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WATER RETENTION RATIOS OF MULCHING MATERIAL CONSISTING PRIMARILY OF PINE BARK OVER DIFFERENT SOIL TYPES

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Abstract

Study was carried out in the Turkish province of Düzce to compare the water absorption ratios of a mulching material, formed using different mixtures of tree bark materials. Soils compounded from clay, turf and sandy materials were laid in 1m by 1m experimental plots within a thickness of 10 cm, and then, soil surfaces in each plot was blanketed with a mulching material containing Corsican pine bark (*Pinus nigra* Arnold) in 5 cm and 8 cm. thickness settings: Furthermore, application was repeated with and without the possibility of a plant species presence.

Experimental plots were watered every three days; 15 liters per plot using a colander. After 12, 24, 48 and 72 hours of watering, the first 10 cm up to the soil surface underneath the mulching material, was sampled to determine the weighing percentages of the internal moisture levels.

A statistically significant relation was established between the thickness of the mulching material and the site in terms of the soil moisture levels ($P= 0.0001$). Turf sheeted with an 8 cm mulching material kept the highest water absorption capacity 12 hours after watering, as opposed to the least water absorption capacity of sandy soil without a mulch cover. This ratio between the above mentioned comparisons was raised to 174 %, 24 hours after watering. However, moisture content of the sandy soil without mulching cover disappeared upto 90 % compared to that of turf with an 8 cm mulching material, over the period of 3 days after watering. Accordingly, the site with turf shielded by an 8 cm mulching material performed approximately two times better in terms of moisture absorption, compared to sandy soil with an 8 cm turf cover. Moisture was easily drained due to large pores inside the sandy soil if the mulching material was absent. Mulching, three days after watering, positively affected and increased the water absorption up to four times better.

Introduction

Water for plants survival, is the most essential ingredient (Kozlowski & Pallardy, 1997). However, water scarcity in majority of the terrestrial ecosystems is the most important stress factor affecting the plant growth (Kozlowski & Pallardy, 1997). Water is also the leading factor impeding plant development in Turkey, which is currently placed in a semi humid-semi arid climatic zone (Çepel, 1995). Due to high levels of evapotranspiration, a water deficit during vegetation period is always present in Turkey (Özyuvacı, 1999; Atalay, 2002). Because of the ever decreasing precipitation measures and the considerable attenuations on the subterranean and surface water sources, some ecological and even jurisdictional restrictions have been mandated to manage the available water sources. Furthermore, an initiative towards efficient irrigation systems and the selection of specific plant species better withstanding dry conditions has been started and economical incentives are also given by the government.

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More than half of the amount of precipitation received in semi-humid, semi-arid regions, returns to atmosphere by means of evaporation (Brady & Weil, 1999). Although capillary cavity structure and rate occur more often in clayey soils, the same rate in sandy soils decreases due to their large particle composition (Paul & Clark, 1996). Since capillary cavity network descend to the very depths of clayey soils without hindrance, these soils can easily be dried up to where this capillarity reaches during the dry summer seasons, whereas, the easily broken water column in sandy soils, does not allow the water to be sucked through capillarization from the depths of soil profile (Kimmins, 1997).

To keep the water from evaporating from the soil surface and to control the underbrush, soil surface is blanketed with inorganic (geo-textile, stone, pebble, plastic tarp, etc.), or organic (sawdust, manure, hay, leaves, bark, etc.) material, which is called mulch. Mulch originated from organic materials with its generally large porous composition can reduce the water losses in mineral soils (Kimmins, 1997). Dahiya *et al*., (2007) reported that untreated harvest residue (stem and straw) reduced the water loss 0.39 mm at average per day, compared to control plots, in a typical "Hapludalf" powdery wet clay in Germany. Besides, mulching also decreased soil temperature 0.74 C^0 and 0.66 C^0 at depths of 5 cm and 15 cm, respectively. Further that large porous composition increased throughout the soil surface, provides more water to turn into soil moisture and decreases storm water runoff (Mulumba *et al*., 2008).

