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Evaluation Acreage, Production and Yield of Wheat (*T. aestivum* L.) by Krigging Method in Turkey

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ABSTRACT

The purpose of this study was to reveal similarities and dissimilarities of provinces and to determine the potential of provinces on wheat in terms of for acreage, production and yield by using krigging method in Turkey. Wheat is the most important and strategic crop for Turkey and plays important a role in crop production, food industry and animal husbandry whether it is given greater importance in production marketing and valorization. Results revealed that, significant relationships appear between acreage, production and crop yield. Besides, climatic, topographic and soil conditions are very significant factors in determining acreage, yield and production of wheat. The use of cultivars having higher yield, more tolerance to drought cold, and have a shorter growing period allowing rapid development will increase crop, yield therefore acreage and production.

Keywords: Wheat, acreage, crop production, crop yield, krigging method, map and Turkey.

Türkiye'de Buğday (*T. aestivum* L.) Ekim Alanı, Üretim ve Veriminin Krigging Yöntemi ile Değerlendirmesi

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ÖZET

Bu çalışmanın amacı Krigging metodu ile Türkiye'de buğday yetiştiriciliği yapılan illerin ekim alanı, üretim ve verimi bakımından benzerlik ve farklılıklarının saptanması ve potansiyellerinin belirlenmesidir. Buğday Türkiye için önemli ve stratejik bir ürün olup bitkisel üretim, gıda sanayi ve hayvan beslenmesinde kullanılmaktadır. Çalışmalar ekim alanı, üretim ve verim arasında önemli ilişki olduğunu ortaya koymuştur. Buğdayın ekim alanı, verim ve üretim miktarında iklim, topografya ve toprak koşulları önemli faktörler olarak karşımıza çıkmaktadır. Bunun yanı sıra verimi yüksek, soğuğa ve kurağa daha dayanıklı, vejetasyon süresi kısa çeşit kullanımı da buğdayda ekim alanı, verim ve üretim miktarında artışlara neden olmaktadır.

Anahtar kelimeler: Buğday, Ekim alanı, Üretim miktarı, Verim, Krigging metod, Harita ve Türkiye

INTRODUCTION

Wheat (*T. aestivum* L.) is valuable of the cereal foods and meets need of nourishment than other food sources (Leonard and Martin 1963). Since last century, demands to food have been increasing more and more with tremendous increase in human population. Wheat is accepted as wonderful crop due to well adaptability and splendid growth in most areas of the world, and it is accepted the most cultivated crop in the world (Peterson 1965). In other words, 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 (Orth and Shellenberger 1988). Even though, a number of cultivars having high yield and quality, resistant to cold, drought and heat stress; success to overcome these troubles is not sufficient, sustainability in these properties of is also important (Wilson 1984; Blum 1988; Metakovsky and Branlard 1998).

Acreage, production and yield on wheat in Turkey are almost 9 million ha, 20 million ton and 2.3 t/ha (Anonymous 2011). In more than 50% land area of Turkey where wheat is dominant crop rainfall occurs between 250 and 1100 mm of annual precipitation (Tuğay and Akdağ 1989). High yield and thus more production require an adequate source of moisture availability during the growing season (Curtis 1982; Dalrymple 1986). Cultivars with wide range of pedigree are grown under varied conditions of soil and climate and give different trait variations (Percival 1921). Besides, the climate of Turkey varies from coastal to continental, with very cold winters, hot and dry summers. Major constraints to production in Turkey include drought, diseases, lodging and winterkill of plants. Especially, drought is big problem and result in serious crop losses (Curtis 2002). 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 (Curtis 2002). Yields are frequently diminished and sometimes crops are lost entirely due to drought (Fischer and Maurer 1978). Major agricultural activity in bread wheat occurs in Central Anatolia. Studies stressed that variations in different prevailing climatic conditions in different areas of Turkey determine obtaining different yield production (Kanbertay 1994; Keser et al. 1999; Partigöç and Olgun 1999; Altınbaş et al. 2004). Report of CIMMYT declared that the 29 million ha of wheat grown and 102.6 million tons harvested annually in China the largest area and production of any country in the world. The greatest gain was during the period 1977-1985 when the yield growth rate increased 8.4 percent during the same period was 8.6 percent. Yield averaged 3.5 tones/ha in the period 1993-1995. India is one of the largest wheat producers in the world with about 25 million ha under production and averaging almost 60 million tons in recent years. More than 90 percent of the area is sown to bread wheat, which is grown throughout the country. Durum or macaroni wheat accounts for around 8 percent of the area (Anonymous 1996). The effect of environmental conditions (climate, soil etc.) concluded that increasing wheat yield and production for at least more than 50% is possible by using proper production system (Yılmaz et al. 1993; Tuğay 2012). The purpose of this study was to classify similarities/dissimilarities of provinces and to determine the potential of provinces on wheat for acreage, production and yield by using krigging method in Turkey.

