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*Full Length Research Paper*

# The effects of different soil tillage methods on soil water dynamic

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**Water is an important factor effecting plant growth especially under dry farming conditions. Therefore, different factors, such as mulch, organic matter, polymer and different soil tillage application, to decrease the water loss from soil was extensively studied. Among these practices, methods of soil tillage is important, because its effects may vary from region to region. In this study, different methods of soil tillage; Chisel ploughing (C), chisel ploughing combined with combine harrowing (CK) and chisel ploughing combined with disc harrowing (CD) in a 3 year crop rotation (sunflower (*Helianthus annuus* L.)-barley (*Hordeum vulgare* L.)-Hungarian vetch (*Vicia pannonica* Crantz)+triticale) were studied in 2005 - 2006 season under dry conditions in loamy soil. Soil moisture dynamics were measured when Hungarian vetch+triticale was cultivated. When moisture loss is high, volumetric soil moisture was measured at different depths (10, 20, 30, 40, 60 and 100 cm) at four day intervals to measure soil moisture during the month of May in 2005 - 2006 season. Although there were no statistical differences among soil tillage methods, moisture values found at different depths in the soil varied depending on the measurement period ($P < 0.01$). In addition, different soil tillage methods had different effects on soil moisture content during the measurement period ($P < 0.01$). The compaction on top of the soil caused by CD method had a positive effect on moisture content and yield; however, the CK method led to an increase in soil moisture loss. Therefore the effects of secondary cultivation machines may vary to a great extent.**

**Key words:** Chisel plowing, soil tillage, soil moisture.

## INTRODUCTİON

All mechanical applications on soil, the principal aim of which is to cultivate soil for sowing seeds, though they may have other functions as well, are in the scope of soil tillage. Depending on the soil tillage methods, it is known that soil depth, level of organic matters and differences in pore geometry may all be pressure elements on plant growth. Besides this, different soil tillage methods can affect soil's behaviour against erosive factors. Therefore, soil tillage methods have a significant effect on sustainable soil management.

There are many different research reports dealing with on the effects of the different soil tillage methods on surface roughness (Guzha, 2004), penetration resistance (Licht and Al-Kaisi, 2005; Çetin et al., 2005), aggregation properties (Hermawan and Bomke, 1997; Doğan et al., 2000; Işildar and Bayhan, 2005), bulk density (Dao, 1993; Çetin et al., 2005; Özpınar and Çay, 2005) and seedling emergence and yield (Özpınar and Işık, 2004).

Under dry farming conditions, among the applications to retain soil moisture so that plants can benefit most, choosing the right tillage method has a great importance. On the other hand, on the land where dry farming applications are carried out, it is essential that surface flow be decreased and infiltration be increased so that more water can be retained in the soil. Guzha (2004) examined the effects of different soil tillage methods on soil moisture content, surface roughness, infiltration and sorghum grain yield. Infiltration rate was significantly higher in the tilled soils than untilled soils. It was well known that conservative soil tillage methods such as raise soil water storage capacity, due to high infiltration

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**Table 1.** Meteorological data when soil water content was measured in May and June months in 2006.

| Dates (May) | Air temperature (°C) | Precipitation (mm) | Dates (June) | Air Temperature (°C) | Precipitation (mm) |
|---|---|---|---|---|---|
| 18 | 13.6 | - | 1 | 22.8 | - |
| 19 | 14.1 | 1.2 | 2 | 24.2 | - |
| 20 | 16.7 | 0.7 | 3 | 24.6 | - |
| 21 | 19.1 | - | 4 | 24.4 | - |
| 22 | 19.8 | - | 5 | 24.1 | - |
| 23 | 21.4 | - | 6 | 22.0 | - |
| 24 | 22.2 | - | 7 | 20.4 | - |
| 25 | 22.5 | - | 8 | 18.0 | - |
| 26 | 20.7 | - | 9 | 14.3 | 0.1 |
| 27 | 19.7 | 0.2 | 10 | 14.2 | 14.3 |
| 28 | 19.8 | - | 11 | 16.4 | 1.0 |
| 29 | 20.2 | - | 12 | 17.7 | - |
| 30 | 20.5 | - | 13 | 15.4 | - |
| 31 | 20.2 | - | 14 | 15.3 | 6.8 |
| | | - | 15 | 16.7 | - |
| | | - | 16 | 18.3 | - |
| | | - | 17 | 18.9 | - |

