4

Alternative Management Practices for Water Conservation in Dryland Farming: A Case Study in Bijar, Iran

Fardin Sadegh-Zadeh[1], Samsuri Abd Wahid[1],
Bahi J. Seh-Bardan[1], Espitman J. Seh-Bardan[2] and Alagie Bah[1]
[1]Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, Serdang, Selangor
[2]Department of Water Science, Faculty of Agriculture, Zabol University,
[1]Malaysia
[2]Iran

1. Introduction

1.1 Water conservation

Water conservation in the arid and semi arid regions is an important issue that influences both the environment and crop production. Runoff which is induced by rainfall can cause soil erosion which poses a dominant threat against long-term sustainability of farming (Derpsch et al., 1986). A further problem usually associated with runoff is the loss of soil particles that may pollute water bodies. Pollutants commonly found in runoff include soil particles, phosphorous, nitrogen, pesticides, etc. (Motavalli et al., 2003a)

During runoff, soil particles in the form of displaced sediments are carried along with the flowing water. The runoff mostly settles around the edge of a dam and the sediments it contains will subsequently be deposited underneath the reservoir. This continuous and gradual silting of the dam over time will consequently affect its capacity to store water. The decrease in the capacity of reservoir depends on the concentration of soil particles in the river that supplies the dam. In spite of decades of concerted research efforts, sedimentation is still considered the most serious problem threatening the dam industry. The deposition of soil particles in the dam may decrease the efficiency of the dams' turbines.

1.2 Soil and water conservation practices in dryland farming

Dryland farming is the profitable production of useful crops without irrigation on lands that receive annual rainfall of less than 500 mm per year. In the arid and semiarid regions, the conservation of precipitation water for crop production is very vital. In dryland crop production areas, a major challenge is to conserve precipitation water appropriately for use during crop growth (Baumhardt and Jones, 2002). It is imperative that farming practices should conserve and utilize the available rainfall efficiently. To optimize water storage under any precipitation condition, the soil should have enough infiltrability, permeability and capacity to store water. Water is the main constraint in dryland farming in the West of Iran. Precipitations tend to accrue during winter, while crops' growth season in spring is accompanied by high temperatures. These conditions are the constraints limiting crop production in dryland agriculture in Iran (Hemmat and Eskandari, 2004b).

1.3 Tillage

The objective of tillage operations is to improve soil conditions including porosity, temperature, and soil water storage capacity for increased crop production (Alvarez and Steinbach, 2009). Tillage systems that practise conservation farming during the winter are known as important methods in controlling soil erosion and runoff (Alvarez and Steinbach, 2009; Derpsch et al., 1986). Tillage practices play an important role in dry farming agriculture; however, the appropriate implements, their time and method of use have to be specific for different agro-climatic zones.

1.3.1 Conservation tillage

Conservation tillage research studies have focused on the effects of tillage practices on soil and moisture conservation for increased crop production, water conservation and soil erosion control. Several studies have attempted to develop appropriate and sustainable tillage and residue management methods that would maintain favorable soil conditions for crop growth. After harvest, stubble mulch is accumulated on the soil surface. Such materials do not only prevent direct impact of raindrops on the soil, but also impede the flow of water down the slope, thereby decrease the water flow on the soil surface and increase the amount of infiltration water (Hemmat et al., 2007). Conservation tillage systems have the potential to improve soil quality and reduce soil loss by providing protective crop residue on the soil surface and improving water conservation by decreasing evaporation losses (Su et al., 2007). Tillage creates a rough cloddy surface that lengthens the time necessary for the rain to break down the clods and seal the surface. Reduced tillage practices have been used in the production of many crops to increase soil water conservation (Locke and Bryson, 1997; Peterson et al., 1998). Reduced tillage practices protect soils from erosion and runoff by maintaining more crop residue on the soil surface. The magnitude and trends of change in soil physical properties depends on antecedent conditions, wheel tracks, soil texture and climate (Hobbs et al., 2008). However, contradictory results have been reported in literature about these effects. Mahboubi et al. (1993) showed the beneficial effects of long-term conservation tillage systems including chisel plowing and no-tillage compared to conventional tillage in ameliorating soil physical properties.

