, 2009). For example, genotype x environment interaction of seven common vetch genotypes was found to be significant for seed yield at three locations for two years. Similarly, Albayrak et al. (2005) stated that significant differences between genotype x environment were determined for seed yield of common vetch genotypes. Regression coefficient ($b_i$) for seed yield ranged from 0.58 to 1.52. Genotypes 56.3, 47.2, and Egebeyazi had high seed yield with regression coefficients 1.52, 1.07, and 1.39, respectively (Table 4). Due to greater value of regression coefficient ($b_i$>1), 56.3 and Egebeyazi are expected to give good yield under favourable environmental conditions. Genotypes 84.1, 42.1, and 47.1 having low seed

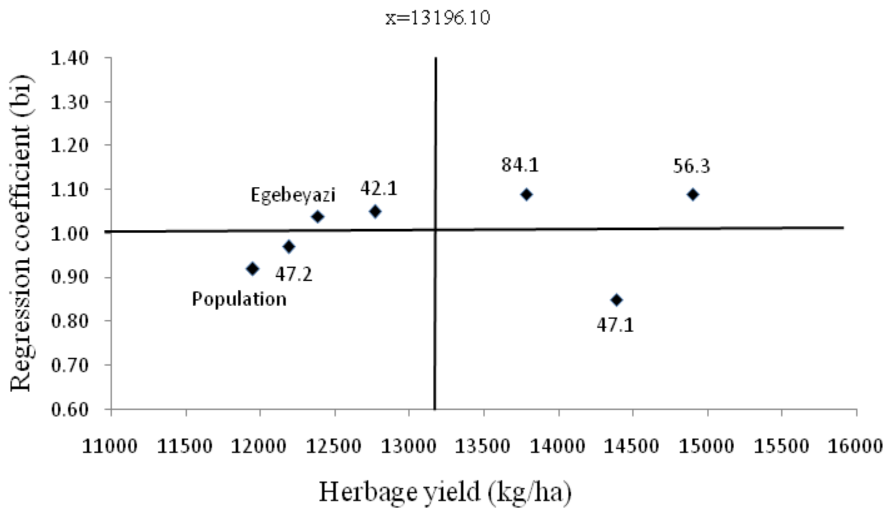


**Figure 1.** Combination of stability and average herbage yield of some Hungarian vetch genotypes.

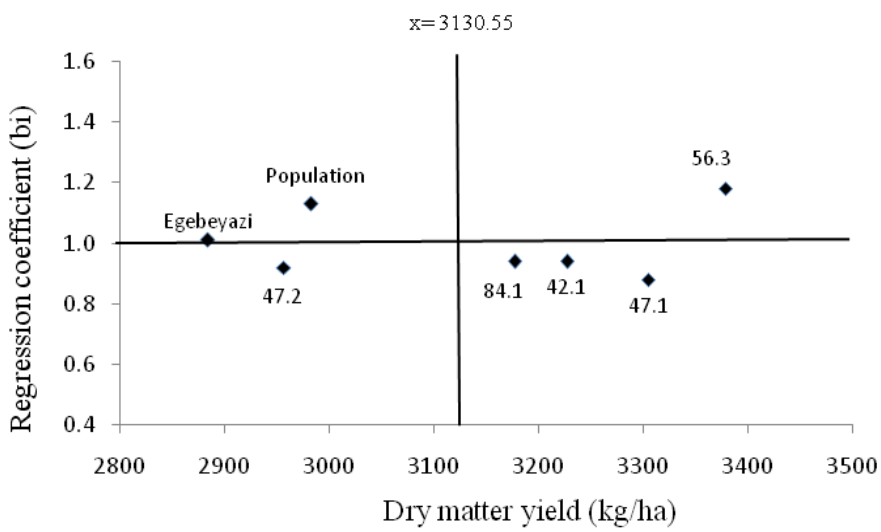


**Figure 2.** Combination of stability and average dry matter yield of some Hungarian vetch genotypes.

yield and a low regression value ($b_i$<1) adapted poorly to unfavourable environmental conditions (Figure 3). Genotype 47.2 can be considered the most stable genotype with $b_i$ values equal to 1 and a small deviation from regression ($S^2d$).

