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The Effect of Irrigation on Crop Yield Change in Some Cereals in Drought Conditions Determined Using SPI and PNI: Ankara Province Example

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ABSTRACT

In this study, Standard Precipitation Index (SPI) and Percent of Normal Index (PNI) values were found in order to determine the drought conditions between 2012-2020 in Ankara province. Drought severity interpretations were made according to the index values obtained and these values were evaluated together with some grain yields grown in the region. Separate regression analysis was performed between the different drought index values obtained within the scope of the study and the irrigated and dry agricultural yield values of wheat, barley and triticale. According to the index values calculated between 2012 and 2020 according to the SPI method, drought conditions are generally close to normal in the region. According to the PNI values, it was determined that 2013 had mildly dry conditions and other years had near-normal drought conditions. According to both indices, a drought close to normal was observed during the research period. In the regression analysis made according to wheat, barley and triticale yields, the highest linearity was obtained in barley, and values close to barley were found in triticale. Wheat is the cereal with the lowest linearity. The regression coefficients obtained as 0.4294 for barley, 0.3331 for triticale, and 0.0502 for wheat were found to be 0.0584 for SPI and 0.0013 for PNI. According to the results obtained, it can be said that statistically linearity is in barley and triticale. In average yields, an increase of 47% in wheat, 55% in barley and 34% in triticale was observed with irrigation. In order to ensure sustainable grain cultivation in drought conditions, it is recommended to expand modern irrigation practices in coordination with drought analysis studies and to increase scientific studies on this subject.

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Introduction

Drought occurs as a result of less precipitation than normal values or expected in a region. This condition develops over time and does not occur suddenly. However, its calculation and forecasting processes are complex events. The occurrence of drought conditions reveals the absence of sufficient moisture in the root zone, which is necessary for the growth and development of plants. As a result of this situation, product yields decrease significantly. In addition, drying winds and high temperature values cause increased drought effects (Wilhite, 2000).

There are many methods for the determination of drought, SPI and PNI methods are the leading among these methods. The Standard Precipitation Index (SPI) is generally used to reveal and follow the current situation of drought in regions where the climate varies according to precipitation data by Mckee et al. (1993). Another common method, PNI, is known as the percent-of-normal index and provides the determination of drought for periods of 12 months or less in time series. In this method, a percentage value is obtained by dividing the total precipitation in a certain period by the average precipitation. (Werick et al., 1994).

The effect of drought on crop yields affects the economic development of countries as well as meeting the need for healthy nutrition. For this reason, studies for the accurate determination of drought in today's conditions have gained momentum. One of the comprehensive studies on this subject in Türkiye was conducted by Şimşek and Çakmak (2010). The drought experienced in 2007-2008 Agricultural Year of Turkey was analyzed and some recommendations for future production activities. The drought was evaluated by using Standardized Precipitation Index (SPI), Percent of Normal Index (PNI) and the analyses of precipitation and temperature analysis. Among these studies, drought analysis of Kırıkkale province was made between 1950 and 2007, and analysis was made with SPI method by using monthly precipitation data. (Oğuztürk

and Yıldız, 2014), In another study, Hezarani determined the drought conditions in the Yeşilırmak Basin with SPI and PNI methods. (Hezarani et al., 2021)

The process of giving the plant the amount of water required for the development of the plant, which cannot be met naturally in the required time and amount by precipitation, is called irrigation. In agricultural terms, irrigation is an important factor in terms of productivity increase, economic development and sustainable development. The inability of existing water resources to meet the required amount of water has brought water management to a very important point. Population growth will be the most important factor affecting the use of water resources in the coming years. In this respect, the effective management of water resources will directly affect the water resource. (Aydoğdu et al., 2015).

Obtaining the highest yield and quality product from the unit area is the main purpose of agricultural production. Today, due to the rapid depletion of natural resources and environmental concerns, maximum product per unit area can no longer be targeted; rather, optimum yield should be targeted. In this respect, irrigation activities gain importance with the amount of precipitation. As a result of the researches carried out in different ecosystems, it has been observed that high rates of yield and quality increases occur in cereals under sufficient precipitation conditions or when the required water needs are met by irrigation (Spehar and De Barros Santos, 2005; Razzaghi et al., 2012), in which the amount of change in triticale yield with irrigation was investigated. In one study, while 187 kg grain yield was obtained per decare with irrigation, 169 kg grain yield was obtained under dry farming conditions. In a different study conducted in Bolivia, where the yield differences between irrigated agriculture and dry agriculture were investigated, it was stated that while 204 kg of seed yield was obtained per decare by irrigation, it decreased to 168 kg/da in dry farming conditions (Geerts et al., 2008).

Grains, which are of great importance in terms of healthy nutrition, are one of the main nutrients alternative to animal proteins. (Ertas, 2016). Some of the most cultivated cereals can be listed as wheat, barley, oat, rye, triticale, corn, paddy. Wheat, which is one of the most important cereals for our country, is a cereal that has great importance in our country and all over the world in terms of nutrition, field agriculture, economy and culture. When the nutritional conditions in Turkiye are examined, 36% of the total calories consumed are met from wheat and its products. At the same time, most of the producers who make a living from agricultural production are engaged in wheat cultivation (Anonymous, 2016). In terms of healthy nutrition, it is a source of protein, carbohydrates and fat, and it is one of the main nutritional sources due to the dietary fibers, vitamins and phytochemicals it contains. These substances in wheat provide protection against coronary heart diseases, cardiovascular diseases and cancer diseases (Shewry and Hey, 2015).

Barley is one of the first cereals cultivated. It has the most cultivation area worldwide after wheat, corn and paddy. Although it is mainly used as animal feed, it is also used in beer and flour production and takes place in human nutrition (Kün, 1996; Sezer, 2007). In Turkiye, barley is cultivated on approximately 3.2 million hectares of land and 8.5 million tons are harvested annually. (TÜİK, 2023-a). Compared to wheat, barley harvested earlier is also more resistant to salinity and drought. It is also more suitable for crop rotation than wheat (İlker, 2006).

The first studies for triticale, which was produced with a wheat/rye hybrid, started in Scotland and entered the literature in Germany in 1935 (Stallknecht et al., 1996). Currently, triticale is grown mainly in Germany, Poland, Canada, China, Australia, France and Mexico (Ammar et al., 2004; McGoverin et al., 2011). These studies continued with summer varieties made by İbrahim Demir in the 1970s (Demir et al., 1986). Tatlıcak 97 is the first triticale variety registered in Turkiye (Kınacı and Kınacı, 2000).

When evaluated in terms of water and soil resources, Ankara, which has resources below the average of Turkiye, is located in the center of the Sakarya Basin. It is also located within the borders of Kızılırmak and Konya Closed Basin, in small proportions. These basins, within the borders of Ankara, constitute approximately 11% of Turkey's water potential (Köle, 2012).

The total agricultural area of Ankara is 11 594.222 decare, and its agricultural production potential is mainly based on grain farming. Approximately 73% of the agricultural products produced are field crops, with grains having the highest share in this ratio. Vegetable farming is approximately 3.5%, fruit and spice crops are grown at 2%. (TÜİK, 2023-b).

