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Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi. 2024; 10 (2): 85-92 Araştırma Makalesi/Research Article

Farklı Kapalılıktaki Sarıçam Meşcerelerinde Bazı İklim Faktörlerinin Toprak Nemi Üzerine Etkileri

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Öz

Çalışma, Çamkoru Dr. Fuat ADALI Araştırma Ormanı Mühendisliği Ormanlarında 30.09.2014-19.10.2016 tarihleri arasında gerçekleştirilmiştir. Bu çalışmada, farklı kapalılıklara sahip sarıçam meşcerelerinde iklim faktörlerinin toprak nemi üzerine etkileri araştırılmıştır. Çalışma sonucunda sarıçam meşcerelerinde toprak nem değerlerinin aynı bakı, derinlik ve eğim grubunda farklılık gösterip göstermediği ortaya koyulmuştur. Sarıçamın farklı kapalılıklarda parsellerde bazı iklim elemanlarının (hava sıcaklığı, hava nemi ve yağış) toprak nem değerlerine etkileri araştırılmıştır. Aynı derinlik, eğim ve bakı grubunda 6 farklı parsel belirlenmiştir. Ortalama toprak nem değerleri Açık orman parselinde (POF) %23,91, P1 parselinde (Düşük kapalıktaki sarıçam meşceresi) %26,84, P2 (Orta kapalılıktaki sarıçam meşceresi) parselinde %16,72, P3 (Tam kapalılıktaki sarıçam meşceresi) parselinde %16,00, Simülasyon parselinde (PS) %30,79 ve Erozyon parselinde (PE) ise %28,62 olarak bulunmuştur. En düşük ortalama toprak nemi değerlerinin P2 ve P3 parsellerinde, en yüksek toprak nemi değerlerinin ise PS ve PE parsellerinde olduğu belirlenmiştir.

Effects of Some Climatic Factors on Soil Moisture in Scots Pine Stands with Different Crown Closure

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Abstract

In this study, the effects of climate factors on soil moisture in Scots Pine stands with different crown closure were investigated. As a result of the study, it was revealed whether soil moisture values differ in Scots Pine stands in the same aspect, depth and slope group. The effects of some climate elements (air temperature, air humidity and rainfall) on the soil moisture values in the areas where the Scots Pine in different crown closures were investigated. We took 6 different forest plots in the same depth, slope and aspect group. The average soil moisture values was found 23.91% in Open forest plot (POF), 26.84% in P1 plot (Low crown closure scots pine stand), 16.72% in P2 (Medium crown closure scots pine stand), 16.00% in P3 (Full crown closure scots pine stand), 30.79% in Simulation plot (PS) and 28.62% in Erosion plot (PE). It was determined that the lowest average soil moisture values were found in the P2 and P3 plots and the highest soil moisture values were in the PS and PE plots.

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INTRODUCTION

Water is vital to all individuals and is of great importance for the survival of plants. All vital processes, such as extracting nutrients from the soil with the help of plant roots, transporting them to the leaves and photosynthesis, can occur with water. Chemical exchange of organic substances occurring with photosynthesis, cells can perform their functions by maintaining life, dissolving toxic substances in the soil and thus water plays a major role in the realization of events such as dilution and the most favorable soil ventilation. Consequently, most watershed management studies are aimed at improving water efficiency and water quality in forest-covered watersheds.

The water yield and the quality of the watersheds vary depending on the topography, slope, view, soil characteristics and size of the basin, as well as the amount of precipitation falling in the basin and the manner in which the land is used (Calder, 2007; Tsiko vd., 2012). Nevertheless, in contrast with the basins covered with the forest cover and other vegetation cover, factors such as the hydrological cycle and the water retention properties of the soil litter are the activated soil moisture, soil temperature and water quality values differ depending on the type of vegetation in the watersheds (Neris et al.vd., 2012; Babalik and Yazici, 2011; Núñez vd., 2006; Calder 2007; Neary vd., 2009). When the studies are compared with areas covered by herbaceous and arborescent vegetation and open areas where rampikes are found, the moisture and temperature conditions of the soils in the open area have changed, the maximum shown that the temperature increases and the upper soil moisture decreases due to the consumption of herbaceous plants in areas covered by vegetation (Fernald et al. 2009). In a separate study of the effects of forest and herbaceous vegetation on soil temperature and soil moisture, soil moisture and soil temperature values are significantly higher than those estimated to be influenced by vegetation cover (Özkan 2015).

