Pak. J. Bot., 41(3): 1069-1076, 2009.

ADAPTABILITY PERFORMANCES OF SOME SOFT WHEAT (*TRITICUM AESTIVUM* VAR. *AEST.* L.) CULTIVARS IN THE MARMARA REGION OF TURKEY

RAMAZAN DOĞAN* AND MEHMET AYCICEK

Department of Field Crops, Faculty of Agriculture, Uludağ University, Bursa, Turkey 16059.

Abstract

This study was conducted to determine the adaptability and stability of 7 wheat cultivars, viz., Cumhuriyet-75, Momtchill, Tosun-22, Gemini, Katea-1, Kırkpınar-79 and Atilla-12 under Bursa conditions for nine years between 1986 and 1996. The trials were conducted at the Research and Application Center of Faculty of Agriculture located at Görükle Campus of Uludag University.

Cultivars were sown in October in 10 x 12-m plots, which were arranged as a randomized complete block design with four replications. In the study in which grain yield was used a criterion to determine stabilities of soft wheat cultivar, three stability parameters: regression coefficient (b), mean squares of deviation from regression (S^2) and determination coefficient (r^2) values were calculated. The years were considered as an environment in the study.

According to the results, genotype x environment interactions for grain yield was highly significant. Thus, the stabilities of seven soft wheat genotypes were different for grain yield. According to the stability parameters, Momtchill, Katea-1, Gemini and Kırkpınar-79 were stable, while Atilla-12, Tosun-22 and Cumhuriyet-75 were no stable for grain yield. Genotypes Tosun-22 and Atilla-12 could be considered as having high adaptability to poor condition, but Cumhuriyet-75 adapted to good environments. On the other hand, the genotypes Momtchill, Katc-1 and Kırkpınar-79 whose yields were higher than mean yield of trial (5310 kg ha^{-1}) could be considered as having good adaptability to all environments.

Introduction

Wheat is world's leading grain crop and Turkey is one of the most important wheat producer in the world. The Marmara Region located in northwest Turkey is an important wheat production area in Turkey with a cultivation area of 500,000 ha with an average yield of 2640 kg ha^{-1} (Anon., 1996).

Genotype-environment interactions and adaptation studies are widely used in wheat breeding programs to assist in the selection of genotypes for different management and environmental regimes. Sometimes inconsistent results were obtained in genotype-environment interactions among wheat genotypes from one environment to another. This inconsistency may arise in responses of the same genotypes to different environments, or different genotypes in different environments (Falconer, 1952; Robertson, 1959; Cockerham, 1963). When assessing grain yield of wheat cultivars in a multi-environment trial, changes are commonly observed in the relative yield performance of the cultivars. The widely used procedure for modeling statistical interaction is a simple regression of the cultivar performance on the site mean (Yates & Cochran, 1938; Finlay & Wilkinson, 1963; Eberhart & Russell, 1966; Vargas *et al.*, 1998; Vargas, *et al.*, 1999; Crossa *et al.*, 1999). A widely used technique for characterizing genotype x environment interactions and to predict varietals response was proposed by Eberhart & Russell (1966). This method requires analysis of stability parameters of genotype performances over a series of experiments. Mean yield of individual genotype is regressed against the environmental

*Corresponding author E-mail: rdogan@uludag.edu.tr

index to provide 2 stability parameters. One is a regression coefficient (bi) for comparing relative response of a particular genotype to average of all genotypes. Another parameter is the deviation from regression mean square (S^2d) for measuring how well the predicted response arise with the observed response.

The determination of well-adapted cultivars is of importance, because of the ecological suitability of Marmara region and the importance of wheat production in the region. The stability and adaptability of seven soft wheat cultivars was determined for seed yield across a nine-year period in Bursa region. The results will provide the basis for future research and to assist in the selection of cultivars to be used under different management and environmental regimes.

The objective of this study were twofold: (i) to determine cultivar x environment (CxY), identify stable genotype, and (ii) to compare the stability parameters at the Research and Application Centre of Faculty of Agriculture located at Gorukle Campus of Uludag University, Turkey.

Materials and Methods

plant materials: Seven soft wheat cultivars viz., Cumhuriyet-75, Momtchill, Tosun-22, Gemini, Katea-1, Kırkpınar -79 and Atilla-12 were used in the study.