The aim of this study is to make a comparative statistical analysis of irrigated agriculture and dry agriculture yield values for wheat, barley and triticale in the drought conditions determined by SPI and PNI methods in Ankara, where grain production is intense in Turkish conditions, and to evaluate the obtained data in a comprehensive manner. For this purpose, drought index values calculated with the help of SPI and PNI methods using precipitation data (MGM, 2021) for Ankara province between 2012 and 2020, and irrigated agriculture and dry agriculture yield values (TÜİK, 2021) for wheat, barley and triticale were analyzed with regression analysis. were compared and correlation coefficients were obtained. According to the correlation coefficients obtained, the effect of drought conditions on yield and the effects of irrigation were revealed. Within the scope of the research, action plans for future periods according to drought conditions and results and suggestions have been created for the development of irrigation opportunities.

Materials and Methods

Research Area

Ankara, the second most populous city and the capital of Turkey, is adjacent to Çankırı in the northeast, Kırıkkale in the east, Bolu in the northwest, Eskişehir in the west, Konya in the south, Kırşehir and Aksaray in the southeast. The geographical location of Ankara in Turkiye is given in Figure 1. and its total surface area is 25.632 km². According to the 2023 census, 5 803.482 people live. (TÜİK, 2024). The total surface area of Ankara province is 25 632 decares, and the total agricultural area is 11 594.222 decares. In addition, the total area of pastures is 461.927 hectares, fallow land is 2.583 hectares and forest area is 28.846 hectares.(TÜİK, 2023-b)

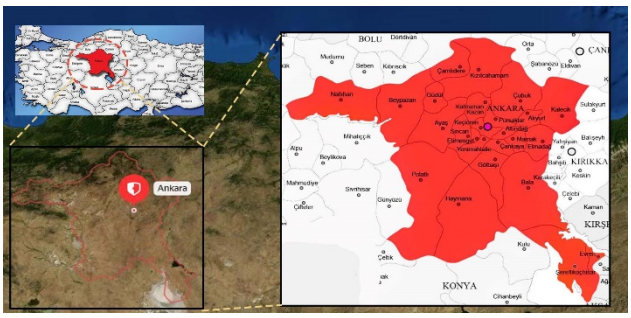
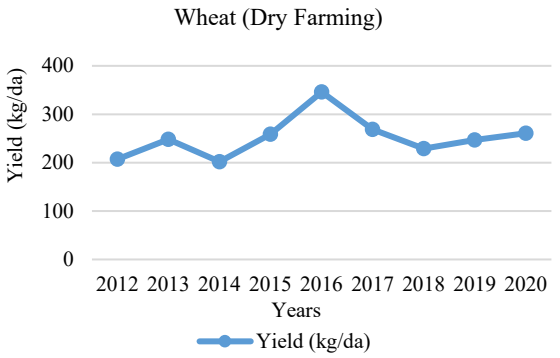
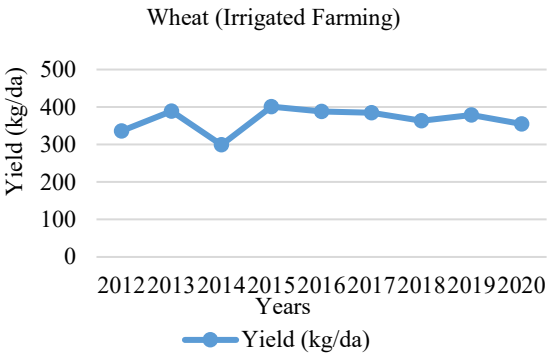
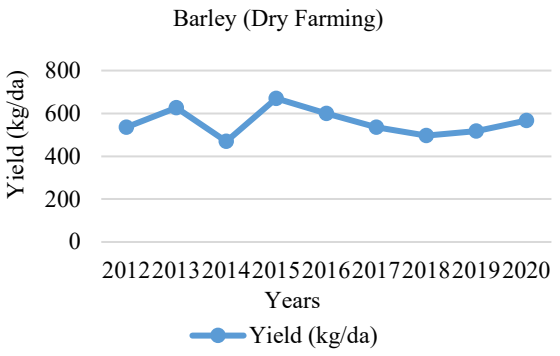
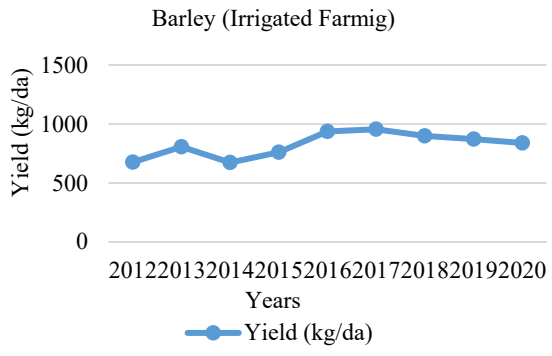


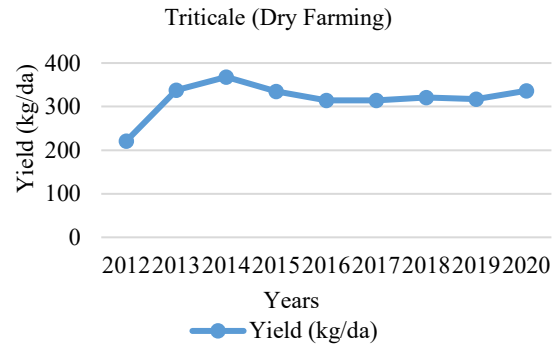
Figure 1. Location of the research area











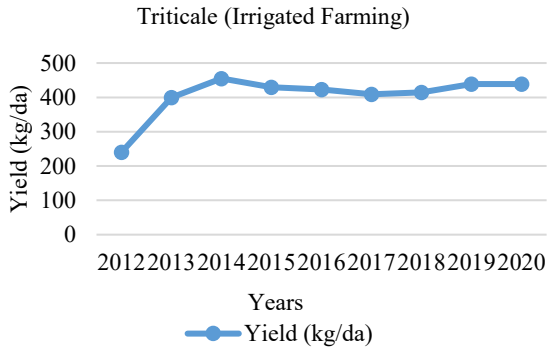


Figure 2. Yield of some cereals grown under dry farming conditions in Ankara between 2012 and 2020

Figure 3. Yield of some cereals grown under ırrigated farming conditions in Ankara between 2012 and 2020

Agriculture has gained importance in Ankara in terms of livelihoods and meeting the country's nutritional needs. The most important field products are wheat and barley. 5.77% of Turkey's total wheat production and 8.79% of barley production are produced in Ankara province. (TÜİK, 2023-b). For example, Polatlı district has one of the busiest grain exchanges in our country, as it is the second largest "granary" of Turkiye. The yield to be obtained in cereals varies with irrigation opportunities. In Ankara province, irrigation is carried out on a total area of 17.898 hectares. (DSİ, 2021) Since the total irrigated area occupies very little space in the irrigable land, it adversely affects the grain cultivation, which is at the forefront in the region.

The material of the research is wheat, barley, triticale, which are the most cultivated cereals in Ankara, the yield values formed as a result of dry (Figure 2.) and irrigated (Figure 3.) agricultural activities between 2012-2020 and the SPI values of these yield values. The precipitation amounts between 2012-2020 were obtained to determine the change due to drought calculated with the SPI and PNI methods. Irrigated and dry farming yield values of wheat, barley and triticale analyzed in the study were obtained from the Central Distribution System (TÜİK, 2021).