MATERIALS and METHOD

This study was conducted to classify similarities and dissimilarities of provinces

and to determine the potential of provinces on wheat for acreage, production and yield by using kriging method in Turkey. Data (2006-2010 years) in acreage (ha), production (ton) and yield (ton/ha) for all

provinces of Turkey were taken from Turkish Statistical Institute (Anon., 2012) and map of Turkey showing all provinces are given in Figure 1.



Figure 1. Map of Turkey.

Cluster and biplot analyses were made in Minitab 15 software statistical analysis programmed. 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 semivariogram to define the weights that determine the contribution of each data point to the prediction of new values at unsampled locations (Erdogan 2010). 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.

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

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 means of acreage (ha), production (ton) and yield (t/ha) on wheat for all provinces in Turkey were shown in Table 1. Table 1 showed that minimum, maximum and mean values in acreage of wheat were 9.000 ha and 4.000.000 ha. and 790.000 ha, respectively. Besides, mean values in production (about min. 1900 ton, max. 1.100.000 ton) and in yield (about min. 1.1 t/ha, max. 4.1 t/ha) were about 200.000 ton and 2.3 t/ha, respectively. Relationship between acreage, production and yield in wheat

were given in Figure 2. Figure showed that excluding yield there is a close relationship between acreage, production. Studies

stressed that genotype x environment interaction is main factor in determination of yield performance.

Table 1. Minimum, maximum and means of acreage (ha), production (ton) and yield (t/ha) on wheat for all provinces in Turkey.

	Minimum	Maximum	Mean
Acreage (ha)	8872,6	4227542,2	791904,9±764076,3
Production (ton)	1939,2	1106918,6	203946,8±217626,1
Yield (t/ha)	1,09	4,11	2,30±0,71

While increase was recorded with increasing acreage, yield should be under genotype x environment interaction. Studies stated that yield amount is designed by genotype x environment interaction that is main decisive force in yield Figure 3 showed that provinces were divided into seven groups for wheat acreage. Burdur, Edirne, Ankara, Hatay, Osmaniye, Ardahan, Zonguldak, Artvin Giresun, Kütahya, Karaman, Tunceli, Aydın, İzmir, Denizli, Muğla, Elazığ, Isparta, Iğdır, Bingöl, Kocaeli Sakarya, Gaziantep, Hakkari, Düzce, Balıkesir, Ordu, Bursa. Bilecik, Kırıkkale, Bitlis, Adana Kırklareli, Erzincan, Malatya, Sinop, Aksaray, Karaman, Çanakkale, Karabük, Gümüşhane, Samsun, Çorum provinces

increases/reductions (Baker 1969; Kara 1997). Moreover, grouping of provinces by biplot analyses is shown in Figure 3 for acreage, in Figure 4 for production and in Figure 5 for yield for wheat.

constituted of the most crowded group. Şanlıurfa and Sivas provinces; Amasya, Bolu, Konya provinces formed in pairs and groups of threes, respectively. While Uşak, Nevşehir, Mersin, Erzurum provinces formed four-member group; Kayseri, Tekirdağ, Eskişehir, Kars, İstanbul provinces, and Diyarbakır, Bayburt, Antalya, Afyon, Kahramanmaraş provinces occupied the two of five-membered groups.

