SOIL PHYSICS AND MECHANICS

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INVESTIGATING SOIL TEMPERATURE VARIABILITY AND THERMAL DIFFUSIVITY IN GRASS COWERED AND SHADED AREAS BY TREES

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Abstract: Changes in the soil temperature conditions are one of the most important components of soil microclimate and have a considerable impact on changes in soil properties and plant development processes. In this research, soil temperature and thermal diffusivity values were determined at two different fields which are grass covered and shaded areas by peach trees. Theoretical soil temperature values obtained from the solution of thermal conductivity equation were compared to experimental soil temperature values. Field studies were carried out on a farm field in Turkey, Samsun, Çarşamba County, Yesilırmak neighborhood (36° 43.380' to the East, 41° 13.061' to the North) between August and September, 2011. Mean soil temperatures at the first experimental field covered by grass at 7:00, 12^00, 18^00 hours were determined as 19.5°C; 28.4°C; 23.4°C at the soil surface, 20.2°C; 26.9°C; 23.3°C at 10 cm, 20.7°C; 26.0°C; 23.1°C at 20 cm, 21.1°C; 25.3°C, 22.9°C at 30 cm and 21.4°C; 24.9°C; 22.9°C at 40 cm soil depth, respectively. Mean soil temperatures at the second experimental field shaded by peach trees at 7:00, 12:00, 18:00 hours were determined as 19.4°C; 24.7°C; 22.5°C at the soil surface, 20.3°C; 24.5°C; 22.7°C at 10 cm, 20.8°C; 24.1°C; 22.6°C at 20 cm, 21.1°C; 23.7°C; 22.4°C at 30 cm and 21.0°C; 23.5°C; 22.2°C at 40 cm soil depth, respectively. Mean thermal diffusivity in the 1st experimental field from 0 to 40 cm soil layer were 0.460 cm^2s-1; 0.029 cm^2 s-1 and 0.167 sm^2 s-1 at 700, 1200 and 1800 hours, respectively. Mean thermal diffusivity in the 2nd experimental field from 0 to 40 cm soil layer were 0.234 cm^2 s-1; 0.115 cm^2 s-1 and 1.677 cm^2 s-1at 7:00, 12:00 and 18:00 hours, respectively. The mean relative errors between the estimated results using the solution of heat conductivity equation and the experimental temperature measurements were 0.089 at the soil surface and 0.055 at 20 cm soil depth. Comparison of the experimental temperature measurements to estimated temperature values showed that the initial unconditional solution of the heat conductivity equation in a short period (≤ 3 days) gives much better periodic thermal changes on the soil surface and in soil layers.

Keywords: soil temperature, thermal diffusivity, heat conductivity equation, measured and estimated temperatures.

INTRODUCTION

Temperature readings of each soil layer characterize the thermal situation of the soil. Soil temperature is one of the most important factors that affect significantly the soil formation process, strength of chemical, physical, biochemical and biological variability, growth and development of plants. Furthermore, soil temperature changes affect moisture level, nitrogen circulation and thermal and physical properties in soils. The maximum crop fertility usually depends on the optimal level of soil temperature. In turn, the soil temperature is influenced by some environmental factors such as soil properties (bulk density, humidity, a layer of organic substances on the surface, groundwater level, soil color, etc.), topography (slope angle, direction, length etc.) and climatic conditions (precipitation, temperature, wind, atmospheric pressure, etc.). Temperature changes in the soil affect greatly the carbon (C) and nitrogen (N) mineralization of soil, the process of plant vegetation (Wang et al., 2006; Guntinas et al., 2012; Krzysztof et al., 2014; Schütt et al., 2014; Guo et al., 2014). However, soil temperature and moisture influence the formation and potential of CO_2 emission in the soil (Li et al., 2013; Hassan et al., 2014). The results of studies showed that the soil respiration and mineralization of organic substances at different temperatures (15, 20, 25, 30°C) are very sensitive to temperature increase, that is in case of increasing the soil temperature they are characterized by a positive ratio (Ghee et al., 2013).

Microclimate of the soil surface is in constant contact with the soil temperature and humidity. Therefore, it is one of the main factors that influence the plant development. Microclimate controls also the biological process (appearance of germs, plant development, etc.) and hydrological process (penetration, surface flow, erosion etc.) of earth adjacent to the soil surface. Controlling the soil temperature and humidity can influence the microclimate of the soil surface. Due to the fact that the vegetation cover affects directly the temperature and humidity, it affects the climate as well. (Flerchinger and Pierson, 1997). Change in the shadowing formed by vegetation influences the temperature, humidity and CO_2 concentration as well as soil respiration, which, in turn, leads to a restriction of thermal and hydrological soil characteristics (Tanaka and Hashimoto, 2006).

Change in soil temperature depends on thermal properties of the soil (Arkhangel'skaya and Umarova 2008) and has a great impact on hydrophysical properties of the earth (Hopmans and Dane, 1985), water permeability factor (Jaynes, 1990), hydraulic conductivity (Constantz, 1982; Andry et al., 2009) and the soil formation process (Ponomoryov et al., 1984; Ekberli et al., 2002; Arkhangel'skaya et al., 2005). Furthermore, soil temperature affects the decomposition of plant residues in the soil, formation of microbial biomass and enzyme activity (Zibilske and Makus, 2009; Terrence and Hugh, 2011). Also, the formation of soil-water-salt regime depends on daily, seasonal and annual changes in the soil temperature. For this reason, the determination of temperature variability of soil having different soil properties is on the agenda. Climatic conditions, which cannot be controlled but can be predicted, are also one of the main factors that influence the soil temperature. Meteorological data (Chow et al, 2011) during 4 years of research (2006 to 2009) shows that at a depth of 0.5-3.0 m the temperature is proportional to the temperature of dry air (the correlation coefficient is 0.869) and interacts slightly with relative humidity, precipitation, solar radiation and wind velocity (the correlation coefficients are 0.223, 0.136, 0.089, 0.033, respectively).

