THE EFFECT OF CLIMATIC FACTORS ON WHEAT YIELD IN TURKEY: A PANEL DOLS APPROACH

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ABSTRACT

Climatically factors has been affecting the agricultural sector in the world. Wheat production is one of them. It is an important crop because it is used basic food by many people. For this reason, climatic factors affecting yield need to be analyzed well. The aim of this research is to determine the long-term effect of temperature and precipitation on yield in Turkey. Provinces are divided into two groups as drought (60 provinces) and non-drought (15 provinces). Panel Unit Root Test, Panel Cointegration Analysis, and Panel Dynamic Ordinary Least Squares (DOLS) analysis were performed using the panel data set. The results have shown that climatic factors have long-term effects on yield. For this reason, it is considered important to reduce the risks of using the appropriate varieties according to temperature and precipitation conditions. On the other hand, as a policy of the country, actions to make a positive contribution to the climate change process should be regulated.

KEYWORDS:
Wheat Yield, Climatic Factors, Temperature, Precipitation, Panel DOLS, Turkey.

INTRODUCTION

Past 150 years, increasing temperatures due to human-induced deterioration have been affecting many sectors negatively. Significant increases have been observed in temperatures at different times in history, especially at the beginning of the third millennium [1]. Awareness of these increases has only emerged in the last few decades [2, 3]. Upon developing this awareness, countries have shown a tendency to take policy measures [4, 5, 6]. In the Intergovernmental Panel on Climate Change (IPCC), the greenhouse effect is attributed to human activities [7]. There is a consensus among scientists that human activity has contributed significantly to the change in the atmosphere, and this contributes to climate change [7]. If no measures are taken, it is estimated that by 2050 the global average temperature will increase by about 1.0 – 1.7 °C [7]. By the end of this century, it is estimated to increase between 1.0 – 3.7 °C [8]. In the scenario of the IPCC in Turkey, it is stated that the average annual temperature in the country will increase by 2.5 – 4 °C in the following years, the south of the country will face serious threats of drought, and the northern regions will be subject to flood [9]. In Turkey, an important agricultural country, excessive precipitation has increased, especially in summer, whereas time periods of precipitation have got longer. This observable aspect of the drought is initially seen as meteorological drought, later as hydrological and agricultural drought. The temperature and precipitation trends for the last 20 years in Turkey are given in Figure 1 and Figure 2, respectively. The average temperature was 12.48 °C in Turkey in 1997, but it was risen 14.13 °C in 2016. An increase of 13.22% is observed in the 20-year period. Similar changes have occurred in precipitation. The average precipitation amount of 60.47 mm in 1997 became 61.02 mm in 2016. An increase of 0.91% on average was observed across the 20-year period [10]. Even though these precipitation increases are low, sudden precipitation has begun to appear in Turkey.

Temperature and precipitation factors play an important role in the growth and development stages of agricultural products. The change in temperature and precipitation amounts directly affect production on national scale [11, 12]. As a consequence of the change in precipitation periods and the prolongation of precipitation intervals, problems have arisen in meeting the water needs of plants during their development. This lack of water also adversely affects product yield and producer income.

The aim of agricultural production is both to provide basic foodstuffs for people and to make a significant contribution to the economy of the country. From this point of view, wheat production within agricultural production is regarded as a strategic product among the countries of the world. In terms of wheat production in the world, China is the leader with 128 million tons. Turkey is among the top 10 producing countries in the world with 20.6 million tons production. China is the first country with 5.27 tons / ha of yield, and Turkey is among the top 10 countries in the world with 2.68 tons / ha [13]. Wheat is also an extremely important item to Turkey's conditions. It is necessary to discuss such an important product and the natural risks that it faces, both in terms of sector and country policy. In this research, several econometric methods was investigated the effect of precipitation and temperature on yield in Turkey. In addition, this study seems to be important because wheat is the main source of income for farmers, and it is an important raw material for the agricultural industry.