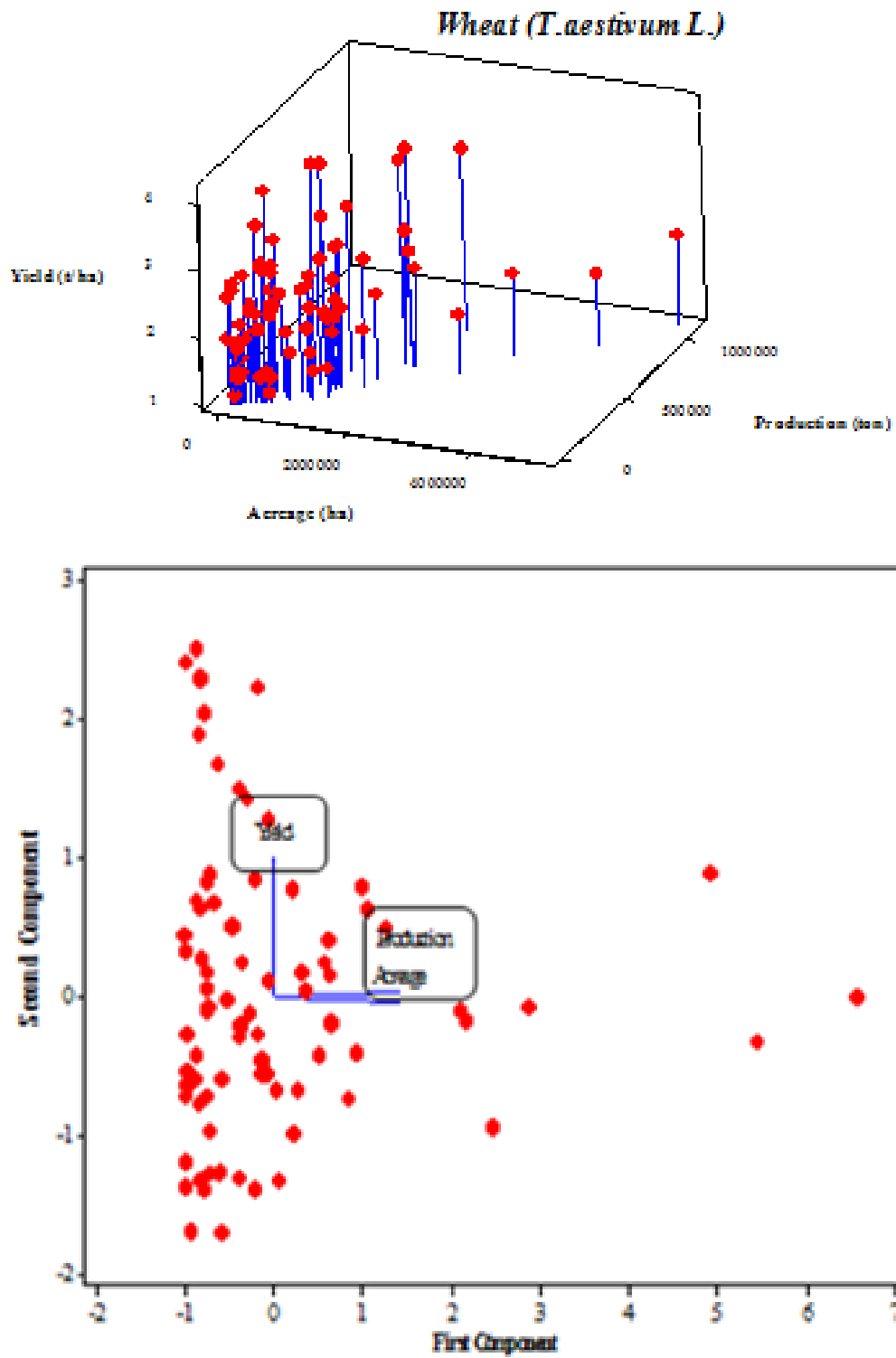


Figure 2. Relationship between acreage, production and yield in wheat.

