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Türkiye'de Ekmeklik Buğdayda İklim Kuraklık Verim İlişkisinin Krigging Metoduna Göre Değerlendirilmesi

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Özet

Bu çalışmanın amacı Türkiye'deki şehirlerin krigging metodu kullanılarak yağış miktarları ve sıcaklıklara göre (maksimum, minimum ve ortalama sıcaklık) göre benzerlik ve farklılıklarını sınıflandırarak buğdayda verim ve kuraklık potansiyeli belirlemektir. Çalışmada üretim ve verim arasındaki ilişki önemli olarak bulunmuştur. İklim faktörleri (yağış miktarı, minimum, maksimum ve ortalama sıcaklık) kuraklık, verim ve üretimde temel etki olarak görülmektedir. Bunlardan en büyük etkinin kuraklık ve verimi şekillendirmesi bakımından yağışa ait olduğu tespit edilmiştir. Türkiye'de buğday üretimini etkileyen en temel faktörler kuraklık, hastalık, yatma ve kış zararıdır. Bunun yanı sıra buğdayın üretiminde ve veriminde iklim, topografi ve toprak özellikleride önemli faktörler arasında yer almaktadır.

Anahtar Kelimeler: *Türkiye, buğday, iklim, yağış, sıcaklık, kuraklık indeksi, üretim, verim, krigging method ve harita*

Evaluation of Climate-Drought-Yield Relationship on Wheat (T. aestivum L.*) by Krigging Method in Turkey*

Abstract

The purpose of this study to classify similarities/dissimilarities of provinces and to determine the potential of provinces on wheat for rainfall, temperature (maximum, minimum and mean temperatures), yield and drought by Krigging method in Turkey. Important relationships appear between acreage, production and crop yield. Climatic factors (rainfall, minimum, maximum and mean temperatures) seemed main determiners to built drought and to yield and production of wheat. Particularly rainfall is most efficient factor on drought and crop yield. Drought, diseases, lodging and winterkill could be assumed as major determinants in wheat crop production in Turkey. Besides, climatic, topographic and soil conditions are very significant factors in determining yield and production of wheat.

Key Words: *Turkey, wheat, climate, rainfall, temperature, drought index, crop production, crop yield, krigging method and map*

Introduction

Wheat (*T. aestivum* L.) has been one of the most cultivated crops not only in the world but in Turkey. Demand to wheat and relatively its production has been dramatically increasing. Whereas, acreage of wheat has long ceased to be a major source of increased wheat output (Skovmand et al., 2001, Tonk et al., 2011), growing on more than 240 million ha, cultivation in wheat larger than for any other crop, and trade of world is greater than all other crops (FAO, 2010). Acreage, production and yield on wheat in Turkey are almost 9 million ha, 20 million ton and 2.3 t/ha In more than 50% land area of Turkey where wheat is dominant crop rainfall occurs between 250 and 1100 mm of annual precipitation (FAO, 2010). High yield and thus more production require an adequate source of moisture availability during the growing season. Climatic conditions as main determiners form yield and production of wheat drought, diseases, lodging and winterkill could be assumed as major determinants in wheat crop production in Turkey. Especially, drought is big problem and result in serious crop losses (Taner and Sade, 2005). Variability in weather from year to year, region to region has deleterious effects on agricultural production. Yearly and regionally fluctuations affect not only yield but acreage and production (Taner and Sade, 2005). Climatic factors such as rainfall, temperature and humidity have significant effect on crop yield in cereals when cultivated in rainfed conditions. The two periods; September-October and April-June are important for high yield and the precipitation during this period is essential for the crop yield in Turkey where yield is frequently diminished and sometimes crops are lost entirely due to drought (Olgun et al., 1998b). Besides, the effect of environmental conditions (climate, soil etc.) revealed that increasing wheat yield and production for at least more than 50 % is possible by using proper production system (Şahin et al., 2006). Last fifty years were important period in which studies related to crop-weather relationships have been made (Olgun et al., 2000).