Daily and annual changes in the temperature of the soil surface and its deeper layers are determined by soil properties and thermal and physical soil characteristics (thermal diffusivity, thermal conductivity, heat capacity etc.) (Gülser and Ekberli, 2002; Gülser and Ekberli, 2004; Ekberli et al., 2005; Ekberli, 2006a, 2006b; Gao et al., 2007; Onder et al., 2013). As the salt amount increases, thermal diffusivity of clay loamy soil increases; when soil moisture increases until 40 %, the difference between the thermal diffusivity coefficients of salty and none salty soils decreases, and when the moisture level reaches 35-40 %, both coefficients are equal approximately (Tikhonravova, 2007). The thermal diffusivity coefficient increases as the particle density of grey forest soils increases. If a compaction occurs in a plow layer of soil tilled by agricultural machinery, the thermal diffusivity coefficient decreases up to 26 % soil moisture level, and increases when the soil moisture exceeds 26 % (Arhangel'skaya, 2004). Tikhonravova and Khitrov (2003) determined that the thermal diffusivity coefficient in the vertisols had significant multiple correlations with fine soil fractions, organic matter, particle density and porosity values (R2=0.81-0.96 and P=0.95). The soil thermal diffusivity coefficient has a positive relation with thermal conductivity and a negative relation with volumetric heat capacity. When the thermal diffusivity coefficient is high, daily and annual heat waves impact much more soil depths and retardation of temperature to lower soil layers decreases.

The objective of this study was to determine the soil temperature and thermal diffusivity coefficients which depends on temperature readings at two different fields which are grass covered and shaded areas by peach trees in Samsun (Turkey), Çarşamba County, and to compare experimental temperature readings with theoretical soil temperature values obtained from the solution of thermal conductivity equation.

MATERIAL AND METHODS

Field studies were carried out in Turkey, Samsun, Çarşamba County, Yeşilırmak neighborhood in August-September of 2011 on a farmer's field having the following coordinates: 36° 43.380' to the East, 41° 13.061' to the North. The altitude of field is 6 meters above the sea level. The Region is characterized by warm climate. The average annual precipitation and temperature in the Çarşamba County are 600-936.9 mm and 15°C, respectively. There is no significant temperature difference between summer and winter seasons because of the sea effect. The soil group in the experimental field is alluvial great group (Anonymous, 1984).

Field studies were done in two different fields. The first experimental field was covered with grass; the second field (peach orchard) was shaded with peach trees. During the experiment, the temperature readings were taken from soil surface to 40 cm depth at each 10 cm of soil profile. Thermometer measurements were recorded at 70:00, 12:00 and 18:00 h daily between August and September, 2011 (Sterling and Jaskson, 1986). Soil texture of 0-20, 20-40 cm soil layers in the experimental field were determined by the "Bouyoucos Hidrometre" method (Black, 1957; Demiralay, 1993). Soil pH based on the water-volume ratio of 1:1 suspension was measured using a pH meter with a glass electrode (Bayraklı, 1987) and electrical conductivity (EC) in the same suspension was measured using an EC meter (Richards, 1954). Organic matter in the soil were determined by the "Walkley-Black" method (Kacar, 1994). The amount of lime ($CaCO_3$) content in the soil was measured using the Scheibler calcimeter (Allison and Moodie, 1965). Statistical calculations were made based on the software package MİNİTAB-32.

The equations given below were used to calculate the theoretical values.

$$T(x,t)=T_o + Ae^{-x\sqrt{\frac{\omega}{2a}}}\cos\left(-x\sqrt{\frac{\omega}{2a}}+\omega t\right) \quad \text{or} \quad T(x,t)=T_o+\frac{A}{e^{x\sqrt{\frac{\omega}{2a}}}}\cos\left(-x\sqrt{\frac{\omega}{2a}}+\omega t\right) \qquad (1)$$

where; $T(x,t)=[T]$,- temperature at x soil layer, x - depth, t - time; $T_0=[T]$ - average temperature of soil surface; $A=[T]$-amplitude; $a=[l_1][t_{-2}]$- thermal diffusivity coefficient (diffusion of heat); $\omega=2\pi/P=[t_{-1}]$- angular frequency; $P=[t]$ - period.

The thermal diffusivity coefficient was determined based on values.

$$a=\frac{\omega x^2}{2\ln^2\frac{A(x)}{A}} \qquad (2)$$

where; $A(x)=[T]$-amplitude (Hillel, 1982, 1998; Nerpin and Chudnovski,1984; Cichota et al., 2004; Gülser and Ekberli, 2002, 2004; Ekberli, 2006a, 2006b, 2010; Gao et al., 2007; Evett et al., 2012; Arkhangelskaya, 2014).

RESULTS AND DISCUSSION

In the first experimental field, soil texture in 0-20 cm and 20-40 cm soil layers were silty loam (SiL), soils have slightly alkaline reaction, low in organic matter content; none salty and have a moderate lime content. In the second experimental field, soil texture in 0-20 cm, and 20-40 cm soil layers were loam (L) and silty loam (SiL), respectively. Soil in 0-40 cm layer has slightly alkaline reaction, low in organic matter content; none salty and has a moderate lime content.