Environment: The experimental area is located in the coastal zone of northwest Turkey (40°11′ North, 29°04′ West), 70 m above the sea level.

Average annual rainfall of Bursa province is about 699 mm year^{-1}, the distribution of precipitation is uneven and nearly 90% occurs during the period when wheat exists in the field. Evaporation is 1048 mm year^{-1}, mean temperature for the whole year is 14.7°C and relative humidity average is 69% (Anon, 1999). During the experimental period, average November-March temperature and precipitation was 6.9°C and 70.0 mm, May-June was 19.9°C and 39.2 mm (Figs. 1,2).

The soil of experimental field is heavy-textured, slightly alkaline (pH is 7.2), contains no salt, classified as vertisol typic habloxrert, low in organic matter (1.4 %) and high in available phosphorus (73 kg ha^{-1}) and potassium (1130 kg ha^{-1}).

Experimental design and cultural practices: Plots consisted of eight row spaced 15 cm apart and 10 m long. Plots were arranged in randomized complete block design with four replications. 8.1 m² (Turan, 1988). The recommended fertilizer consisting of nitrogen, in the form of nitrate and phosphorus (20.20.0) were manually drilled and incorporated in the soil both @ 50 kg ha^{-1} at planting. Fertilizers that supplied 100 kg ha^{-1} NH_4NO_3 (26%) were uniformly sprayed in early spring. Weeds were controlled by herbicides. Data on seed yield were taken from the middle six rows (8.1 m²) of each plot. The plot yield was converted to kg ha^{-1}.

Statistical analyses: Analyses of variance were computed for the seed yield data within and across the nine years of the study. The variance of "Homogenity of Regressions" and "Regression-Biased Variance were partitioned from the cultivar x year interaction sum of squares in the analyses of variance (Eberhart & Russell, 1966; Yıldırım *et al.*, 1979). The "Simple Regression Method" was used in estimating the adaptation and stability parameters (Finlay & Wilkinson, 1963). The regression coefficient (bi), regression-biased square means (S^2, xi) and determination coefficient (ri^2) were estimated.

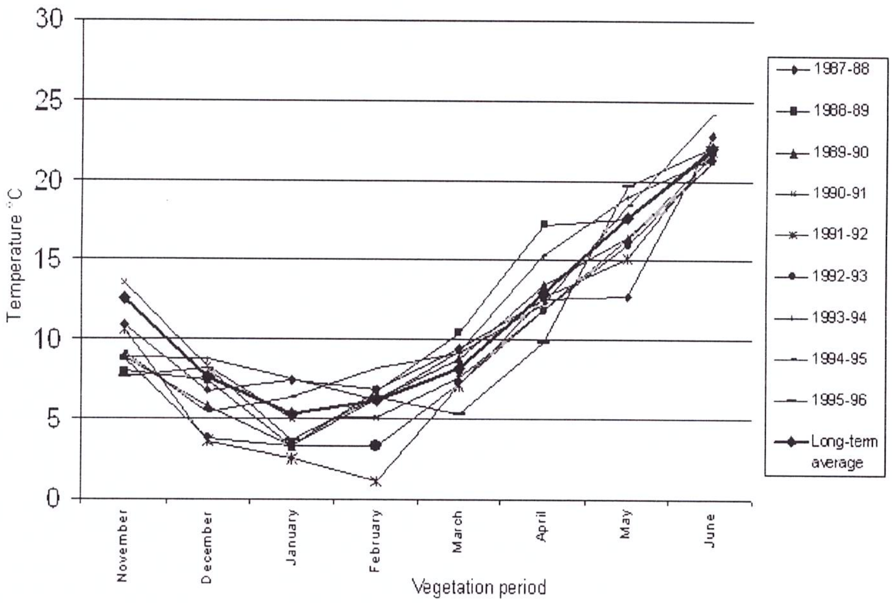

Fig. 1. Temperature datas of 1988-1996 years and long-term average in Bursa.