It is directly related to the fact that precipitation falling in the soil is more regular or increased infiltration the soil surface is covered by vegetation. Due to the amount of precipitation falling in the soil, the amount of seepage of this precipitation, the condensation of some of the water vapor present on the surface under different temperature conditions, in particular the base water near the surface, the loss of moisture due to evaporation from the soil and the use of water in the soil by living organisms, the moisture in the soil (Mater 2004). Although there are studies that show that the activities carried out in forest cover in forestry watersheds increase water yield, forestry activities occur in the soil Adequate and detailed studies on the effects of changes on soil moisture and soil temperature affecting biological, chemical and hydrological processes are inadequate, especially in our country (Özkan 2015). Water in arid and semi-arid regions represents the main ecological constraint for plant survival, and hydrological processes determine the direction and ecological functions of evolution of soil vegetation systems (Li 2011). The water content of the soil profile is not the only factor that can be tracked and interpreted by surface and atmospheric activities, but plays a vital role in the growth of vegetation. The soil water content varies due to environmental factors such as depth precipitation, soil texture, soil activity (Wang et al. 2013).

Therefore, it is important, understanding the relationships and linkage mechanisms between soil, water and vegetation interactions can help understand land surface development processes and biogeochemical balances on dry surfaces. (Dunn et al., 1985; Moyano et al. 2013; Xia and Shao 2008; Babalik and Sonmez 2009; Deng et al. 2020; Istanbulluoglu and Bras 2006, Turcu et al. 2005, Schwinning et al. 2004; Suo et al. 2005; Legates et al. 2011; Yang et al. 2012; Owe et al. 1982; Grayson et al. 1997; Xiao et al. 2014; Choi and Jacobs 2007; Gao and Shao 2012; Liang et al 2018). Soil moisture is an important factor in plant growth and species diversity, as the climate created by the interaction between the earth and the atmosphere influences plant growth. The relationship between soil moisture and soil temperature has a leading and initiating role in many ecosystem processes (Hinzman et al. 2005; Yi et al. 2009). Soil moisture is an essential component in terrestrial ecosystems system because it is major influencing factor for many hydrological and biochemistry processes and influences water dynamics, the energy and carbon flows between the surface of the earth and the atmosphere, and the distribution of various hydrological mechanisms such as such as runoff, infiltration, soil evaporation, plant transpiration and water accumulation in soil processes. (Peng and Loew, 2017; Tuttle and Salvucci, 2014; Kerr et al. 2016; Serrana et al. 2020).

Soil moisture and soil temperature may also differ temporally and spatially, depending on soil surface temperature and evapotranspiration (Núñez et al. 2006; Calder 2007; Neary et al. 2009). Such differences can be used as essential parameters for the determination of different dynamics in terrestrial ecosystems and the construction of ecological models (Carlson et al. 1994; Zhan et al. 2006; Mao et al. 2007).

In this study, the effects of climate factors such as temperature, moisture and precipitation on soil moisture in in Scots Pine (*Pinus sylvestris* L.) stands with different crown closures were investigated. As a result of the study, it was revealed whether soil moisture values differ in in Scots Pine stands in the same exposition, depth and slope group.

Study Area

The study was conducted in Camkoru Dr. Fuat Adalı Research Forests located in Çamlıdere district of Ankara. Forest management plan of Çamkoru Dr. Fuat Adalı Research Forest Engineering Forests were firstly carried out in 1956. Later, the Management Plan was made to apply for 1973-1992 under the name "Camkoru Research Forest Series". The plan unit is in two parts, Block-A and Block-B, in the area of Çamkoru Forest Operation Chief. The general area of the research forest within these limits is 611.9 hectares. 573.8 hectares of this area are forestland and 38.1 hectares are non-forested land (Anonymous 2005).