METHODS

The study was conducted with annual data from the years 1997-2016. The effect of temperature and precipitation on yield has been examined using Panel Data Method, definitions and sources of the variables used in the research are shown in Table 1.

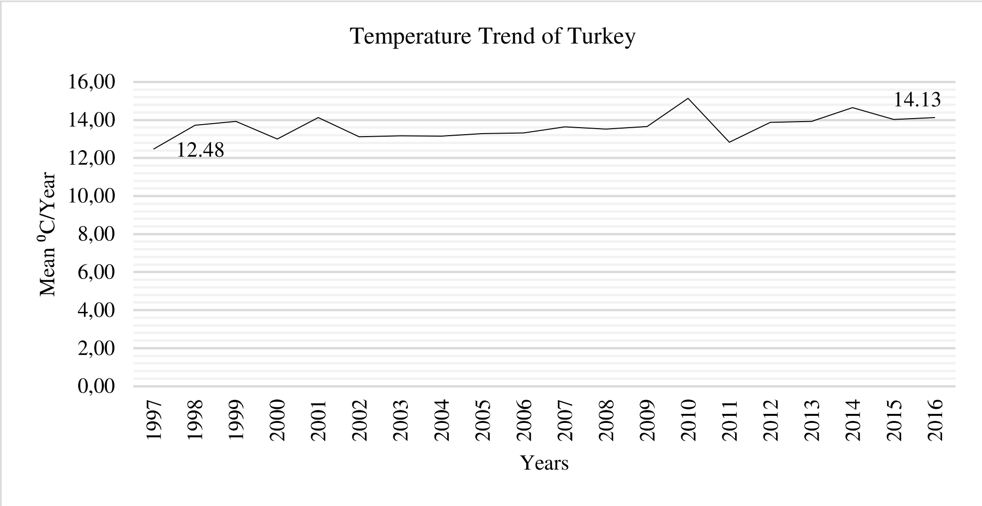

FIGURE 1
Average annual temperature in Turkey between the years 1997-2016

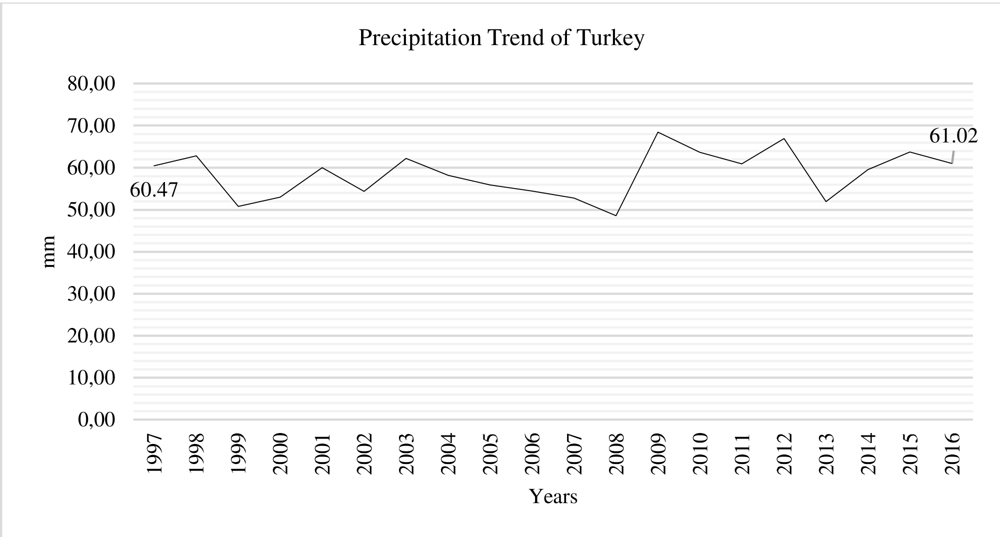

FIGURE 2
Average annual precipitation in Turkey between the years 1997-2016

TABLE 1
Definitions of variables used in the research

Variables	Symbol	Unit	Data Source
Wheat Yield	Ɣ	Kg/da	Turkish Statistical Institute
Temperature	Ƈ	Celsius Degree	Turkish State Meteorological Service
Precipitation	ƴ	kg/cm^2 =“mm”	Turkish State Meteorological Service
Drought Province	D		
Non-Drought Province	ND		