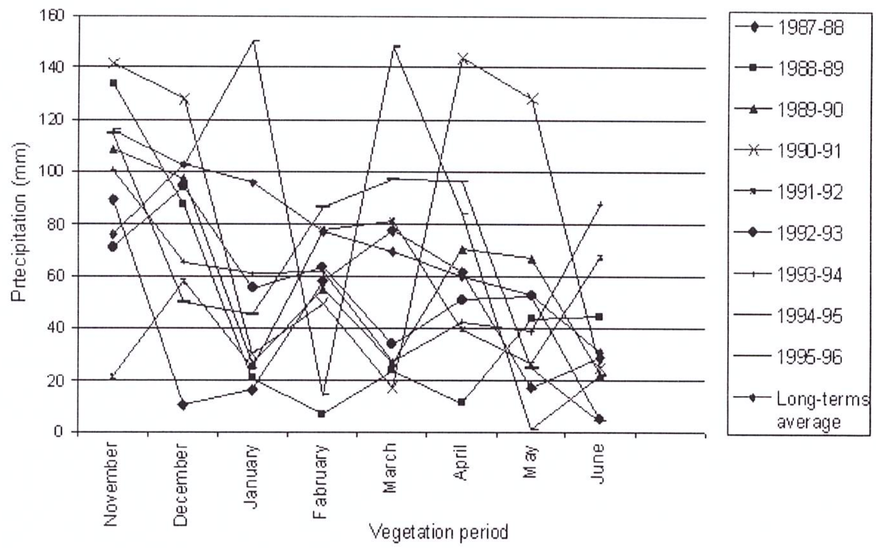

Fig. 2. Precipitation datas to belong to 1988-1996 years and long-term average Bursa.

1. Regression coefficient (bi) for 1 th genotype proposed by Finlay & Wilkinson (1963) was defined by the following formula:

$$b_i = \frac{\sum_{j=1}^{m} Y_{ij} X_j - \frac{(Y_{i.})(X_{.})}{m}}{\sum_{j=1}^{m} x_j^2 - \frac{X^2.}{m}}$$

where i and j explain genotype (1-7) and environment (1-9), respectively. In addition, m was number of environments.

2. Mean squares of deviations from regression (Sd_i^2) proposed by Eberhart & Russell (1966) was calculated by the following equation:

$$Sd_i^2 = \frac{1}{m-2} \left[\left(\sum_{j=1}^{m} Y_{ij}^2 - \frac{Y_{i.}^2}{m} \right) b_i^2 \left(\sum_{j=1}^{m} X_j^2 - \frac{x^2.}{m} \right) \right]$$

were b_i^2 was square of regression coefficient for genotype, and the term $\sum_{j=1}^{m} Y_{ij}^2 - \frac{Y_i^2.}{m}$ was sum of squares of dependent variable (genotype).

All data were subjected to analysis of variance for each character using MSTAT-C (version 2.1 Michigan State University of Texas at Austin). The significant of genotype, year and cultivar x year (Environment) interactions were determined at 0.05 and 0.01 probability levels, by the F-test. The F protected least significant difference (LSD) was calculated at 0.05 probability level according to Steel & Torrie (1980).

Results and Discussion

Differences among cultivars for seed yield were not significant in 1988, 1990, 1995 and 1996, but these differences were significant ($p<0.01$) in other years. Differences among blocks were significant only in 1989 ($p<0.01$) and 1995 ($p<0.05$). In the analyses of variance for seed yield combined across years, differences among years, blocks, and cultivars were significant ($p<0.01$); however, relative differences among cultivars were not consistent across years as indicated by the significant ($p<0.01$) cultivar x year interaction.

This, feature appear itself by the interaction between year and cultivar being statistically significant throughout the experiment period. Considering the components obtained through division of cultivar-year (C-Y) variance, it is seen that the significance of year-cultivar (C-Y) interaction variance originates from the difference of regression coefficients of the cultivars. In fact that, cultivar x year interaction in the analyses of variance was accepted as genotypes x environment interaction. Because the years were considered as an environment in the study. Grain yield values of the cultivars are given in Table 1 and Fig. 3 for single years and as the overall mean of nine years.

Table 1. Mean seed yield (kg ha^{-1}) of wheat cultivars across nine years.