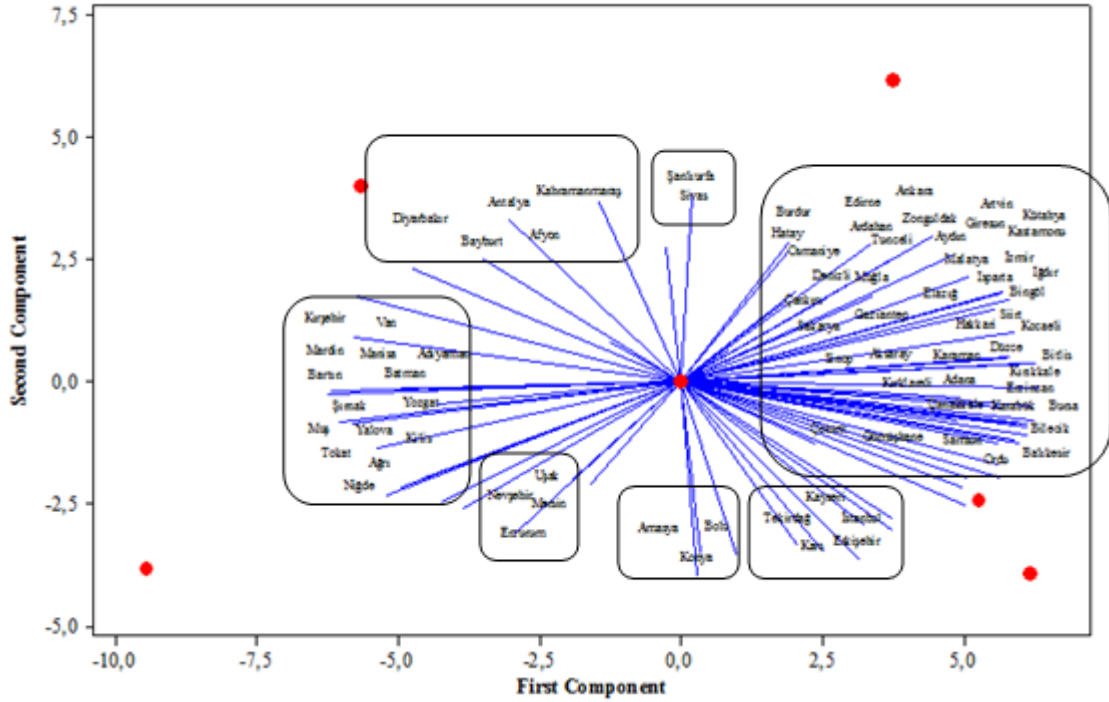


Figure 3. Biplot analysis of acreage on wheat in Turkey.

The other crowded group had Kırşehir, Van, Mardin, Bartın, Batman, Adıyaman, Şırnak, Yozgat, Muş, Yalova, Tokat, Ağrı, Niğde, Kilis, Manisa provinces (Figure 3).

Biplot analysis in production of wheat had five subgroups and were shown in Figure 4. Two big groups; the first big group had Edirne, Hatay, Ardahan, Çanakkale, Muğla, Isparta, Gümüşhane, Hakkari, Iğdır, Ordu, Bingöl, Artvin, Karaman, Sinop, Düzce Kocaeli, Adana, Zonguldak, Kırklareli, Sakarya, Tunceli, Kars, Giresun, Yalova, Tekirdağ, Erzincan, Samsun, Kastamonu, İstanbul, Bursa, Karabük, Kütahya, Aydın,

