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Investigations on the Effect of Genes Controlling Response to Vernalization on Adaptation of Common Wheat (*Triticum aestivum* L.)

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ABSTRACT

Wheat is a very strategic product because it concerns to large communities. The only way to increase the required product is to increase the yield from the unit area. Spring wheat is sown in coastal ecology starting from Samsun and extending to Marmara, Aegean, Mediterranean, Çukurova and Southeast Regions to Diyarbakır and Şanlıurfa. Despite the genetically superior yields of spring wheats planted in these coastal areas, which have large and important ecological zones, there are adaptation problems. They suffer from the cold in winter. This prevents the high yielding varieties to achieve their potential yields. Moreover, in the coastal zone, spring wheats are damaged in late spring frosts due to their early heading. Even low temperatures in the flowering period cause flower infertility. Genes that control the response to vernalization play an important role in the adaptation of wheat as these not only ensures the adaptation of the wheat to the environment in early growth stages but also affects the heading dates. In this study, where winter and spring isogenic lines and their parents and some standard varieties were investigated in 22 coastal environments for grain yield, straw yield, biological yield, harvest index, hectolitre weight, thousand grain weight, plant height, days to heading, days to physiological maturity, grain filling period and protein content. Thirty genotypes of bread wheat (common wheat) varieties developed by CIMMYT and utilized commercially in many countries of the world, isogenic lines bearing their spring and winter vernalization genes (*Vrn-vrn*) and some standard bread wheat varieties were used in the research. Anza sibs show good adaptation to all environments, the superiority of winter isolines in the spring wheat ecology in terms of grain, straw and biological yield characteristics and the earlier heading of spring isolines are remarkable results of this investigation.

***Keywords*:** Common wheat, *Triticum aestivum* L., vernalization, isolines, grain yield, yield related traits.

Introduction

Wheat is a very important product for all countries of the world and takes priority in feeding the rapidly growing world population. It is the major source of energy, protein and fibre in human diet (Arya *et al.* 2012, Preeti *et al.* 2016). One of the world's most wheat consuming countries is Turkey. It is a highly strategic product because annual production and consumption amounts are of importance that can affect the national economy, as well as for very large communities, including its producers.

Wheat is produced in about one-third of Turkey's workable farm-land. Although, production varies from year to year, it is estimated that it has changed between 17-22 million tons in recent years. It is not possible to increase the sown area for more products, even substitution of other crops and so on. The only way to increase the required product is to increase the efficiency taken from the unit area or at least not to decrease the product ceiling reached.

Winter and alternative wheats are produced in most of the cultivation areas. The coastal ecology starting from Samsun and extending to the Marmara, Aegean, Mediterranean, Çukurova and Southeast Regions to Diyarbakır and Şanlıurfa includes spring wheats. Although, the winter season in the coastal zones is generally not severe enough to kill spring habitus wheats, it is able to meet the vernalization needs of all types of wheat, including winter and alternative types. It is frequently observed that winter habit types are more low-temperature tolerant than spring habit types (Limin and Fowler 2006). Despite the genetically superior yields of spring wheat planted in this coastal belt, which has large and important zones, there are adaptation problems. Generally, when wheat is planted early in these regions, it is damaged by the cold of winter as the plants develop rapidly due to the warm weather. However, the plant does not die due to the fact that this process is at the beginning of the development phase and the growth cone is close to the soil. Although, the negative effects of cold damage are not felt much due to regeneration in advanced stage, this situation prevents high yielding varieties from reaching their potential yields. On the other hand, in the coastal belt, especially the spring wheat of CIMMYT (1997) origin, early spike due to reach the stage of late spring frosts will be irreparably degree damaged to the extent that they cannot be recovered. Even low temperatures in the flowering period cause flower infertility. Although, the yield potential of spring wheat sown in the coastal belt is generally 8000-10000 kg/ha, the average of the region varies between 2500-3000 kg/ha. Various agricultural systems (cultivation technique applications) have an effect on this as well as the environmental incompatibility of genotypes. This mismatch, which causes fluctuations in production, is attributed to the damage from the cold in the growth cycle. In addition, early sowing is risky because late planting is preferred in the case, due to the short vegetation period; grain yield as well as biological yield is affected so that, genotypes performance is not possible to the desired level. In general, cereal plants have four ways of increasing the length of the vegetative phase, all of which extend the time that low-temperature tolerance genes are more highly expressed: (i) vernalization; (ii) photoperiod responses; (iii) increased leaf number; and (iv) increased length of the phyllochron [(interval between the appearance of successive leaves) (Limin and Fowler, 2002)]. Genes that control the response to vernalization play an important role in the adaptation of wheat as it not only ensures the adaptation of the wheat to the environment in early growth stages but also affects the time of heading. This hypothesis was supported by Davoud *et al.* (2015) as "vernalization responses regulate phenological growth and affect cold tolerance through influence on the rate of plant development." There are different features in the adaptation of plants to the environment. Heading or flowering in bread wheats are the most important characteristics of adaptation to the environment. Heading is determined by three factors: (i) vernalization request (response to vernalization), (ii) day length (photoperiod), and (iii) temperature (Yasuda and Shimoyama 1965). Their regulation of heading by combining them separately, with each other or with other factors, enables the distribution and adaptation of wheat to very large areas. Among these factors, many investigators have been based on the response to vernalization.

In general, winter types are considered to be the ancestors of springs. Aamodt (1923) reported that it is a general belief that winter forms are more ancient and more primitive.

The way to increase the yield in spring and winter wheats is to know the vernalization process well. Genes that respond to vernalization are identified by their growth property (growth nature). Flood and Halloran (1982), the property of being a little or no response to vernalization as a spring, described as a strong reaction as winter. In fact, this classification is both very sharp and very broad. Disintegration is also possible between these two extremes. Pugsley (1983), the concept of spring and winter based on the responses to the application of vernalization in bread wheat has brought a description based on genotype rather than phenotype. (*i*) *Vrn1* major gene wheats; This class which was unresponsive to vernalization was called "genetically spring wheat". (*ii*) Wheats carrying the *Vrn2, Vrn3, Vrn4* gene or combinations of these genes which are not *Vrn1* gene; also called semi-winter "genetically semi-winter=facultative wheat" (*iii*) Recessive alleles *(Vrn1, Vrn2, Vrn3* and *Vrn4),* which carry strong vernalization of wheat with the desire to "genetically winter wheat" is classified as (Molina 1985).