and low evaporation (Jones et al., 1968; Triplett et al., 1968). Gomez et al. (1999) studied effects of two different soil tillage methods (conventional and zero tillage) in an olive orchard in South Spain for 15 years. Researches found that surface soil organic matter content, bulk density and hydraulic conductivity showed significant differences between the tillage methods. In addition, Fabrizzi et al. (2005) reported the effects of minimum tillage and no tillage on soil temperature, soil compaction and soil water storage capacity and crop yields. No tillage showed higher soil water storage capacity during the growth stage, but in both tillage systems available water has been frequently below the 50% threshold.

Owing to the variety of plant species, soil characteristics, climate conditions, different soil tillage methods may not be able to used. Besides this, properties of the cultivation equipment may vary greatly. The objective of this study was to find, effects of different soil tillage methods on plant growth and soil moisture dynamics under dry farming conditions in Isparta Turkey and to explain the causes of potential differences among treatments.

## MATERIALS AND METHODS

This study that was started in 2001 was carried out in the research farm of (37°50'31" N, 30°32'09" E, 1015 m elevation, 1% slope) the faculty of Agriculture at Suleyman Demirel University. The experiment soil has a xeric soil moisture and mesic soil temperature regime (Akgül et al., 2001). The experimental soil composed of sand 33.9%, silt 43.8% and 22.3% clay. Soil pH was 7.84, electrical conductivity was 0.256 dS $m^{-1}$, organic carbon was 6.55 $gkg^{-1}$ and cation exchange capacity was 29.29 cmol $kg^{-1}$ (Bayhan et al., 2005).

The 52 year (1931 - 1980) average annual rainfall was 600.4 mm, the highest precipitation month is december (100 mm) and the dryest month is agust (9.6 mm). Of the total annual rainfall 77.3% was recorded during October - April. The average annual air temperature was 12.1°C, the annual evaporation amount was 123.6 mm (Utku, 1990). Meteorological data were the experimental year are shown in Table 1. In experiment, three plant species, sunflower, barley and hungarian vetch + triticale mixture rotation, and three tillage systems chisel ploughing (C), chisel ploughing combined with combine harrowing (CK) and chisel ploughing combined with disc harrowing (CD) were used. The study was set up as three replications randomly assigned, and each plot (3 x 50 m) in the 2005-2006 production year. In all tillage treatments, chisel applications were done at 20 - 25 cm depth on 22.09.2005. Disc and combine harrowing in CD and CK applications were done at the same day at 8 -10 cm depth, before sowing (10.10.2005). Planting and row distances were 0.13 m was performed by a pneumatic planter, seeding rate was 76.6 $kgha^{-1}$. Plants were not fertilized. Fiberglass tubes (115.4 cm height and 2.8 cm diameter) of a moisture meter device (-ΔT-PR2 Model) were placed on the plots as four repetition in April. Soil water amount was determined at every 4 day during 222 and 250 days of vegetation period at soil depths of 10, 20, 30, 40, 60, and 100 cm to monitore the moisture dynamics along soil profile. Disturbed and undisturbed soil samples were taken from 5 cm intervals at depths of 0 - 20 cm. Bulk density (Blake and Hartge, 1986), field capacity and wilting point (Klute, 1986) were determined. Available water capacity was calculated from difference in soil moisture content at field capacity (-33 kPa) and wilting point (-1500 kPa). Plants were harvested to a total 5 $m^2$ of 1 $m^2$ $plot^{-1}$ on 17 June 2006. Plant samples were dried at 65°C and dry matter yield were determined. Statistical analyses were calculated using SPSS statistical programme version 15.0..