Block-A in the western part of the Research Forest was selected for this study. According to topographic maps of 1/25000 scale, Camkoru Dr. Fuat Adalı Research Forests are located between BLOK-A: 40 34' 03" - 40 35' 40" Northern latitudes and 32 28' 54"

- 32 30 16” East longitudes. General land use consists of forest and open forest (OF) areas in the field of study. There's a terrestrial climate here. Summers are dry and hot, and winters are cold and snowy. There are high temperature variations in both summer and winter, night and day (Anonymous 2005). The average amount of precipitation of research areas is 593.60 mm. The average annual temperature is 6.6°C, the maximum temperature is 30.5 °C (August), the minimum temperature is -20.59 °C (January). The terrain is volcanic and consists of andesite and andesite tuff to the bedrock. Total lime ($CaCO_3$) in soils is a trace amount or absent. Research Engineering soils are generally shallow and acidic, and the average pH ranges from 5.50 to 6.50. The soil is usually a dark and brown forest soil class. The soil type is mostly sandy slime, slime and sandy clay. Ah horizon (0-10 cm) is rich in organic matter (Anonymous 2005).

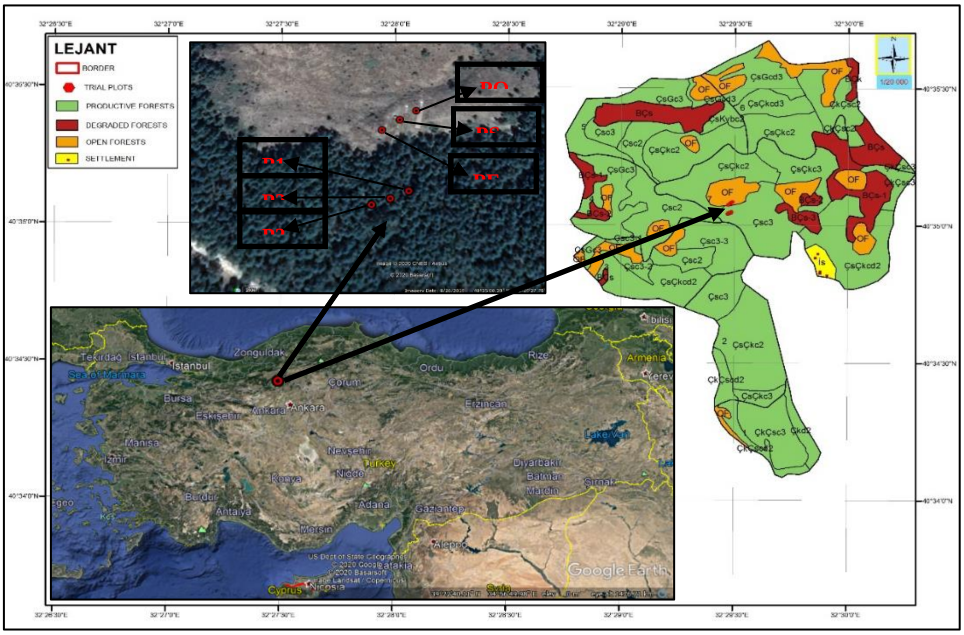

Figure 1. Geographical location and land use status of research plots

MATERIAL AND METHODS

Materials

In this study, the values of air temperature, air humidity, precipitation and soil moisture at a depth of 0-30 cm were measured in 6 different plots (POF, P1, P2, P3, PS ve PE) and for 2 years (between September 2014 and October 2016). A total of 647904 data were obtained from the plots for 2 years. The data obtained was reduced to 4506 data by obtaining daily averages.