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Thompson's model have been largely used (1969) in evaluating features of climatic variations in agriculture (Katz, 1977). Studies revealed that taking into consideration of rainfall and temperature for year realistic forecast could safely be made, but it could also be made by using rainfall and temperature in cropping season (Olgun et al., 1998b). Drought index formulas were developed to describe and to categorize drought. Fournier index, Bagnouis and Gaussen index clearly categorized drought (Doğan and Benli, 1999; Olgun et al., 1999).The purpose of this study to classify similarities/dissimilarities of provinces and to determine the potential of provinces on wheat for rainfall, temperature (maximum, minimum and mean temperatures), yield and drought by Krigging method in Turkey.

Materials and Method

This study was conducted to classify similarities/dissimilarities of provinces and to determine the potential of provinces on wheat for rainfall, temperature (maximum, minimum and mean temperatures), yield and drought by Krigging method in Turkey. Data (1990-2011 years) in rainfall, temperature (maximum, minimum and mean temperatures), and yield for all provinces of Turkey were taken from Turkish Statistical Institute and Turkish State Meteorological Service (Anon., 2011; Anon., 2012). Drought index of provinces were calculated by Olgun Drought Index (ODI) formula (Olgun et al., 2000). **ODI**=A/[(12*(A/B)+(A/C)))] A: Annual total rainfall (mm), B: Total rainfall for first six months (mm), C: Total rainfall for second six months (mm).If IDI denotes; < 6: Arid, 6-10: Semi arid, 10-19 Semi humid, 19-38: Humid and > 39: Very humid. Besides, map of Turkey showing all provinces are given in Figure 1

Cluster and regression analyses were made in Minitab 15 software. Kriging interpolation method is used in the study. Interpolation is the procedure of predicting the values of attributes at unsampled sites from measurements made at a set of locations within the same region. Kriging, interpolation technique is the stochastic geostatistical method that takes into account both the distance and the degree of variation between measurement points. It uses a semi variogram to define the weights that determine the contribution of each data point to the prediction of new values at unsampled locations (Erdogan, 2004). The accuracy of the interpolation process can be evaluated from different aspects. The most straightforward is to predict some single, global accuracy measures that characterize the interpolation accuracy via validation techniques. Therefore the RMSE indices calculated from the difference between the surveyed and the predicted values for each point were examined to understand the distribution of the error.

Figure 1. Map of Turkey.

$$\text{RMSE}=\sqrt{\frac{1}{N}\sum_{i=1}^{N}\{z(x_i)-\hat{z}(x_i)\}^2}$$

It should be noted that the accuracy reported with these validation methods assumes uniform error values for the entire surface. The best way to examine the spatial distribution of error is to obtain a graphical representation of the accuracy by generating error maps. So that error maps generated to understand the spatial distribution of the error in the country.

Results and Discussion

Minimum, maximum and mean values on minimum, maximum and mean of temperatures (°C), total rainfall (mm) and yield (t/ha) and Olgun's Drought Index in wheat for all provinces in Turkey were given in Table 1.

Table 1 showed that minimum, maximum and mean values in mean temperature were 13,1 °C 19,3 °C and 13,2 °C, respectively. Besides, mean values in minimum temperature (min. -39,8 °C, max. -3,0 °C) and in maximum temperature (min. 34,4 °C, max. 46,8 °C) were -17,8 °C and 41,1 °C, respectively. While maximum, minimum and mean values occurred in total rainfall as 2244,9 mm, 258,8 mm and 623,3 mm; yield

had 96,30 kg/da in minimum yield, 227,53 kg/da in maximum yield and in 411,00 kg/da in mean yield. Moreover Olgun's Drought Index had 12,21 in minimum index, 68,26 in maximum index and in 25,93 in mean index. Studies stressed that genotype x environment (rainfall, temperature) interaction is important factor in determination of yield performance close relationship was found between yield with rainfall and temperature. Studies stated that yield amount is designed by water availability and suitable temperatures; rainfall and temperature are main determinants in variations in yield in rainfed conditions (Ma et al.,2004; Karamanos et al., 2009; Sehgal et al., 2002). In rainfed conditions drought and relatively yield are mainly formed by available water supply that means rainfall (Öztürk, A., 1999, Kınacı and Kınacı, 2004). The effects of minimum, maximum and mean of temperatures (°C), total rainfall (mm) on yield in regression analysis were given in Table 2.