There has been no comprehensive and solution-oriented study on genes that react to vernalization in Turkey's coastal zones. The preponderance of genotypes carrying the recessive vernalization gene (*Vrn)* has been reported by many researchers in many countries whose ecology meets Mediterranean climate conditions. Molina (1985), in the Central California Valley, early sown winter wheat is very unlikely to suffer from late frosts at the time of heading, indicating that photoperiod insensitive winter wheat reduces the risk of product loss and benefit from this simple inheritance, reported that it would be an advantage even in a normal year when there is no frost at the time of the spike winter isolines according to springs 11% of yield superiority. If the genes controlling the response to vernalization lead to higher yield and improvement of other agronomic characteristics related to yield, the guided and consciously use of winter x spring crosses is an important consideration for the bread wheat programs in Turkey.

Materials and Methods

Genotypes

Genotypes used in the experiment; Bread wheat (*Triticum aestivum* L) varieties developed by CIMMYT (1997) and planted commercially in many countries of the world consist of isogenic lines carrying their spring and winter vernalization genes (*Vrn-vrn*) and some standard bread wheat varieties. Information on these genotypes is given in Table 1.

In the isogenic lines used in the study, a photoperiod insensitive winter wheat variety (Phoenix) and relatively photoperiod insensitive six spring wheat varieties (Anza, Yecora Rojo, Tanori 71, Portola, Siete Cerros 66, and Pitic 62) were used (Molina 1985). The isogenic lines were obtained by backcrossing three to five times and single plant selection was performed by pedigree method after each crossing.

The trial included isolines and their parents, as well as Anza-W, Anza-S, Yecora Blanco-W, Tanori-W, Tanori-S and Pitic-W, which have white-grained, close lines with both winter and spring nature. Yolo, a type of spring bread wheat developed at the University of California and Seri 82, Cumhuriyet 75, Ata 81, and Kaklıç 88 Turkish spring bread wheat varieties, which have large sowing areas in Turkey's coastal belt, especially in Çukurova and Aegean Regions, were also added as standards to the experiment.

Experimental locations

Carried out in three different locations of Aegean Region in 1991-1992 was established in the first year of the experiment in Menemen-İzmir, Milas-Muğla and Sarayköy-Denizli. In the 1992-93 season; In addition to these three trials, the application was carried out in 10 locations: Merkez-Balıkesir, Merkez-Çanakkale, Adapazarı-Sakarya, Merkez-Samsun, Merkez-Diyarbakır, Akçakale-Şanlıurfa and Yüreğir-Adana. In the third year (1993-94), Aksu-Antalya location was added along with İzmir, Denizli, Balıkesir, Sakarya, Samsun, Diyarbakır, Şanlıurfa and Adana. When the year and locations were accepted as an environment, the research was carried out in a total of 22 environments (Table 2).

In this research, the "Coastal Belt" in another words "Spring Wheat Ecology" which starts from Samsun and extends to Marmara, Aegean, Mediterranean and Southeast Regions, to Diyarbakır and Şanlıurfa provinces. In the coastal belt, the winter season is strong enough not to kill spring wheat and has the advantage of meeting the need for vernalization all types of wheat, including winter and alternative (facultative) types.

Field trials management

The experiments were conducted in randomized block design with four replications. The plots were planted in 6 rows 5 m length and the distance between the rows was 20 cm. The amount of seed used was determined to be 500 seeds/m^2, depending on the weight of 1000 seeds of each variety. Planting was carried out with trial seeder in a timely manner with no gap between the parcels. The harvest was carried out in an area of 3.6 m^2 (4 rows x 4.5 m x 0.20 m) by removing 2 edge rows of 6 m^2 parcels and 25 cm from the both heads.

In the fields where the trials were established, care was taken to ensure that there were plants that will not adversely affect wheat as a preliminary plant. Before planting, soil tillage, seed bed preparation, fertilization, post-emergence maintenance works were conducted according to the research findings in the region where the experiment was performed. For example; optimum fertilizer doses of the region were applied by taking soil analysis reports into account.

Necessary measures have been taken where bird damage can be significant; weed growth was not allowed and chemicals were used when necessary. However, no chemicals were used and weed control was done manually because it might affect the heading dates in Menemen location. Although, all fertilizers of (P) and (K) were applied together with planting, fertilizer N was applied twice in planting and spring. The research findings of the region were also taken into consideration in terms of fertilizer type and application times.

The harvest was made with parcel harvesters, and the table of the harvester was completely lowered to the soil surface to measure the biological yield of the parcel, and special sacks were installed on the back of the harvester to collect the harvested straw.

Application differences in some of the experiments carried out in a total of 22 environments over years and location (such as mowing and mowing with a parcel threshing machine) are not mentioned as they do not affect the result of the experiment.

Scored traits

Grain yield (kg/ha), straw yield (kg/ha), biological yield (kg/ha), harvest index (%), hectoliter weight (kg), thousands kernel weight (g), plant height (cm), heading date (days), maturity date (days), grain filling period (days) and protein content (%) (Uluoz 1965; Tecator manual 1979) were scored.

Statistical Analysis

Analysis of variance was performed according to the models proposed by Steel and Torrie (1960), Rusmusson and Lambert (1961) and Snedecor and Cochran (1960). The methods developed by Comstock and Moll (1963) were used to determine the variance components in the agronomic characteristics studied.

Four different linear models have been considered for the determination of variance components (Gordon *et al.* 1973; Mead, 1988):

Model 1: Describes single-site and single-year trials.

Model 2: Linear mathematical model for experiments conducted in more than one site in a year.

Model 3: Linear mathematical model for experiments conducted in the same site in multiple years.

Model 4: Linear mathematical model applicable to experiments conducted in different sites and years.

Test of ordered means: Although, the F test was not statistically significant, the differences were checked at 0.05 significance with the LSD (Least Significant Difference) test, since the comparison of the ordered means for the characteristics of genotypes was one of the purposes of the study (Steel and Torrie 1960).

Test of grouped means: The average of six winter isogenic lines {$\mathbf{W_{(IL)}}$} and six spring isogenic lines {$\mathbf{S_{(IL)}}$} obtained from six springs and one winter parent were calculated from the linear function of the averages described by Steel and Torrie (1960).

The calculations were made using the MSTAT-C package program at the Aegean Agricultural Research Institute in Izmir.

Results and Discussion

The most important goal of this study was to examine the adaptation of the isogenic lines of vernalization. The interaction of the agronomic characteristics of the genotypes with the environment is of great importance. In this respect, the 11 agronomical characteristics were examined in four different models.