TABLE 2
Descriptive Statistics of Variables Used in Research

	D			ND		
	DƇ	DƔ	Dƴ	NDƇ	NDƔ	NDƴ
Mean	13.17	219.29	51.86	15.26	235.56	70.41
Median	13.07	213.00	46.27	15.77	236.00	65.62
Maximum	21.30	501.00	145.21	19.85	465.00	171.54
Minimum	3.41	43.00	13.56	2.37	62.00	21.62
Std. Dev.	3.20	75.48	22.09	3.28	85.23	24.68
Skewness	-0.14	0.64	1.06	-1.72	0.13	1.03
Kurtosis	3.37	3.28	4.05	6.22	2.51	4.50

The study was carried out on the basis of the drought and non-drought according to drought map, prepared by the Turkish Meteorology General Directorate [10]. There are 60 drought provinces and 15 non-drought provinces in Turkey. The effect of temperature and precipitation on wheat yield in provinces can be expressed functionally as follows:

$lnDƔ_{it} = f(lnDƇ_{it}, lnDƴ_{it})$ (1)

$lnNDƔ_{it} = f(lnNDƇ_{it}, lnNDƴ_{it})$ (2)

In the study, the data were converted to logarithmic form (ln) and the following econometric analyses were performed. Econometric analyzes were done using Eviews 9.1:

-Descriptive statistics of variables,

-Panel Unit Root Test,

-Panel Cointegration Analysis

-Panel Dynamic OLS Analysis

Descriptive statistics of yield; temperature and precipitation variables; and mean, median, maximum, minimum, std. deviation, skewness and kurtosis values are given in Table 2.

Panel Unit Root Test. Appropriate unit root tests have been done for the data used in the research. Stability tests of the units are performed with the unit root test. Working with series containing unit roots leads to biased results.

$lnY_{it} = \rho_i lnY_{it-1} + \delta_i lnX_{it} + \mathcal{E}_{it}$ (3)

Where 'i': 1-75 provinces used in the study; 't': the number of observations (20 years, from 1997 to 2016), N: the number of units in the model and $\mathcal{E}_{it}$; is the error term in i province at time t. It is assumed that $\mathcal{E}_{it}$ error term is independent for all time and units and is distributed as IID (0, σ2) [14]. It is assumed that ρ_i self-coupling coefficients are equally independent for all time and units. If $|\rho_i|$ is lower 1, Y_i series is stationary, if $|\rho_i|$ equals 1, it contains the unit root.

Unit root tests have been proposed by many researchers [15, 16, 17, 18, 19, 20, 21]. In this study, LLC - ADF Fisher and PP Fisher test statistics were used for the unit root test. The LLC unit root tests widely used in panel data stationarity analysis can be explained as follows from the study of Levin, Lin and Chu [20]. The LLC unit root test differs from the different assumptions regarding the ρi coefficient in Equation 3 and from the test statistics used. In the LLC unit root test, ρi coefficients are assumed to be identical for the panel horizontal sections. This can be expressed as ρi = ρ for all i 's. For the unit root tests based on the ADF principles, the basic connection can be expressed as follows:

$$\Delta lnX_{it} = \beta_i lnX_{it-1} + \sum_{j=1}^{n} \theta_{ij} \Delta lnX_{it-j} + e_{it} \quad (4)$$

In Equation 4, X_{it} is the variant, e_{it} is the error term, and Δ is the difference operator. The appropriate lag length is determined by the Schwarz Information Criteria (SIC). As a result of the calculations, evaluations were made according to the Null Hypothesis below:

$$\begin{cases} H_0 = \beta_i = 0 \\ H_A = \beta_i < 0 \quad \text{for } i = 1,2,3, \ldots N \\ \beta_i = 0 \quad \text{for } i = N+1, N+2, N+3 \ldots \end{cases}$$

If result is statistically significant at 1%, 5%, or 10%, the null hypothesis is rejected, and the alternative hypothesis is accepted.