## RESULTS AND DİSCUSSİON

### Soil moisture dynamic

For different soil tillage methods; between the 222nd and

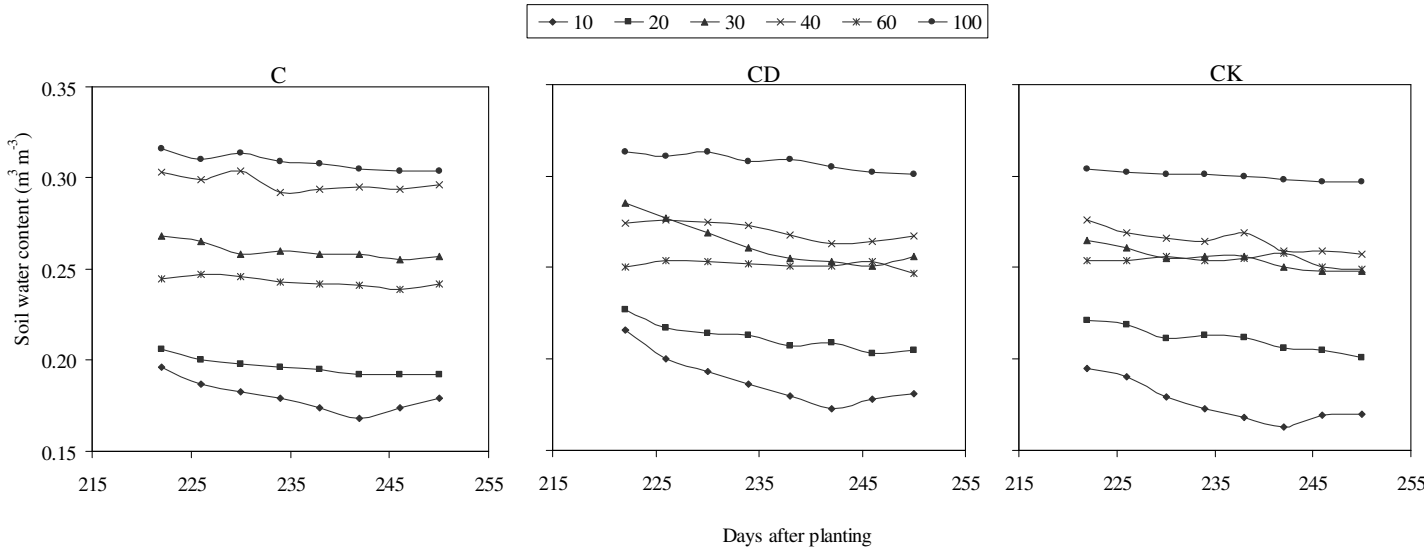


**Figure 1.** The effects of different soil tillage applications on the changes in moisture content at various soil depths. (Day; F = 89.42, P<0.01, DayxTreatment; F = 2.64, P <0.01, DayxDepth; F = 7.24, P < 0.01, DayxTreatmentxDepth; F = 1.30, P = 0.078).

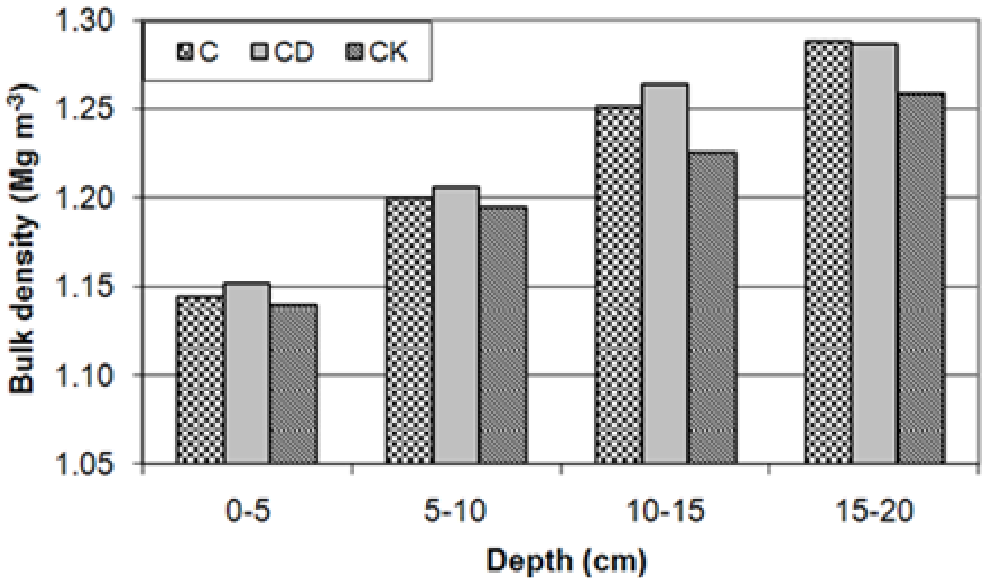


**Figure 2.** The effects of soil tillage methods on the bulk density. (Treatment; F = 3.80, P <0.05, Depth; F = 54.85, P <0.01, TreatmentxDepth; F = 0.519, P = 0.79)

250th days of plant vegetation, volumetric soil moisture at different depths in soil are shown in Figure 1. Due to precipitation, evapotranspiration and water movement variation in the soil moisture depending on soil depth was not found constant during the measurement period (P < 0.01).