Temperature measurements at the experimental fields

Temperature changes at the experimental fields through soil profile are shown in Figure 1. In the 1st experimental field cowered with grass, soil temperature readings at 7:00, 12:00, 18:00 h varied between 16.5-23.0°C, 21.0-34.0°C, 19.5-26.5°C at the soil surface, between 18.0-21.5°C, 23.2-30.0°C, 20.0-25.5°C at 10 cm depth, between 18.5-22.8°C, 23.7-29.0°C, 20.9-26.0°C at 20 cm depth, between 19.0-23.0°C, 22.8-27.0°C, 20.5-25.5°C at 30 cm depth, between 19.2-24.0°C, 22.7-26.5°C, 20.8-25.0°C at 40 cm depth, respectively. Mean temperatures at 7:00, 12:00, 18:00 h were determined as 19.5°C, 28.4°C, 23.4°C at the soil surface, 20.2°C, 26.9°C, 23.3°C at 10 cm depth, 20.7°C, 26.0°C, 23.1°C at 20 cm depth, 21.1°C, 25.3°C, 22.9°C at 30 cm depth, 21.4°C, 24.9°C, 22.9°C at 40 cm depth, respectively.

In the second experimental field shaded with peach trees, soil temperature readings at 7:00, 12:00, 18:00 h varied between 16.5-22.0°C, 19.0-27.5°C, 19.0-24.5°C at the soil surface, between 18.0-22.5°C, 20.0-25.5°C, 20.0-24.8°C at 10 cm depth, between 18.5-23.0°C, 20.1-26.0°C, 20.5-24.5°C at 20 cm depth, between 19.0-23.0°C, 20.5-25.0°C, 20.0-24.5°C at 30 cm depth, between 19.2-23.0°C, 20.2-25.0°C, 20.0-24.5°C at 40 cm depth, respectively. Mean temperatures at 7:00, 12:00, 18:00 h were determined as 19.4°C, 24.7°C, 22.5°C at the soil surface, 20.3°C, 24.5°C, 22.7°C at 10 cm depth, 20.8°C, 24.1°C, 22.6°C at 20 cm depth, 21.1°C, 23.7°C, 22.4°C at 30 cm depth, 21.0°C, 23.5°C, 22.2°C at 40 cm depth, respectively.

High energy entrance from soil surface causes higher temperature fluctuation at the surface of soils. In general, temperature variability in deeper soil layers of both fields was observed in a narrow range, and this variability becomes much narrower as the soil depth increases. The reason for narrow temperature variability is explained by the fact that the uniformity of soil structure in both fields together with the other factors (which affect the temperature such as; physical, chemical and biological processes in soils, climatic conditions), generally balanced thermal regime and regular soil formation process. When comparing the temperature values of the 1st with 2nd experimental field, the reason of the lower temperature values in second field is the shadowing, which affects the process of soil warming and cooling, as well as plant (peach trees) root density which had a mechanical influence on the soil as a result of increasing porosity.

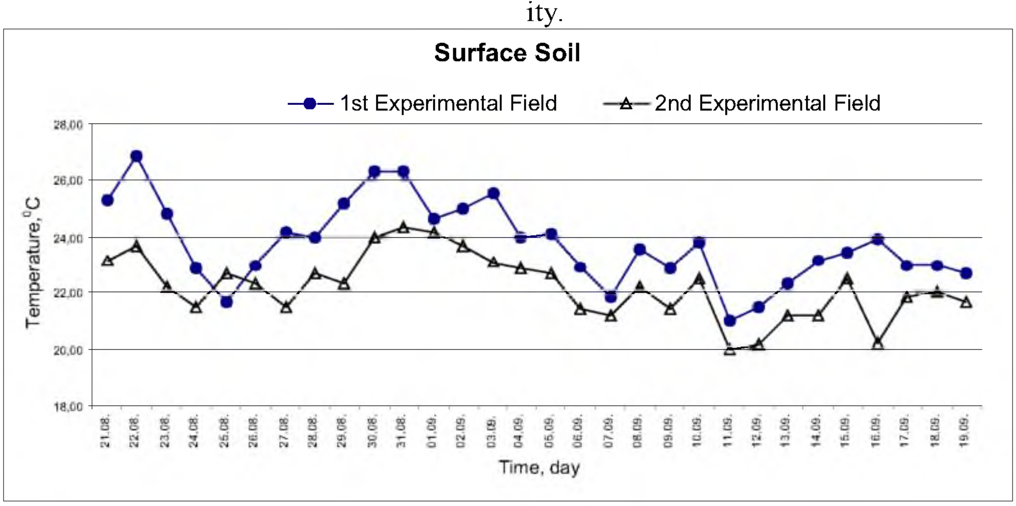
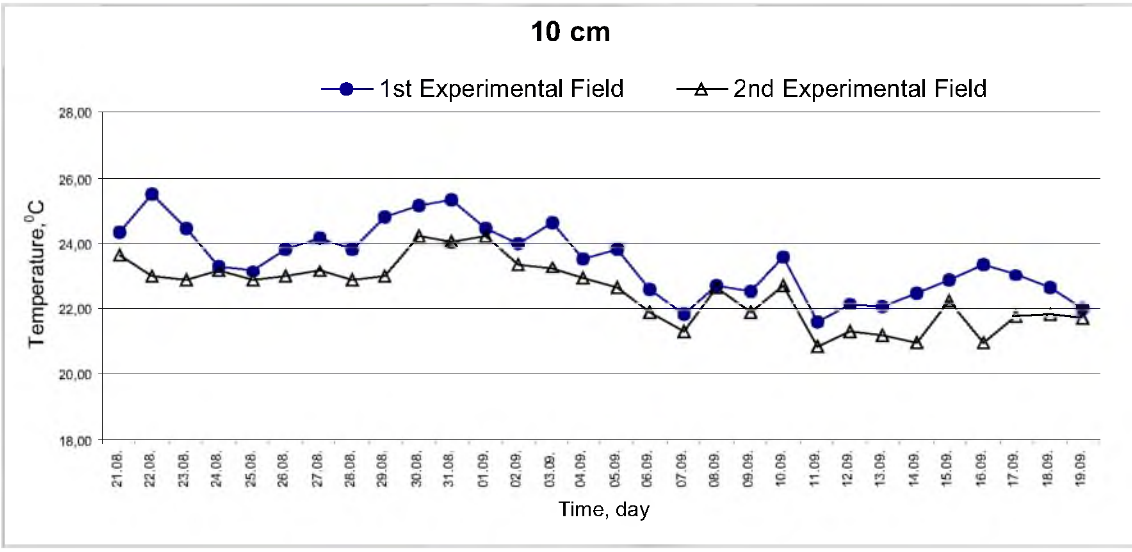
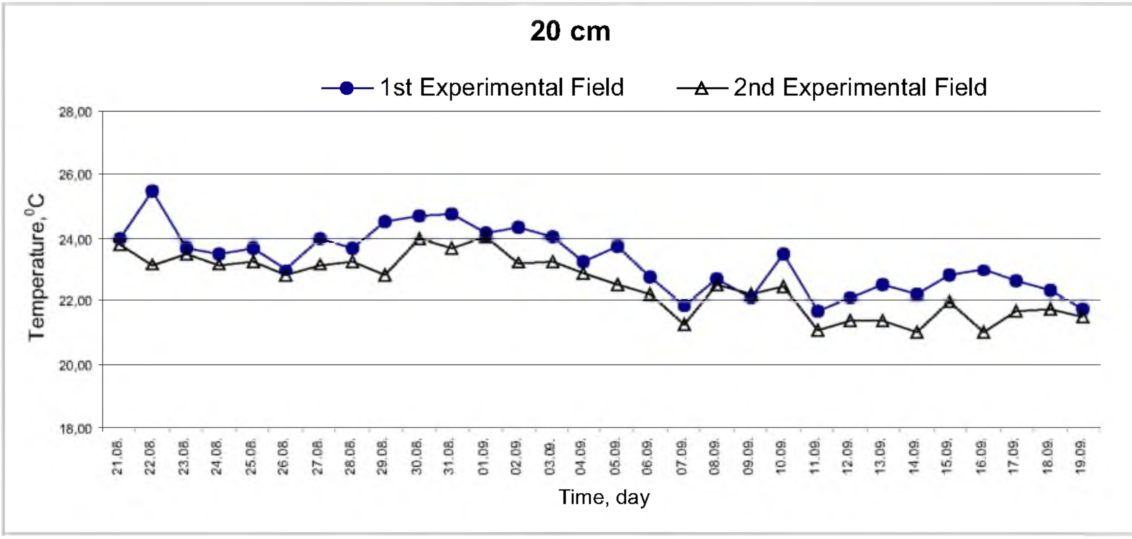