Compacted soils of arid regions have low organic matter contents and are proned to crusting which may decrease infiltration, seedling emergence and plant growth (Unger and Jones, 1998). For soils that are hard setting or have a root-restricting layer, some form of mechanical loosening through deep tillage is necessary to conserve the soil and water in order to facilitate crop growth (Nitant and Singh, 1995; Vittal et al., 1983). On the other hand in some soils, water conservation and water and wind erosion contros are major goals of conservation tillage systems. Any tillage method that keeps residue on the surface may protect the soil against dispersion by rain drop impact and the pounded or flowing water will decrease crusting (Hoogmoed and Stroosnijder, 1984; Pikul Jr and Zuzel, 1994)

1.3.2 Comparing various tillage systems

Studies have revealed that tillage operations do modify soil properties including soil structure (Roger-Estrade et al., 2004; Saggar et al., 2001), bulk density and porosity (GLSB and KULIG, 2008; Lampurlanés, 2003; Unger and Jones, 1998), water retention and distribution (Hemmat et al., 2007), root growth and yield (Box Jr and Langdale, 1984; Busscher and Bauer, 2003; Shirani et al., 2002; Su et al., 2007).
Conventional tillage methods used by farmers result in physical degradation of soil and increased soil erosion and runoff (Unger and Fulton, 1990). Excessive tillage results in deterioration in the soil environment and also increases the cost of production. On the other hand, the no- tillage system can affect the growth and establishment of plants through increased weed competition and poor soil physical conditions. Reduced tillage has been found to be feasible in improving soil properties (Locke and Bryson, 1997; Peterson et al., 1998). Each tillage system modifies soil properties differently. Moldboard plow buries plant residues and stubble, but chisel plow enables retention of plant residues on soil surface.

1.3.3 Organic amendments and tillage

Previous studies have reported that application of sewage sludge, compost, farmyard manure and other kinds of organic amendments resulted in a significant increase in aggregate stability, water content, hydraulic conductivity and infiltration and a decrease in bulk density (Arshad and Gill, 1997; Bahremand et al., 1999; Motavalli et al., 2003b; Shirani et al., 2002). Some literature reported that application of manure to the soil decreased soil compactibility (Mosaddeghi et al., 2003). They also showed that mixing manure with the soil does not only decrease compactibility but also decrease subsoil compaction.

1.4 Mulching and water conservation

Stubble mulching aims at disrupting the soil drying process by protecting the soil surface at all times either with a growing crop or with crop residues left on the surface during fallow. The first benefit of the stubble mulch is that wind speed is reduced at the surface by up to 99% and, therefore, losses due to evaporation are significantly reduced (GLSB and KULIG, 2008). In addition, crop residues can improve water infiltration (Hemmat and Taki, 2001) and decrease water runoff losses (Morin et al., 1984). Layered mulch could keep soil moist, change soil moisture regime and help to keep the soil moist(Sadegh-Zadeh et al., 2009). The decrease in evaporation by layered mulch was due to the ability of the mulch to decrease soil temperature during the hot-dry season. Other studies on mulching and soil moisture showed that tephra mulch could keep more soil moisture than the un-mulched soil and tephra mulch were able to change aridic soil moisture regime into a udic one (Diaz et al., 2005; Tejedor et al., 2002).

1.5 Justification of the study

Dryland production of wheat is the main cultivation system that accounts for the largest area of Iran (Hajabbasi and Hemmat, 2000; Hemmat; Hemmat and Eskandari, 2004a; Hemmat and Eskandari, 2006). In the semi-arid region of Iran, most of the precipitations occur in the late autumn, winter and early part of spring, while the growth of wheat is almost in the late spring. Hence, there water is not sufficient to grow wheat. On the other