Table 1. Minimum, maximum and mean values on minimum, maximum and mean of temperatures (°C), total rainfall (mm) and yield (t/ha) and Olgun's Drought Index in wheat for all provinces in Turkey.

Variable	Minimum	Maximum	Mean
Mean Temperature (°C)	13.1	19,3	13,2±3,7
Maximum Temperature (°C)	34.4	46,8	41,1±2,7
Minimum Temperature (°C)	-39,8	-3,0	-17,8±9,0
Total Rainfall (mm)	258,8	2244,9	623,3±295,2
Yield (t/ha)	96,30	411,00	227,53±73,04
Olgun's Drought Index	12,21	68,26	25,93±9,84

Table 2. The effects of minimum, maximum and mean of temperatures (°C), total rainfall (mm) on yield.

Source	Deg. of Freedom	Mean Square	F Value
Regression	4	45658	14,21**
Error$_{Residual}$	76	3213	
R^2 = 42,8%			
Predictor	**Coefficient**	**Coefficient of S_x**	**T Value**
Constant	-22,4	111,6	-0,20ns
Mean Temperature (°C)	2,906	5,161	0,56ns
Maximum Temperature (°C)	7,713	3,365	2,29*
Minimum Temperature (°C)	3,204	1,652	1,94*
Total Rainfall (mm)	-0,07753	0,02480	-3,13**

** Significance level (P<0,05) ** Significance level (P<0,01).*

As seen in regression analysis (Table 2), general effect of climatic factors on wheat yield was determined as significant at 1%. Moreover, individual effect of climatic factors were analyzed and revealed that the effects of rainfall was found as significant at 1%, and the significant (p<0,05) effects of maximum and minimum temperatures were determined. Rainfall and minimum temperatures significantly affect wheat yield in where dry farming is obligation in (Öztürk, A., 1999; Kınacı and Kınacı, 2004; Başer et al., 2005; Kutlu, 2010).Climatic factors such as rainfall, temperature and humidity have significant effect on crop yield in cereals when cultivated in rainfed conditions. Theoretical mean yield could be made by formula below;

Mean Yield = - 22 + 2,91 x Mean Temperature + 7,71 x Maximum Temperature + 3,20 x Minimum Temperature - 0,0775 x Total Rainfall

Literatures emphasized that with increasing global warming, demand to available water will tremendously increase and water need for crops and economy in water use will naturally increase (Parry and Carter, 1989; Downing and Parry, 1994; Wallace, 2000; Brown, 2002; Doll, 2002). More extreme weather conditions such as extreme droughts and extreme heat are likely to further increase volatility of wheat production not only in the world but in Turkey. Furthermore, given the global importance of this wheat as staple food, the impact of increased yield variability of the world's largest exporter will not go unnoticed (Williams, 1972; Liu et. al., 2007). Maps of minimum, maximum and mean temperatures (°C), total rainfall

(mm), yield (kg/ha) and drought index in wheat for Turkey by Krigging Method and were given Figure 2, 3, 4, 5 and 6.

Figure 2 showed that the coldest temperatures belonged to with -30C-40C, Erzurum, Kars, Ağrı and Ardahan provinces. Van, Bitlis, Muş, Erzincan, Tunceli, Yozgat Sivas provinces had -20-30°C coldest temperatures. Coldest temperatures go up toward to western and southern parts of Turkey. Coldest temperatures occur close to zero in İzmir, Aydın, Muğla Adana and Antalya provinces. The coldest temperatures varied between -3 °C-40 °C. Studies revealed that having spacious variation among genotypes cold resistance could appear until -15 °C in bread wheat (Fowler, 1979; Gustaet al., 1987). Being a linkage between cold resistance and red seed color, hard red winter wheat genotypes have more cold resistance than white hard white ones (Taner and Sade, 2005; Yıldırım and Akten, 2008).

