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Short Communication

Trend analysis of agricultural drought and crop yield in Eastern Thrace provinces of Turkey

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Drought is a natural disaster that starts with a decrease in precipitation and negatively affects the hydrological balance, water budget and crops. Various yield estimation models are used to determine crop yield (Boualem, 2023). Various drought indices like Palmer Drought Severity Index (PDSI), Reconnaissance Drought Index (RDI) and Standard Precipitation Index (SPI) are used to determine drought severity. Gocic and Trajkovic (2013) analyzed the trend of SPI in Serbia. In Turkey, Oguz *et al.,* (2021) examined the trend and drought in Mugla region. Nouri and Homaee (2019) applied gamma and log-logistic distribution in their study for SPI and SPEI and concluded that SPI do not correlate well with SPEI in arid regions. The studies of Ouatiki *et al.,* (2019), Alsafadi *et al.,* (2020), and Naz *et al.,* (2020) show that drought tendency is increasing in the World, especially in the Mediterranean watershed. Dabanli (2019) determined that 5 out of 81 provinces in Turkey have low drought risk, 61 provinces are at medium drought risk and 14 provinces have high drought risk. Thrace is one of the driest regions (500 water falls in Thrace). The Thrace side of the Marmara Region is especially more prone to drought (60% of Thrace is agricultural land). Along the Marmara Sea coast, Mediterrenean climate type (summer seasons are dry and winter seasons are rainy) is seen. Average temperature is 14 °C and monthly total precipitation average is 580 mm. Considering the scarcity of studies on meteorological drought in Thrace, which is one of the arid regions in Turkey, this study was planned to investigate the effect of drought on agriculture in Thrace.

The monthly precipitation data of two stations viz Tekirdag (Lat. 40.95^0N, Long. $27.49\ ^0$E) for the period of 1941-2020 and Edirne (Lat. 41.67^0N, Long. $26.55\ ^0$E) for the period of 1953-2020 were obtained from Meteorological General Directorate of Turkey. The yield data of wheat, sunflower and barley crops for two provinces (Edirne and Tekirdag) for the period of 2004 and 2021 were obtained from Turkish Statistical Institute (2023). Standard precipitation index (SPI) was used to determine the meteorological drought. A distrubiton function was fitted to the rainfall data. The gamma distribution is the most suitable for rainfall data. Cumulative probabilities calculated by the distribution function was then converted to SPI values, which has a standard deviation of 1 and a mean of 0 (McKee *et al.*, 2013). The trend analysis was carried out using a non-parametric method (M-K test) and Sen's slope method (Oguz *et al.*, 2021). The SPI values were further related with the yields of wheat, sunflower and barley crops of 2004-2021 using simple regression technique. Suitable statistical distribution for the data was determined in DrinC model. 3-month seasonal analysis (October-November-December, January-February-March, April-May-June, July-August-September, respectively) were produced. Afterwards, drought severity was calculated along with trend analysis. SPI of different scale (1, 3, 6, 9, and 12 months) were obtained from the DrinC model. Besides, XLSTAT program was used to obtain for the different scale results of the trend analysis.

The results of the M-K trend and the SPI results are in parallel. If it is accepted that drought will decrease sunflower yield, a parallelism is determined between the SPI results and the crop yield trend. Even in the prone to drought climate in Tekirdag, wheat and barley yields were very high. In this case, it was concluded that grain yields were not adversely affected by drought in Tekirdag conditions. Moreover, the crop most coherent with the drought results in Thrace was sunflower. The trend analysis method that best represents the result of the SPI was M-K (Kendall's tau). The graphs of wheat and barley yields in the grain group were very similar to each other in terms of both shape and count (Table 1).

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Table 1: Drought-trend and (crop yield) comparison in Tekirdag and Edirne during 2004 -2021

Province	Drought (SPI)	Crop yield (kg)			Trend of the drought (SPI)		
		Wheat	Sunflower	Barley	Kendall's tau	p-value	Sen's slope
Edirne	0.39 (normal)	37.6	22.3	40.7	0.072 No trend (Increasing)	0.705	0.006
Tekirdag	-0.03 (normal)	41.3	20.7	45.3	-0.150 No trend (Decreasing)	0.405	-0.049

Table 2: Trend analysis of the SPI in Tekirdag and Edirne

		P values (α=0.05)	Kendall's tau	Sen's slope
Edirne	SPI 1	0.940	-0.002 (↓)	0
	SPI 3	0.459	0.017 (↑)	0
	SPI 6	0.447	0.018 (↑)	0
	SPI 9	0.532	0.015 (↑)	0
	SPI 12	0.453	0.018 (↑)	0
Tekirdag	SPI 1	0.322	0.021 (↑)	0
	SPI 3	0.066	0.040 (↑)	0
	SPI 6	0.039 (Significant)	0.045 (↑)	0
	SPI 9	0.034 (Significant)	0.046 (↑)	0
	SPI 12	0.022 (Significant)	0.050 (↑)	0

In these Thrace Provinces, no trend was observed in the SPI values between 1960 and 2020 years, only in Tekirdag, there was a significant increase trend in SPI 6, 9 and 12 values. This situation shows that an agriculturally wet situation prevails in Tekirdag (Table 2). The studies of Dabanli (2019), Kankal and Akcay (2019), and Oguz *et al.,* (2021) showed that the cities of Turkey were more affected by drought. It was understood that humidity was observed in places where the Black Sea climate was dominant.

The results of Eroglu (2021) shows parallelism with the results of my study. It is also supported by the literature that Edirne is prone to drought and that there is no significant trend in Thrace in general.

When correlation coefficient to compare with crop yields and drought index for the period between 2004 and 2021 was used, the following data were obtained. The strongest crop yield-drought relationship was in sunflower yield in Edirne and the weakest of the relationship was in wheat yield in Edirne. Generally, in Tekirdag conditions, there were stronger relationships between the effects of drought and crop yields (Table 3). If the R^2 is less, it could be said that non-climatic factors were more effective on these crops yield for theses cities. This situation is thought to have occurred due to the suitability of climatic condition of these cities for the crop diseases and pests. Therefore, the low R^2 count is normal (Table 3).

Table 3: Relation betwen crop yields and SPI

Crops	Edirne	Tekirdag
Wheat	$Y = 0.0026x + 0.3888$ ($R^2 = 0.009$)	$Y = -0.0064x - 0.0277$ ($R^2 = 0.084$)
Sunf-lower	$Y = 0.0107x + 0.3888$ ($R^2 = 0.122$)	$Y = -0.0079x - 0.0277$ ($R^2 = 0.042$)
Barley	$Y = 0.0035x + 0.3887$ ($R^2 = 0.0255$)	$Y = -0.0062x - 0.0277$ ($R^2 = 0.1102$)

In this study, the trend analysis method that best represents the result of the SPI was M-K (Kendall's tau). It was understood that an agriculturally wet situation prevailed in Tekirdag. Besides, in Tekirdag conditions, there were stronger relationships between the effects of drought and crop yields. Non-climatic factors such as crop type, fertilization, crop diseases and pests have an extreme impact on crop yield. Therefore, the correlation between drought and crop yield may be weak. For this reason, it is recommended that non-climatic factors also should be improved.

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