Cultivars	Years									
	1988	1989	1990	1991	1992	1993	1994	1995	1996	Mean
Momtchill	5610	3660 ab	6550	4660 a	6910 abc	7390 ab	5700ab	5970	6830	5920 a
Katea-1	4920	3930 a	6030	2610 de	7240 ab	7990 a	6300 a	5930	6220	5690 ab
Atilla-12	4380	4830 a	5660	4250 ab	6250 cd	6750 bc	5360 bc	5640	6120	5470 b
Kırkpınar-79	4500	3870 a	5100	3610 bc	7520 a	7830 a	5030 cd	5390	6130	5440 b
Tosun-22	5480	4650 a	4810	3120 cd	5790 d	6120 c	4460 d	4950	4980	4930 c
Gemini	4840	2240 c	4750	1870 e	6600 bc	6870 bc	5370 bc	6270	5530	4930 c
Cumhuriyet-75	4470	2520 bc	4780	2350 de	6580 bc	7270 ab	4920 cd	5060	5010	4770 c
L.S.D (0.05)	**NS**	**118.5**	**NS**	**84.17**	**77.24**	**89.12**	**66.27**	**NS**	**NS**	**32.97**

According to mean of nine years, four of the seven soft wheat cultivars had higher yields than the mean of trial (5310 kg ha^{-1}). These higher yielding cultivars were Momtchill (5920 kg ha^{-1}), Katea-1 (5690 kg ha^{-1}), Atilla-12 (5470 kg ha^{-1}) and Kırkpınar-79 (5440 kg ha^{-1}). The cultivars Momtchill and Katea-1 were in the same statistical group, whereas cvs Katea-1, Atilla-12 and Kırkpınar-79 formed a different group. The cultivars Tosun-22, Gemini and Cumhuriyet-75 had a lower yield value compared with the mean of trial (5310 kg ha^{-1}), giving the yields of 4930 kg ha^{-1}, 4930 kg ha^{-1} and 4770 kg ha^{-1}, respectively.

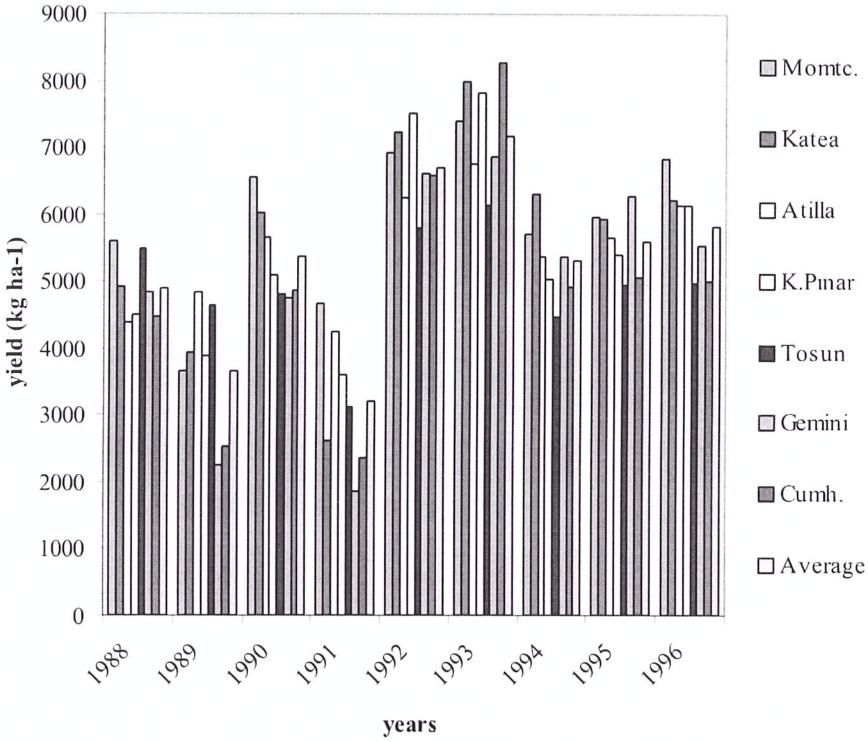

Fig. 3. Mean seed yield (kg ha-1) of wheat cultivars across nine years.

The analysis of variance indicated that the mean square of homogenity of regressions belonging to cultivars was statistically significant, whereas the regression biased mean squares was non significant. The regression coefficients of cvs Momtchill, Katea-1 and Kırkpınar-79 were found to be equal to the mean regression coefficient value, i.e., 1, as shown in Table 2 and Fig. 4. The regression coefficient (bi) of cultivar Gemini was not statistically significant although it was higher value than the mean regression coefficient (Ъ =1). No significance of the regression coefficient (bi) of cv Gemini was due to the high error variance associated with this cultivar. The regression coefficients of cvs Atilla-12 and Tosun-22 were determined to be lower than 1, whereas that of cv Cumhuriyet-75 was found to be higher than 1. Statistically significant values were obtained in all cultivars with respect to the determination coefficient values.