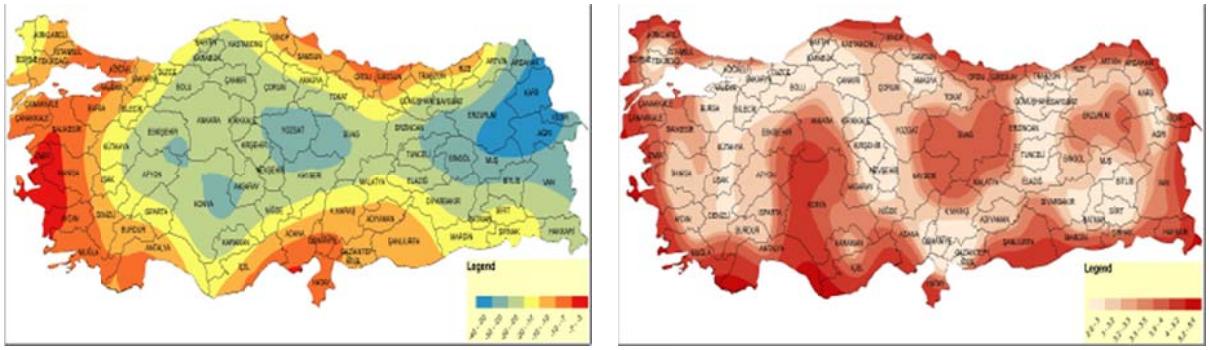

Figure 2. Maps of minimum temperature and its error on wheat in Turkey

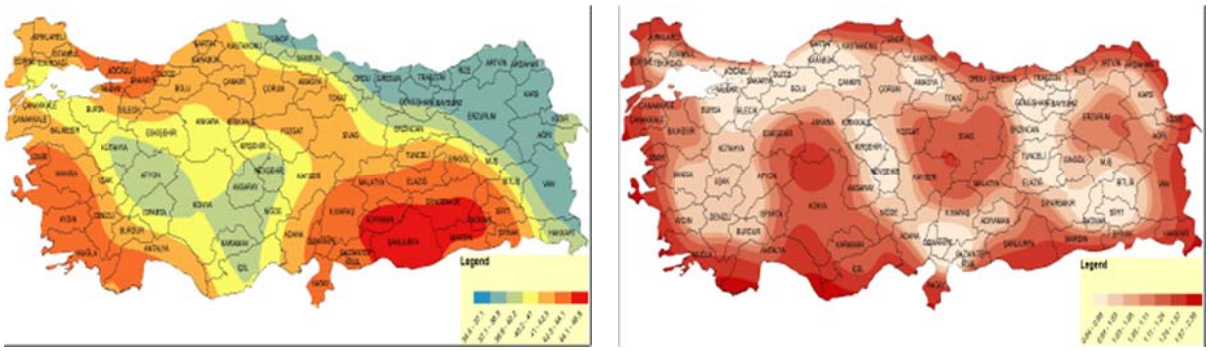

Figure 3. Maps of maximum temperature and its error on wheat in Turkey

Heat stress is important factor limiting crop growth and relatively yield and cool season cereals are generally damaged by excessively high temperatures over 35 °C (Kün,1996). Figure 3 showed that maximum temperatures ranged 34°C-46°C. With 44°C-46°C, the highest temperatures seemed in Adıyaman, Şanlıurfa and Diyarbakır provinces. Eastern part of Anatolia had almost 35°C- 40°C maximum temperatures and these increased toward to west parts. Maximum temperatures occurred as 40°C- 45°C in İzmir, Muğla, Aydın, Kahramanmaraş, Malatya, Siirt provinces. 38°C- 42°C ranges in maximum temperatures took place in rest of Turkey. Adıyaman, Şanlıurfa and Diyarbakır provinces were found as the hottest places in crop growing season and successful studies related to heat stress could be carried out in these areas (Aktaş et. al., 2004; Özberk, 2004; Özberk et. al., 2005). As a means of maximum and minimum temperatures Figure 4 assigned provinces having mean temperature potential. İzmir, Manisa, Muğla, Aydın, Antalya, Adana, Mersin, Hatay, Gaziantep, Kahramanmaraş, Osmaniye, Adıyaman, Diyarbakır, Şanlıurfa provinces were determined as the hottest places; whereas Erzurum, Kars, Ağrı, Van, Sivas, Yozgat, Ardahan provinces were the coldest places in Turkey. Besides, Thrace region, Bursa, Kütahya, Uşak, Konya, Karaman, Afyon, Niğde, Kayseri,Ankara, Kırşehir, Çankırı, Çorum, Isparta, Sakarya, Nevşehir, Kırşehir provinces seemed suitable areas to growth of winter wheat. Studies revealed that Thrace and Middle Anatolia Regions are assumed as the most suitable regions for winter wheat where 0.4- 0.6 t/ha seed yield could be taken in rainfed climatic conditions (Taner et. al.,

2004; Konyalı and Gaytancıoğlu, 2007; Öztürk et. al., 2009).