At the beginning(222nd day), at 10 cm soil depth, soil moisture values were found higher for the CD method compared to the other methods and this was true for 20 cm depth, too. At the depth of 0 - 15 cm, in the CD method, the bulk density values found after the harvest were (Figure 2) higher than the other methods. This is due to the fact that compaction in the soil at certain depths help to raise the number of pores, which retain water (Çetin et al., 2005). In the methods in which disc harrow is used as secondary soil tillage machine at 0 – 10 cm soil depth, one can attribute the higher bulk density to the fact that disc harrow causes compaction in the soil. In addition, in a study carried out by Şeker and Işildar (2000) it was found that a tractor's passing twice on the same spot brings the rate of pores to the level of control practice and a four time passing causes it

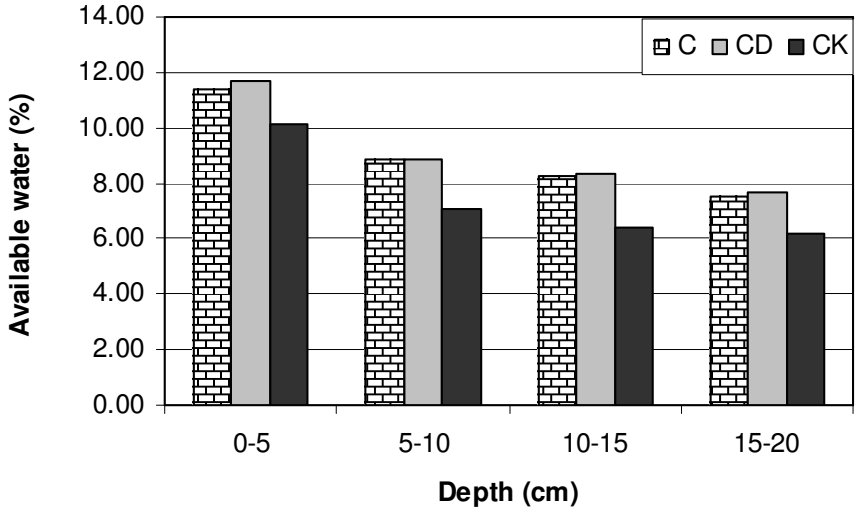


**Figure 3.** The effects of soil tillage methods on the available water. (Treatment; F = 4.12, P<0.05, Depth; F = 10.87, P <0.01, TreatmentxDepth; F = 0.03, P = 1.00).

to get above the control level. In this study, at 20 cm depth, the highest level of available water amount was also found in the CD method (Figure 3). Differences in soil moisture at 30 - 40 cm soil depth between CK and CD methods can be related to the fact that CK method indicated lower bulk density values at 0 – 20 cm soil depth. On the other hand, the fact that soil moisture values were low for the C practice at 10 - 20 cm soil depth and the difference it indicated compared to the other methods at 40 cm soil depth seemed to support the above findings. In the C method, when the soil was left as clody ploughed, precipitation in spring infiltrated faster into soil, especially 40 cm depth. Like regular soil tillage applications regarding the preperation of seedbeds destroys macropore continuity and decreases water movement at the surface soil. In all soil tillage methods, the tendency that as the soil depth increases, the soil moisture increases does not apply at 60 cm soil depth, can be explained with the fact that at 60 cm depth the texture of soil becomes rougher (Akgül and Başayiğit, 2005). This depth is far from the effects of soil tillage methods and there is no difference between soil moisture contents. The change in the soil moisture content depending on the soil tillage methods was not found constant during the measurement ($P < 0.01$). Between the 222nd and 250th days of plant vegetation, the change in soil moisture content varied depending on soil tillage methods at 10 - 20 cm soil depth. In the method of CK and CD, compared to the C method, it was found that the difference in moisture content was faster and higher at 10 - 20 cm depth (Figure 1). No significant change depending on period was observed at 20 cm depth. However, especially loss of moisture in the CK method was fast at 10 cm soil depth. In the measurements carried out on the 246th and 250th days, for all soil tillage methods at 10 cm soil depth, it was found that soil moisture increased, which was the result of 22.1 mm rainfall on the 240th and 244th days (Table 1).