Grain yield

According to the results of variance analysis obtained in single location and single year in Antalya in 1992-1993 cultivation season in Canakkale in 1993-94 cultivation season, significant differences were found between genotypes (p=0.001). While the average yield in Çanakkale ranged from 4174 to 6622 kg/ha, these limits were lower (2160-4611 kg/ha) in the Antalya location. The average location in Canakkale was 5909 kg/ha and the average location in Antalya was 3142 kg/ha. In the comparison of six winter {$\mathbf{W_{(IL)}}$} and six spring {$\mathbf{S_{(IL)}}$} isolines, there was no statistically significant difference between both Çanakkale and Antalya locations. However, yield differences were in favor of spring isolines (Çanakkale $\bar{y}_w = 5655 - \bar{y}s = 5745 = -90^{ns}$ kg/ha; Antalya $\bar{y}w = 2805 - \bar{y}s = 2870 = -65^{ns}$ kg/ha). In the combined analysis of variance of İzmir, Denizli and Muğla locations according to the single year and multi-site model, the variation between genotypes was found to be very high in both 1991-92 and 1992-93 sowing years (p=0.001). Location averages for years are given as kg/ha in Table 3.

Grain yield of İzmir, Denizli, Muğla and Şanlıurfa locations according to single location and multiyear model, year variations varied according to locations. Although, the variation between years in Denizli location was statistically nonsignificant, it was very high in İzmir location (p=0.001) and high in Muğla location (p=0.01). In the Şanlıurfa location, the year variance was significant at 0.05 level. The difference between genotypes was very high in all four locations. Genotype x year interactions were important for all four locations. Grain yield of the locations in different years in the general average was given in Table 4.

The combined grain yield averages over the years were 5318-6793; 6031-7500 in Denizli; 4605-6571 in Muğla and 4142-6188 kg/ha in the province of Şanlıurfa.

Grain yields obtained from seven locations for two years in the analysis of combined data according to multi-site and multi-year model; In addition to the main sources of variation such as year, location, genotype, all binary and triple interactions were also very important. The combined year and location averages of grain yields ranged between 4549-5725 kg/ha.

The average (kg/ha) of the seven locations analyzed according to the combined grain yield data for two years is given in Table 5.

The comparison of the six winter {$\mathbf{W_{(IL)}}$} and six spring lines {$\mathbf{S_{(IL)}}$} from the isogenic lines obtained by back crossing in the six spring and the one winter parent was significant at the level of p=0.001 between spring and winter. In the comparison where one isoline from each cross was taken into consideration, the average winter grain yield (**$\bar{y}$w**) was 5234 kg /ha, while that of spring isoline (**$\bar{y}$s**) was 5041 kg/ha and the difference of the mean (**$\bar{y}$w-$\bar{y}$s**) was 193 kg per hectare combined genotype averages over 7 locations and 2 years for grain yield (kg/ha). The genotypes belonging to the first group of the averages listed in the analysis are given in Table 6.

When the results of the experiments are analyzed in separate locations, over years, combined data over locations and years; genotypes other than standard varieties in terms of grain yield; Anza-S, Anza-W, Anza-S, Anza-W, Anza, Phoenix, YecoraRojo-W, Yecora Blanco-W, Tanori-W, Tanori-W, Tanori -S, Pitic-S, Pitic-W, Pitic-W, Siete Cerros-S and Yolo were prominent genotypes. On the other hand, Turkey's spring wheat ecology in coastal areas-especially in the Aegean Region-largely from local standard varieties in cultivation which finds Kaklıç88 and Seri 82 are all the trials came to the fore in terms of grain yield. Ata 81 also included in these two varieties in many locations. For Cumhuriyet 75, average grain yield was obtained at the locations. In the grain yield analysis of varieties and lines, it is note worthy that Anza variety and all sibs (Anza-S, Anza-W, Anza-S and Anza-W) were at the fore front in almost all locations. Seri 82, Kaklıç 88 and Ata 81, which are standard varieties, competed with Anza sibs in many locations. Anza is a variety registered in the US State of California and later in Australia, similar to WW15, with a winter genotype in its pedigree. It is widely used in crossing programs in the USA, Mexico, South Africa, Australia and many other countries and is known to have good adaptability (Molina 1985; CIMMYT 1997). In Western Australia and particularly California, Mediterranean climate of ongoing and climate shows great similarities with Turkey's spring wheat ecology. On the other hand, Seri 82 and Kaklıç 88 come from the same hybrid and are sister lines. Seri 82, Kaklıç 88 and Ata 81 have winter variety Kavkaz blood. The fact that breeding lines and varieties with a winter base in pedigree came to the fore both confirms the purpose of this research and confirms Pugsley's (1983) claim.

In combined analyzes over locations that allow genotype x location interaction, genotype x location interaction was statistically significant at p=0.001 in both 1991-92 and 1992-93. Likewise, it allows the calculation of genotype x year interaction; In the analysis of the combined data of İzmir, Denizli, Muğla and Şanlıurfa locations over different years, genotype x year interactions were very important in statistical terms. Allowing three-way interaction; seven locations and locations of two years and in the combined analysis over the years, both genotype x location, genotype x year and triple interaction genotype x year x location p=0.001 levels were found to be non-zero**.** This shows that double and triple interactions are highly effective on grain yield. This emphasizes that these locations for the grain yield in bread wheat trials requires that the trials be performed in more than one location and year. Baker (1969) and Ikiz (1976) on spring bread wheats, Gill *et al.* (1984), Sabancı (1991) on common vetch, Öztan (1992) and Attary (1993) reached similar results in studies on wheat and triticale.

A significant difference was found between winter and spring isolines for grain yield at the level of p=0.001. Winter isolines $\{\mathbf{W_{(IL)}}\}$ yielded an average of 193 kg per hectare than spring isolines $\{\mathbf{S_{(IL)}}\}$. In the case of 11 locations where spring wheat ecology is studied in terms of plant genetic resources, the fact that many of the village populations or varieties specific to these regions are facultative and even winter type confirm that these results are expected results. Since no research has been found with vernalization isogenic lines in spring wheat ecology in Turkey, it is not possible to compare the results of the research with others. However, the results are consistent with the findings that the researchers conducted in the State of California, USA, using the same isogenic lines, yields a yield advantage of 11% compared to spring isolines (Molina 1985). Whereas in Romania on average, spring isolines over-yielded the winter ones by over 400 kg/ha at the normal planting date and by about 160 kg/ha at late planting, and also a significant correlation ($r=0.80^{*}$) was found between the effect of *Vrn* alleles on heading date and the effect on grain yield (Mustatetea *et al.* 2011).