Method

Trial plots were selected in Scots Pine (*Pinus sylvestris* L.) stands with low, medium and full crown closure in forest land, OF, erosion and simulation parcel in non-forest land (Table 1). As a result, we took 6 different land use type (Figure 1). A total of six trial plots is created in size 80 m² (4m x 20 m).

Table 1. Trial plots and features

Trial Plots	
POF	Open Forest (OF) Plot, (<10 % coverage)
P1	Low Crown Closure Class (low coverage, 11-40 %) in Scots Pine (*Pinus sylvestris* L.) Stand Plot
P2	Medium Crown Closure Class (medium coverage, 41-70 %) in Scots Pine (*Pinus sylvestris* L.) Stand Plot
P3	Full Crown Closure Class (full coverage, 71-100 %) in Scots Pine (*Pinus sylvestris* L.) Stand Plot
PS	Simulation Plot (Pasture Plot). Herbaceous species are cut off from the top in April-May from this plot, which is very rich in vegetation.
PE	The plot where the worst agricultural processing is done. In the plot, the clods harrowed and ploughed in the direction of the slope of the soil. This plot is the plot where erosion is most severe.

When selecting trial plots, attention was paid to the presence of a homogeneous structure. The plots are selected in similar or close slope class, in the same aspect and in areas where the soil structure does not differ much. There is no silvicultural prescription in trial plots. However, when the percentage of vegetation in the plot called PE plot reached 10%, the PE plot was processed and ploughed in the direction of the slope and prepared again. The crown closure, altitude, slope, aspect, stand type and features of geological structure of the trial plots are given in Table 2.

Table 2. General features of trial plots

	Trial Plots	Crown Closure (%)	Altitude (m)	Slope (%)	Aspects	Stand Types	Geological Structure
Çamkoru Dr. Fuat Adalı Research Forest Area	POF	0	1500	13	Sunny	OF	Andezit
	P1	11-40	1510	12	Sunny	Çsc1	Andezit
	P2	41-70	1510	12	Sunny	Çsc2	Andezit
	P3	71-100	1510	12	Sunny	Çsc3	Andezit
	PS	0	1500	13	Sunny	OF	Andezit
	PE	0	1500	13	Sunny	OF	Andezit

The trial plots are surrounded by concrete wall (Figure 1). A Datalogger was placed in a point where access to all plots was easiest and in the box inside the mast, which was installed by pouring concrete after leveling the lower ground. A Datalogger has been activated 7/24 via charging battery with 40 W solar panel and recorded soil moisture every 10 minutes. Moisture sensors placed on the plots are connected to the Datalogger by cables. The cables are embedded in the ground by inserting them into spiral pipes to protect them from the high temperature differences (Table 3).

In addition, the meteorological station was installed to ensure automatic measurement of temperature, air humidity, precipitation and soil moisture values in the trial plots (Fig. 2).

Figure 2. The appearance of trial plots

By means of the meteorological station and equipment installed on plots, the values of air temperature, air humidity, precipitation and soil moisture are recorded momentarily every 10 minutes on a daily basis from the plots. The values of air temperature, air humidity, precipitation and soil moisture at a depth of 0-30 cm were measured in 6 different plots (POF, P1, P2, P3, PS and PE) and for 2 years (between September 2014 and October 2016). A total of 647904 data were obtained from the plots for 2 years. The data was reduced to 4506 data by obtaining daily averages and statistical analysis was performed with SPSS program.

RESULTS AND DISCUSSION

The average soil moisture value of six plots was determined as 23.82% according to the data obtained from plots as a result of 2 years of measurement in Camkoru Dr. Fuat Adalı Research Forests. According to the data obtained separately from each plot, soil moisture value was determined as 23.91% in POF plot, 26.84% in P1 plot, 16.72% in P2 plot, 16.00% in P3 plot, 30.79% in PS plot and 28.62% in PE plot. The highest value of soil moisture was 30.79% in the PS plot and the lowest value was 16.00% in the P3 plot (Fig. 3). Our results are supported by other study. Öner (2016) found that soil moisture value was determined as 12.7% for 0-5 cm depth level, 20.5% for 5-15 cm depth level and 16.4% for 15-30 cm depth level (2016). Lizhu Suo et al. (2018), found that temporal variation in soil moisture content decreased with increasing soil depth on the Loess Plateau of China.