Table 1. Spatial information of Ankara Regional Station (MGM,2021)

Specifications	Value
Latitude	39° 58' 21.7"
Longitude	32° 51' 49.3"
Altitude	950
Data period	2012-2020

Table 2. Annual average climate values of Ankara (1991-2020) (MGM, 2022)

Temperature (°C)	Max. Temperature (°C)	Lowest Temperature (°C)	Sunbathing Time (hour)	Number of Rainy Days	Average Total Rainfall Amount (mm)
12.6	18.4	7.3	6.3	103.7	413.6

Table 3. SPI values and drought classifications (Mckee et al., 1993)

SPI	Drought Class
> 2	Extremely wet
1,50 ~ 1,99	Very wet
1,00 ~ 1,49	Moderately wet
0,99 ~ -0,99	Near-normal drought
-1,00 ~ -1,49	Moderately drought
-1,50 ~ -1,99	Very drought
< - 2	Extremely drought

Table 4. PNI values and drought classes

Period	Normal and Above Drought	Mild Drought	Moderately Drought	Severely Drought
1	>75	65-75	55-65	<55
3	>75	65-75	55-65	<55
6	>80	70-80	60-70	<60
9	>83,5	73,5-83,5	63,5-73,5	<63,5
12	>85	75-85	65-75	<65

Table of precipitation and temperature data. It was obtained from the Ankara Regional Unit with the location and general characteristics of the station numbered 17 130 in 1. (MGM, 2021). In addition, the long-term climatic averages of the province of Ankara Table. It is given in 2. (MGM, 2022)

Standard Precipitation Index (SPI) Calculations

SPI (Mckee et al., 1993) calculations were made in order to determine the drought severity of Ankara province between the years 2012-2020. The SPI calculations were calculated separately for each year. The Standard Precipitation Index (SPI) is a drought index calculated with precipitation data in order to determine drought conditions and monitor future periods, especially in regions with climatic changes. The calculation is carried out by dividing the value obtained by subtracting the average precipitation from the total precipitation in a certain region by the standard deviation of the precipitation data (Mckee et al., 1993), (Yacoub and Tayfur, 2017).

$$SPI = \frac{x_{i-}x_i^{ort}}{\sigma} \quad (1)$$

Xi given in the equation; current precipitation amount and xi avg ; mean precipitation amount and σ; The drought classes obtained according to the SPI value calculated according to the standard deviation data are given in Table 3. The SPI values determined for Ankara province were interpreted according to the relevant drought classes.

Percent of Normal Index (PNI) Calculations

In the drought calculations made with the PNI method, the result is obtained by dividing the total precipitation amount at a certain time by the average precipitation and multiplying the value by 100. The obtained value is taken into account as a percentage, and the calculations made for 12 months and shorter time periods give accurate results.

$$PNI = \frac{x_i}{x_i^{ort}} * 100 \quad (2)$$

Xi given in the equation for the province of Ankara; actual precipitation amount and xi avg ; PNI values were calculated by using the average precipitation data. The obtained values were interpreted according to the drought classifications given in Table 4 (Werick et al., 1994).

Regression Analysis

In the research, first of all, the yield values obtained without irrigation were analyzed according to temperature and precipitation changes. Yield values were compared for each grain separately according to the years examined within the scope of the research, as a percentage according to the effect of irrigation. Regression and correlation analysis were carried out in order to reveal the bilateral relations between irrigated agriculture and dry agriculture. Regression and correlation analyzes are performed in order to determine the effect of a change in one of the variables on the other variable, the change at the same rate and indirectly the predicted situations that will occur in the future.

Table 5. Correlation coefficient and correlation strength

Correlation Coefficient (r)	Correlation Strength
<0.2	Very low correlation
0.2-0.4	Low correlation
0.4-0.6	Moderately correlation
0.6-0.8	High correlation
0.8>	Extremely correlation

Table 6. SPI values and drought classes of Ankara province between 2012-2020

Year	SPI Value	Drought Class
2012	- 0.9219	Near-normal drought
2013	-0.9276	Near-normal drought
2014	-0.5006	Near-normal drought
2015	-0.4984	Near-normal drought
2016	-0.5106	Near-normal drought
2017	-0.6451	Near-normal drought
2018	-0.8012	Near-normal drought
2019	-0.7129	Near-normal drought
2020	-0.6714	Near-normal drought

Correlation analysis is performed to determine the direction (positive or negative) and intensity (full relationship or incomplete relationship) of the relationship between variables, and Regression analysis is performed to determine the cause-effect relationship (formula of the relationship) between variables. The correlation coefficient is a value used to show the relationship between these variables (Orhunbilge, 2002). The equation used for the correlation coefficient calculation is given below.

$$r = \frac{\sum(xy) - (\sum x)(\sum y)/n}{\sqrt{(\sum x^2 - (\sum x)2/n)}\,\sqrt{(\sum y^2 - (\sum y)2/n)}} \quad (3)$$

The values obtained as a result of the correlation coefficient calculations Table. It was interpreted according to the intervals given in 5. (Yıldız et al., 1999)

The formula used for the linearity test between two variables, with y as the dependent variable and x as the independent variable, in the equations to be created for the regression analysis is given below. α and β show the parameters of the model, and ε the error value.

$$Yx = \alpha + \beta x + \varepsilon \quad (4)$$

While creating the regression equation, calculations were made using the least squares method so that the sum of the squares of the errors, which are the differences of the x and y values, is at a minimum value. The equation (3) necessary for the margin of error to be minimum is given below. As a result of the calculations, the regression equations (5;6), in which a and b parameters are obtained by using the least squares method, are given below.

$$\sum ei = \sum yi - yi = yi - a - bxi \quad (5)$$

$$y = ax + b \quad (6)$$

Within the scope of the research, the regression curve, equation and correlation coefficients were calculated for wheat (durum), barley, triticale grown in the drought conditions determined by SPI and PNI methods in Ankara, by using the above-mentioned regression and correlation formulas. analysis was made.

Results and Discussion

Within the scope of the study, the drought conditions obtained according to the SPI and PNI calculations determined according to the climate data of Ankara province between the years 2012-2020, together with the analysis of the yield in dry agriculture and the yield as a result of irrigation, were presented separately for each product. Then, binary statistical analyzes, regression graph and coefficients between dry farming and irrigated farming yield values according to SPI and PNI values are explained separately for each product.

Standard Precipitation Index (SPI) Results

Within the scope of the research, the 12-month SPI values of Ankara province between the years 2012-2020 were determined between -0.4984 and -0.9276. These obtained values show that the drought conditions in the research period constitute a drought conditions close to normal. According to the results given in Table 6, it is seen that humid conditions were not observed during the research period and a climatic situation close to drought occurred with the presence of normal precipitation conditions.