The results showed that all 7 cultivars were stable according to the Breese´s determinations, considering only the regression-biased square means. However, when the regression coefficients are also considered as an indication of stability, beside the variance of deviations from regression, Momtchill, Katea-1, Kırkpınar-79 and Gemini were found to be stable ($S^2Y.xi = S^2$ and bi=b), while cvs Atilla-12, Tosun-22 and Cumhuriyet-75 were not stable (Eberhart & Russell, 1966). When the determination coefficient (r^2), another statistical parameter, used with the regression-biased square means was considered, all cultivars were found to be stable.

The classification made depending on regression coefficient values accordingly, it can be concluded that cv Cumhuriyet-75 **(7)** is adapted to good conditions, while cvs Atilla-12 **(3)** and Tosun-22 **(5)** are adapted to unfavorable conditions. Moreover it was determined that among the cultivars Momtchill**(1)**, Katea-1**(2)** and Kırkpınar-79 **(4)** were well-adapted to all environments with their yields 5920, 5690 and 5440 kg ha^{-1}, respectively which were higher than the trial mean (5310 kg $ha^{-1)}$, whereas cv Gemini **(6)** was poor adapted to all environments with yield of 4930 kg ha^{-1} . Schematic representation of the adaptabilities of cultivars was presented in Fig. 4 and 5.

Conclusion

This study has provided evaluation of the environmental and yield performance of some soft wheat cultivars. According to the analysis of variance, differences between years and cultivars, and cultivars x year interaction effects were significantly found for grain yield. Differences temperature and precipitation among years were environmental factors that had a major effect on wheat yield. Stability analysis indicated that there were stable cultivar for grain yield, whereas some cultivars were considered as having high adaptability to good environments and the other several cultivars to the unfavorable conditions. The cultivars Momtchill **(1)**, Katea-1 **(2)** and Kırkıpınar-79 **(4)** were determined as the most suitable cultivars for the ecology of region, depending on the results of trials which had been carried out at Bursa location for 9 years (Fig. 5). These cultivars may be recommended for wheat production areas in Marmara region due to their stability and well-adaptability to all environments. Nevertheless, cv Cumhuriyet-75 **(7)** may also be recommended for favorable conditions although it was not determined to be stable with respect to its regression coefficient, for example, in case that very rich soil conditions are implemented. On the other hand, cv Gemini **(6)** was badly adapted to all environment conditions, while Tosun-22 **(5)** and Atilla-12 **(3)** had adaptability to poor environment conditions.

Table 2. The Statistics of adaptation and stability of experimented wheat cultivars.

Cultivars	bi	$S^2_{Y \cdot xi}$	ri^2
Momtchill	0.847	8733	0.86**
Katea-1	1.261	5045	0.96**
Atilla-12	0.610*	5465	0.84**
Kırkpınar-79	1.109	8102	0.92**
Tosun-22	0.560*	10177	0.70*
Gemini	1.340	11890	0.92**
Cumhuriyet-75	1.273**	1056	0.99**
Mean	**1.000**		

*,** Significantly different at p= 0.05 and p= 0.01, respectively
bi=Regression coefficient; S^2 Y.xi=Regression-biased square means; ri^2=coefficient of determination

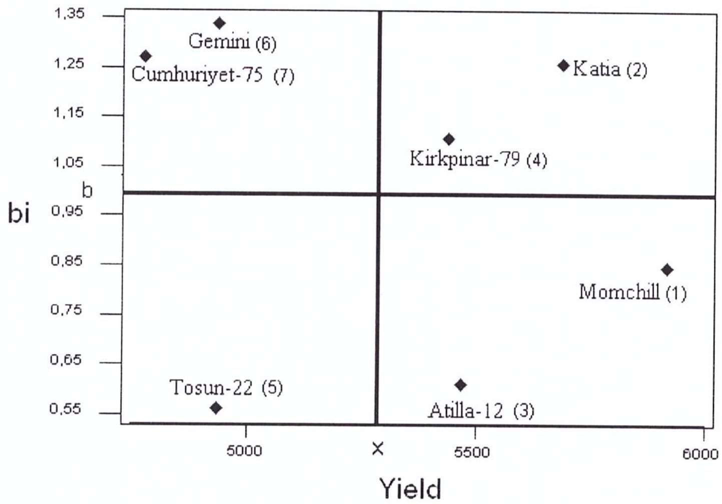

Fig. 4. Classification of cultivars according to their adaptabilities.