hand, most of the precipitation water are lost as runoff, particularly for bare lands and when conventional tillage systems are used (Hemmat and Eskandari, 2006).
Chisel plow enables retention of maximum amount of stubble and residues on the soil surface and there is no induced hard pan in soil profile (Barzegar et al., 2003). Consequently, there tends to be an increase in water infiltration and storage, leading to a decrease in soil erosion (Barzegar et al., 2003). Deep plowing with subsoiler has similar characteristics to that of the chisel plow, but the only difference is the plowing depth. Studies have shown that deep tillage system can improve soil physical properties including decreased bulk density, infiltration rate and hydraulic conductivity, increased soil moisture in soil profile and yield under dryland production (Busscher et al., 2000; Busscher et al., 2002; Busscher et al., 2006; Laddha and Totawat, 1997; Motavalli et al., 2003b; Nitant and Singh, 1995) .
Conservation tillage is the recommended method which helps to retain the crop residues in the soil surface at the same time conserves the soil and water (Sow et al., 1997). However, the presence of stubble and crop residues in soil surface may negatively influence yield (Hemmat and Taki, 2001). Hence, farmers seem not to prefer practicing conservation tillage. The use of moldboard plow is the frequently used method in this area but it buries stubble and plant residues and produce a hard pan in the bottom of plow layer (Barzegar et al., 2003).
Mulching is another feasible method to conserve water in semi-arid and arid regions (Sadegh-Zadeh et al., 2009). Considerable amount of literatures have been published on various tillage operations commonly used in some parts of Iran (Hemmat and Eskandari, 2004b; Hemmat and Eskandari, 2006; Mosaddeghi et al., 2009; Shirani et al., 2002). However, there is no reported study on the combined effects of tillage systems and mulching practices in the arid and semi-arid areas characterized by seasonal hot and dry summer and cold winter. The production of winter wheat (*Triticum aestivum L.*) of the cultivar Sardary is commonly practiced in this area.

1.6 Objectives of the study

The general objectives of the present study were to develop appropriate tillage and farm yard mulching systems for water and soil conservation in an aridisols with the aim of improving the grain yield of wheat (Triticum aestivum L.) of the cultivar Sardary. Specific objectives of the study were to (i) compare the effect of moldboard plow (MP), chisel plow (CP) and deep plow (DP) on soil properties, soil water content, runoff, soil loss and grain yield of wheat, (ii) investigate effect of farmyard mulch (FM) on soil properties, water content, runoff, soil loss and grain yield of wheat, and (iii) introduce a tillage system which is capable of conserving precipitation water to optimize grain yield and decease surface runoff and soil loss.

2. Materials and methods

2.1 Site characteristics and soils

The experiment was conducted at three sites in one of the famous areas of dryland wheat production in Bijar, Kurdestan province of Iran. The soils belong to the Aridisols order (Soil Survey Staff, 2006). The soil of the experimental sites consist of different textural classes (sandy loam, loam and clay loam). The mean annual precipitation of the region is 400 mm, most of which is received from late autumn, winter and early spring. During winter, most of the precipitation water is converted into snow. The soils of the region have low organic matter and nitrogen, with medium amount of phosphorus and high potassium content. The soil had been cultivated since long time ago. The climate of the area is characterized by a cold and snowy winter and a warm and dry summer with high evapotranspiration potential (in excess of 1500 mm in an evaporimetric tank).

2.2 Experimental site and design

2.2.1 Tillage treatments

Three tillage treatments were imposed during seed bed preparation. The plot layout was arranged using a randomized complete block design with four replicates. Plowing operations were carried out in April 2003 and disking was performed twice in September of 2003.

Tillage systems used were as follows:

Moldboard plow (MP) (200 mm depth) and twice offset disking (70 mm depth).

Chisel plow (CP) (300 mm depth) and twice offset disking (70 mm depth).

Deep plow (DP) with subsoiler (450 mm depth) and twice offset disking (70 mm depth).

The experimental design for each soil type was a spilt-split plot with three tillage systems as main plots, manure applications (no application, application of 3 mm thickness of farmyard manure (FM) on soil surface after sowing and mix same amount of FM with the soil surface (70 mm depth before sowing) as split plots, and planting (no planting and planting) as split–split plots. Each plot size was 2 m × 20 m in four replications.

Fertilizer including urea, ammonium phosphate, and microelements (Zn, Mn, Fe and Cu) were applied before sowing according to soil analysis results and recommendation rates. Wheat (*Triticum* aestivum L.) seeds (cultivar Sardary) were sown (at a rate of 150 kg ha^{-1}) and weeding was done manually.

2.3 Runoff and soil loss

Runoff and soil loss were measured in each plot. The plot edges were made of solid materials (wood plank). The edges of the plots were about 15 cm above the soil surface to prevent input from splashes entering the plot from the surrounding areas and were sufficiently embedded into the soil. Runoff and soil loss were measured by collecting the runoff water in 40-liter capacity buckets (Khan and Ong, 1997), which were placed at the bottom of each plot. The collection buckets were connected to the runoff plots via PVC tubes, which collected both soil sediments and runoff water from the each plot after every rainfall event. Sediment concentration was determined through sampling collected runoff at the out let of each plot. Sediment content was determined by means of drying and weighing (Inbar and Llerena, 2000). Sediment yield was assumed to be equal to the rate of soil erosion. Runoff and sediment measurements were conducted from cultivation to harvesting stages.