Panel Cointegration Analysis. [22] set out the panel regression model in time series, and the notations for drought and non-drought regions for this study are expressed in the equations below (5-8):

$lnDƔ_{it} = \varphi_i + \delta_{it} + \beta_{it} lnDƇ_{it} + e_{it}$ (5)

$lnDƔ_{it} = \varphi_i + \delta_{it} + \beta_{it} lnDƴ_{it} + e_{it}$ (6)

$lnNDƔ_{it} = \varphi_i + \delta_{it} + \beta_{it} lnNDƇ_{it} + e_{it}$ (7)

$lnNDƔ_{it} = \varphi_i + \delta_{it} + \beta_{it} lnNDƴ_{it} + e_{it}$ (8)

Here, $Ɣ_{it}$, $Ƈ_{it}$, and $ƴ_{it}$ represent observable variables. In the notation, the δ_{it} time trend, φ_i constant coefficient, equal residuals, and β_{it} trend for the horizontal section 'i' in the period "t" are given. This may indicate that the cointegration vectors of the horizontal cross-sectional members in the panel are heterogeneous [22]. The long-term relationship of the I (1) level in the series can be tested by cointegration analysis [22, 23, 24]. The tests that were used include different techniques and assumptions. Pedroni offers two types of tests. First, the within dimension approach and its four test results are followed by the between dimension approach and three related test results. Test statistics were evaluated according to the null hypothesis. The hypothesis that there is no cointegration between the series is based on the Null Hypothesis, while the opposite hypothesis is based on the assumption that there is cointegration between the series. Kao test statistic is used within the framework of the ADF approach. The statistics are obtained from Panel Least Squared Dummy Variable

(LSDV) analysis [25]. If these coefficients are statistically significant, the Null Hypothesis is rejected and the existence of a long-term relationship is accepted.

Panel Dynamic OLS Analysis. After the existence of long term relationships was revealed by Panel Cointegration Analysis, Panel Dynamic OLS (DOLS) analysis was performed to determine the direction and coefficient of relations. The model used in the research can be expressed as in Equations 9 and 10 [26, 27, 28].

TABLE 3
Unit Root Test Results

Regions	**Unit Root Test Method**	**Level**			**First Difference**		
		Ɣ	Ƈ	ƴ	dƔ	dƇ	dƴ
		No Deterministic Intercept and Trend			No Deterministic Intercept and Trend		
D	Levin, Lin-Chu	3.1413	4.1431	0.5019	-44.7134*	-47.9523*	-40.4647*
	ADF Fisher	36.8158	27.7475	55.9942	1222.64*	1280.77*	1220.13*
	PP Fisher	40.9056	14.4830	64.2457	1222.03*	1140.01*	1230.02*
ND	Levin, Lin-Chu	1.0930	1.0495	-0.0759	-17.0904*	-23.2099*	-19.9146*
	ADF Fisher	10.3170	9.4065	15.0108	253.022*	343.731*	291.511*
	PP Fisher	10.5996	4.3970	14.9478	311.220*	286.374*	313.874*