In a similar study, it was conducted by Mehr et al. to reveal the drought forecast of Ankara province, and the study was conducted using SPI and SPEI. Within the scope of the study, it was concluded that relatively close to normal drought conditions could occur between 2016-2040. (Danandeh Mehr et al., 2019). In another study, duration, intensity and trend studies were conducted in order to determine the drought characteristics in Ankara province. As a result of trend analyses within the scope of the study, it was determined that the drought characteristics of Ankara province increased. (Danandeh Mehr and Vaheddosti, 2020) In another study, drought conditions for Ankara province were similarly conducted using SPI. It was concluded that extremely dry conditions would decrease relatively in the coming years. (Afshar et al., 2020)

Percent of Normal (PNI) Results

According to the results of PNI, another drought analysis of Ankara province, the 12-month values obtained between 2012 and 2020 ranged from 76.12% to 135.79%. Drought conditions, which were in the mild arid class in 2013, took normal values in other years. This showed that results close to drought conditions obtained according to SPI values were obtained. Obtained PNI values and drought classes are given in Table 7.

A study conducted using PNI together with SPI to analyze agricultural drought across Turkey concluded that drought will increase in the coming periods and that this situation will create a negative situation for many field crops, including wheat (Şimşek and Çakmak, 2010) In a similar study, PNI was used and drought analysis was conducted for Samsun province. As a result of the study, it was determined that drought gave a value close to normal with the trend analysis conducted. (Beden et al., 2020)

Yield Changes Between Irrigated and Dry Farming According to Drought Conditions and Comparative Analysis According to SPI and PNI

Wheat

According to the yield values of wheat in dry farming conditions given in Figure 2, the highest yield was obtained in 2016. In 2016, when the highest yield determined in dry farming conditions was achieved, an increase of approximately 12% was observed with irrigation (Figure 4). This rate rises to 62% in 2012. The lowest yield in dry farming was realized in 2012 and 2013. Especially, 2013 showed a difference compared to other years according to PNI values and it was determined that drought conditions increased. In 2020, there was a 36% increase in yield with irrigation.

When the change in wheat yield with irrigation between 2012-2020 in Ankara province conditions is examined, an average yield increase of 47.2% is observed. According to the SPI and PNI values, this yield increase was generally obtained in near-normal drought conditions. It can be mentioned that the increase in yield can be more with irrigation for the periods when the severity of drought will increase.

Equations, regression trend lines and correlation coefficients created to statistically analyze the bilateral relations of wheat with varying irrigation yield under dry farming conditions Figure 5 and Figure 6. According to the results of the analysis, correlation coefficients of 0.0502, 0.0891, 0.0584 and 0.0013 were found according to irrigated agriculture-dry farming yields, SPI and PNI drought conditions. This situation shows that there is no linear relationship between dry farming and irrigated farming in wheat yield under current drought conditions for Ankara province. There is a very weak relationship between dry farming and irrigated farming conditions at a level that cannot be correlated.

Table 7. PNI values and drought classes of Ankara province between 2012-2020

Year	PNI Value	Drought Class
2012	110.48	Normal and Above Drought
2013	76.12	Mild Drought
2014	135.79	Normal and Above Drought
2015	132.49	Normal and Above Drought
2016	122.06	Normal and Above Drought
2017	97.39	Normal and Above Drought
2018	126.77	Normal and Above Drought
2019	105.98	Normal and Above Drought
2020	97.49	Normal and Above Drought

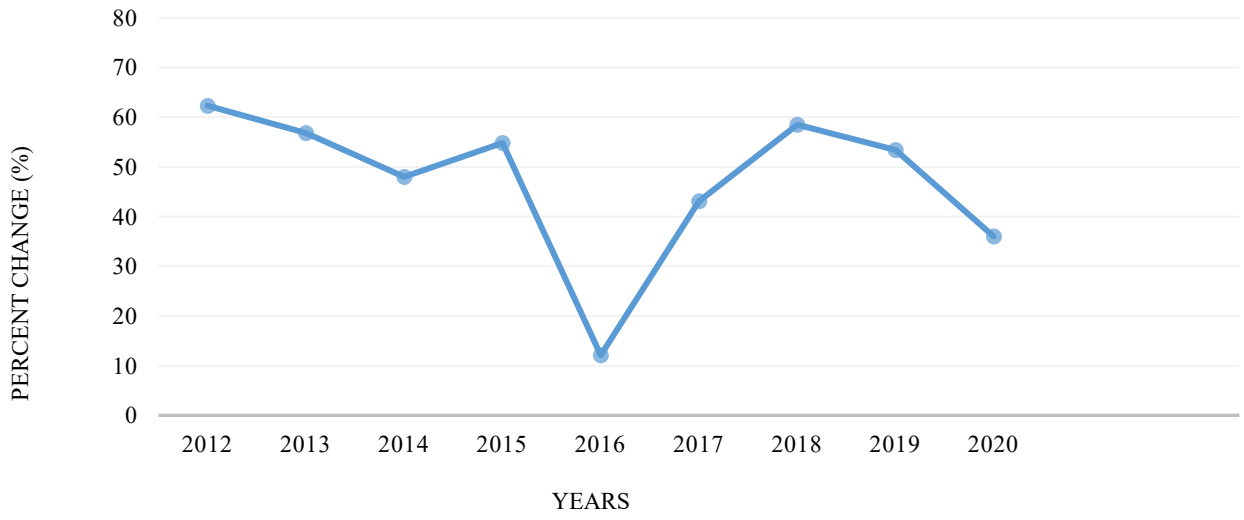


Figure 4. Yield change percentages of wheat in irrigated agriculture compared to dry agriculture