2.4 Measurement of soil properties

The measured soil properties were pH, $CaCO_3$ content, soil water content at field capacity (FC) and permanent wilting point (PWP), organic matter (OM) content, particle size distribution, electrical conductivity of saturation extract (ECe), cation exchange capacity (CEC), and soil bulk density. Soil bulk density was measured on undisturbed core samples (Blake and Hartge, 1986). Particle size distribution was determined by the Bouyoucos hydrometer method (Bouyoucos, 1962). Water infiltration rates were determined in the soil surface of various treatments using a double-ring infiltrometer (Bouwer, 1986). The CEC was determined according to method used for alkaline soils (Bower et al., 1952). The pH and electrical conductivity were determined from a saturated paste extract (Rhoades, 1982). The amount of $CaCO_3$ was determined by acid neutralization method (Allison and Moodie, 1965) and the OM content was determined by the potassium dichromate oxidation method (Nelson et al., 1982). The soil water content was measured using gravimetric method. Water retention capacity was measured at FC (− 33 kPa) and PWP (− 1500 kPa) (Gardner and Klute, 1986). Soil water content was measured at depths of 1 to 100 cm in every 5 cm intervals by the gravimetric method.

Wet aggregate stability was determined using the method of Kemper and Rosenau (Kemper and Rosenau, 1986). Fifty grams of air-dried aggregates (3–5 mm diameter) from each soil type was wet sieved through a 2 mm sieve. The sieving time was 10 min at 50 oscillations per minute. The percent of aggregate size bigger than 2 mm was calculated and used as an aggregate stability index among treatments. Soil compaction was determined using the Cone index readings which were taken with a hand held 13-mm diameter, 30 ° cone tip penetrometer (Carter, 1967) at soil surface of each plot. The soils were sampled to determine their properties during the months of October (2003), April (2004) and June (2004) to represent the planting time, middle and end of wheat growth, respectively. The dry weight of roots per plot was measured at harvest.