For two years (1992-93 and 1993-94), in the analysis of the combined data of the seven locations over the years and locations, it was determined that the Aegean Region locations out performed the other coastal area locations in terms of grain yield. The significance of the differences between 1991-92, 1992-93 and 1993-94, in which the trial was applied, varied according to locations. While, the differences between years in İzmir, Muğla and Şanlıurfa locations were significant at p=0.05 level, there was no difference between years in Denizli location. The result obtained in Denizli location can be attributed to the cultivation technique and the effectiveness of irrigation.

The coefficients of variation determined in the analysis of the experiments in 22 different environments separately or combined according to various models over the years and locations where the research was applied were found to be non-hindering values for the evaluation of the experiments. The findings for grain yield are summarized as follows: (i) Genotypes were significantly different; (ii) Anza and sibs have attracted attention among other genotypes; (iii) Genotype x site, genotype x year and genotype x year x site interactions were highly effective in grain yield; (iv) Winter isolines showed yield superiority over spring isolines; (v) Aegean Region locations have yield superiority over other spring wheat ecology locations; (vi) Significant differences between the years were observed in the majority of locations; (vii) CV% values found to be appropriate to the extent that they do not interfere with the evaluation of trials.

Straw yield

In the analysis of the data obtained in sown year 1992-93 at the Çanakkale location, no significant variation was found among the genotypes in terms of straw yield. The average straw yields were between 5826-8042 kg/ha.

In the combined variance analysis for straw yield of İzmir, Denizli and Muğla locations; The genotype x location interaction variance of the years 1991-92 and 1992-93 was non-significant for 1991-92 and highly significant for 1992-93. The combined genotype averages over the locations were found to be straw yields of 6750-9498 kg/ha; In the second year, it ranged between 6248-8755 kg/ha.

In the analysis of the combined data of İzmir, Denizli and Muğla locations separately over the years, the main variables for all three locations are; year and genotype variances were found to be very important in uniform level. Genotype x year interaction variances showed variability between locations, although, it was found to be significant with the probability of 0.01 in İzmir and Denizli, it was non-significant in Muğla.

Fitting in the variance analysis results obtained for straw yields of genotypes over multiple years and locations, although, the variance of genotype x year was significant at 0.05 level, the variances of all other variation sources including triple interaction were found to be significant at 0.001 level. Genotype average yields ranged from 6640 to 8618 kg/ha. According to the two-year data averages of straw yields (kg/ha) of the locations are given in Table 7.

The comparison of winter $\{\mathbf{W}_{(IL)}\}$ and spring $\{\mathbf{S}_{(IL)}\}$ isolines in terms of straw yield was significant at p=0.001. While the average of winter isolines ($\bar{\mathbf{y}}\mathbf{w}$) was 7830 kg/ha, the average of spring isolines ($\bar{\mathbf{y}}\mathbf{s}$) was measured as 7577 kg/ha and the difference between winter and spring ($\bar{\mathbf{y}}\mathbf{w}$-$\bar{\mathbf{y}}\mathbf{s}$) was calculated as 253 kg/ha.

Genotypes belonging to the first group of averages listed in the analysis of combined genotype averages over 7 locations and 2 years for straw yield (kg/ha) are given in Table 8.

The results obtained in 20 different environments in terms of straw yield are summarized as follows: (i) Genotypes were found to be significantly different; (ii) Anza and sibs and Siete Cerros sibs have attracted attention among other genotypes; (iii) Binary and triple genotype x environment interactions had an effect on straw yield; (iv) Winter isolines were more productive in terms of straw yield than the spring counterparts; (v) CV% values calculated in variance analysis showed that the data were healthy and safe in terms of straw yield.

Biological yield

In the analysis of the biological yield data obtained in the planting season of 1992-93 in the Çanakkale location, a very high level of variation was found among the genotypes. The distribution range of genotype averages was 11120-14170 kg/ha.

In the combined variance analysis of the 1991-92 data of İzmir, Denizli and Muğla locations; location, genotype and genotype x location interaction and genotype and genotype x location interaction variance of 1992-93 were found to be significant at p=0.001 level. In the combined analysis of these three locations in 1992-93, the variation between the locations was non-significant. The distribution range of the combined average of genotypes over İzmir, Denizli and Muğla locations was 13010-16190 kg/ha in 1991-92 and between 12110-15010 kg/ha in 1992-93. In the combined analysis, İzmir and Denizli data were calculated for 3 years and Muğla data for 2 years. Although, all of the year, genotype and genotype x year interaction variances of İzmir and Denizli locations were statistically significant, year and genotype x year interaction variances were non-significant except for the variation between genotypes in Muğla location. In Muğla location, a significant difference was found between the biological yields of genotypes at the level of 0.001. The combined biological yield values over the years and locations varied between 11.350-14.330 kg/ha.

When the results of combined variance analysis of biological yield data over 7 sites and 2 years were examined, it was seen that the variances of all variation sources such as year, location, year x location, genotype, genotype x year, genotype x location and genotype x year x location were found to be highly significant. In terms of biological yield, the average hectare yields of the seven locations in the analysis are given in Table 9.

The comparison of winter $\{\mathbf{W}_{(IL)}\}$ with spring $\{\mathbf{S}_{(IL)}\}$ isolines in 1 degree of freedom was statistically significant at p=0.001. The average of winter isolines is $\bar{\mathbf{y}}\mathbf{w}$ = 13063 kg/ha, the average of spring isolines was $\bar{\mathbf{y}}\mathbf{s}$= 12620 kg/ha and the difference between the average of winter and spring isolines is $\bar{\mathbf{y}}\mathbf{w}$ - $\bar{\mathbf{y}}\mathbf{s}$=443 kg/ha.

The biological yields of the genotypes included in the first group in the combined analysis of seven locations and two years are as shown in Table 10.

The findings for the biological yield feature are summarized; (i) Genotypes were significantly different; (ii) Anza and sibs, as well as the winter genotype Phoenix and the standard variety Ata 81 have been more productive genotypes; (iii) Genotype x environment interactions were effective for biological yield; (iv) Denizli location was determined as the most efficient location in biological yield as well as grain and straw yields; (v) Winter isolines were found to be more efficient than spring isolines; (vi) CV% values calculated in variance analysis showed the reliability of biological yield results.