Rainfall map were given in Figure 5. Figure denotes that rainfall ranged between about 250 mm and 2250 m. The lowest rainfall belonged to Igdır and Aksaray provinces. Kırıkkale, Konya, Niğde, Karaman, part of Ankara provinces had lower rainfall with 250 mm-440 mm. Eskişehir, Afyon, Çankırı, Kayseri, Ankara and Çorum provinces had 450 mm-500 mm rainfall. While Hakkari, Erzurum, Bingöl, Muş, Bitlis, Bayburt, Artvin, Trabzon, Giresun, Ordu, Samsun, İzmir, Aydın, Muğla, Manisa, Bursa, Istanbul, Kocaeli, Sakarya, Düzce, Bartın, Karabük provinces had 650 mm-1000 mm rainfall; only 1100 mm- 2250 mm rainfall were seen in Rize. The other parts of Turkey had 500 mm-625 mm rainfall. With significant variations, rainfall ranges but when almost 330 mm-2500 mm and rainfall seems mostly 500 mm-700 mm. Besides naturally though more rainfall occurs in during the year, yield is mainly based on rainfall in crop growing season, so rainfall in the crop growing season is so affective for yield. Olgun's drought index map was given in Figure 6. Drought index drew similar trends with rainfall. Naturally, drought index mostly takes its power from rainfall and trend fit is surely similar to rainfall (Olgun et al., 1999; Olgun et al., 2000). Having 12-20 index values, Kırıkkale, Kırşehir, Konya, Ankara, Aksaray, Karaman, Niğde, Nevşehir, Çankırı, Çorum provinces had semi arid – semi humid climate. Sami humid- humid climate conditions with 21-23 drought index values prevailed in Eskişehir, Afyon, Iğdır, Kayseri, Yozgat, Amasya, Tokat, Samsun, Sinop, Içel, Isparta provinces. Muğla, Hatay, Mardin, Siirt, Bitlis, Muş, Giresun, Bingöl, Rize, Artvin provinces had humid climate conditions with 28-41 drought index value.Thrace region İstanbul, Kocaeli, Sakarya, Düzce, Bartın, Karabük, Bolu, Bilecik, Yalova, Bursa, Çanakkale, Balıkesir, Izmir, Manisa,Aydın, Denizli, Kütahya, Uşak, Burdur, Antalya, Adana, Osmaniye, Kahramanmaraş, Gaziantep, Kilis, Şanlıurfa, Diyarbakır, Batman, Adıyaman, Malatya, Elazığ, Tunceli, Erzincan, Erzurum, Tokat, Ordu, Sivas, Ağrı, Van, Kars and Ardahan provinces humid climate conditions.