Mersin, Balıkesir, Bilecik provinces and the other group were created by Batman, Şırnak, Malatya, Kırıklale, Şanlıurfa, Erzurum, Diyarbakır, Bayburt, Muş, Afyon, Mardin, Bartın, Adıyaman, Van, Ağrı, Kilis, Kahramanmaraş, Çankırı, Nevşehir, Eskişehir, Kırşehir, Ankara, Yozgat, Niğde, Çorum, Sivas, Konya provinces. Besides, Kayseri, Tokat, Amasya, Uşak, Manisa, Denizli, Burdur provinces created one group and Gaziantep, Osmaniye, Aksaray, Siirt, Bitlis, Elazığ provinces took part in same group. Last group owned İzmir, Antalya, Bolu provinces (Figure 4).

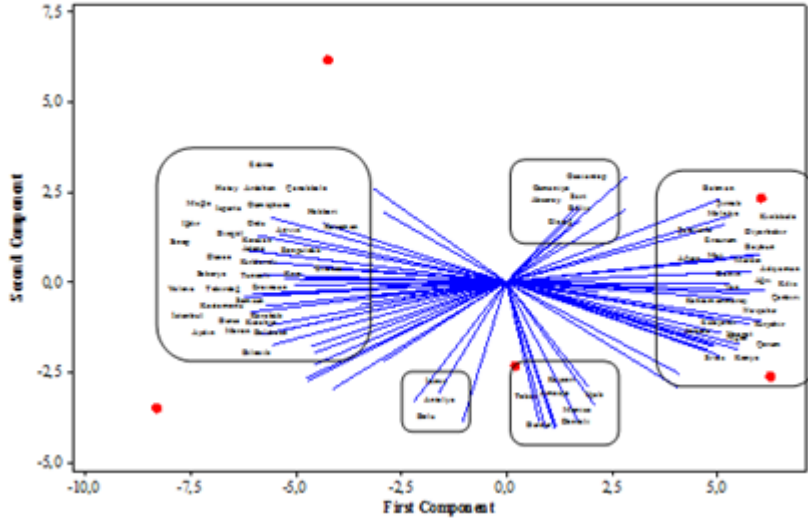


Figure 4. Biplot analysis of production on wheat in Turkey.

Figure 5 pointed to classification of provinces for yield of wheat. Figure 5 denotes that provinces classified in seven groups. First group contained Tunceli, Çanakkale, Giresun, Şanlıurfa, Ordu, Edirne, Gümüşhane, Van, Düzce, Kars, Kocaeli, Yalova, Artvin, Bartın, Zonguldak, Kırklareli, Adana, Bingöl, Mersin, Tekirdağ, Sakarya, Bursa, Ardahan, Karabük, Balıkesir, Samsun, Hatay, İstanbul, Aydın, Muğla, Kütahya provinces. While Osmaniye, Şırnak, Batman, Gaziantep, Siirt, Elazığ, Erzurum, Kilis, Diyarbakır, Bayburt, Bitlis, Malatya,

Muş provinces took part in one group; Afyon, Ağrı, Konya, Aksaray, Adıyaman, Kahramanmaraş, Hakkari, Eskişehir, Kırşehir, Nevşehir, Kırıkkale, Niğde, Çorum, Yozgat, Sinop, Ankara, Çankırı provinces joined in same group. Another group was created by Iğdır, Erzincan, Karaman, Mardin, Antalya provinces. Last three groups occupied Sivas, Uşak, Kayseri provinces; Isparta, İzmir, Denizli, Tokat, Burdur, Amasya, Manisa provinces; and Bolu, Kastamonu, Bilecik provinces, respectively.