Harvest index

According to the results of the variance analysis performed on the data obtained at the Çanakkale location during a growing season, there was a significant variation among the genotypes in terms of harvest index. In Çanakkale, the distribution of harvest index of genotypes was found to be between 36.99-49.44%.

In the combined analysis of İzmir, Denizli and Muğla locations, both the location, genotype and genotype x location interactions were found to be highly significant in both 1991-92 and 1992-93. Distribution of genotypes over these three locations was 38.01-49.35% for 1991-92 and 41.27-51.10% for 1992-93.

According to the combined data of the locations one by one over three years, it is seen that the variations calculated for all variation sources in İzmir, Denizli and Muğla locations are highly important. In the combined data over the years, the distribution ranges were 36.02-46.86% for İzmir location; It was found to be 39.62-51.18% for Denizli and 36.21-47.62% for Muğla.

In the combined variance analysis over seven locatons and two years, the binary and triple interactions as well as all the main variables were found to be highly significant (p=0.001). The percentage of harvest indexes in the combined genotype averages of different locations and years ranged from 37.76 to 43.99.

Corresponding to data of multi-location and multi-year, the locations of the harvest index percentages are grouped in Table 11.

The comparison of winter $\{\mathbf{W}_{(IL)}\}$ and spring $\{\mathbf{S}_{(IL)}\}$ isolines showed no difference in harvest index. The percentages of winter and spring isolines as $\mathbf{\bar{y}w}$=40.19 and $\mathbf{\bar{y}s}$=40.06, and the non-significant difference of the means are $\mathbf{\bar{y}w}$-$\mathbf{\bar{y}s}$=0.13%.

In the combined analysis over seven locations and two years, the genotypes included in the first group of the averages were Seri 82 (43.99%) and Yecora Rojo-W (43.40%).

Summary results of harvest index feature; (i) Genotypes were significantly different; (ii) Yecora sibs, Seri 82 and Kaklıç 88, attracted attention among other genotypes; (iii) Binary and triple genotype environmental interactions appeared to be highly effective in harvest index; (iv) No statistical difference was observed between winter and spring isolines in terms of harvest index; (v) Adana location was identified as a region that promotes high harvest index; (vi) Low CV values indicate that harvest index data can be used safely

Hectoliter weight

Genotype variance was found to be highly significant in both variance analyzes (Çanakkale and Antalya) performed on one site and one year. The distribution ranges of the genotype averages were 69.78-79.25 kg in Çanakkale and 64.99-77.75 kg in Antalya.

In the analysis of variance based on locations in two separate years of the trials, both location and genotype and genotype x location interaction variances were found to be highly significant within two years. The combined genotype averages of İzmir, Denizli and Muğla locations were 68.71-78.48 kg in cultivation year 1991-92 and 73.73-81.91 kg in cultivation year 1992-93. Location, genotype and genotype x year interaction variances were found to be statistically significant in all three locations of İzmir, Muğla and Şanlıurfa. The genotype averages of the combined data over the years ranged between 72.53-80.88 kg at İzmir location; 66.85-78.20 kg at Muğla location; 74.39-81.22 kg at Şanlıurfa location.

In the variance analyzes performed by combining two trial years and 6 locations for hectolitre weight, all interaction variances were found to be very important as well as location, year and genotype variances. The means (kg) and LSD tests of the combined locations are as shown in Table 12.

There was no statistically significant difference between winter $\{\mathbf{W}_{(IL)}\}$ and spring $\{\mathbf{S}_{(IL)}\}$ isolines in terms of hectolitre characteristics. The mean values of isolines were $\mathbf{\bar{y}w}$=74.73 kg and $\mathbf{\bar{y}s}$=74.88 kg. The genotype Tanori-W was with 77.74 kg, which was statistically in the top group according to the combined results of the six locations, two years, over locations and years.

In summary: (i) Variation between genotypes was found to be highly significant for the weight of the hectoliter; (ii) Tanori and Portola sibs have received more attention than other genotypes; (iii) Genotype x environment interactions were effective and significant for hectolitre weight; (iv) No difference was observed between winter isolines and spring isolines; (v) Balıkesir and İzmir locations were found to promote hectoliter weight compared to other locations; (vi) Uniformly low CV values calculated in the analysis results showed the liability of the data.

Thousand grain weight

Data obtained from Çanakkale and Antalya locations showed that the variation between genotypes was very important and the average weight of the genotypes ranged from 28.22-45.01 g in Çanakkale and 23.63-43.85 g in Antalya.

The variance between location and genotypes was very important in the combined analysis over İzmir, Denizli and Muğla locations, genotype x location interaction variance showed great variability between years, but it was found significant at p=0.001 level in 1992-93 cultivation year, whereas, it was non-significant in 1991-92 cultivation year.

Agreeing with the combined data of the three locations, the distribution ranges of the average thousand grain weights of the genotypes did not deviate much compared to the years. In 1991-92 the dispersal ranges were 30.41-51.11 g in 1992-93 years 34.17-51.98 g. Checking out the analysis of combined data over three years in İzmir location and two years in Muğla and Şanlıurfa locations, the variance of all sources was significant at p=0.001 for thousand grain weight. For Izmir, Muğla and Şanlıurfa, the ranges of thousand grain weight changes combined over the years were 29.35-47.94 g; 26.20-45.23 g and 34.31-48.15 g respectively. According to the combined data of multi-site and multi-year genotype averages, the distribution ranges are 28.50-45.80 g.

As it can be seen in the combined variance analysis over six locations and two years, the variances of year, location, year x location, genotype, genotype x year, genotype x location and genotype x year x location interaction were very important. Based on the analysis of the combined data over the year and location, the six locations were listed in terms of thousand grain weights as in Table 13.

Winter {$\mathbf{W_{(IL)}}$} and spring {$\mathbf{S_{(IL)}}$} isolines were statistically different at p=0.001. Corresponding to the results of six locations and the combined data of two years, the average weight of the winter isolines is $\bar{\mathbf{y}}\mathbf{w}$ = 34.77 g and the average weight of the spring isolines $\bar{\mathbf{y}}\mathbf{s}$ = 35.82 g. The difference was 1.05 g and it was found in favor of the springs. Agreeing with the combined averages over years and locations, the largest grain genotype is Cumhuriyet 75 and a thousand grain weight was 45.8. After Cumhuriyet 75, the highest thousand-weighted genotype was Tanori-W with 40.85 g.