Figure 1 - Temperature in different layers of experimental soils





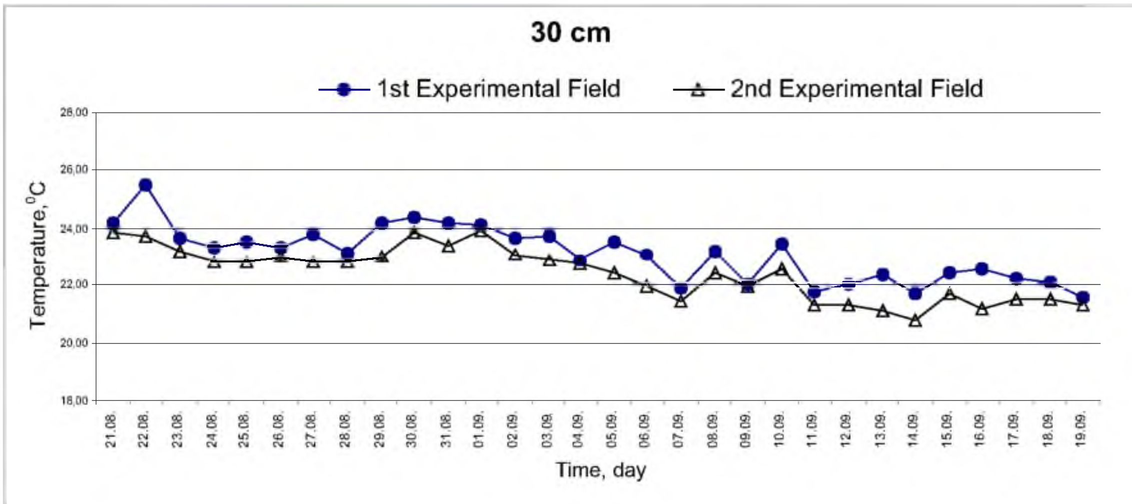


Figure 1 (continuous) - Temperature in different layers of experimental soils

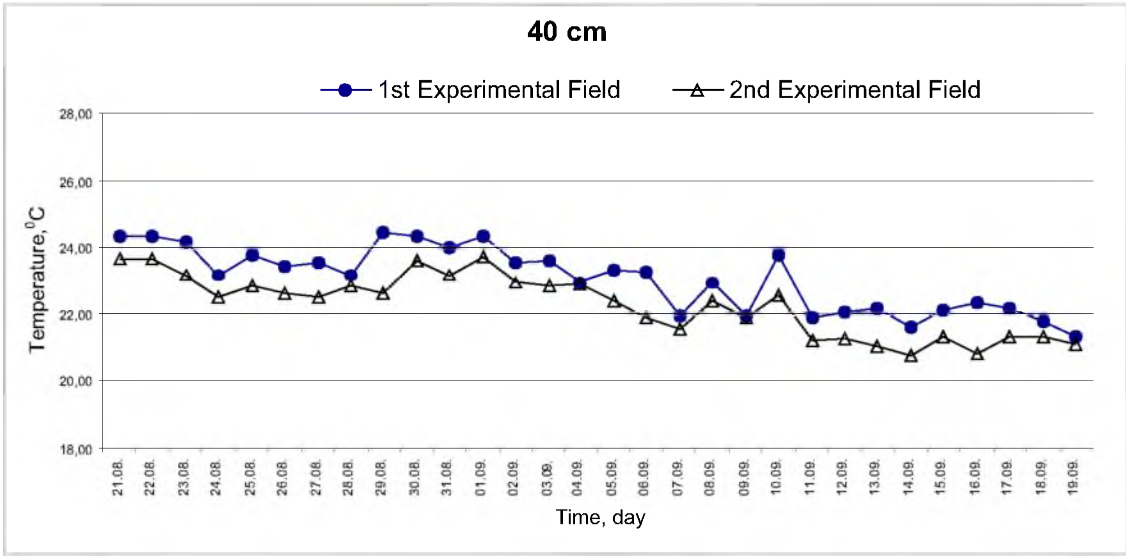


Figure 1 (continuous) - Temperature in different layers of experimental soils

Assessment of the thermal diffusivity coefficient

During the study, mean and maximum temperatures measured through soil profile are given in table 1 and 2. The standard errors of the mean temperatures (0.975-1.176 %) are minimum levels. The mean temperature values from 0 to 40 cm soil depth have no high fluctuations for both fields. Grass and trees have a clear impact on the amplitude of daily temperature fluctuation and slow down the rate of the total heat flow from soil surface, then changes in temperature occurs in a narrow range. However, the maximum temperature values at the first field are higher than the second field. Temperature variability in deeper soil layers of silt-loamy and loamy textured soils decreases due to the slow heating and cooling process and increased moisture content. Less temperature differences in deeper soil layers (at $\geq$ 30 cm) can be affected by the factors such as homogeneous soil structure, less heat penetration and relatively high moisture into deeper layers.

The amplitude and thermal diffusivity values through the soil profiles of the experimental fields calculated according to $A = T_m - T$ and equation (2); the values were given in table 3 and 4. Amplitude values of the 1st experimental field in the measuring times varied from 2.03 to 5.6°C at the soil surface and from 0.93 to 3.07°C at $\geq$ 10 cm depth. In the 2nd experimental field, these values varied from 1.97 to 2.77°C and from 1.30 to 2.46°C, respectively. Low temperature fluctuation and mean temperature values in deeper soil layers of both experimental fields caused significant reduction in amplitude values. Temperature values at the deeper soil layers in the 2nd field were lower than that of the 1st field, therefore the amplitude reduction in the 2nd field was higher than the other field.

The reason for the low thermal diffusivity at 12:00 when compared with the other measurement hours can be explained with the high temperature values through the soil profile and the maximum amplitude values at this time (heat flow is almost stabilized temporarily). The temperatures in deeper soil layers have usually the lowest variability than that of the soil surface, therefore at different times of the day, the temperature diffusivity coefficients at these layers were much higher than in the upper layers (Schachtschabel et al., 2001; Ekberli et al., 2011). The reason for the low temperature variability in the 2nd field at 18:00 can be explained by the fact that the cooling