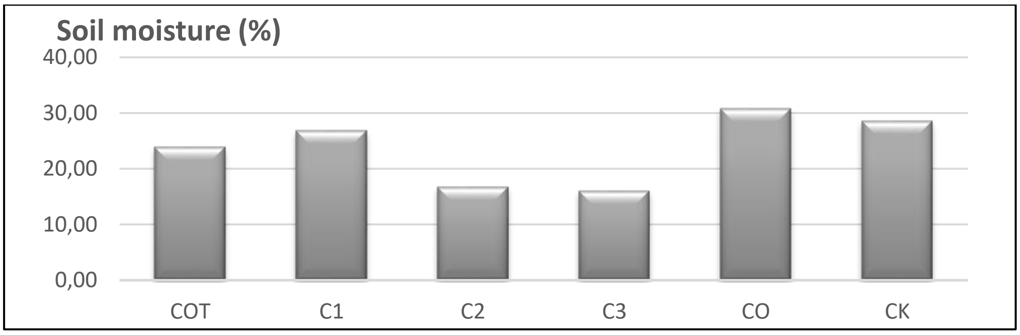

Figure 3. Soil moisture content values of different plots

The data were compared with the Tukey test (Zar 1996). In the statistical analysis, it was determined that all plots had a statistical discrepancy in terms of soil moisture values (Table 3). Regression analysis was performed to determine whether the air temperature, air humidity and rainfall values of the measured climatic factors had an effect on soil moisture values and regression models of air temperature, air humidity and precipitation, which are thought to be effective on soil moisture, have been set in these analyzes conducted.

Table 3. Statistical analysis of soil moisture values of different plots

Plots		X (Average)	P (Significance Level)	Tukey (HSD)
1	POF	23.91	0.000	(3-1)*, (3-2)* (3-5)* , (3-6)* (4-1)*, (4-2)* (4-5)*, (4-6)* (1-2)*, (1-5)* (1-6)*, (2-5)* (2-6)*, (5-6)*
2	P1	26.84		
3	P2	16.72		
4	P3	16.00		
5	PS	30.79		
6	PE	28.62		

The estimate model obtained as a result of regression analysis to reveal the impact of air temperature, air humidity and precipitation values on soil moisture in the study site is as follows;

Soil Moisture = 0.218 – (0.05 X air temperature) + (0.01 X air humidity) + (0.04 X precipitation)

According to regression model, there is positive and meaningful relation in soil moisture with air humidity and precipitation and negative relation with air temperature. The R2 value of the model was 0.190, which explains 19% of the variability of air temperature, air humidity and precipitation. This suggests that other variables are also effective on soil moisture. Similarly, Liang et al. (2018), state that soil moisture content was positively correlated with climatic factors (mean annual precipitation (MAP), mean annual temperature (MAT), and the Palmer drought severity index (PDSI)), indicating that the SMC under R. pseudoacacia plantations was highly consistent with the hydrothermal conditions at the regional scale. At the same time the decreasing amplitude of SMC was linearly related to the increasing number of restoration years, especially in the areas below the 500–550 mm precipitation threshold. Considering that the average annual precipitation of Ankara is 391 mm (Anonymous 2020), the results obtained in this study are similar.