Since mulching is an expensive operation, it is generally employed in floriculture, fruit and vegetable cultivation, etc. In addition to the water conserving effect of mulching, it may also dampen soil borne disease; eliminate weeds; keeps the soil from overheating; increase the infiltration; supplies nutrients; promotes living organism populations in soil; lessens the irrigation intervals; and increases soil aeration by preventing soil compaction etc. (Rees *et al*., 1999; Yamarak *et al*., 2004; Diaz *et al*., 2005; Dahiya *et al*., 2007). These significant benefits gained when organic matter was used as mulching material which cannot be obtained if polyethylene based inorganic material were to be used. For example, since organic matters have countless electric laden internal facades, which can grasp the water molecules and plant nutrients, in the form of ions, they prevent the loss of important plant nutrients such as nitrate (NO_3^-), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) from the system (Rees *et al*., 1999). Besides, using plastic mulching materials may result in unexpected consequences. For example, soil temperature in a field mulched with plastic materials may go up to 8-10 C^0 degree higher than that of a field mulched with organic materials during summer (Brady & Weil, 1999). Organic materials may reveal the visual effects garden *via* increasing the impacts of plants in the composition.

Tree barks are among the most attractive and expensive organic mulching materials. Tree barks can resist decomposition for many years. During cool season mulching with tree barks can increase soil temperature about 3-5°C degree. Thus plant roots grow better and vegetation season can extend several weeks. Thickness of mulching materials laid on soil surface depends on water holding capacity and drainage of the site. For example, since it dries earlier than the other soil types, sandy soils may require thicker mulching materials. On the other hand soil with high soil moisture during most of the growing season may not benefit from mulching at all. Using excessive mulching materials may contain root growth in organic material and restrict to growth into minerals soil.

To produce mulching materials from the barks usually cedar, pine and fir trees are preferred. Some regions have opportunity for producing cheap mulching materials from the residues of agriculture, forestry and other related plant operations developed in the region. For example, Turkey has more than 12 million hectare conifer forest lands (Anon., 2006). And harvesting residues from these forestlands create significant opportunities for production of mulching materials. Therefore the aims of this study were to compare water-holding capacity of different soil types covered with mulching materials produced from pine barks and 2- to give suggestions to landscape and garden practitioners.

Materials and Methods

The study which was formulated to compare the water absorption ratios of a mulching material, formed using different mixtures of tree bark materials, was conducted in the Turkish province of Düzce with annual average precipitation and temperature rates of 850 mm and 13^{o}C, respectively (Yildiz *et al*., 2007). In the study, soils compounded from clay, turf and sandy materials were laid in 1m by 1m experimental plots within a thickness of 10 cm, and then, soil surfaces in each plot was blanketed with a mulching material containing Corsican pine bark (*Pinus nigra* Arnold) in three different thickness settings of 0, 5 cm and 8 cm. Furthermore, keeping the fact that plants would affect the soil water retention through their natural cycle of evaporation, in mind, every application was repeated with and without the possibility of a ground-cover plant species presence. Treasure flower (*Gazania reptens)* was used for plant species. Treasure flower can grow up to 30 cm height, it can tolerate water stress, but not shade. It is a perennial ground cover species. Experiment used 3*3*2 factorial design with tree replications.

Experimental plots were watered every three days @ 15 liters per plot using a colander. After 12, 24, 48 and 72 hours of watering, the first 10 cm up to the soil surface underneath the mulching material, was sampled and weighed and then every sample was oven dried at 105^{o}C and weighed again to determine the weighing percentages of the internal moisture levels. Measurements were repeated & 4 weeks where during July and August of 2007.

During measurement the experimental plots did not receive any out source water (rain etc.) besides controlled watering. The average daily temperature measured by Düzce meteorology station was 24 ± 2^{o}C. The average relative humidity during measurement was recorded as 66 ± 6%.

Analysis of variance was performed according to factorial analysis. SAS (Sas, 1996) was used for statistical software. The results were considered statistically different at alpha= 0.05 level.