Table 1. Average (T) and maximum (T_m) temperature values (°C) on the 1st experimental field by the soil profile. (21.08.-19.09.2011)

Depth, cm	Time (hour)														
	07:00					12:00					18.00				
	T	σ	$V,\%$	$P,\%$	T_m	T	σ	$V,\%$	$P,\%$	T_m	T	σ	$V,\%$	$P,\%$	T_m
0	19.47 ± 0.282	1.544	7.929	1.448	21.5	28.40 ± 0.495	2.713	9.552	1.744	34.0	23.41 ± 0.339	1.862	7.952	1.451	27.0
10	20.19 ± 0.264	1.448	7.172	1.310	23.0	26.93 ± 0.312	1.711	6.352	1.159	30.0	23.26 ± 0.274	1.503	6.462	1.179	26.0
20	20.66 ± 0.227	1.243	6.017	1.099	23.0	26.03 ± 0.262	1.440	6.253	1.141	29.0	23.14 ± 0.252	1.383	5.977	1.091	26.0
30	21.37 ± 0.215	1.179	5.512	1.007	23.0	25.25 ± 0.211	1.157	4.582	0.836	28.0	22.94 ± 0.222	1.217	5.305	0.968	25.5
40	21.37± 0.217	1.190	5.568	1.017	24.0	24.94 ± 0.192	1.055	4.230	0.772	26.5	22.86 ± 0.218	1.199	5.245	0.957	25.0
Average	20.61 ± 0.241	1.321	6.440	1.176	22.9	26.31 ± 0.294	1.615	6.194	1.130	29.5	23.12 ± 0.261	1.433	6.188	1.129	25.9

Table 2. Average (T) and maximum (T_m) temperature values (°C) on the 2nd experimental field by the soil profile. (21.08.-19.09.2011)

Depth,cm	Time (hour)														
	07:00					12:00					18.00				
	T	σ	$V,\%$	$P,\%$	T_m	T	σ	$V,\%$	$P,\%$	T_m	T	σ	$V,\%$	$P,\%$	T_m
0	19.35 ± .254	1.390	7.184	1.312	22.0	24.73 ±0.347	1.901	7.686	1.403	27.5	22.53±0.268	1.472	6.533	1.192	24.5
10	20.26 ±0.251	1.372	6.771	1.236	22.5	24.54 ±0.249	1.368	5.573	1.017	27.0	22.72 ±0.250	1.373	6.043	1.103	24.8
20	20.83 ±0.241	1.321	6.342	1.158	23.0	24.13 ± 0.220	1.210	5.013	0.915	26.0	22.57 ± 0.221	1.214	5.378	0.981	24.7
30	21.12 ± 0.219	1.199	5.678	1.042	23.0	23.70 ± 0.188	1.032	4.353	0.794	25.0	22.39 ±0.226	1.242	5.547	1.012	24.6
40	21.20 ± 0.195	1.069	5.043	0.921	23.0	23.47 ± 0.175	0.962	4.099	0.748	25.0	22.19 ± 0.218	1.195	5.384	0.983	24.5
Average	20.55 ±0.232	1.270	6.204	1.134	22.7	24.11 ± 0.236	1.295	5.345	0.975	26.1	22.48 ±0.237	1.299	5.777	1.054	24.6

Here: T - average temperature ◦C in layers; Tm- maximum temperature ◦C in layers;

$\sigma = \sqrt{\frac{(T-T_i)^2}{n-1}}$ - average standard deviation; T_i - temperature in layers, ◦C; $V = \frac{\sigma}{T}100$ - dispersion coefficient, %; $P = \frac{V}{\sqrt{n}}$ -error, %;

n - number of days.

process was fast and excess water leads to increase in the thermal diffusivity coefficient. In general, the soil temperature diffusivity coefficient depends on the variability of temperature and other climatic conditions, vegetation cover, soil properties (most frequently physical properties).

