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AN INVESTIGATION ON EFFECTS OF DRY AND WET CLIMATE CONDITIONS ON PISTACHIO (*PISTACIA VERA*) YIELD IN MIDDLE EUPHRATES BASIN, SOUTHEAST OF TURKEY

Mehmet Ali ÇELİK[1], Muhittin KULAK[2, 3], Hakan CETİNKAYA[4], Mehmet KOC[4,] Ali GÖCERİ[5], Salman ÖZÜPEKÇE[1]

[1]Kilis 7 Aralık University, Faculty of Arts and Sciences, Department of Geography, Kilis, Turkey
[2]Kilis 7 Aralık University, Faculty of Arts and Sciences, Department of Biology, Kilis, Turkey
[3]Kilis 7 Aralık University, Yusuf Serefoglu School of Health, Department of Nursing, Kilis, Turkey
[4]Kilis 7 Aralık University, Faculty of Arts and Sciences, Department of Horticulture, Kilis, Turkey
[5]Kahramanmaras Sutcu Imam University, Graduate School of Natural and Applied Sciences, Kahramanmaras, Turkey

Corresponding author email: hcetinkaya67@gmail.com

Abstract

Extreme conditions in the climate play an important role on the plant growth and yield of crops. Meteorological drought is one of these extreme climate conditions. In this study, 16 days photosynthetic activity of pistachios was investigated by integrating both field research and modern techniques (remote sensing and statistical methods). Furthermore, the effects of climatic factors on the yield of pistachio were analysed. Along with the present study, the relationships between pistachio and dry and wet climatic conditions were presented. According to the results of the drought analysis of both Birecik (a district in the south-eastern parts of Turkey) and Gaziantep (a province in the south-eastern parts of Turkey) stations, pistachio is significantly affected by extreme climatic conditions. The photosynthetic activity of pistachio increased during the periods of wet climatic conditions.

Key words*: climate, drought, photosynthetic activity, Pistacia vera.*

INTRODUCTION

Turkey's southern line constitutes one of the sensitive areas where short or long-term climate change in the world can be experienced. Southeast Anatolia is particularly vulnerable to climate change (Cosun and Karabulut, 2009). One of the most important consequences of climate change is the increase in extreme climatic conditions. The arid period, in which the humid period with extreme precipitation and the amount of rainfall and humidity are well below the average, is the extreme climate. Depending on the climate change, there is an increase in the frequency of extreme climatic conditions in the area where Gaziantep, Şanlıurfa and Adıyaman province are located.

Depending on this increase, significant changes occur in the phenology and yield of agricultural products. Also, many previous studies report that changes in climate varieties can lead to phenological changes in agricultural products and changes in phenological cycles will have significant effects on agricultural production (Box et al., 1989; Alexandrov and Hoogenboomb, 2000; Chmielewski and Rötzer, 2001; Ichii et al., 2002; IPCC, 2007; Sanchísa and Feijoo Bello, 2009; Cheng and Wu, 2011).

The study of the impact of climate change on the phenology of agricultural products has a major precaution in terms of food supply and socio-economic in the world with a population of over 7 billion. One of the most worried issues for the future is the danger of agricultural production due to extreme climatic conditions and the resulting scarcity. The answer to the question of how global climate change will impact on agricultural production is among the most important concerns of concern all over the world (Tubiello and Fischer, 2007).

Pistacia vera (pistachio) belonging to Anacardiaceae is of the characterized crop for the South-eastern parts of Turkey. Southeastern Anatolia Region of Turkey is the most pistachio producing region. This region is followed by the Mediterranean and Aegean