Results and Discussion

Results showed that presence of plant did not affect soil moisture ratios 12, 24, 48 and 72 hours after irrigation. However, thickness of mulching had significant effects on each of the four measurements (*p=0.0001*). Twelve hours after irrigation, soil moisture ratio (SMR) of the plot mulched with 8 cm turf (T8) was 127 % higher than that of the sandy soil plot without mulching (S0). This particular ratio between the above mentioned comparisons was even raised to 174% at the 24th hour after watering. Water absorption capacity measured at the 48th hour after watering was similar to the measurement taken at the 24th hour. However, up to 90% of moisture content of the S0 plots disappeared compared to that of T8 plots, over the period of 3 days after watering. Accordingly, the T8 sites performed approximately two times better in terms of moisture absorption, compared to sandy soil with an 8 cm mulching cover (S8). Water can easily drain inside the sandy soil due to large pores if the mulching material is absent. However, mulching increased the water absorption capacity of sandy soil up to four times even three days after watering. Diaz *et al*., (2005) investigated the affects of mulching thickness and size of mulching granule on water evaporation in a volcanic region (basaltic tephra) with less than 150 mm annual rain in Canary Island of Spain. Results of their research showed that water evaporation decreased with mulching thickness. Water evaporation was reduced by 92 and 52% with 10 and 2 cm thick mulching cover, respectively. The present study was conducted in a region with much higher annual precipitation (>800 mm) but the relationship between mulching thickness and evaporation was similar to the findings of Diaz *et al*., (2005). T8 plots hold 15% more water than the turf plot without mulching (T0) at the 12th hour after watering. The difference between these two plots increased up to 52% at the 24th hour after watering. The difference was leveled of at the 48th hour after watering. But, at 72th hour after watering T8 plot contained two times more soil water than T0 sites (Fig. 1a).

The plots containing clay soils showed similar trend to turf site in terms of water retention. Clay soil covered with 8 cm mulching materials (C8) hold 16 % more water than the plots contain clay soil but without mulching (C0) 12 hours after watering. This difference increased up to 90% at the 24th hour after watering and stabilized at the 48th hour after watering. However, C8 plots had 1.5 times more water than that of C0 plots at the 72th hour after watering (Fig. 1b).

In sandy soils, the difference in soil water retention between the sites with 8 cm mulching (S8) and without mulching (S0) was about 35% at 12th hour after watering. This ratio for the same mulching thickness and period was significantly higher than those of the other two soil types (turf and clay). This difference in soil water between the soil types can be attributed to the fact that sandy soils with higher ratio of macro pores drained the water more easily than the other two soil types. Soil water ratio of S8 plots was 60% higher than that of the S0 sites at the 24th hour after watering. The same ratio between the treatments was sustained at 48th hour after watering. But at 72th hour after watering S8 plots had about 4 times more soil water than that of S0 plots (Fig. 1c). The data indicate that water retention affects of mulching is more pronounced for sandy soil than clay soil and turf sites. The results also imply that after irrigation considerable amount of water was drained through macro-pores in the first 24 hour period. After free drainage rest of the water was held by soil matrix at field capacity. Therefore, after the first day there wasn't any significant change in soil moisture between the sites. However, high temperature kept evaporating soil water and at the end of the third day after watering the plots without mulching lost significant part of their soil moisture (Fig. 1 a,b,c).

Moisture content of S0 differed from those of C0 and T0 (Fig. 2a) and more than two times water holding difference between T0 and S0 sites was retained during 3 days period after watering (Fig. 2a).

Turf plots mulched at 5 cm thickness (T5) contained 55 and 78 % more water than clay soil (C5) and sandy soil (S5), respectively with the same mulching thickness at the 12th hour after watering. After the first 24 hour period T5 site contained 50 and 90 % more water than C5 and S5 plots, respectively (Fig. 2b). The ratio of the water holding capacity among the treatments for the first 24 hour period sustained until the 48th hour after watering. But at the end of the 3rd day T5 plots had 35 and 93% more soil water than those of C5 and S5 plots (Fig. 1b).