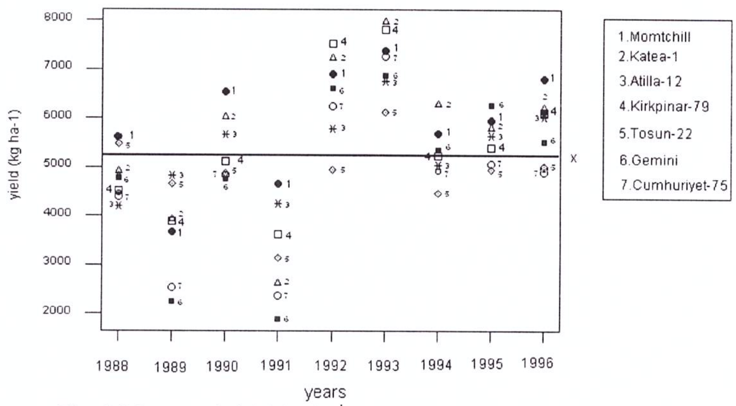

Fig. 5. Mean seed yield (kg ha^{-1}) of wheat cultivars across nine years.

References

Anonymous. 1996. *Agricultural structure.* (Production, Price, Value). State Institute of Statistics Prime Ministry Republic of Turkey, pp.78-79. No: 1685, Ankara.

Anonymous. 1999. Temperature and rainfall values for Bursa province. Turkish State Meteorological Service, Climatic Data, Ankara.

Breese, E.L. 1969. The Measurement and Significance of Genotype-Environment Interactions in grasses. *Heredity,* 24: 27-44.

Cockerham, C.C. 1963. Estimation of genetic variances In: Statistical genetics and plant Breeding (Eds.): W.D. Hanson and H.F. Robinson. Washington, DC: National Academy of Sciences/National Research Council; 53-94.

Crossa, J., M. Vargas, F.A. van Eeuwijk, C. Jiang, G.O. Edmeades and D. Hoisington. 1999. Interpreting genotype 3 environment interaction in tropical maize using linked molecular markers and environmental covariables. *Theor. Appl. Genet.*, 99: 611-625.

Eberhart, S.A. and W.A. Russell. 1966. Stability Parameters for Comparing Varieties. *Crop Sci.,* 6: 36-40.

Falconer, D.S. 1952. The problem of environment and selection. *The American Naturalist,* 86: 293-298.

Finlay, K.W. and G.N. Wilkinson.1963. The Analysis of Adaptation in a Plant Breeding Programme. *Aust. J. Ag. Res.*, 14: 742-54.

Robertson, A. 1959. The sampling variance of the genetic correlation coefficient. *Biometrics,* 15: 469-485.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics. A biometrical approach. 2nd ed. Mc Graw-Hill, New York.

Turan, Z.M. 1998. *Araştirma ve Deneme Metodlari.* Uludağ Univ. Agric. Faculty Press, No. 62, Bursa, Turkey.

Vargas, M., J. Crossa, F.A. van Eeuwijk, M.E. Ramirez and K. Sayre. 1999. Using partial least squares, factorial regression and AMMI models for interpreting genotype 3 environment interaction. *Crop Sci.*, 39: 955-967.

Vargas, M., J. Crossa., K. Sayre, M. Reynolds, M.E. Ramirez and M. Talbot. 1998. Interpreting genotype 3 environment interaction in wheat using partial least squares regression. *Crop Sci.*, 38: 679-689.

Yates, F. and W.G. Cochran. 1938. The analysis of groups of experiments. *J. Agric. Sci.*, (Cambridge), 28: 556-580.

Yıldırım, M.B., A. Öztürk, E.B. İkiz and H. Püsküllü. 1979. Statistical-Genetical Methods in Plant Breeding. Agricultural Research Institute. Menemen-İzmir.

(Received for publication 22 April 2005)