As a result of the study, it was determined that the soil moisture value varies significantly according to the types of land use. Our results are similar to Kantarci's (1974 and 1986) study and they found that there is a significant difference between the characteristics of soils under the same climate influence and the same bedrock under the forest society and the pasture society. Ozyuvacı (1976) indicated that deep-rooted forest plants use soil water stored in the sub-soil more and therefore a significant reduction in the sub-soil, especially in the vegetation season in forested lands, and in lands covered with shallow roots herbaceous vegetation, there was a decrease in top-soil water in the vegetation period due to the use of the top-soil water. Therefore, the results obtained from this study are in parallel with the results of previous studies. In addition, Kozlowski et al. (1997) stated that with an increase in temperature, the amount of transpiration and water use of plants increases, and accordingly, the absence of a canopy covering the soil in herbaceous vegetations to reach more precipitation on the soil surface, the water lost by transpiration is less than forest vegetation and the moisture content is higher than the forest. Forests increase the amount of water usage as a result of sweating, especially during hot months, using root systems and lower soil water and reduce the moisture content and they cause less rainfall to reach the soil surface because they shelter the forest floor by their canopies (Özyuvacı 1976; Blume 1968). Therefore, it is understood that the water usage and root activities of plants take an active role in the change in soil moisture values of the land covered with forest or herbaceous vegetation. It has been determined that soil moisture values have decreased in high-crown closure stands. It is thought that the reason for this is because of the high interception in the high crown closure stands, the precipitation reaching the surface of the soil may be less and plants in the land may be reducing soil moisture by using water in the soil (Çepel 1971).

Fernald et al., (2009) stated that the area is covered with herbaceous or woody vegetation or non-forested land is also effective in changing the moisture values in the soil. In non-forested land, the moisture and temperature of the soils increase in maximum temperatures, while in lands covered with herbaceous plants, the moisture in the upper soil decreases due to the use of plants. Similarly, Muhammad et al. (2010) stated that, the amount of precipitation reaching the soil in lands covered with herbaceous vegetation is greater and this causes an increase in soil moisture. Özkan (2015) revealed that the chemical content of soil water, soil moisture and soil temperature values are significantly affected by vegetation cover. Lei Yang et al. (2012) stated in their study, deep soil moisture content decreased more than 35% after land use conversion, and a soil moisture deficit appeared in all types of land with introduced vegetation. And, they revealed high planting density to be the main reason for the severe deficit of soil moisture. Similarly, Liang et al. (2018) underline that the depth-averaged SMC was generally lower under forest sites than under cropland, both in the shallow layers and in the deep profiles. Chen (2009) stated that land cover changes strongly affect the distribution of soil moisture and hydraulic properties. They found soil moisture content values are 30.5, 20.1 and 10.2% greater in the forest, shrub and grass areas, respectively.

CONCLUSION

The results of the study showed that soil moisture is as effective as the use of land and vegetation on the land as well as external factors (temperature, moisture and precipitation). As a result of the research, soil moisture values are determined respectively; PS (30.79%), PE (28.62%), P1 (26.84%), POF (23.91%), P2 (16.72%), P3 (16.00%). Water losses, especially caused by interception from vegetation, constitute a significant part of the precipitation falling into the soil and have a significant effect on soil moisture. In addition, the amount of water used by vegetation from the soil also reduces the amount of water in the soil, which leads to a decrease in the amount of soil moisture. Jia et al. (2017) state that, the depth-averaged soil moisture content was much lower under forest than under cropland. Artificial forests consumed more deep soil moisture than cultivated crops, inducing soil desiccation and dry soil layer formation. They stated that, future afforestation should consider those species that use less water and require less thinning for sustainable soil conservation without compromising future water resources demands in the Loess Plateau.

This study has shown that the amount of moisture in the soil decreases in forest areas with high crown closure (especially medium and full crown closure). Therefore, forestation studies should be carried out in the direction of increasing soil moisture and the amount of water in the soil, especially in watersheds where water needs are high. In these lands, preference should be given to plant species that consume water less and use less water in the soil.

a) Authors' contributions

M.A.: Design of the study, field and laboratory studies, evaluation of the results, preparation of the article.

A.S.H.: Design of the study, field work, preparation of the article.

b) Conflict of interest

The authors declared that they have no conflict of interest.

c) Statement on the Welfare of Animals

This study does not include experiments on animals.

d) Declaration of Human Rights

This study did not involve human participants.

e) Acknowledgements

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