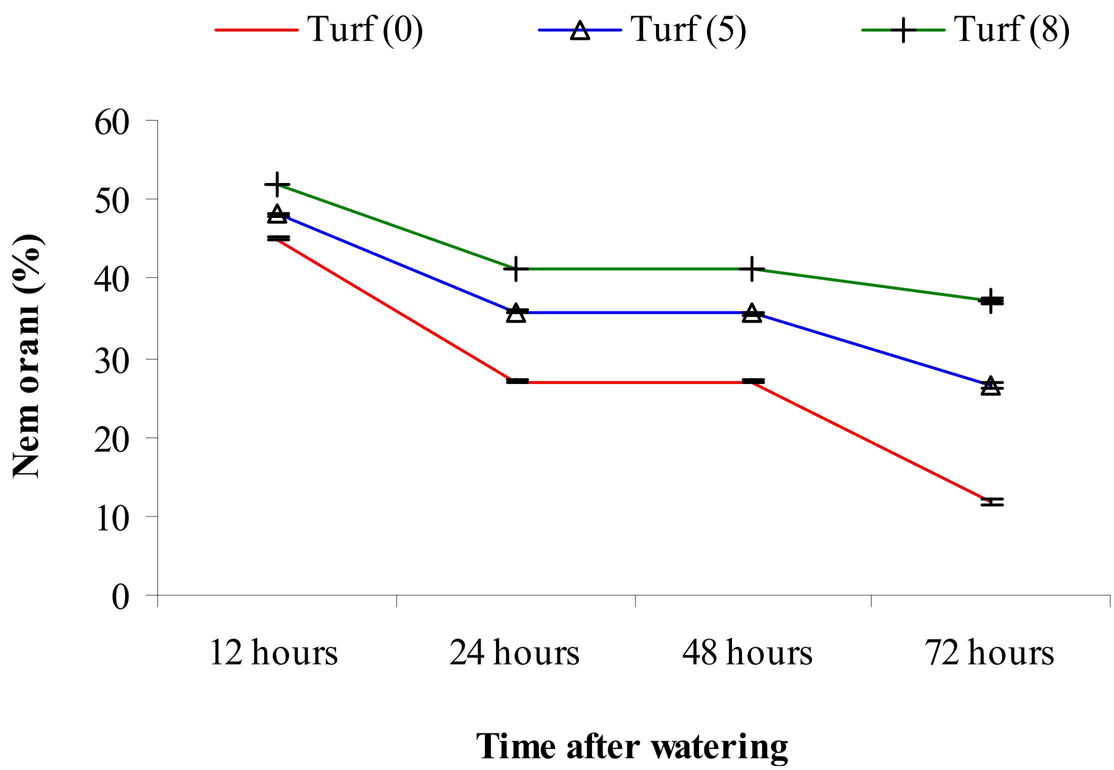

Fig. 1a. Mean and ± std error of moisture rates (weight: weight) at 10 cm soil depth of the sites containing organic turf as a growing medium and covered with pine barks at tree layer thickness (0, 5, 8 cm).