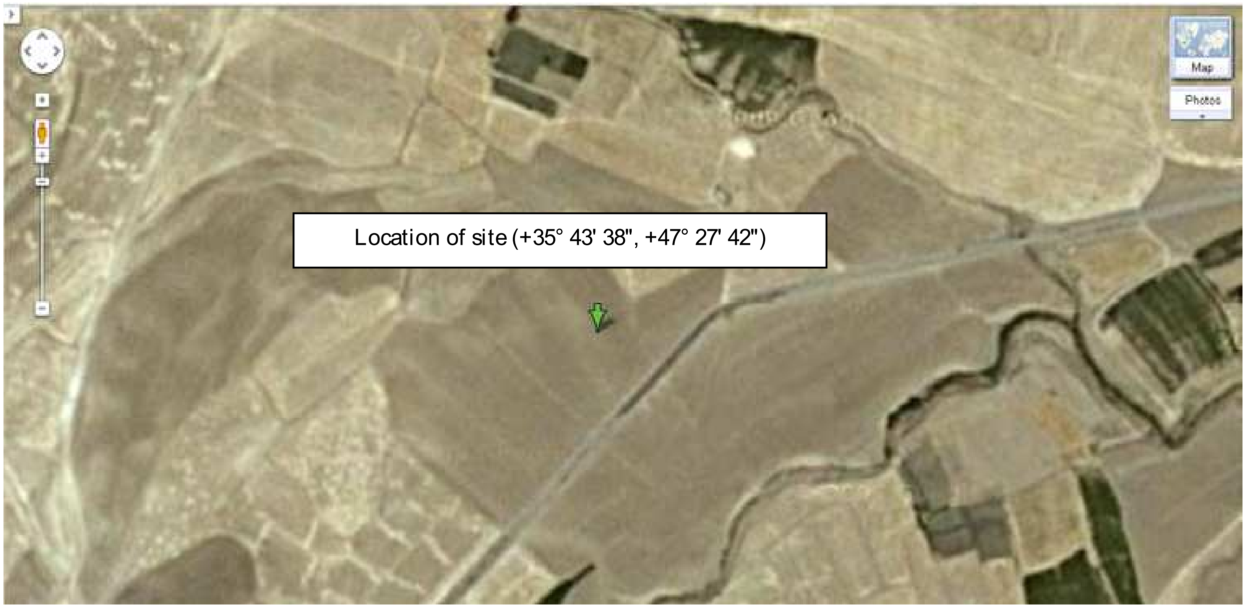
3. Result and discussions

The soil properties of the experimental sites are shown in Table 1. There were considerable differences between the various soils in term of soil pH, $CaCO_3$, FC, PWP, texture, CEC, and slope. Results of sandy loam and clay loam soils were similar to loam soil; therefore, only result of loam soil is presented in this chapter. Figure 1 shows the location of the experimental site which is adjacent to a watershed areasituated behind the Golbolagh reservoir dam.

Soils	Slope (%)	FC	PWP	$CaCO_3$	OM	EC_e (dS m^{-1})	pH	CEC ($cmol_c\,kg^{-1}$)
		(g kg^{-1})						
Sandy loam	4	210	95	130	14	1.1	7.1	11
Loam	8	270	107	140	13	0.8	7.5	15
Clay loam	5	300	114	90	16	0.7	7.3	18

FC: field capacity; PWP: permanent wilting point; ECe: electrical conductivity of saturation extract; CEC: cation exchange capacity; OM: organic matter.

Table 1. The properties of the soils



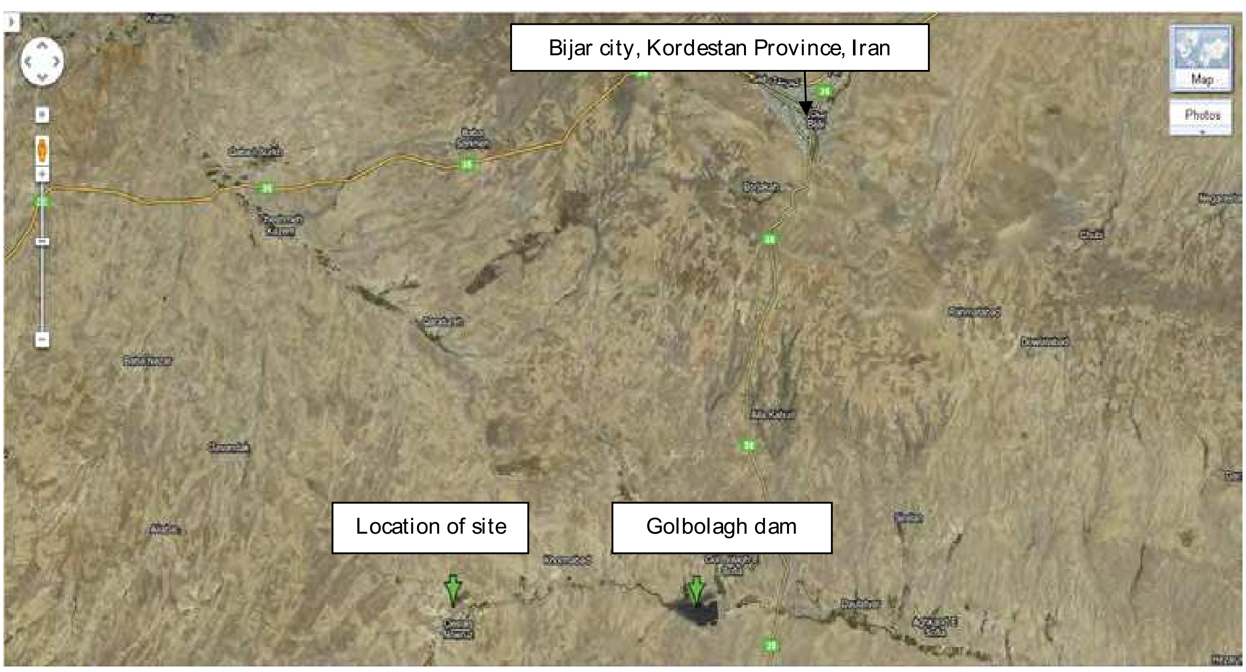


Fig. 1. Location of experimental site (a) and location of site in the watershed behind the Golbolagh dam (b).