The findings for a thousand grain weight are summarized as follows: (i) Significant variation was observed between genotypes; (ii) Cumhuriyet 75 differs from the others in this feature. After Cumhuriyet 75, Tanori and Yecora sibs became prominent genotypes; (iii) Genotype x environment interactions were found to be significantly effective on thousand grain weight; (iv) Thousand grain weights of spring isolines were found to be better than their counterparts the winters; (v) Sakarya has been identified as the best location for a thousand grain weight; (vi) The CV values determined in all trials were calculated around the expected values from a sensitive trial.

Plant height

Check out the results of variance analysis obtained from one location and one year, significant differences were found between genotypes in terms of plant height in one-year trials conducted in Çanakkale during the 1992-93 sowing season and in Antalya during the sowing season of 1993-94. While the average height of genotypes in Çanakkale ranged from 55.65 to 90.70 cm, these limits were higher 88.75-130.30 cm in Antalya.

In the single-year, multi-site model of variance analysis of İzmir, Denizli and Muğla sites; location, genotype and genotype x location interaction variances were found to be significant in both of 1991-92 and 1992-93 sowing years.

In 1991-92, the combined average plant height limits of İzmir, Denizli and Muğla locations decreased to 59.67-99.67 cm.

Agreeing with the single-site and multi-year model of İzmir, Denizli, Muğla and Şanlıurfa locations, in the combined variance analyzes for plant height, over 3 years in İzmir and Denizli and 2 years for Muğla and Şanlıurfa; only in İzmir and Şanlıurfa locations, year variance was found to be 0.05, and in all other locations all variables and interaction variances were found to be significant at 0.001.

Distribution ranges of genotype averages according to combined data over the years in Izmir, Denizli, Muğla and Şanlıurfa has been 68.62-108.90; 66.38-105.40; 63.22-99.53 and 65.18-99.61 cm, respectively.

In the analysis of the data obtained from seven locations for two years; In addition to the main sources of variation such as year, location, genotype, all binary and triple interactions were also very important.

The average of plant heights combined over two years and seven locations ranged between 68.36-105.70 cm.

The average of the seven locations analyzed according to the combined plant height data over years and locations are given in Table 14 in cm.

No statistically significant difference was observed between winter {$\mathbf{W_{(IL)}}$} and spring {$\mathbf{S_{(IL)}}$} isolines in terms of plant height characteristics. The average heights of isolines in cm is $\bar{\mathbf{y}}\mathbf{w}$=92.05 and $\bar{\mathbf{y}}\mathbf{s}$=91.20. Agreeing with the combined data over seven locations and two years for plant height feature; The highest winter isoline Tanori-W: 105.7 cm; the highest spring isoline is Ciete Cerros-S: 101.3 cm; the shortest winter isoline Yecora Blanco-W: 68.36 cm; The shortest spring isoline is Yecora Rojo-S: 72.36 cm.

The results obtained for plant height are summarized as follows: (i) Genotypes were found to be significantly different. (ii) The highest genotype was Tanori-W and the shortest genotype was Yecora Blanco-W; (iii) Seri 82 and Kaklıç 88 with Anza sibs, yield type genotypes; It was determined to be of medium height around 90 cm; (iv) Genotype x environment interactions were highly effective for plant height; (v) No difference in height between winter and spring isolines; (vi) Sakarya has been identified as an encouraging location for plant height; (vii) Uniformly low CV values implied reliability of the data.

Heading date

Genotype variance was found to be statistically significant in all analyzes performed in one location and one year in Antalya, Samsun and Diyarbakır locations. In the Antalya location, Tanori-S, Yecora Rojo-S, Portola, Portola-S, Tanori 71, Yecora Rojo and Tanori-S lines and varieties were found to be earlier than Cumhuriyet 75. Siete Cerros-W, Anza-W and Phoenix have been identified as the latest line and variety. The earliest genotypes in Samsun location; Tanori-W and Tanori-W; The latest genotypes are Siete Cerros-W, Siete Cerros 66, Yolo and Siete Cerros-S. The earliest genotype in Diyarbakır was Tanori-W, Tanori-S, Tanori 71, Tanori-S and Tanori-W, respectively. The latest genotypes in this location were Siete Cerros-W and Ata 81.

In the analysis of the combined data over three years in İzmir location; year, genotype and genotype x year interaction variances were found to be very important for the number of days to heading. According to the combined three year data, Tanori-S and Tanori 71 were the earliest genotypes and Siete Cerros-W as the latest genotypes.

In the three year average of the İzmir location, the number of heading days ranged from 102.3 to118.3, while the variety of Cumhuriyet 75 was found to be close to the general average with 110.1 days.

Checking out the results of combined variance analysis over the years, a significant difference was observed at the level of p=0.001 in the comparison of winter $\{\mathbf{W}_{(IL)}\}$ and spring $\{\mathbf{S}_{(IL)}\}$ isolines. The difference between the average of winter and spring isolines was 4.6 days, and the winters were determined as late. The average of winter isolines was calculated as $\bar{\mathbf{y}}\mathbf{w}$=112,9 days while the average of spring isoline was calculated as $\bar{\mathbf{y}}\mathbf{s}$=108.3 days. However, in the analysis of multi year combined data; Yecora Blanco-W, Yecora-W, Portola-W, Tanori-W and Tanori-W winter isolines appear to be earlier than the Seri 82 standard variety.

The findings obtained in terms of spike characteristics are summarized as follows: (i) Variation between genotypes was sufficient to allow selection of early or late varieties; (ii) Tanori-S and Tanori 71 were the earliest and Siete Cerros-W as the latest genotypes; (iii) Anza's winter isolines are identified as late in days to spike and spring isolines were defined as intermediate-early; (iv) Anza-S was average of one day later than Seri 82 in number of days to spike; (v) Winter isolines were later than spring isolines; (vi) Genotype x year interaction was found to be very effective on heading dates; (vii) CV values of 1% or less indicated the sensitivity of spike observations.

Number of days to physiological maturity

In the analysis of the combined data over three years in İzmir location, the variance between genotypes as well as year and genotype x year interaction variance were found statistically significant at the level of 0.001. In the combined analysis over the years, the average number of physiological maturity days of genotypes ranged from 146.9-155.2. In terms of physiological maturity, Tanori-S, Portola-S, Tanori 71, Yecora Rojo, Tanori-S, Portola were the earliest and Siete Cerros-W, Siete Cerros 66, Anza-W, Phoenix were identified as the latest genotypes. Standard variety Cumhuriyet 75; It was found to be close to the general average with the number of 152.2 days while the average of spring isoline was calculated as $\bar{\mathbf{y}}\mathbf{s}$=149.5 days.