Table 3 - Measurement of temperature diffusivity amplitude (A,°C) and thermal diffusivity (a, $cm^2 s^{-1}$) on the 1^{st} experimental field by the soil profile (21.08.-19.09.2011)

Depth, cm	Time (hour)					
	07: 00		12:00		18:00	
	A	a	A	a	A	a
0	2.03	0.0000	5.60	0.0000	3.59	0.0000
10	2.81	0.0344	3.07	0.0101	2.74	0.0498
20	2.34	0.7198	2.97	0.0361	2.86	0.2813
30	1.63	0.6792	2.75	0.0647	2.56	0.2861
40	2.63	0.8672	1.56	0.0356	2.14	0.2173
Average	2.29	0.4601	3.19	0.0293	2.78	0.1669

Table 4 - Measurement of temperature diffusivity amplitude (A,°C) and thermal diffusivity (a, $cm^2 s^{-1}$) on the 1st experimental field by the soil profile (21.08.-19.09.2011)

Depth, cm	Time (hour)					
	07: 00		12:00		18:00	
	A	a	A	a	A	a
0	2.65	0.0000	2.77	0.0000	1.97	0.0000
10	2.24	0.1286	2.46	0.2580	2.08	1.2310
20	2.17	0.3640	1.87	0.0942	2.13	2.3840
30	1.88	0.2776	1.30	0.0572	2.21	2.4750
40	1.80	0.3887	1.53	0.1650	2.31	2.2939
Average	2.15	0.2318	1.99	0.1149	2.14	1.6768

Comparison of theoretic and experimental soil temperature values

When using a modelling method, in terms of evidence of the applicability of this model, one of the most important stages is the comparison of theoretical and experimental values. In this regard, the experimental soil temperature values of experimental fields at 0 and 20 cm soil depths were compared with the theoretical soil temperature values calculated using the basic thermal conductivity equation (1) based on the mean daily temperature between 27.08 and 30.08.2011 at 07:00, 12:00 and 18:00. Also, a curve $T(x,t)$ showing continuous changes in theoretical soil temperatures of experimental fields was created. The results obtained are given in Figures 2 and 3.

As shown in figure 2, measured soil temperature values at the soil surface (0 cm) of the 1st experimental field varied between 20.00 and 30.50°C; and the calculated values varied between 25.25 and 30.50°C. The mean relative error$\left(|T_{measured}-T_{calculated}|/T_{calculated}|\right)$ between the measurement and calculated results was 0.089. These measured and calculated temperature values of the 2^{nd} experimental field varied between 19.50 and 26.00°C, and between 23.16 and 26.36°C respectively, and the mean relative error between the measured and calculated values was 0.088. The vegetation cover caused a relatively narrow change between measured and calculated temperature values in the 2^{nd} experimental field.

The mean temperature, amplitude, mean air temperature (≈25°C) during the study have great impact on temperature variability in the experimental fields along with other factors (precipitation, density and distribution, soil humidity, organic substances, groundwater level, soil color, inclination angle and direction, altitude, etc.) (Dinç and Şenol 1997).

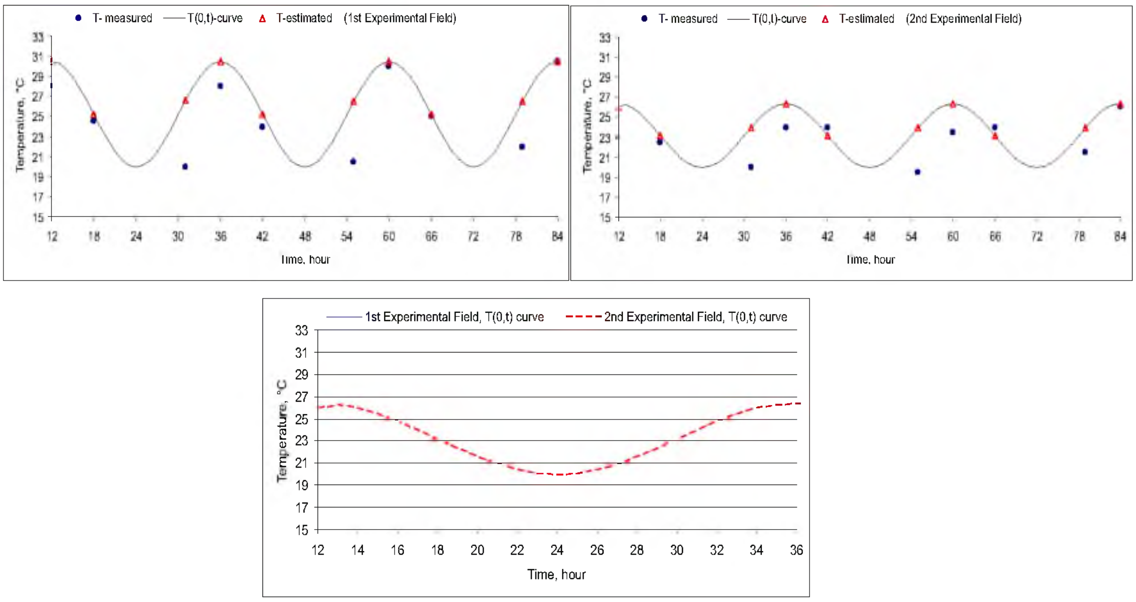


Figure 2 - Comparison of measured and calculated temperature values at a depth of 0 cm