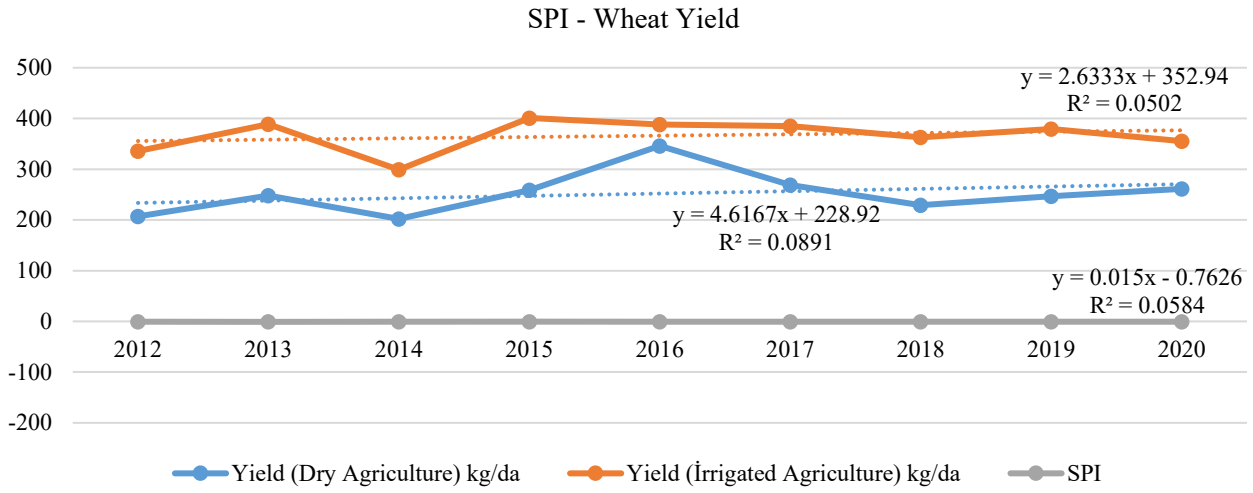


Figure 5. Regression Analysis of Wheat Yield and SPI Drought Conditions

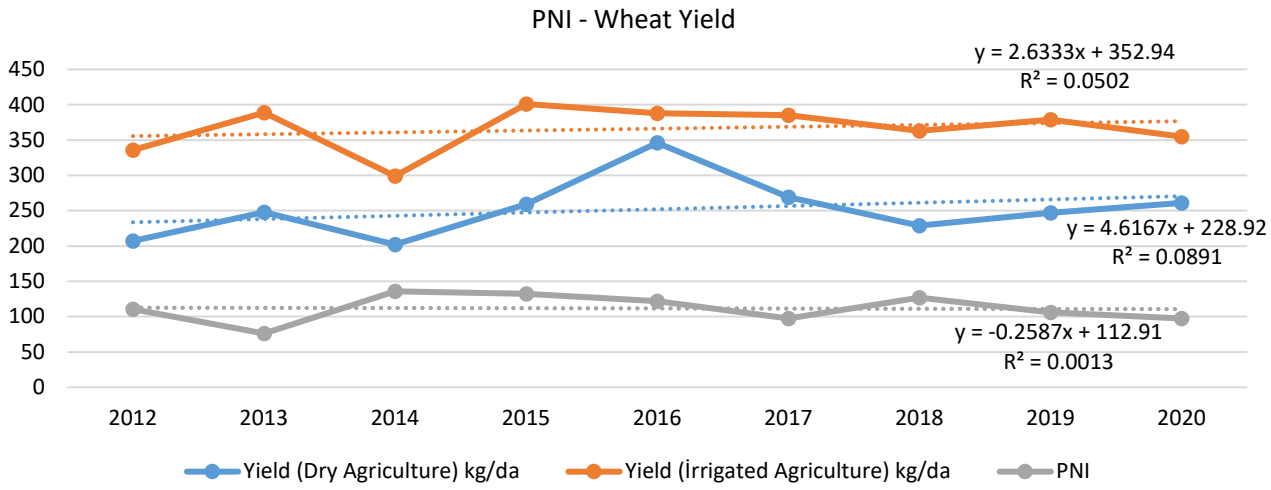


Figure 6. Regression Analysis of Wheat Yield and PNI Drought Conditions

A study conducted in the Adana region examined the effect of irrigation on yield changes in wheat. As a result of the study, it was concluded that 326.66 kg/da more wheat yield was obtained in the flat planting method, 267.46 kg/da more in the ridge planting method and 140.91 kg/da more in wide ridge planting. (Aykanat and Barut, 2018) In a study comparing the wheat yields of Hatay and Şanlıurfa provinces, it was determined that there were significant increases in wheat yields with irrigation, especially in Hatay province. (Tiryakioğlu et al., 2017)

Barley

According to the yield values given in Figure 2 and Figure 3 for barley, the lowest yield was experienced in dry farming in 2014, while the yield obtained with irrigation in the same year was 43.5% higher. This year was determined as the year in which the index value of -0.5006 was obtained according to SPI calculations. Between 2012 and 2020, which was examined within the scope of the research, an average of 46% yield increase was experienced with irrigation in barley cultivation in Ankara province conditions (Figure 7). This situation is similar to wheat. According to SPI and PNI calculations, 55% increase in yield in years with near-normal drought indicates that irrigation will be more important in case of a change in drought severity.

Equations, regression trend lines and correlation coefficients in which barley yield was established according to irrigated farming - dry farming variables in SPI and PNI drought conditions Figure. It is given in Figure 8 and Figure 9. The correlation coefficients found according to the equations created are 0.4294, 0.0402, 0.0584 and 0.0013. Although a linear linear relationship is not provided, it has been observed that there is a statistically weak relationship. This shows that there is a relatively better statistical relationship in barley compared to wheat. Although the yield obtained with irrigation is much higher in percentage, it is seen that the yield difference will increase in the following planting periods in terms of statistics.

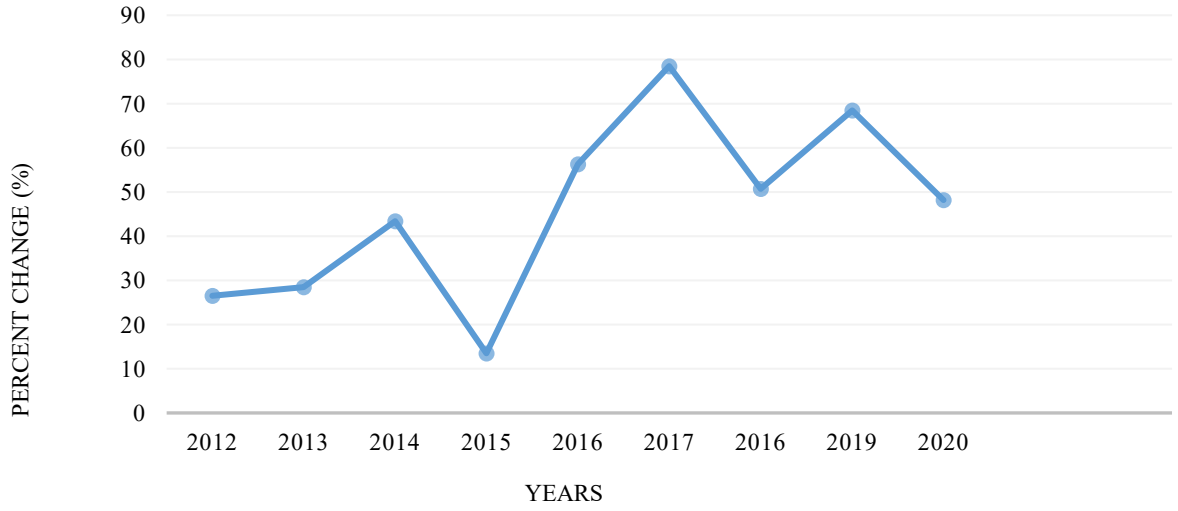


Figure 7. Yield change percentages of barley in irrigated agriculture compared to dry agriculture