regions (Külekçi and Aksoy, 2011; Ertürk et al., 2015). More than 80% of the pistachio-planted areas in the Southeast are in Gaziantep and Şanlıurfa. Gaziantep and Sanliurfa also covers a portion of 78% of the pistachio field in Turkey. Therefore, any possible incident regarding drought that may emerge in Sanliurfa and Gaziantep affect significantly the production of pistachios in Turkey. In Turkey, pistachio plantings of that period it was first built in 1960 production was 34 tons (Gul and Akpinar, 2006) in a humid climate today late in the period, this figure rises to 150 tons. In the years when the climate is arid (for example in 2014), pistachio production has been determined as 80 tons. Therefore, it is necessary to extensively analyze the effect of climate conditions on the production of pistachio nuts. The results of the drought analysis applied to the climate data obtained from the General Directorate of Meteorology (MGM) show that both in Sanliurfa and in Gaziantep, the years of 2012 and 2013 are humid. On the other hand, in 2014, it is observed that dryness occurs in these two stations where pistachio production is highest. Significant changes in Turkey's pistachio yield during dry and wet climate periods are great concern.

In this context, the current study was designed to investigate the possible influence of dry and wet climate conditions on the pistachio nut yield from two stations, namely Gaziantep and Sanliurfa, which are considered as main pistachio suppliers for Turkey.

MATERIALS AND METHODS

For the current study, three provinces in the south-eastern parts of Turkey (Gaziantep, Sanlıurfa and Adıyaman) were selected to due to their potential pistachio production (Figure 1). In this study, during the dry and wet climatic periods, the yield and phenology of pistachios were monitored. In this context, Moderate Resolution Imaging Spectroradiometer (MODIS) and National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) satellite data were used. The meteorological satellites carrying the NOAA-AVHRR sensor with spatial resolution of 1 km are scanning the globe twice a day. The first of these takes place at around 10 pm local time and the other at 2.30 pm. All these collected data are collected via various earth stations (Karabulut, 2006).

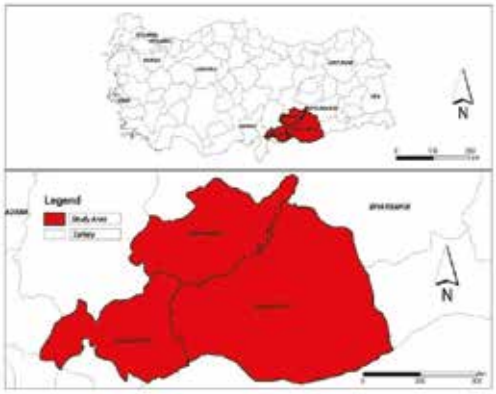

Figure 1. Location map of study area

MODIS NDVI images with a spatial resolution of 250 m are published in 16 day composites for drawing twice a day. Radiometric resolution of the images taken twice a day for 16 days is published by compositing the images that are free from brdf and cloud. The MODIS NDVI images, consisting of 4800 rows and 4800 columns, are capable of analyzing the variation in vegetation activity over a wide area (Çelik and Sonmez, 2013).

Another plant index model that has recently been used frequently is Enhanced Vegetation Index (EVI). EVI images are not affected much by aerosol and cloudiness. The EVI images provided by MODIS to its users are calculated by the following formula (Huete et al., 2002; Galvão et al., 2011; Zhang et al., 2014):

$$EVI = G \times (\text{Near Infrared-Red}) / (\text{Near Infrared} + C1 \times \text{Red-C2} \times \text{Blue} + L)$$

The gain factor used in the formula is 2.5, L = 1, C1 = 6, C2 = 7.5. With this formula values appear in the band interval ranging from -1 to +1. EVI displays, which are not much affected by atmospheric conditions, do not show too much deviation during the year as a trend.

In order to determine the periods when the climate was arid and humid, Standardized Rainfall Index (SPI) developed by Mckee et al. (1993) was used and SPI was calculated by the

following formula;

$$SPI = \frac{X_i - X_i^{ort}}{\sigma}$$

According to the results of the formula, when the index falls below zero, it is considered as the beginning of the month, and when the index is positive, the month is considered as the end of the drought.