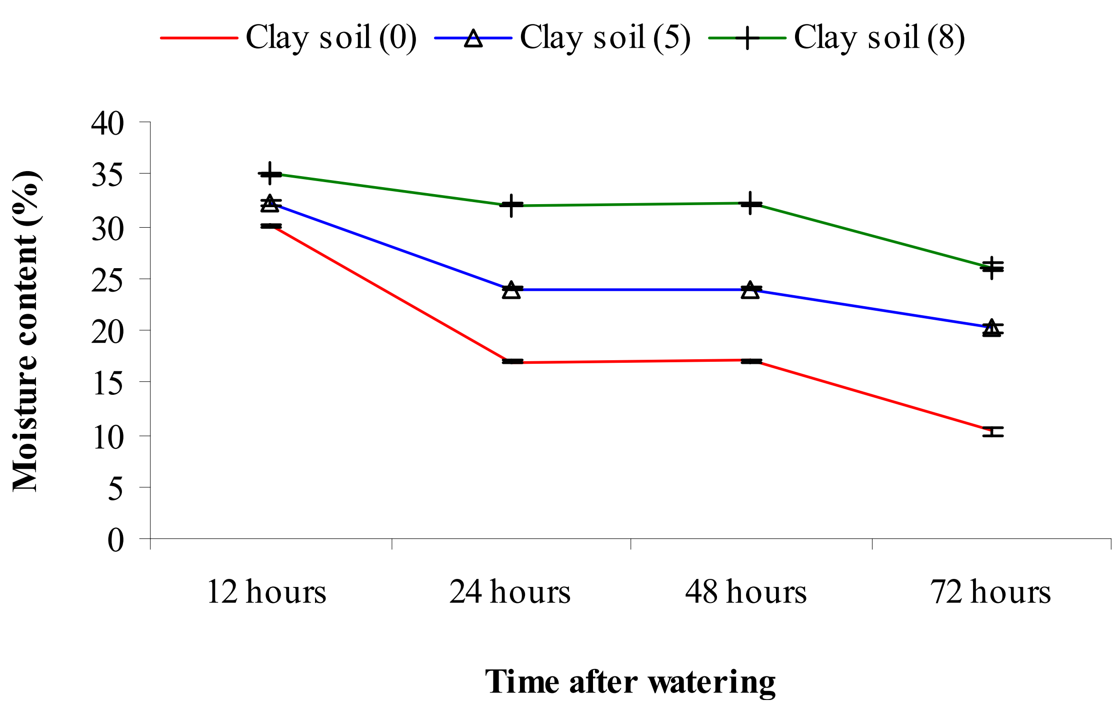

Fig. 1b. Mean and ± std error of moisture rates (weight: weight) at 10 cm soil depth of the sites containing clay soil as a growing medium and covered with pine barks at tree layer thickness (0, 5, 8 cm).