Significant differences were observed between winter isolines $\{\mathbf{W}_{(IL)}\}$ and spring $\{\mathbf{S}_{(IL)}\}$ isolines at the level of p=0.001. Checking out the combined data over the years, it is concluded that spring isolines were 2.7 days earlier than the winters. The average of winter isolines was calculated as $\bar{\mathbf{y}}\mathbf{w}$=152.2 days and average of spring isolines $\bar{\mathbf{y}}\mathbf{s}$=149.5 days. On the other hand, Seri 82 and Cumhuriyet 75 standard varieties were found in the same group, but earlier winter isolines Tanori-W has reached to physiological maturity in 150.3 days and Cumhuriyet 75 and Seri 82 in 150.3 and 151 days, respectively.

The findings obtained in terms of the number of days to physiological maturity are summarized as follows: (i) The variation among the genotypes investigated was very high; (ii) The physiological maturity characteristic gave findings parallel to the spike characteristic; (iii) Tanori-S, Portola-S, Tanori 71, Yecora Rojo, Tanori-S and Portola were identified as the earliest genotypes; (iv) Siete Cerros-W, Siete Cerros 66, Anza-W and Phoenix were the latest genotypes; (v) Genotype x year interaction was found to be highly effective on physiological maturity; (vi) It was determined that winter isolines were later than the spring counter parts; (vii) Tanori-W winter isoline was observed to be approximately one day earlier than Seri 82; (viii) Very low CV values calculated in the trials were indicative of the sensitivity of the observations.

Grain filling period

Genotype and year variance and genotype x year interaction variance were significant at p=0.001 in the analysis of combined data over one location and three years in terms of grain filling period. The combined genotype averages over the years in İzmir location vary between 36.42-44.58 days. Standard variety Cumhuriyet 75 was determined to be close to the general average with 40.08 days in terms of grain filling periods. Tanori-S, Tanori 71, Yecora Rojo, and Yecora Rojo-S are the genotypes with the longest days of grain filling period. Kaklıç 88, Ata 81 and Siete Cerros-W were the lines and varieties with the minimum number of days.

In the analysis of the combined İzmir location data over the years, a significant difference was found in the comparison of winter $\{\mathbf{W}_{(IL)}$ and spring $\{\mathbf{S}_{(IL)}\}$ isolines at p=0.001. It was determined that spring isolines had an additional grain filling period of 1.97 days. The average of $\bar{y}$**w**=39.29 days, while the average of $\bar{y}$**s**=41.46 days. However, winter isolines with the same period as standard varieties are available, as will be observed from the values obtained.

In summary, the results of the findings obtained for three consecutive years in İzmir location in term of grain filling period: (i) Genotypes were significantly different; (ii) In general, it was found that the early varieties had a long grain filling period and that the late varieties had short grain filling period; (iii) Tanori-S, Tanori 71, Yecora Rojo and Yecora Rojo-S have been identified as the longest genotypes; (iv) Siete Cerros-W, Kaklıç 88 and Ata 81 were found to have the shortest genotypes. (v) Genotype x year interaction had an effect on grain filling period; (vi) Grain filling period of spring isolines was longer than in the winter; (vii) The calculated low CV value implied that the observations were healthy.

Protein content

As it can be seen in the combined variance analysis over the locations of the 1992-93 sowing season data obtained from ten different locations, significant statistical differences in terms of protein content among genotypes as well as location and genotype x location interaction variances were found to be important. The combined genotype averages of the ten locations were distributed between 11.66%-14.97%. Portola-W, Yecora Rojo-S and Portala are the genotypes with the most protein content. Table 16 shows the classification of ten locations in terms of percentage of protein.

According to the combined data over the locations; Cumhuriyet 75 standard variety the average protein content of 13.73 was found close to the average of the experiment.

In the analysis of the combined trials over ten locations, spring isolines $\{\mathbf{S}_{(IL)}\}$ were statistically different from winter isolines $\{\mathbf{W}_{(IL)}\}$ p=0.001 in terms of protein content. Spring $\{\mathbf{W}_{(IL)}\}$ isolines have 0.31% more grain protein than the winters, average of winter isolines **w**$\bar{y}$=13.21%; The average of spring isolines was **s**$\bar{y}$=13.52. On the other hand, winter isoline Portola-W, which is in the first group in the grouping of the combined data over the locations, was found to be the first with 14.97% protein content.

In the combined analysis over the locations, the findings for the percentage protein content in the grain are summarized as follows: (i) The genotypes were found to be different in protein content; (ii) Portola-W, Yecora Rojo-S and Portola were identified as genotypes with the highest protein content; (iii) From the protein analysis results, it was estimated that there was a negative relationship between grain yield and protein content; (iv) Genotype x site interaction was effective for protein content trait; (v) It is possible to combine more protein properties in spring isolines than in the winter; (vii) İzmir location is defined as the location to increase and promote protein percentage in the grain; (viii) The calculated low CV value indicated that the analyzes were performed correctly.

It was concluded that Anza sibs show good adaptation to all environments, the superiority of winter isolines in the spring wheat ecology in terms of grain, straw and biological yield characteristics and the earlier heading of spring isolines are remarkable results of this investigation.

In spring wheat ecology, it is strongly recommended to use spring x winter crosses. The point highlighted here is not entirely about the selection of winter material. The important thing is to transfer the winter base to hybrids. As a matter of fact, the performances of the Seri 82 and Kaklıç 88 varieties, which have a wide base for years in the coastal belt and have a winter base, and the fact that the village varieties (landraces) in the coastal belt and the material of the collected genetic resources are generally of alternative nature strongly support this proposal.

It is believed that at least 10% product increase can be achieved obtaining varieties of wheats to be developed by transferring recessive vernalization (*Vrn*) gene to the high yielding spring wheat varieties or to promising lines according to the procedure and backcrossing three to five times or more until be sure and selecting plant tolerant to winter conditions each time.

Table 1. Genotype names and growing habits in the trial.