* mean that at 1% level is significant

TABLE 4
Cointegration Analysis between Yield and Temperature

Ɣ and Ƈ	**D** Stat	**D** Weighted Stat	**ND** Stat	**ND** Weighted Stat
Common AR coefs. (within-dimension)				
Panel v-Statistic	-0.0827	-2.1410	-0.4001	-0,9217
Panel rho-Statistic	-23.1769*	-22.4430*	-7.4577*	-8,0089*
Panel PP-Statistic	-19.5607*	-19.6152*	-7.3717*	-8,0516*
Panel ADF-Statistic	-9.4081*	-9.8037*	-7.2629*	-8,1497*
Individual AR coefs. (between-dimension)				
Group rho-Statistic	-18.1131*		-5.8123*	
Group PP-Statistic	-26.9206*		-11.9733*	
Group ADF-Statistic	-12.9455*		-6.7596*	
KAO Residual Cointegration Test Results				
ADF	2.2341*		1.3386***	
Residual Variance	0.0543		0.0525	
HAC Variance	0.0142		0.0149	

*,**,*** respectively mean that at 1%, 5%, 10% level are significant

TABLE 5
Cointegration Analysis between Yield and Precipitation

Ɣ and ƴ	**D** Stat.	**D** Weighted Stat.	**ND** Stat.	**ND** Weighted Stat.
Common AR Coefs. (within-dimension)				
Panel v-Statistic	-1.7454	-4.4755	-0.9884	-1.9871
Panel rho-Statistic	-21.2641*	-18.9607*	-9.9128*	-10.1628*
Panel PP-Statistic	-19.1475*	-17.8681*	-8.1412*	-8.3877*
Panel ADF-Statistic	-18.6758*	-17.5103*	-7.9159*	-8.5102*
Individual AR Coefs. (between-dimension)				
Group rho-Statistic	-15.4253*		-6.2175	
Group PP-Statistic	-26.4510*		-9.4219	
Group ADF-Statistic	-23.2116*		-8.6082	
KAO Residual Cointegration Test Results				
ADF	3.5575*			
Residual Variance	0.0546			
HAC Variance	0.0124			

* mean that at 1% level is significant

$$\ln DY_{it} = \varphi_i + \beta 1_t \ln DC_i + \beta 2_t \ln Dy_i + \sum_{k=-K_i}^{K_i} \propto_{ik} \Delta \ln DC_{it} + \sum_{k=-K_i}^{K_i} \emptyset_{ik} \Delta \ln Dy_{it} + e_{it} \quad (9)$$

$$\ln NDY_{it} = \varphi_i + \beta 1_t \ln NDC_i + \beta 2_t \ln NDy_i + \sum_{k=-K_i}^{K_i} \propto_{ik} \Delta \ln NDC_{it} + \sum_{k=-K_i}^{K_i} \emptyset_{ik} \Delta \ln NDy_{it} + e_{it} \quad (10)$$

Panel DOLS estimates are expressed in Equation 11 and 12:

$$\widehat{\beta^*_{DOLS}} = \frac{1}{N}\sum_{i=1}^{N}\left[\left(\sum_{t=1}^{T} Z_{it} Z'_{it}\right)^{-1}\left(\sum_{t=1}^{T} Z_{it} \widehat{\ln DY_{it}}\right)\right] \quad (11)$$

$$\widehat{\beta^*_{DOLS}} = \frac{1}{N}\sum_{i=1}^{N}\left[\left(\sum_{t=1}^{T} Z_{it} Z_{it}'\right)^{-1}\left(\sum_{t=1}^{T} Z_{it} \ln\widehat{NDY_{it}}\right)\right] \quad (12)$$

Here, Z_{it} refers to the regression vectors obtained from Equation 9 and10.

ESTIMATION RESULTS

The results of the unit root tests of the variables used in the study are given in Table 3.

In drought and non-drought regions, yield, temperature, and precipitation series are not stationary at the I (0) level (Table 3). Unit root contains non-stationary series. Inconsistencies can be found in findings from studies conducted with these series [29]. When the differences of the variables were taken and the unit roots were examined, and was determined to be stationary at the I (1) level. Cointegration Analysis can be applied to investigate the existence of long-term relationships in these (stationary at I (1) level) series. Panel Cointegration Analysis results, which are used to determine the long-term relationships of the variables, are shown in Table 4 and Table 5.