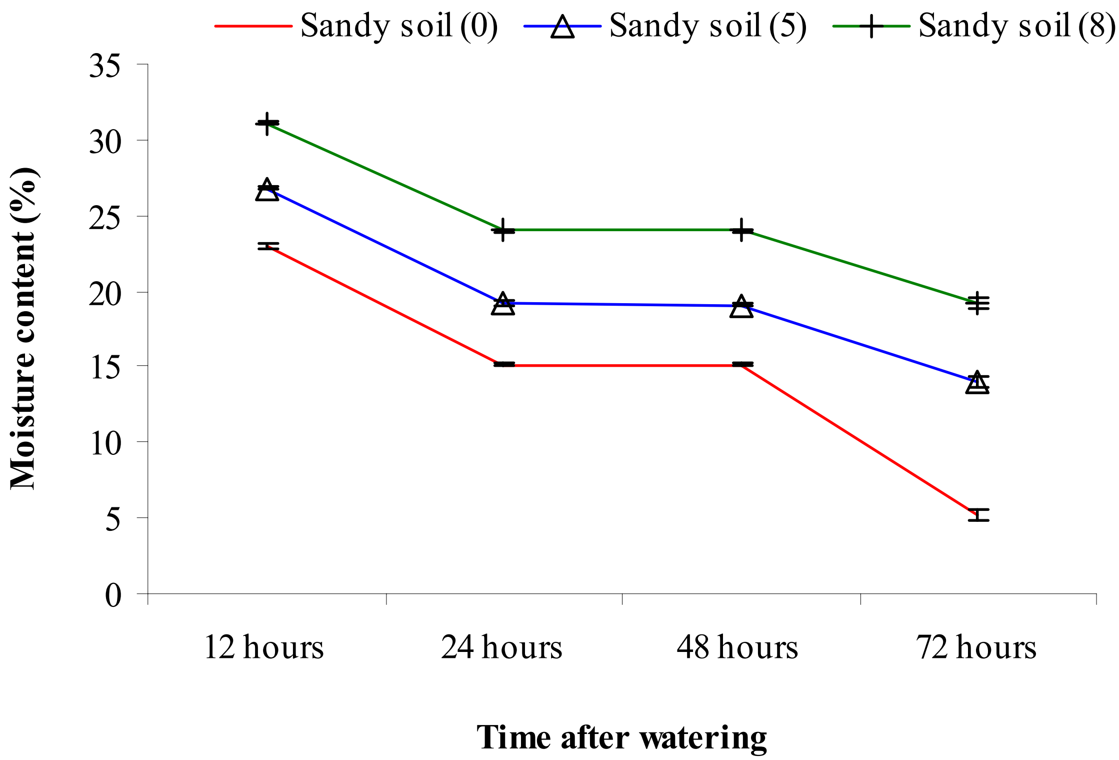

Fig. 1c. Mean and ± std error of moisture rates (weight: weight) at 10 cm soil depth of the sites containing organic turf as a growing medium and covered with pine barks at tree layer thickness (0, 5, 8 cm).

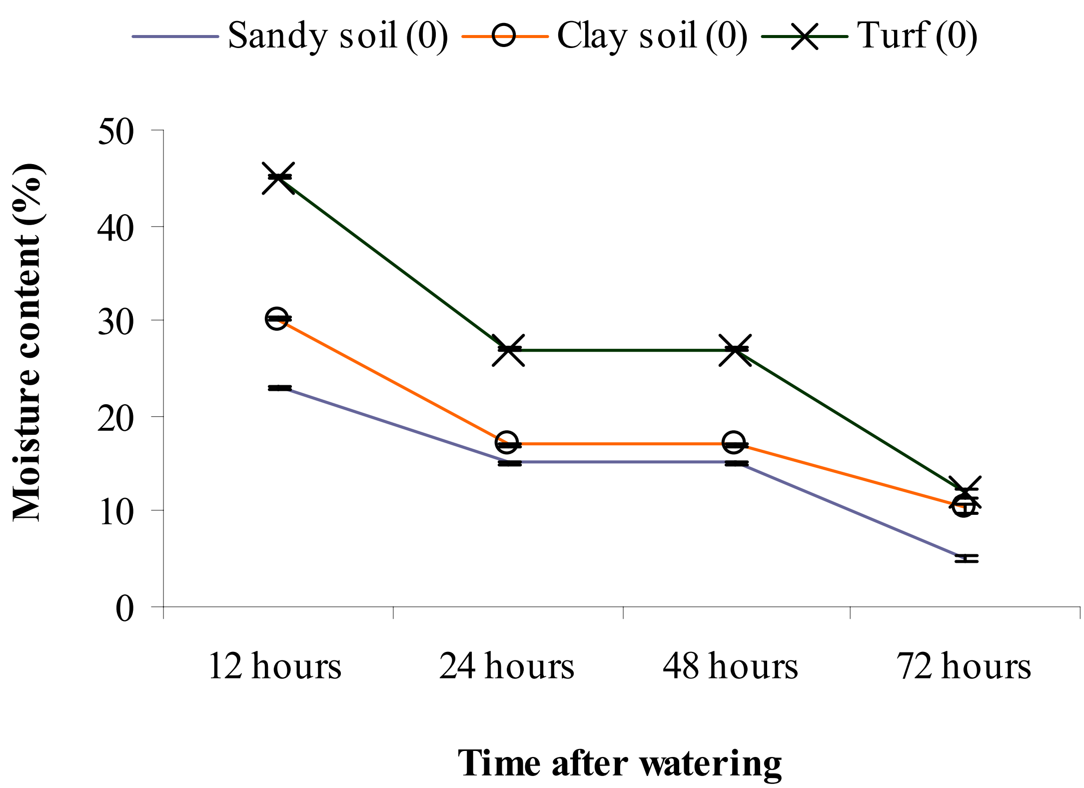

Fig. 2a. Mean and ± std error of moisture rates (weight: weight) at 10 cm soil depth of the sites containing different soil types (turf, clay and sandy soils) with no cover of mulching materials.