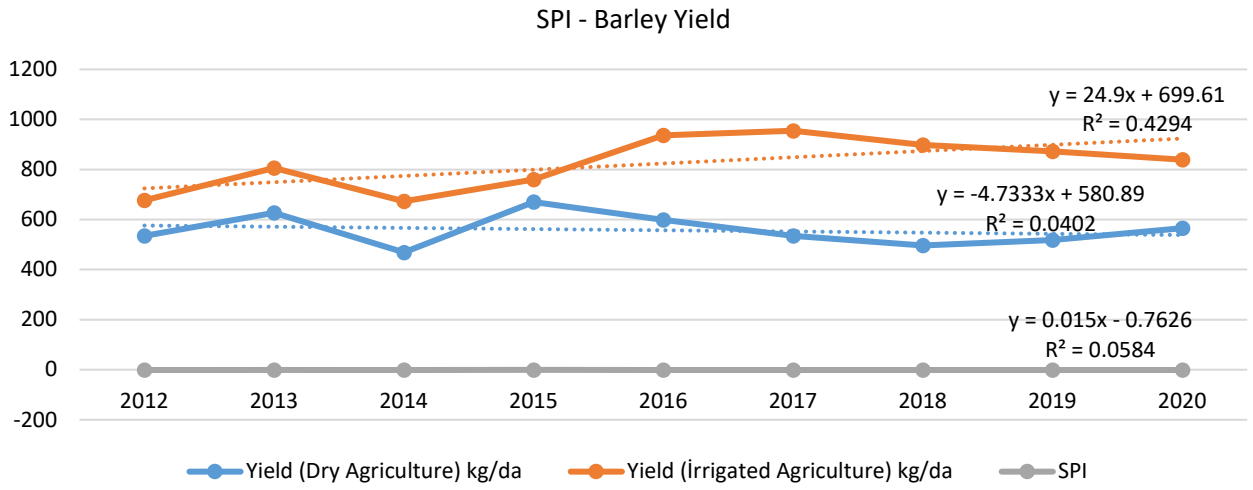


Figure 8. Regression Analysis of Barley Yield and SPI Drought Conditions

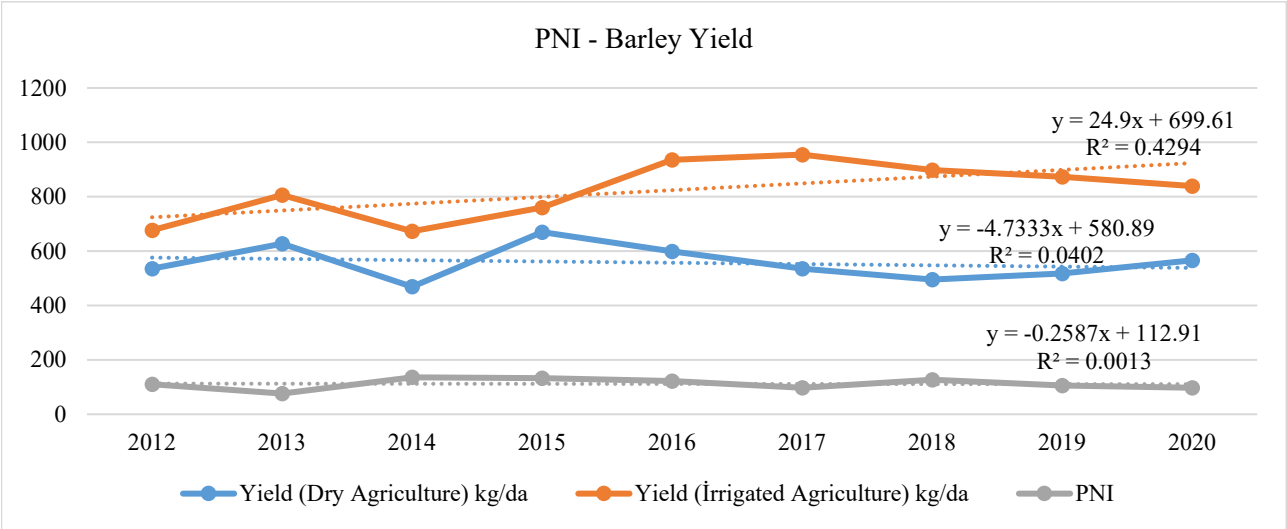


Figure 9. Regression Analysis of Barley Yield and PNI Drought Conditions

In a study examining the effect of irrigation and timing on yield in barley, it was seen that irrigation provided positive effects on quality characteristics as well as yield increase. (Gültekin and Tokgöz, 2008) A similar study investigated the relationship between irrigation and barley yield in Harran Plain conditions. As a result of the study, positive results were obtained in yield and quality with irrigation applied in all growing periods of barley. (Yıldız and Tarı, 2018)

Triticale

According to the graph given in the Figure 10 of triticale, in which the yield and percentage changes are examined, the lowest yield was obtained in dry agriculture in 2012, and 26,9% more efficiency was achieved with irrigation in this year. The yield of Triticale, a hybrid of wheat and rye, increased by 34% on average with irrigation facilities during the period of near-normal drought conditions, according to SPI and PNI values, between 2012 and 2020. This situation is at a lower rate than wheat and barley, and it can be mentioned that the increase in yield with irrigation may also change with the change of drought conditions. The best correlation coefficient after barley among the grains within the scope of the study was calculated in triticale. Shape. The regression analysis given in Figure 11 and Figure 12. According to the equations created, correlation coefficients of 0.3331, 0.1022, 0.0013 and 0.0585 were obtained. The results show that there is a better statistical relationship in triticale than in wheat.

In a study investigating the effect of different nitrogen doses on yield and quality of triticale with irrigation, it was determined that irrigation opportunities had positive effects on yield and quality characteristics. (Takıl and Olgun, 2020) A similar study conducted in the Konya region on triticale showed that there was an increase in yield and quality characteristics during irrigated growing periods (Özer et al., 2010).

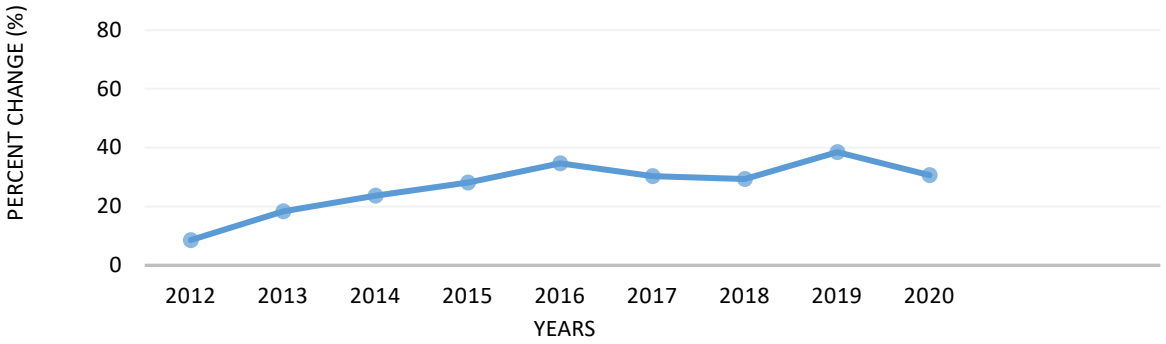


Figure 10. Yield change percentages of barley in irrigated agriculture compared to dry agriculture