The effects of soil tillage methods on the change in soil moisture depending on time at 30, 40 and 60 cm soil depths varied. For example, in the C method, at these depths, soil moisture is almost constant during the measurement. However, soil moisture at 40 cm depth had a high value during the measurements compared to the other methods. In the CD method, at 30 cm and in the CK method, at 30 - 40 cm a drop was observed. However, in the CD method, at 40 - 60 cm and in the CK method at 60 cm, a raise was observed, which indicates the fact that water movement in the CD and CK methods, compared to the C method, was slower.

The effects of soil tillage methods on soil moisture content were not statistically significant. In some similar studies (Barzegar et al., 2003; Aboudrare et al., 2006), it was found that chisel applications were effective while in some other studies (Lampurlanes et al., 2002), no difference between soil tillage methods were observed. The findings obtained depending on the soil, climate and soil management may vary.

## Yield

Hungarian vetch+Triticale yields for the C, CD, and CK methods, were found 2.64; 2.81; and 2.25 ton $ha^{-1}$ respectively and not found statistical difference among treatments (Figure 4). Lower yield in the CK method can be related to the high loss of moisture from soil owing to the relatively slower water movement in the soil. In another study conducted by Bayhan et al. (2005), differences among treatments were found significance.

In addition the highest grain yield was also found in the CD treatment on the same experiment area. Also

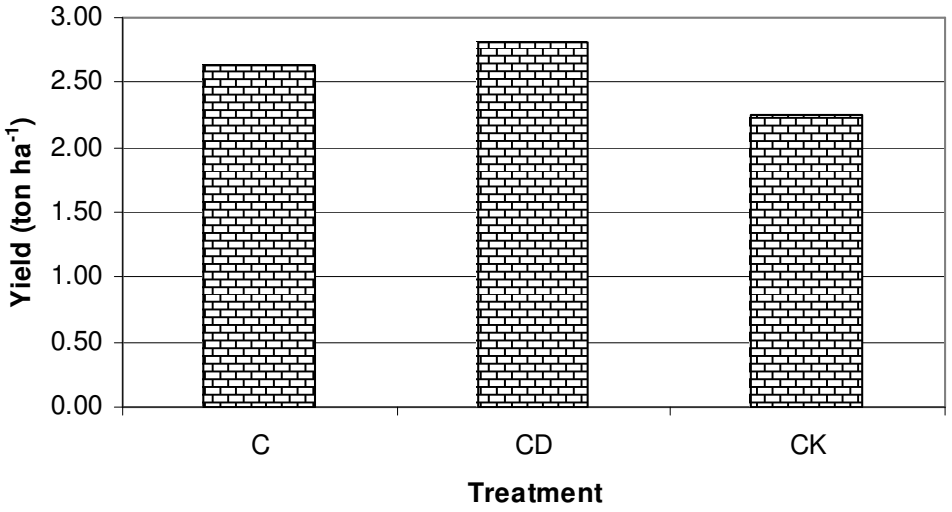


**Figure 4.** Hungarian vetch (*Vicia pannonica Crantz*) +Triticale yields for the soil tillage applications in 2005-2006 season.

Bescansa et al., (2006) noticed that barley yield was not different among different tillage methods (no-tillage, reduced chisel plough tillage, and conventional tillage with mouldboard plough) however in the dry year yield of mouldboard plough treatment was lower than the other treatments.

## Conclusion

Water conservation has became an important issue during soil preparation due to global warming which affects amount of total precipitation and disrupts rainfall schemes. In this study, it was found that among the soil tillage methods, CD method, compared to the other methods, has more advantages in observing moisture dynamics and yield. The effects of disc harrowing and of combine harrowing applications are different. As a result different soil preparation methods should be evaluated to find the best way to prepare soil for different regions.

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