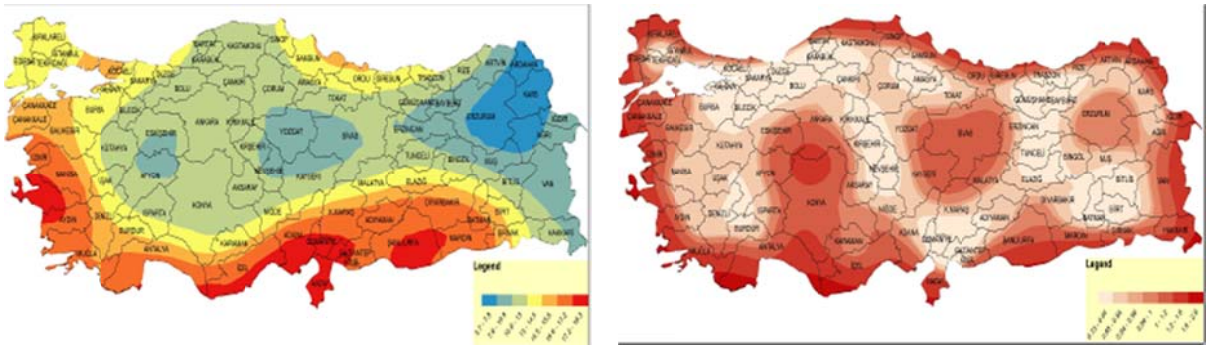

Figure 4. Maps of mean temperature and its error on wheat in Turkey

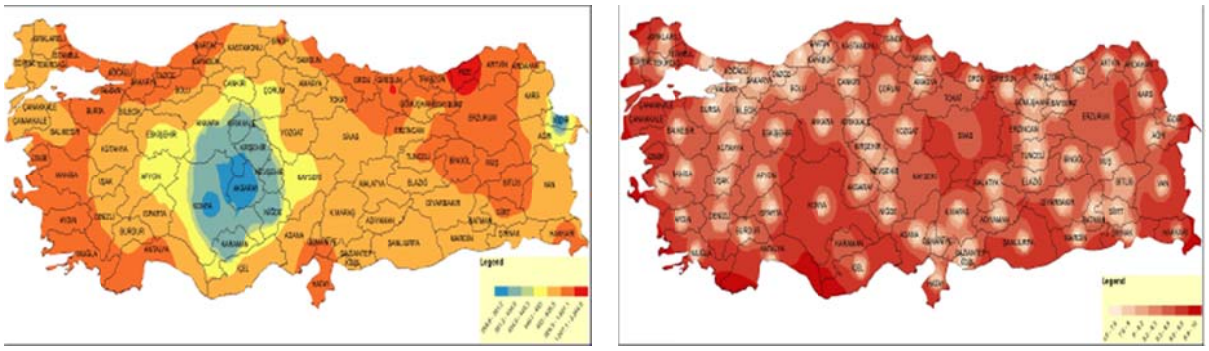

Figure 5. Maps of rainfall and its error on wheat in Turkey

Drought index formulas are so useful to describe prevailing climatic conditions (Olgun et al., 1999; Olgun et al., 2000). It could be said that semi humid climates prevails in Turkey, only Ankara, Konya, Aksaray, Kırşehir, Kırıkkale, Karaman, Niğde have semi arid climates during the year. It was revealed that semi arid and semi humid climates occur in regions where cereals are dominant crops in Turkey (Anon., 2000).

Yield is milestone factor of crop production on cereals in Turkey. Crop production in bread wheat has been made since ancient times up to now, and today is cultivated in widely in dry and wet areas. Yield increase has been taking place by increasing per area for recent 40 years (Kün, 1996). Increase in per area has also been occurred when crop is planted in rainfall or irrigated conditions (Kün, 1996; Oğuz and Arısoy, 2005). Figure 7 shows that yield potential ranged from 1 t/ha to 4 t/ha. Traceregion, Hatay provinces had 3,3 t/ha- 4 t/ha yield potential. Even though, Çanakkale, İzmir, Balıkesir, Aydın, Adana, Osmaniye, Gaziantep, Kilis, provinces had 2,7 t/ha-3,3 t/ha potential; Bursa, Sakarya, Düzce, Bilecik, Kütahya, Uşak, Manisa, Denizli, Burdur, Antalya, Içel, Niğde, Kahramanmaraş, Şanlıurfa, Adıyaman, Diyarbakır, Batman, Şırnak, Bilecik, Samsun, Çorum and Amasya provinces had 2,3 t/ha-2,7 t/ha yield potential. 1,7 t/ha-2 t/ha yield potential were seen in Bartın, Karabük, Kastomonu provinces. Middle Anatolia with almost 2 t/ha-4 t/ha yield potential is known as granary of Turkey (FAO, 2010). With 1 t/ha- 2 t/ha yield potential Ordu, Giresun, Artvin, Trabzon, Sivas, Malatya, Tunceli, Bingöl, Muş, Bitlis, Van, Hakkari, Erzurum, Gümüşhane, Bayburt, Ardahan, Kars, Ağrı, Iğdır provinces had lower yield potential than that of west part of Turkey. Bolu, Sinop, Çankırı, Eskişehir, Ankara, Kırıkkale, Afyon, Isparta, Konya, Karaman, Aksaray, Nevşehir, Kırşehir, Kırıkkale, Çankırı, Yozgat, Kayseri, Tokat, Elazığ and Siirt provinces 2 t/ha-2,3 t/ha yield potential. Rainfall (in amount and distribution) is the most important component for wheat; in dry farming in the world.