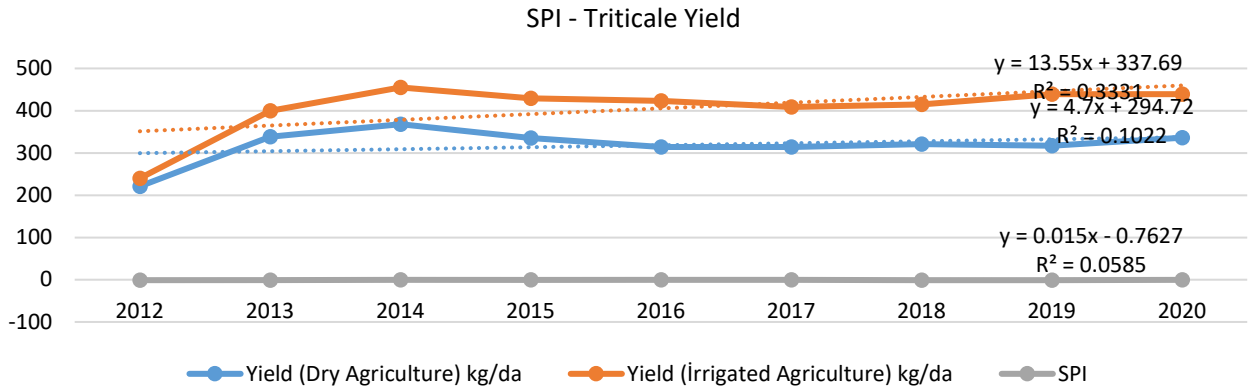


Figure 11. Regression Analysis by Triticale Yield and SPI Drought Conditions

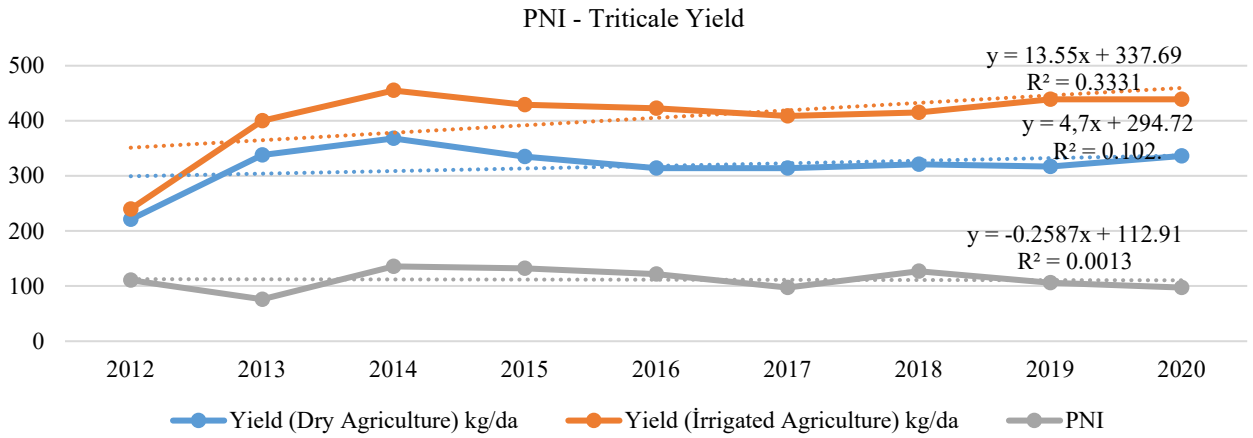


Figure 12. Regression Analysis by Triticale Yield and PNI Drought Conditions

Conclusion

In this study, in which the yield change of wheat, barley, triticale, determined by SPI and PNI methods between 2012 and 2020, was analyzed in the conditions of Ankara, which is one of the most important provinces where grain cultivation is carried out in our country, due to irrigation, it was observed that the harvest amount of all products increased with irrigation. According to the analysis, when the years within the scope of the research are examined, the highest yield increase with irrigation was experienced in barley with 81%, triticale with 75% and wheat with 62%. According to the correlation coefficients as a result of the regression analysis, barley and triticale are the products with the highest linearity between irrigated agriculture and dry agriculture with coefficients of 0.4294 and 0.3331. Correlation coefficients obtained for SPI and PNI were 0.0584 and 0.0013. When evaluated in terms of wheat, their coefficients were calculated as less than 0.1. It is seen that statistically higher values will be obtained with irrigation in the following planting periods of the cereals examined within the scope of the research compared to dry farming yields.

According to the SPI and PNI results obtained, it was determined that Ankara had a mild drought in general between 2012-2020 and a near-normal drought conditions. According to the research, it is seen that there is a decrease in yield when the grains are not irrigated, even during periods of climatic conditions with values close to normal. In this respect, urgent priority should be given to the development of irrigation facilities in regions where grain cultivation is carried out in the form of dry farming. Better results can be obtained by carrying out this situation together with the studies of determining the drought with different methods. In this context, the process and risk status should be determined and combated in drought control studies. In this respect, drought determination studies and trend analysis studies of drought severity in the region are of particular importance. Then, according to the results to be determined, risk assessment studies should be emphasized. In case of high drought severity in some regions in the province, crisis assessment and management studies should be considered in detail. It is extremely important to prepare action plans for the upcoming periods, especially according to the trend analysis of drought conditions in Ankara province. In this context, it is recommended to increase the potential water holding capacity, increase the number and capacity of water storage structures, recycle wastewater and ensure water harvesting practices as much as possible. In addition, R&D studies in combating drought, training and publication services to be provided to farmers in combating drought and afforestation studies should be taken into consideration.

In order to improve irrigation opportunities, instead of surface irrigation systems such as spine and furrow irrigation, irrigation systems such as pressurized sprinkler and drip irrigation should be used in regions where irrigated agriculture is practiced. Farmers should be informed about the use of pressurized irrigation systems and the increase in their yield and income. Providing public incentives as much as possible for the widespread use of pressurized irrigation systems will accelerate the transition to modern irrigation systems. Along with the transition to modern irrigation, studies should be conducted on the use of wastewater in irrigation. In irrigation systems to be created, water saving and especially applications such as solar panels that can reduce energy costs and increase efficiency should be preferred, and farmers' expenses should be reduced.

Declarations

Ethical Approval Certificate

Not applicable

Author Contribution Statement

Murat Ozocak: Data collection, investigation, statical analysis, and writing the original draft, administration, supervision, conceptualization, methodology, review and editing analyzed the data, and wrote the manuscript

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Conflict of Interest

The author declare no conflict of interest.

References

Afshar, M.H., Şorman, A., Tosunoğlu, F., Bulut, B., Yilmaz. M.T., & Danandeh Mehr, A. (2020). Climate change impact assessment on mild and extreme drought events using copulas over Ankara, Turkey. Theoretical and Applied Climatology, 141(3), 1045-1055. https://doi.org/10.1007/s00704-020-03257-6

Ammar, K., Mergoum, M., & Rajaram, S. (2004). The history and evolution of triticale. In: Mergoun M, GomezMacpherson H (eds), Triticale Improvement and Production, Food and Agriculture Organization of the United Nations, Rome, 1-10.

Anonymous. (2008). FAO Production Year Book. Food and Agriculture Organization of United Nations. F.A.O.

Anonymous. (2011). Ankara and its Districts. Turkiye Republic Governorship of Ankara. T.R.G.A.

Anonymous. (2016). Turkey's Wheat Atlas, World Wildlife Fund. W.W.F.

Aydoğdu, M. H., Mancı, A. R., & Aydoğdu, M. (2015). Changes in Agricultural Water Management: Irrigation Associations. Pricing and Privatization Process. Electronic Journal of Social Sciences, 14(52), 146-160. https://doi.org/10.17755/esosder.82927

Aykanat, S., & Barut, H. (2018). Buğday tarımında farklı ekim yöntemleri ve sulamanın teknik yönden karşılaştırılması. International Journal of Eastern Mediterranean Agricultural Research, 1(1), 131-142.