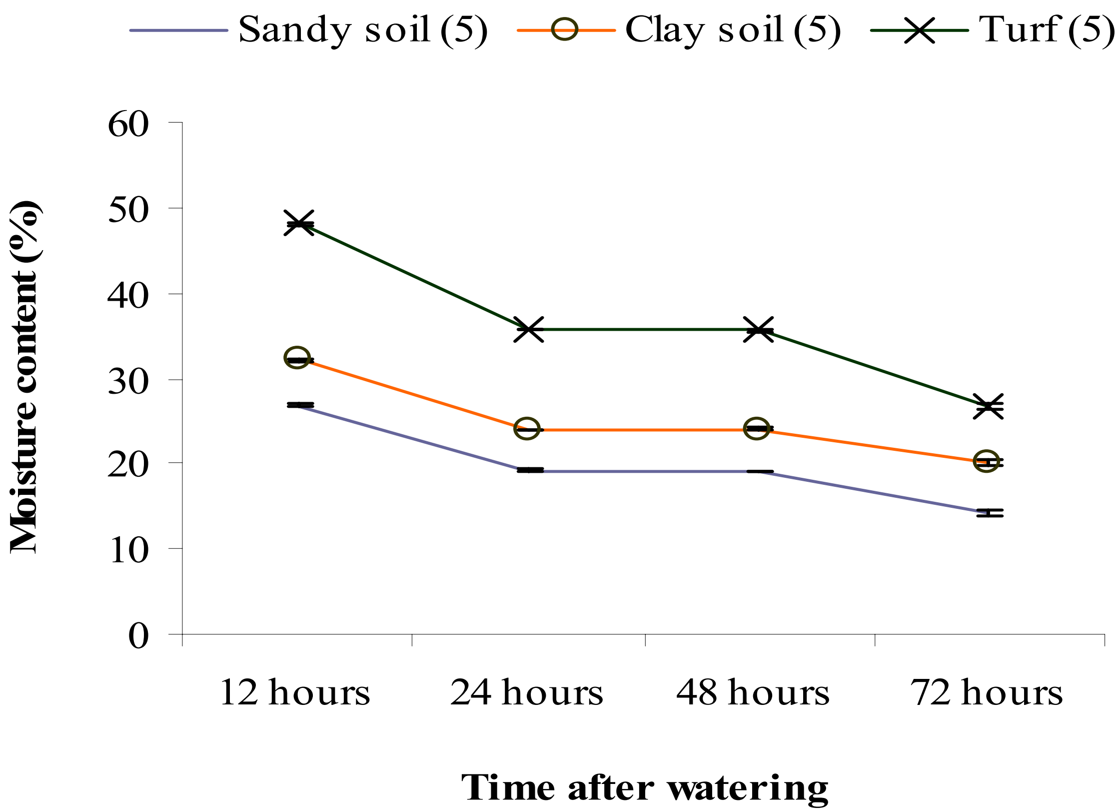

Fig. 2b. Mean and ± std error of moisture rates (weight: weight) at 10 cm soil depth of the sites containing different soil types (turf, clay and sandy soils) and covered with pine barks at 5 cm layer thickness.