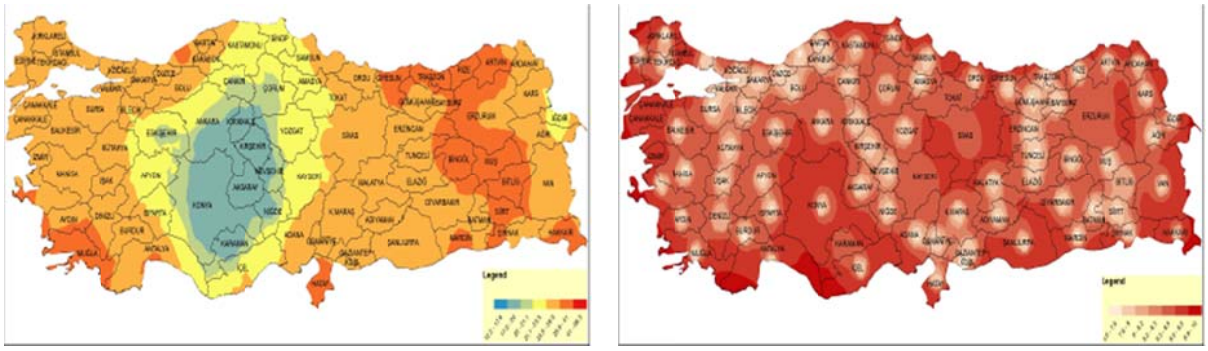

Figure 6. Maps of Olgun's drought index and its error on wheat in Turkey

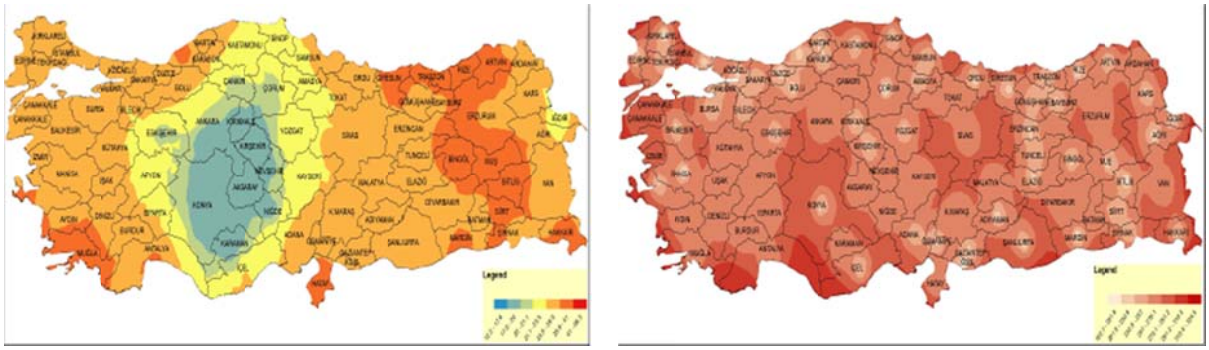

Figure 7. Yield and its error on wheat in Turkey

As a means of factors (max, min and mean temperature, rainfall, yield and Olgun's drought index) cluster analyses should categories of provinces in Figure 8. Figure 8 showed 12 different groups of provinces with their own characteristics Rize and Iğdır provinces created separate groups. While Konya and Aksaray provinces, joined same group, while Bitlis, Giresun and Ordu provinces took part in same group. One group; Antalya, Bolu, Ağrı, Gümüşhane, Kastamonu, Şırnak, Sivas, Ardahan and Kars provinces; other group; Antalya, Muğla, Bingöl, Bartın, Hakkari, Muş, Tunceli, Trabzon and Zonguldak provinces carved out nine member groves. While Artvin, Manisa, Kocaeli, Sinop, Kahramanmaraş and Siirt provinces, made up one group; Bayburt, Van, Isparta, Kütahya, Yozgat, Karabük, Kilis, Malatya and Erzurum provinces formed same group.