Beden, N., Demir, V., & Ülke Keskin, A. (2020). Trend analysis of SPI and PNI drought indices in Samsun province. Dokuz Eylul University Faculty of Engineering Journal of Science and Engineering,, 22(64), 107-116. https://doi.org/10.21205/deufmd.2020226411

Danandeh Mehr, A., Sorman, A. U., Kahya, E., & Hesami Afshar, M. (2019). Impacts of climate change on meteorological drought using SPI and SPEI: A case study from Ankara, Türkiye. Journal of Hydrological Sciences, 65(2),254–268. https://doi.org/10.1080/02626667.2019.1691218

Danandeh Mehr, A., & Vaheddoost, B. Identification of the trends associated with the SPI and SPEI indices across Ankara, Turkey. Theor Appl Climatol 139, 1531–1542. https://doi.org/10.1007/s00704-019-03071-9

Demir, İ., Korkut, K.Z., Altınbaş, M., Akdemir, H., & Dutlu, C. (1986). Summer triticale improvement studies. In: Tübitak-TOAG. Plant Breeding Symposium Proceedings, (pp. 131-140)

DSİ. (2021). Irrigation areas by province. General Dırectorate Of State Hydraulıc Works

Geerts, S., Raes, D., Garcia, M., Vacher, J., Mamani, R., Mendoza, J., Huanca, R., Morales, B., Miranda, R., Cusicanqui, J., & Taboada, C., (2008). Introducing deficit irrigation to stabilize yields of quinoa (Chenopodium quinoa Willd.). European Journal of Agronomy, 28, 427-436.

Gültekin, S., & Tokgöz, M. (2008). Effects of irrigation in different periods on yield, yield components and quality criteria in malt barley. National Cereal Symposium, 2-5.

Hezarani, A. B., Zeybekoğlu, U., & Keskin, A. Ü. (2021). Hydrological and meteorological drought forecasting for the Yesilirmak river basin, Turkey. Journal of Sustainable Engineering Practices and Technological Developments, 4(2), 121-135.

İlker, E. (2006). Relationships between yield and yield characteristics in barley hybrids. Ege University Agriculture Faculty Journal, 43(3), 1-11.

Kınacı, G., & Kınacı, E. (2000). The quality properties of the blends obtained by mixing the new cereal type triticale with wheat and the possibilities of using them in bread making. Bakery Technology, 4, 41-47.

Köle, M. (2012). The Effect of Climate Change on Water Resources Management on Ankara Sample. [Doctoral thesis, Ankara University]. https://acikbilim.yok.gov.tr/handle/330466.pdf

Kün, E., (1996). Cool Climate Cereals (III Edition). Ankara University. Agriculture. Faculty. Publications: 1451.

McGoverin, C.M., Snyders, F., Muller, N., Botes, W., Fox, G., & Manley, M. (2011). A review of triticale uses and the effect of growth environment on grain quality. Journal of the Science of Food and Agriculture 91, 1155-1165.

McKee, T. B., Doesken, N. J., & Kleist, J. (1993). The relationship of drought frequency and duration to time scales. In Proceedings of the 8th Conference on Applied Climatology, 17(22), 179-183.

MGM. (2021). Monthly Precipitation and Temperature Data of Ankara Province by Years. Meteorology General Directorate. Meteorological Data Information Presentation and Sales System.(MEVBIS).

MGM. (2022). Meteorological General Statistics Data of Ankara Province. Meteorology General Directorate.

Oğuztürk, G., & Yıldız, O. (2014). Drought Analysis for Different Time periods in the city of Kırıkkale. International Journal of Engineering Research and Development, 6(2), 19-25.

Orhunbilge. A. N. (2002). Applied Regression and Correlation Analysis. İ.Ü. Directorate of Printing and Publishing House.

Özer, E., Taner, S., & Akçacık, A. G. (2010). Green grass potential and some agronomic properties of Triticale (Triticosecale Witt.) in Konya conditions. Bahri Dağdaş International Agricultural Research Institute. Journal of Plant Research, 1, 17-22.

Razzaghi, F., Ahmadi, S.H., Jacobsen, S.E., Jense, C.R., & Andersen, M.N. (2012). Effects of salinity and soil-drying on radiation use efficiency, water productivity and yield of quinoa (Chenopodium quinoa Willd.). Journal of Agronomy and Crop Science, 198(3), 173-184.

Sezer, İ. (2007). General Principles of Grain Agriculture. Bafra Social and Cultural Development Foundation- BAKAV, TR.0305.02/LDI/114, Bafra Farmer's Export Orientation Project.

Shewry, P.R., & Hey, S.J. (2015). The contribution of wheat to human diet and health. Food and Energy Security, 4(3), 178–202.

Spehar, C.R., & De Barros Santos, R.L. (2005). Agronomic performance of quinoa selected in the Brazilian savannah. Pesquisa Agropecuaria. Brasileira Brasilia, 40(6), 609-612.

Simsek, O. & Cakmak, B. (2010). Drought Analysis for 2007-2008 Agricultural Year of Turkey. Tekirdag Ziraat Fakültesi Dergisi/Journal of Tekirdag Agricultural Faculty (3), 99-109.

Stallknecht, G.F., Gilbertson, K.M., & Ranney, J.E. (1996). Alternative wheat cereals as food grains: einkorn, emmer, spelt, kamut, and triticale. In: Proceedings of the third National Symposium, ASHA Press, Alexandria, (pp. 156-170).

Takıl, E., & Olgun, M. (2020). Effect of Different Nitrogen Doses on Yield and Yield Components in Some Triticale (X Triticosecale Wittm.) Varieties. Journal of the Faculty of Agriculture 226-232.

Tiryakioğlu, M., Demirtaş, B., & Tutar, H. (2017). Comparison of Wheat Yield in Turkey: The Case of Hatay and Şanlıurfa Provinces. Journal of the Faculty of Agriculture, 12(1), 56-67.

TÜİK. (2023-a). Barley Production Statistics of Turkey. Turkish Statistical Institute

TÜİK. (2023-b). Agricultural production statistics of Ankara province. Turkish Statistical Institute

TÜİK. (2021). Crop Production Statistics of Turkey. Turkish Statistical Institute

TÜİK. (2024). Population of Ankara province according to address-based population registration system. Turkish Statistical Institute

Werick, W. J., Willeke, G. E., Guttman, N. B., Hosking, J. R. M., & Wallis, J. R. (1994). National drought atlas developed. https://doi.org/10.1029/94EO00706

Wilhite, D.A. (2000). Chapter 1 Drought as a Natural Hazard: Concepts and Definitions. Drought: A Global Assessment, (London: Routledge, 200), 1(1), 3–18.

Yacoub, E., & Tayfur, G. (2017). Evaluation and assessment of meteorological drought by different methods in Trarza region, Mauritania. Water Resources Management, 31, 825-845.

Yıldız, N., Akbulut, O., & Bircan, H. (1999). Introduction to Statistics. İstanbul: Active Publisher.

Yıldız, N., & Tarı, A. F. (2018). Effect of Supplementary Irrigation on Yield and Quality of Barley in Semi-Arid Conditions. Journal of the Faculty of Agriculture 435-443.