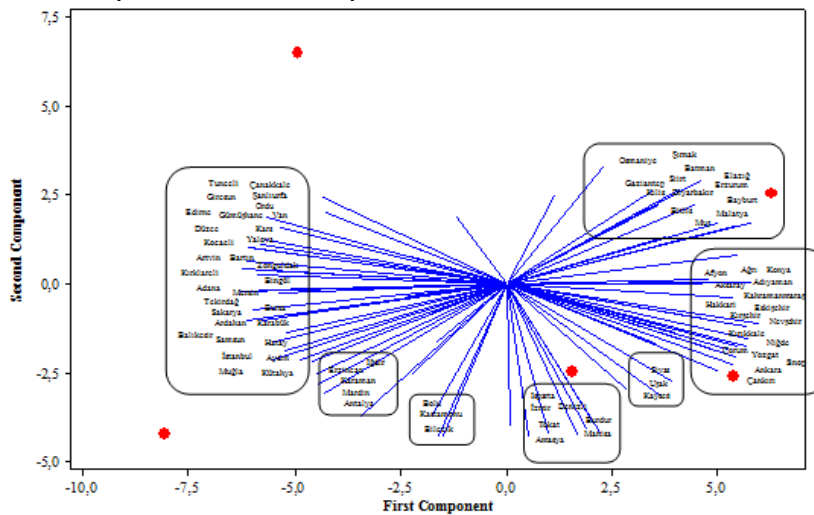


Figure 5. Biplot analysis of yield on wheat in Turkey.

Maps were drawn for acreage, production and yield in wheat for Turkey by Krigging Method and were given Figure 6, 7 and 8. Provinces showed similar results for acreage and production and these were shown in Figure 6 and 7. Nuttanson (1955) stressed that areas having similar climatic conditions for rainfall, altitude and temperature display similar characteristics for cereal acreage and production. Increase/decrease trends therefore similar owing to similar climatic conditions. Results denoted that for acreage and production Ankara, Konya Yozgat, Adana, Kayseri, Sivas, Şanlıurfa, Diyarbakır, Edirne, Eskişehir, Erzurum, Muş, Çorum provinces had similar characteristics. Yield is under genotype x environment interaction and significant variations could be expected depending upon climatic changes (Cook and Veseth 1991) and this explains different behavior in yield against acreage and production. Jones and Davis (2000) pointed out that acreage, production and hereby yield are commonly variable; they are mainly under many factors including climatic, geographic and economic factors. Richards et al. (2002)

stressed that increases in wheat yield and relatively production are possible by applying appropriate cultivation systems and more appropriated areas for wheat.

Figure 8 denoted that provinces for high yield potential in wheat were Kırklareli, Tekirdağ, Edirne, Çanakkale, Bursa, Balıkesir, İzmir, Manisa, Aydın, Denizli, Muğla, Adana, Şanlıurfa, Mardin, Kütahya, Eskişehir, Uşak, Burdur, Antalya, Aksaray, Konya, İçel Çorum, Amasya and Samsun provinces. Acevedo and Fereres (1993) notified that drought, cold are important restrictive factors; and in areas where drought and cold are prevailing limited amount of water supply is main cause for low yield. It was conclude that climate topography and geography have about more than 50% rate on variability of acreage, production and yield in wheat (Charles et al. 2006). Six crops, wheat, rice, maize, soybeans, barley and sorghum are the most common grown crops in the world and production of them these crops accounts for over 40% of global cropland area (Anon. 2006).

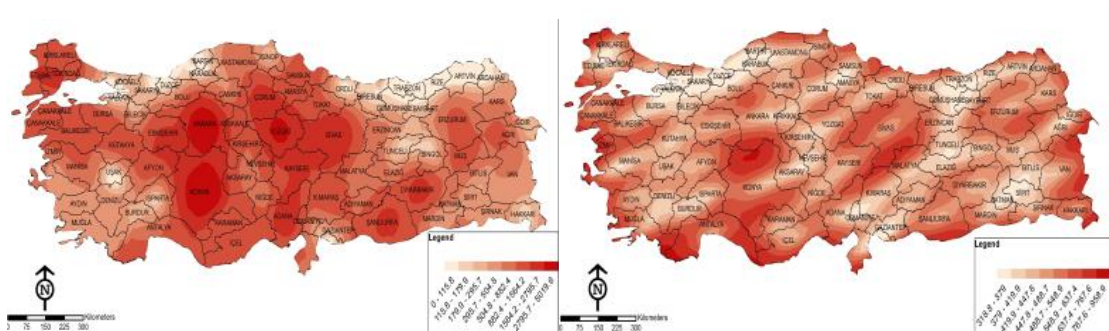


Figure 6. Maps of acreage and its error on wheat in Turkey.