Variety Number	Line or Variety name	Growing Habit	Variety Number	Line or Variety Name	Growing Habit
1	Anza	Winter	16	Pitic	Winter
2	Anza	Spring	17	Pitic	Spring
3	Anza	Spring	18	Pitic 62	Spring
4	Yecora Rojo	Winter	19	Phoenix (WW33)	Winter
5	Yecora Rojo	Spring	20	Yolo	Spring
6	YecoraRojo	Spring	21	Anza	Winter
7	Tanori	Winter	22	Anza	Spring
8	Tanori	Spring	23	Yecora Blanco	Winter
9	Tanori 71	Spring	24	Tanoro	Winter
10	Portola	Winter	25	Tanori	Spring
11	Portola	Spring	26	Pitic	Winter
12	Portola	Spring	27	Seri 82	Spring
13	SieteCerros	Winter	28	Cumhuriyet 75	Spring
14	SieteCerros	Spring	29	Ata 81	Spring
15	SieteCerros 66	Spring	30	Kaklıç 88	Spring

Table 2. Locations of trials over years.

Locations	Years		
	1991-92	1992-93	1993-94
İzmir (Menemen)	•	•	•
Denizli (Sarayköy)	•	•	•
Muğla (Milas)	•	•	
Balikesir (Merkez)		•	•
Çanakkale (Merkez)		•	
Sakarya (Adapazarı)		•	•
Samsun (Merkez)		•	•
Diyarbakır (Merkez)		•	•
Şanlıurfa (Akçakale)		•	•
Adana (Yüreğir)		•	•
Antalya (Aksu)			•

• Implemented locations

Table 3. Grain yield average of location over years (kg/ha).

Locations	Years	
	1991-92	1992-93
İzmir	7310 a	6153 a
Denizli	6707 b	6705 a
Muğla	5013 c	6076 a
LSD $_{(\alpha=0.05)}$	**414**	**636**

Table 4. Averages of grain yield on locations over years (kg/ha).

Growing years	Locations			
	İzmir	Denizli	Muğla	Şanlıurfa
1991-92	7310 a	6707 a	5013 b	-
1992-93	6153 b	6705 a	6076 a	4662 b
1993-94	5136 c	6611 a	-	5630 a
LSD $_{(\alpha=0.05)}$	**414**	**449**	**824**	**622**

Table 5. Averages of combined grain yields over years on locations (kg/ha).

Locations	Combined grain yield for two years (kg/ha)
Denizli	6683 a
Balıkesir	5650 b
İzmir	5644 b
Diyarbakır	5042 c
Adana	4994 c
Sakarya	4588 d
Samsun	3826 e
LSD $_{(\alpha=0.05)}$	**1.136**

Table 6. Combined 7 locations and 2 years averages of genotype for grain yield.

Genotypes	(kg/ha)
Anza-S	5725 a
Anza-W	5711 a
Seri 82	5704 a
Phoenix (WW33)	5679 a
Kaklıç	5672 a
Ata 81	5646 a
Anza-W	5576 a
Anza-S	5510 ab
Anza	5508 ab
Yecora Rojo-W	5490 ab
LSD $_{(\alpha=0.05)}$	**235.2**

Table 7. Averages of straw yield combined on location over two years (kg/ha).

Locations	(kg/ha)
Denizli	9923 a
Diyarbakır	8636 b
İzmir	8338 c
Balıkesir	7653 d
Samsun	7433 e
Sakarya	7022 f
Adana	5988 g
LSD $_{(\alpha=0.05)}$	**195.3**

Table 8. Averages of genotype combined 7 locations and 2 years for straw yield.

Genotypes	(kg/ha)
Anza-W	8618 a
Ata 81	8560 ab
Anza-S	8275 abc
Siete Cerros-S	8267 abc
Siete Cerros-W	8237 abc
LSD $_{(\alpha=0.05)}$	**404.3**

Table 9. Averages of genotype combined 7 locations and 2 years for biological yield.

Locations	Biological yield (kg/ha)
Denizli	15910 a
İzmir	13980 b
Diyarbakır	13680 c
Balıkesir	13300 d
Sakarya	11610 e
Samsun	11260 f
Adana	10980 g
LSD $_{(\alpha=0.05)}$	**260**

Table 11. Percentage of harvest indexes according to data of locations over years.

Locations	Harvest index (%)
Adana	45.66 a
Balıkesir	42.65 b
Denizli	42.53 b
İzmir	40.34 c
Sakarya	39.27 d
Diyarbakır	37.55 e
Samsun	34.10 f
LSD $_{(\alpha=0.05)}$	**0.6293**

Table 13. Averages of thousand kernel weight combined data of locations (g).

Locations	Thousand kernel weight
Sakarya	38.96 a
Balıkesir	37.10 b
Diyarbakır	35.50 c
Adana	35.42 cd
Samsun	35.06 d
İzmir	32.16 e
LSD $_{(\alpha=0.05)}$	**0.3883**

Table 15. Comparison of standard varieties and winter isoline having the same grain filling period.

Standard varieties and winter isoline	Grain filling period (number of days)
Tanori-W	40.92
Cumhuriyet 75	40.08
Seri 82	39.92
LSD $_{(\alpha=0.05)}$	**1.272**

Table 10. Biological yields of the first group of genotypes combined over years and location.

Genotypes	Biological yield (kg/ha)
Anza-W	14330
Ata 81	14210
Anza-S	14000
Phoenix	13850
LSD $_{(\alpha=0.05)}$	**542**

Table 12. Averages of test weights combined data of locations.

Locations	Test weight averages of locations (kg)
Balıkesir	76.91 a
İzmir	76.72 ab
Sakarya	76.51 b
Adana	74.86 c
Diyarbakır	72.60 d
Samsun	72.14 e
LSD $_{(\alpha=0.05)}$	**0.2997**

Table 14. Averages of plant height combined data of locations (cm).

Locations	Plant height
Sakarya	97.37 a
Adana	95.94 b
Denizli	95.42 b
İzmir	93.64 c
Diyarbakır	92.16 d
Samsun	87.95 e
Balıkesir	84.91 f
LSD $_{(\alpha=0.05)}$	**0.6075**

Table 16. Percentage of protein content of locations (1992-93).

Locations	% of grain protein
İzmir	14.90 a
Sakarya	14.55 b
Diyarbakır	14.33 b
Adana	13.80 c
Çanakkale	13.64 cd
Denizli	13.45 d
Muğla	13.42 d
Samsun	12.44 e
Balıkesir	11.27 f
Şanlıurfa	10.89 g
LSD $_{(\alpha=0.05)}$	**0.2716**

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