Adana, Aydın, Çanakkale, Gaziantep and Kırıklareli provinces joined one group; Adıyaman, Sakarya, Yalova, Düzce and Mersin provinces took part in one

group. Besides Afyon, Çorum, Batman, Ankara, Çankırı, Diyarbakır, Tokat, Erzincan, Kırşehir, Niğde, Burdur and Elazığ provinces formed same group. Last group comprised Bilecik, Nevşehir, Kırıkkale, Kayseri, Balıkesir, Istanbul, Karaman, Denizli, Uşak, Eskişehir, Bursa, İzmir, Samsun, Mardin, Amasya, Edirne, Tekirdağ, Osmaniye and Şanlıurfa provinces.

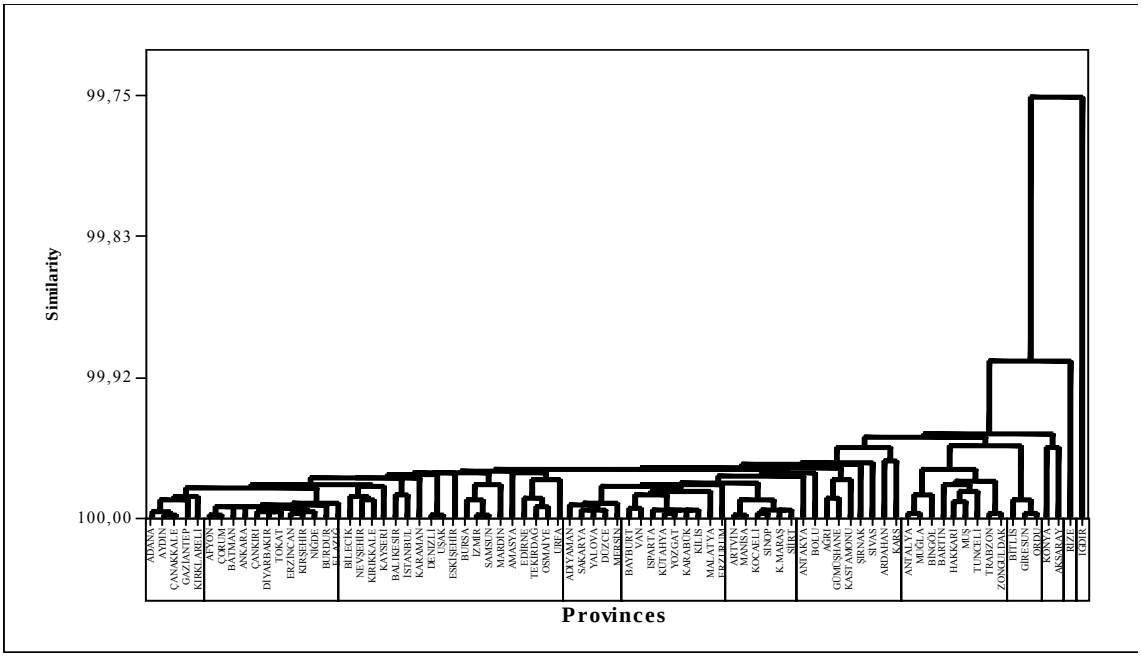

Figure 8. Cluster analysis of provinces in Turkey.

Wheat is accepted as wonderful crop due to well adaptability and growth both in Turkey and in the world. Demands to bread wheat have been increasing more and more with tremendous increase in human population. Important relationships appear between acreage, production and crop yield. Climatic factors (rainfall, minimum, maximum and mean temperatures) seemed main determiners to built drought and to yield and production of wheat. Drought, diseases, lodging and winterkill could be assumed as major determinants in wheat crop production in Turkey. Besides, climatic, topographic and soil conditions are very significant factors in determining yield and production of wheat. The use of cultivars having more tolerance to drought cold and have a shorter growing period allowing rapid development.

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