RESULTS AND DISCUSSIONS

Monitoring of agricultural areas in short periods is of great importance in terms of revealing the effects of environmental phenomena (such as climatic and biotic factors). In this regard, remote sensing technology has many advantages over conventional methods since traditional methods are inadequate in detecting short-term changes in large agricultural areas. In this study, 16 days photosynthetic activity of pistachios was investigated by integrating both field research and modern techniques (remote sensing and statistical methods). Furthermore, the effects of climatic factors on the yield of pistachio were analysed. Along with the present study, the relationships between pistachio and wet and dry climatic conditions were presented. It has been observed that extreme rainfall conditions have caused considerable changes on the pistachio phenology and physiology. The area harvested, yield and production of pistachio between 2000-2016 years in Turkey are represented Table 1 and Figure 2 (FAOSTAT, 2016). Pistachio yield and production values fluctuate between years. Fluctuation or irregular bearing are considered as consequences of endogenous and exogenous factors. Endogenous factors are defined as plant own characteristics including cultivar, agricultural practises, genetic and physiology of plant (Nzima et al., 1997; Spann et al., 2008). Exogenous or environmental factors such as climatic variation of temperature and precipitation, wet and dry climate condition are significant predictor on yield (Elloumi et al., 2013).

Middle Euphrates region provides a significant portion of which Turkey pistachio production. Turkey meets 20-25% of the world pistachio production. Yield and yield per tree are low in Turkey. Kumar et al. (2016) reported that the low yield of pistachio could be consequences of periodicity, inadequate pollination, fertilization, water stressful conditions and traditional cultural practices.

Table 1. Area harvested, yield and production of pistachio between 2000-20016 in Turkey

Years	Area harvested (ha)	Yield (t/ha)	Production (t)
2000	36349	2.0633	75000
2001	36999	0.8108	30000
2002	37428	0.9351	35000
2003	37570	2.3955	90000
2004	37572	0.7985	30000
2005	40000	1.5000	60000
2006	40000	2.7500	110000
2007	40661	1.8056	73416
2008	40954	2.9329	120113
2009	43063	1.8994	81795
2010	42310	3.0253	128000
2011	44097	2.5399	112000
2012	53071	2.8264	150000
2013	54451	1.6272	88600
2014	56186	1.4238	80000
2015	57996	2.4829	144000
2016	60814	2.7954	170000

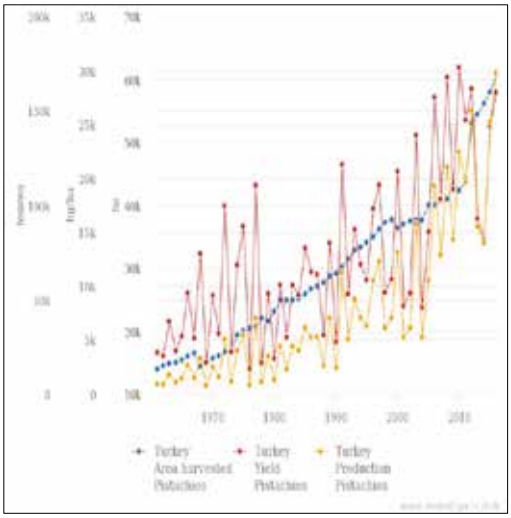

Figure 2. Changes Area harvested, Yield and Production of pistachio between 2000-20016 in Turkey

Variation in climatic changes is of the predictive factors on pistachio yield in Turkey. In the study area, there has been extreme dry period (severe dry, very severe drought, extraordinary dry) 5 times in last 54 years. In

contrast to this, it is observed 8 times extreme humid period (very humid, extremely humid, extraordinary humid). The year 2014 is the most arid period of the last 54 years in the study area. 2012 is one of the five most humid periods of the last 54 years (Figures 3, 4).

Pistachio nut yield changes depending on dry and wet periods in Gaziantep affect the average yield of Turkey. Accordingly, the year 2014 is an extraordinary dry period in the meteorological station of Gaziantep, Şanlıurfa and Adıyaman. Turkey's average yield was 1.4238 t/ha of pistachios for 2014. In contrast, the average value of Turkey was found to be 2.8264 t/ha for 2012 when is excessive wet period.