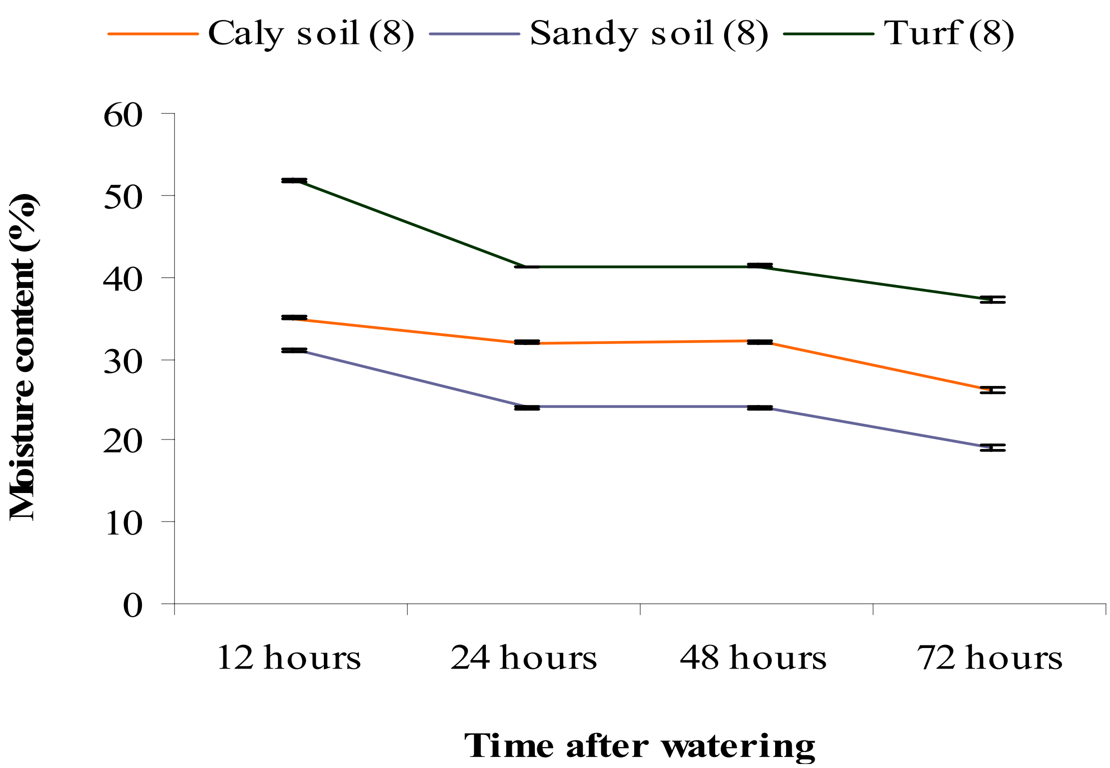

Fig. 2c. Mean and ± std error of moisture rates (weight: weight) at 10 cm soil depth of the sites containing different soil types (turf, clay and sandy soils) and covered with pine barks at 8 cm layer thickness.

The sites covered with 8 cm thick mulching materials the data showed that T8 plots had 49 and 68% more soil water than those of C8 and S8 sites, respectively at the 12th hour after watering. After the first 24 hours, the difference between T8 and C8 sites decreased to 29 %. But the difference between T8 and S8 for the first 24 hours was retained at the 48th hour after watering. At the end of the 72th hour after watering T8 plots had 42 and 95% more soil water than those of C8 and S8 sites, respectively (Fig. 2c).

Clay soil has higher soil surface and lower ratio of macro pores, so clay soil holds water more strongly than sandy soils (Kimmins, 1997). Since organic materials have large surface area and high surface charge, it can hold water up to several times of its own weight (Kilham, 1996). The water applied to sandy soils can rapidly drain from the soil profile. Because of lower matrix potential of sandy soil significant amount of soil water is lost with gravitational force (Fisher & Binkley, 2000). Even though, turf and clay soil contains more water in the absolute amount 3 days after watering, relative affects of mulching on soil retention ratios was more pronounced in sandy soils.

Most of the regions in Turkey receive less than 600 mm precipitation and considered semi-arid regions. Therefore, mulching may benefit landscape and garden practices in the inner land and southern part of Turkey. However, besides knowing water saving affects of mulching, the affects of different mulching types on soil and plant needs to be studying in different regions and habitats. Mulching in dry and semi-dry lands may prevents water evaporation by increasing resistance to capillary water movement from the deeper part of soil profile. Thus, mulching may also decrease salt accumulation which is usually a big problem for these areas.

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