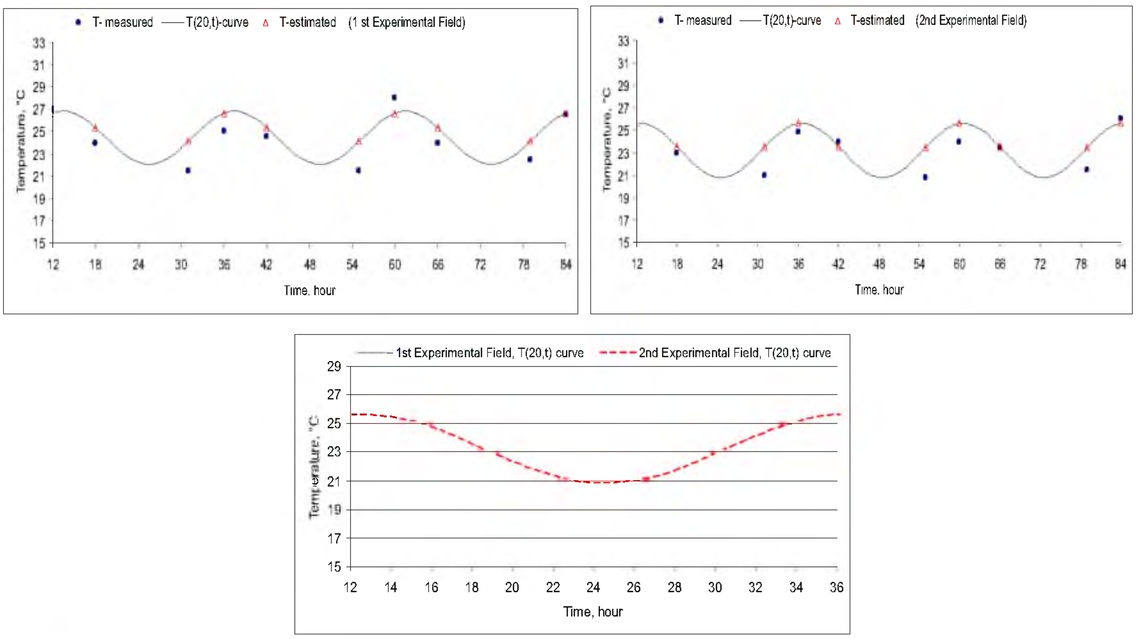


Figure 3 - Comparison of measured and calculated temperature values at a depth of 20 cm

As shown in figure 3, measured and calculated soil temperatures at 20 cm were within the limits of 21.50-28.00°C and 24.12-26.67°C in the 1st field, 20.80-26.00°C and 23.49-25.62°C in the 2nd field, respectively. The mean relative errors between the measured and the calculated values in the 1st and 2nd fields were 0.056 and 0.054, respectively.

According to these findings, the determination of periodic temperature fluctuation on the soil surface and deeper layers can be possible using the solution of equation (1). To determine this periodic distribution in deeper soil layers, the main factors different from the soil surface temperature are the mean temperature value of a particular layer, depth and the thermal diffusivity coefficient. Amplitude value in each layer is used to determine the soil temperature in this layer and surface amplitude and amplitude values in each layer is used to determine the thermal diffusivity at the surface or in each soil layer separately.

The comparison of theoretical temperature values to the measured values showed that periodic thermal changes on the soil surfaces and in soil layers in a short period (≤ 3 days) was defined much better with the solution of equation (1). Application of this solution in a long time period is restricted by the factors such as climatic conditions (Lei et al., 2011). Generally, boundary conditions cannot be harmonious all the time (sinusoidal or cosinusoidal) due to the large variability of daily heat received to soil surface. For this reason, this type or other similar studies cover the studies with heat distribution in dry or nearly dry soils, parent material or rock, soils including close boundary conditions and are limited to the use in natural conditions. Also, some factors such as the complexity of the temperature diffusivity process because of high soil humidity and latent heat emission during the freezing are impossible to take into account in the solution (Tihonov and Samarskiy, 1972; Ekberli et al, 2011). Furthermore, experimental determination of thermal conductivity parameters and comparison of these measurements with theoretical values should be made to improve the theoretical solution.

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РЕЗЮМЕ

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ИССЛЕДОВАНИЕ ИЗМЕНЕНИЯ ТЕМПЕРАТУРЫ ПОЧВЫ И ТЕПЛОВОЙ ДИФФУЗИИ ПОД ТРАВЯНИСТОЙ РАСТИТЕЛЬНОСТЬЮ И В ТЕНИ ДЕРЕВЬЕВ

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Изменения в температурном режиме почвы являются одним из самых важных компонентов микроклимата почвы и оказывают значительное влияние на изменение свойств почвы и развитие растений. В этом исследовании, температура почвы и значения теплопроводности определялись на двух различных полях, которые покрыты травой, и затемненных участках под персиковыми деревьями.