Pistachio trees require very hot climates in summers and cold climates in winters. In this context, pistachios are resistant to extreme hot conditions, while photosynthetic activity declines during the dry periods. It is observed that the photosynthetic activity of pistachio is particularly low in the growing season during the dry season of 2014. In contrast, the Enhanced Vegetation Index (EVI) values are above normal in the corresponding humid period of 2012 (Figure 5).

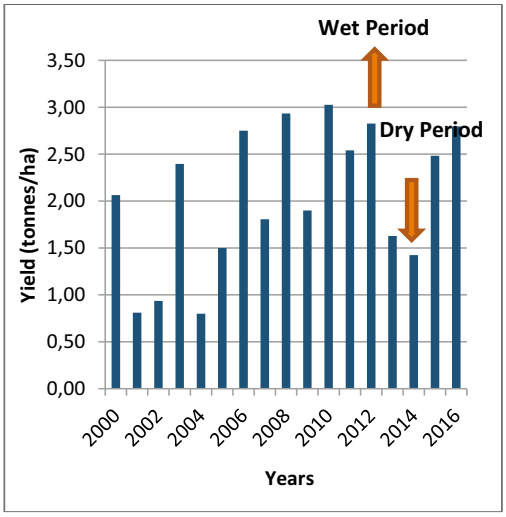

Figure 3. Yield of pistachios in wet and dry periods

As reported in many and various studies, any shift in metabolic activities of plants which might be consequences of plant-own structure or external-induced perturbations result changes in biochemical and physiological aspects as a consequence of molecular level changes. As a response to drought conditions, Khoyerdi et al. (2016) reported the shifts in value of vegetative growth, RWC, TChl and carotenoids, TSP and an increase in MDA and H_2O_2 etc. while reduction rate concerned with cell expansion and division rate were reported by Li et al. (2009).

Based on the literature, we cannot deduce or simplify the factors responsible for irregular bearing, which is of the complex phenomenon of the plant kingdom (Spann et al., 2009).

CONCLUSIONS

Extreme conditions in the climate play an important role on the crop production. Meteorological drought is one of these extreme climate conditions. Depending on global climate changes, plant growth and physiology are influenced and causes many problem in agriculture. According to the results of the drought analysis of Gaziantep, Sanliurfa and Adiyaman (in the south-eastern parts of Turkey) stations, pistachio is significantly affected by extreme climatic conditions. The photosynthetic activity of pistachio trees grown in Gaziantep, Sanliurfa and Adiyaman increased during the periods of wet climatic conditions. Especially at the beginning of 2010, pistachio plant exhibited highest photosynthetic activity and the activity was considered to be associated with wet climatic conditions in both areas at the end of 2009. The present results indicate that the pistachio does not react immediately to wet climatic conditions, suggesting that pistachio respond or develop any mechanisms to this climatic stimulant 2 and 3 months after the humid climatic conditions.

It has been observed that pistachio was affected by extreme climatic conditions and extreme rainfall conditions have caused considerable changes on the pistachio phenology and physiology. As a result it was observed that the photosynthetic activity of pistachio increased during the periods of wet climatic conditions.