## Environment conditions and performance of genotypes

Climatic and soil conditions were more suitable in Tekirdag and Hayrabolu locations than in Kirklareli. Tekirdag and Hayrabolu were the most similar locations for temperature, soil structure, and altitude. Kirklareli location had higher altitude, lower temperature, and unfavourable soil conditions compared to the other two locations. For these reasons, Tekirdag and Hayrabolu could be defined as favourable conditions for Hungarian vetch; Kirklareli could be defined as an unfavourable location. In light of this evaluation, herbage yields of genotypes 56.3 and 84.1 were highest in Tekirdag and Hayrabolu locations defined as having favourable conditions. Genotype 56.3 and Egebeyazi performed better than other genotypes in Kirklareli, defined as an unfavourable condition. Genotype 56.3 gave the highest dry matter yield in Tekirdag and Hayrabolu locations. In

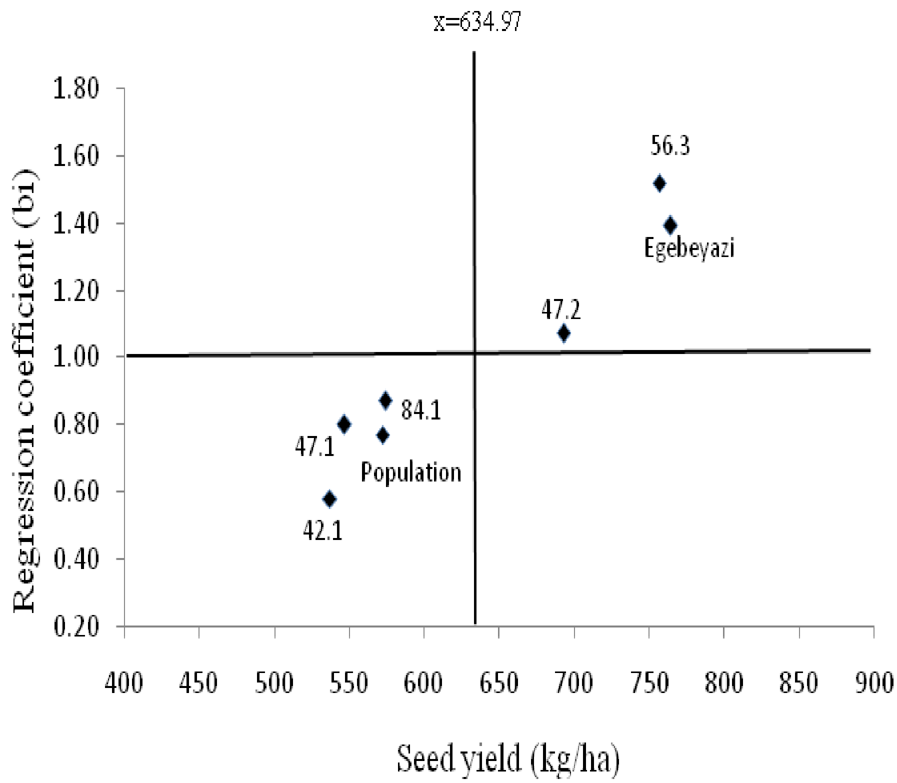


**Figure 3.** Combination of stability and average seed yield of some Hungarian vetch genotypes.

the same way, genotype 47.1 had the highest dry matter yield in unfavourable conditions at the Kirklareli location. Genotype 56.3 and Egebeyazi had the highest seed yield in favourable conditions at Tekirdag and Hayrabolu locations.

## Conclusion

The results showed that there were significant genotype x environment interactions for herbage yield, dry matter yield and seed yield of Hungarian vetch genotypes. Stability analysis indicated that genotypes 56.3 and 84.1 were best genotypes in favourable conditions, unlike genotype 47.1, which adapted to unfavourable environmental conditions for herbage yield. Genotypes 84.1 and 42.1 were the most stable genotypes for dry matter yield. At the same time, genotype 56.3 adapted in favourable conditions and genotype 47.1 was the best genotype in unfavourable environments for dry matter yield. When considering seed yield, genotype 47.2 was most stable in all environments. Genotype 56.3 also was the best genotype in favourable conditions for seed yield.

Hungarian vetch genotype 56.3 can be grown successfully in Trakya region of Turkey because of both high forage and seed yield, and its stability in terms of herbage yield. It might be said that genotype 47.1 may adapt well to unfavourable conditions of the region in terms of high yield and low regression coefficient.

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