It is possible to see a long-term relationship between yield and temperature in drought and non-drought regions (Table 4). Within-dimension and between-dimension values, which give information about long-term relationships, are considered statistically significant. In addition, the KAO test statistic is also considered statistically significant.

The Cointegration relationship between yield and precipitation is shown in drought and non-drought regions (Table 5). When the results are examined, the Cointegration between yield and precipitation is statistically significant in the two regions studied. A study was done by obtained similar relation by different method [30]. We have achieved to results with the Cointegration test. Table 4 and Table 5 show the relationship among temperature, precipitation and yield. However, it is not possible to make detailed comments on the direction and severity of the interactions determined by the Cointegration Analysis results obtained. Dynamic OLS analysis was performed to determine the effect of precipitation and temperature on yield (Table 6).

The effect of climatic factors on yield in drought and non-drought regions was determined by Cointegration Analysis and its coefficient was determined by Dynamic OLS. According to the results of dynamic OLS, temperature has a negative effect on the yield of wheat in drought and non-drought regions (Table 6). However, it is not possible to say the same for precipitation. An increase of 1% in temperature reduces the yield of wheat by 0.19%. In drought regions, an increase of 1% in temperature reduces yield by 0.50% in non-drought regions. On the other hand, a 1% increase in precipitation increased the yield of wheat by 0.10% in drought regions. In the same way, it was determined that a 1% increase in the amount of precipitation in non-drought regions increased the yield of wheat by 0.13%.

DISCUSSION AND CONCLUSION

Agricultural production is always open to some risks such as precipitation and temperature, the most important and almost uncontrollable natural phenomena. Agricultural products, which are frequently affected by natural phenomena in terms of yield and quality, directly affect producer income in the economic cycle. In this study, the long-term effect of temperature and precipitation yield on wheat was investigated. In this study, a panel dataset was established with annual yield, annual average precipitation, and annual average temperature values in 60 drought and 15 non-drought provinces in the years 1997-2016. After the Panel Unit Root Tests were performed, Panel Cointegration Analysis, and Panel DOLS Analysis were performed. As a result of these analyses, it is concluded that the annual averages of temperature and annual averages of precipitation are co-integrated with the yield in the long run. According to DOLS results, temperature negatively affected yield in both regions, but in non-drought regions the effect of temperature is more severe than in drought regions. Precipitation affects the yield of wheat in both regions positively. It is possible to say that non-drought regions are influenced more by precipitation and temperature.

As a result of this study in Turkey, it has been determined that climatic factors have an important effect on yield. Although agricultural production is vulnerable to climatic risks, it is possible to take short, medium, and long-term measures against these risks. [31] said that dry or low-income areas where climatically factors reasons severe impacts. The short-term measures are, suitable for climate conditions, proper tillage, and use of agricultural production techniques planning of sowing dates will

TABLE 6
Panel DOLS Results

Dependent Variable: $\dot{Y}$		$\dot{y}$	$\dot{C}$
	B	0.1066*	-0.1977*
D	S.E	0.0221	0.0689
	t-stat	4.8144	-2.8661
		R2=0.81 Adj.R^2=0.78 S.E.= 0.17	
	B	0.1396**	-0.5016*
ND	S.E	0.0654	0.2041
	t-stat	2.1352	-2.4565
		R2=0.88 Adj.R^2=0.83 S.E.= 0.17	

*,** respectively mean that at 1%, 5% level are significant

not be affected by seasons of extreme temperature or heavy precipitation. [32] suggested that Changing the planting dates can reduce the risk. Medium and long-term measures are avoiding harmful human activities, taking measures to reduce the level of CO_2 release, and complying with agreements at national and international levels.

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