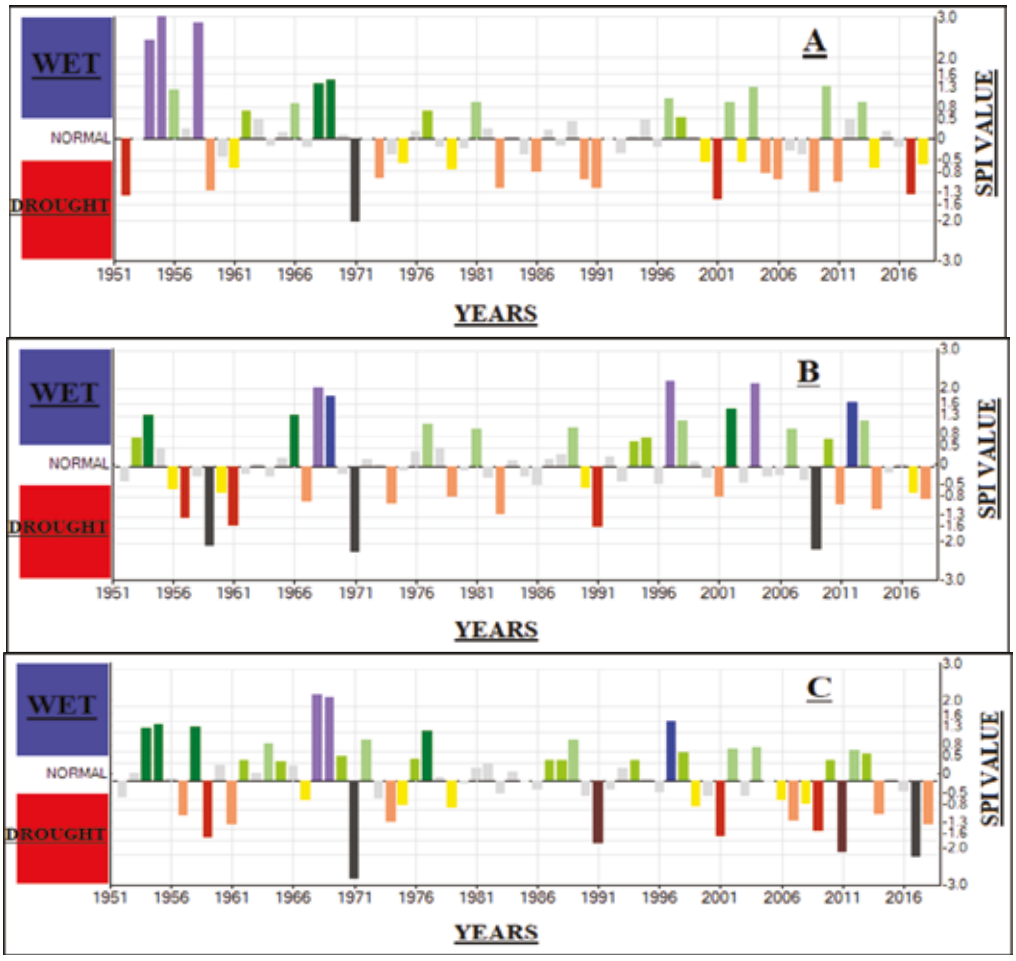

Figure 4. Drought analysis results of Standardized Precipitation Index (SPI) of the Adıyaman (A), Gaziantep (B) and Sanliurfa (C) (1952-2018) Source: General Directorate of Meteorology (MGM)

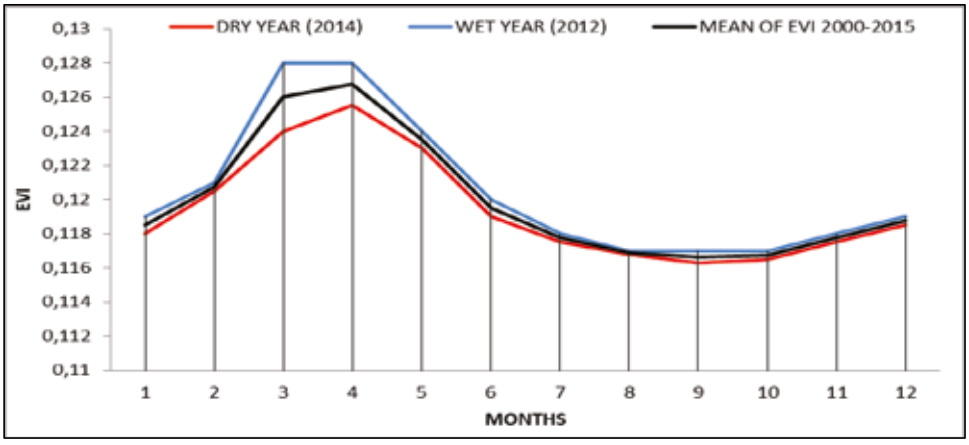

Figure 5. Photosynthetic activity in wet and dry periods according to EVI analysis results

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