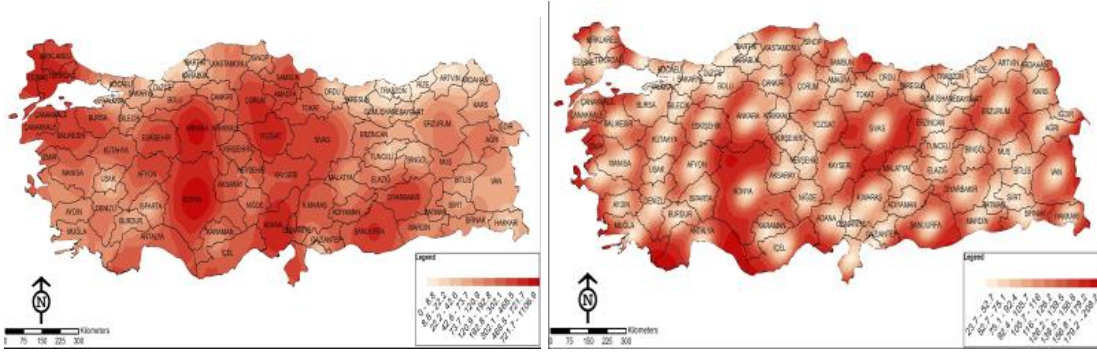


Figure 7. Maps of production and its error on wheat in Turkey.

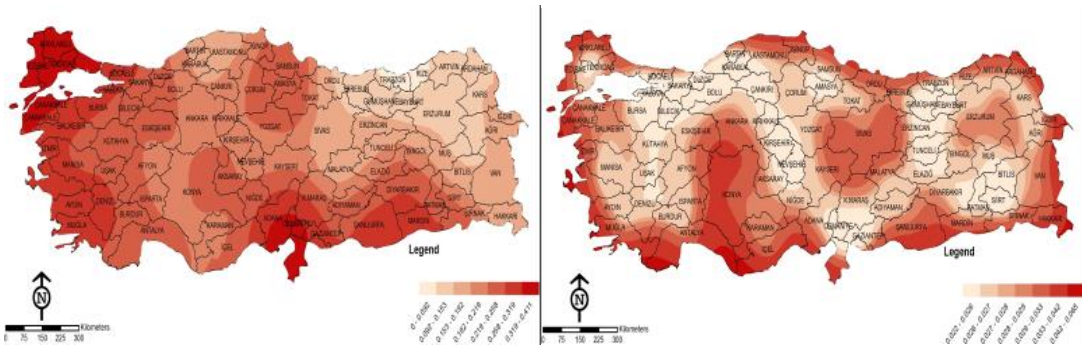


Figure 8. Maps of yield and its error on wheat in Turkey.

Table 2. Error table of acreage, production and yield in wheat.

Wheat (<i>T.aestivum</i> L.)	Yield (t/ha)	Acreage (ha)	Production (ton)
Mean	-0,941269681	-23872,21231	-7224,749039
Root-Mean ²	54,96197862	771144,2307	180664,8737
Mean Standardized	-0,01639598	-0,01043042	-0,022364083
Root-Mean ² Standardized	0,974059622	0,941730338	0,985955649
Average Standard Error	56,83224311	777361,7107	177494,1818

So, wheat is the most important and strategic crop in Turkey and plays important role in crop production, food industry and animal husbandry whether it is given greater importance in production marketing and valorization. Important relationships appear between acreage, production and crop yield. Besides, climatic, topographic and soil conditions are very significant factors in determining acreage, 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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