Теоретические значения температуры почвы, полученные из решения уравнения теплопроводности сравнили с экспериментальными значениями температуры почвы. Полевые исследования проводились на поле фермы в Турции, Самсун, округ Чаршамба, Есилирмакском районе (36 ° 43,380' к востоку, 41° 13,061' к северу) в период с августа по сентябрь 2011 года. Средняя температура почвы на первом экспериментальном поле, покрытом травой, в 7:00, 12:00, 18:00 часов были определены как 19,5° C; 28,4° C; 23,4 ° C на поверхности почвы, 20,2° C; 26,9° C; 23,3° C на глубине 10 см, 20,7° C; 26,0° C; 23,1° C на 20 см, 21,1° C; 25,3° C, 22,9° C на глубине 30 см и 21,4° C; 24,9° C; 22,9° C при глубине почвы 40 см, соответственно. Средняя температура почвы на втором опытном поле в тени персиковых деревьев в 7:00, 12:00, 18:00 часов была 19,4° C; 24,7° C; 22,5° C на поверхности почвы, 20,3 ° C; 24,5° C; 22,7° C на глубине 10 см, 20,8° C; 24,1° C; 22,6° C на глубине 20 см, 21,1° C; 23,7° C; 22,4° C на 30 см и 21,0° C; 23,5° C; 22,2° C на глубине почвы 40 см, соответственно. Средняя проводимость температуры на 1-м опытном поле в слое почвы от 0 до 40 см была 0.460 $cm^2 s^{-1}$; 0.029 $cm^2 s^{-1}$ и 0.167 $sm^2 s^{-1}$ в 700, 1200 и 1800 часов соответственно. Средняя проводимость температуры на 2-м опытном поле в почвенном слое от 0 до 40 см была 0.234 $cm^2 s^{-1}$; 0.115 $cm^2 s^{-1}$ и 1.677 $cm^2 s^{-1}$ в 7:00, 12:00 и 18:00 часов соответственно. Средние относительные погрешности между расчетными результатами с использованием решения уравнения теплопроводности и экспериментальными измерениями температуры были 0,089 на поверхности почвы и 0,055 на глубине почвы 20 см. Сравнение экспериментальных измерений температуры с расчетными значениями температуры показали, что исходное абсолютное решение уравнения теплопроводности в течение короткого периода (≤ 3 дня) дает гораздо лучшие периодические тепловые изменения на поверхности почвы и в слоях почвы.

Ключевые слова: температура почвы, температуропроводность, уравнения теплопроводности, измеренные и расчетные температуры

ТҮЙІН

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АҒАШ КӨЛЕҢКЕСІ АСТЫНДАҒЫ ТОПЫРАҚ ТЕМПЕРАТУРАСЫ МЕН ШӨПТЕГІ ЖЫЛУ ДИФФУЗИЯСЫНЫҢ ӨЗГЕРІСІН ЗЕРТТЕУ

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Топырақтың температуралық режиміндегі өзгерістер топырақ микроклиматындағы ең маңызды компоненттердің бірі және топырақ қасиеттерінің өзгеруіне және өсімдіктердің дамуына айтарлықтай ықпал етеді. Бұл зерттеуде топырақ температурасы мен жылу өткізгіштік мәні шөппен көмкерілген және шабдалы ағашы астындағы көлеңке жердегі екі түрлі алқапта анықталды. Жылу өткізгіштік теңдеуінің шешімімен алынған топырақ температурасының теориялық мәні топырақ температурасының эксперименталдық мәнімен салыстырылды.

Алқаптағы зерттеулер Түркия, Самсун, Чаршамба округі, Есилирмак ауданындағы (36 ° 43,380' шығысқа қарай, 41° 13,061' солтүстікке қрарай) фермалардың егістіктерінде 2011 жылдың тамызы мен қыркүйегі аралығында өткізілді. Бірінші тәжірибелік алқаптағы шөппен көмкерілген топырақтың орташа температурасы сағат 7:00, 12:00, 18:00- де топырақтың беткі қабатында 19,5° С; 28,4° С; 23,4 ° С, ал 10 см тереңдікте 20,2° С; 26,9° С; 23,3° С, 20 см тереңдікте 20,7° С; 26,0° С; 23,1° С, 30 см тереңдікте 21,1° С; 25,3° С, 22,9° С, 40 см тереңдікте 21,4° С; 24,9° С; 22,9° С болып айқындалды. Екінші тәжірибелік алқапта шабдалы ағашының көлеңкесіндегі топырақтың орташа температурасы сағат 7:00, 12:00, 18:00- де топырақ бетінде 19,4° С; 24,7° С; 22,5° С, 10 см тереңдікте 20,3 ° С; 24,5° С; 22,7° С, 20 см тереңдікте 20,8° С; 24,1° С; 22,6° С, 30 см тереңдікте 21,1° С; 23,7° С; 22,4° С, 40 см тереңдікте 21,0° С; 23,5° С; 22,2° С болып анықталды.

Бірінші тәжірибелік алқаптағы 0-ден 40 см аралығындағы топырақ қабатында температураның орташа өткізгіштігі сағат 7:00, 12:00 и 18:00-де 0.460 $cm^2\ s^{-1}$; 0.029 $cm^2\ s^{-1}$ и 0.167 $sm^2\ s^{-1}$ болды. Екінші тәжірибелік алқапта 0-ден 40 см дейінгі топырақ қабатында орташа температура өткізгіштік сағат 7:00, 12:00 және 18:00 0.234 cm^2s^{-1}; 0.115 cm^2s^{-1} және 1.677 cm^2s^{-1} б болды.

Жылу өткізгіштік теңдеуі шешімін пайдалану және температураны тәжірибелік өлшеудің есептік қорытындылары арасындағы орташа дәлсіздік топырақтың беткі қабатында 0,089, ал 20 см тереңдікте 0,055 болды. Температураның тәжірибелік өлшемдерін температураның есептік мәнімен салыстыру барысы көрсеткендей, қысқа кезең ішінде (≤ 3 күн) жылу өткізгіштік теңдеуін бастапқы абсолюттік шешу топырақ бетінде және топырақ қабаттарындағы мерзімдік жылу өзгерістерін жақсы көрсетеді.

Кілтті сөздер: топырақ температурасы, температура өткізгіштік, жылу өткізгіштік теңдеуі, өлшемдік және есептік температура