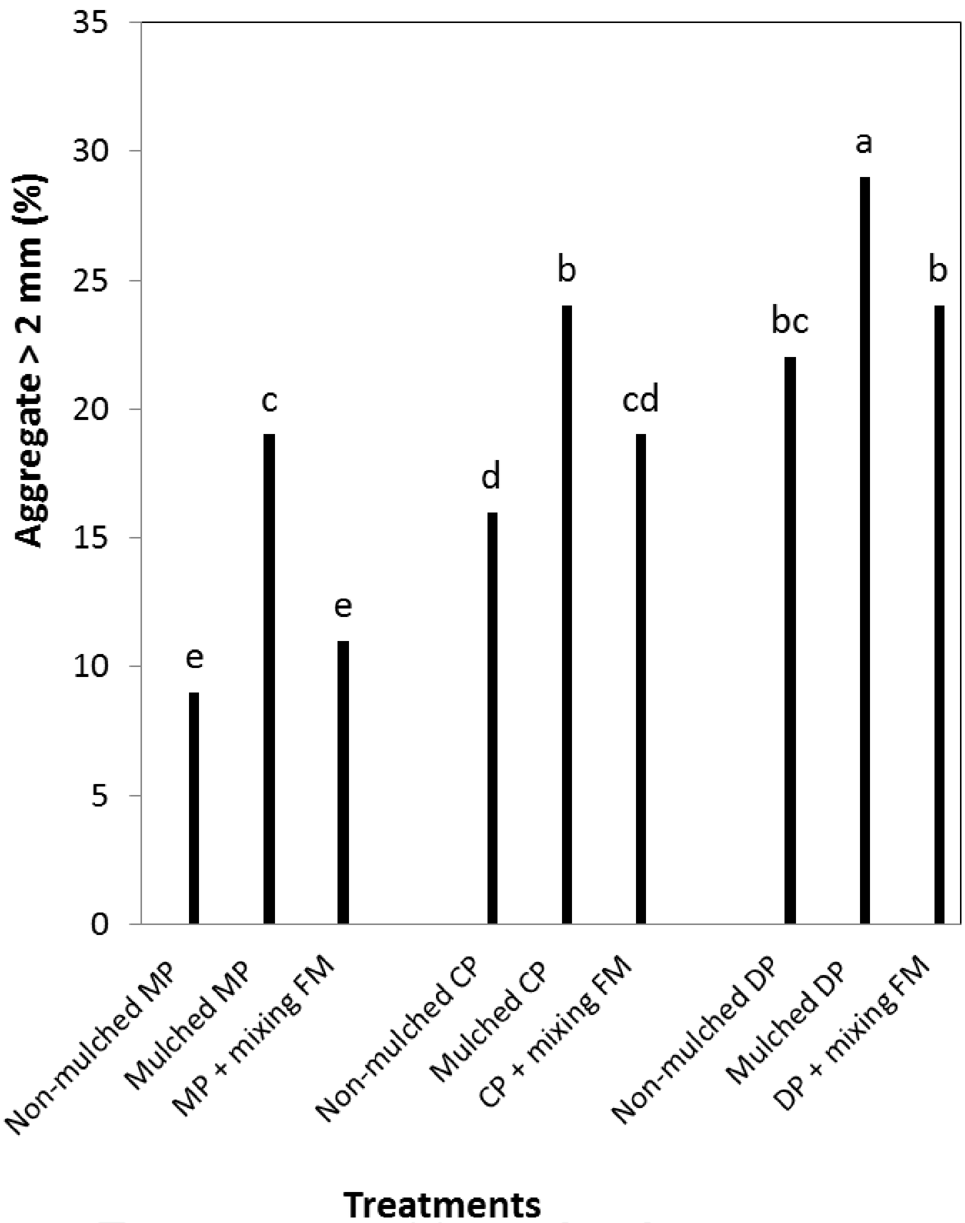


Fig. 2. The percentage of aggregates bigger than 2 mm among treatments in April (2004). Values followed by the same letter are not significantly different ($P < 0.05$).

3.1 Aggregate stability

Soil aggregate stability can be evaluated by determiningthe % of aggregates bigger than 2 mm (Hajabbasi and Hemmat, 2000). The soil aggregates bigger than 2 mm at different treatments are shown in Figure 2. There was significant difference ($P < 0.05$) in soil aggregates percentage among treatments. Non-moldboard plow (MP) had the lowest aggregate percentage. Mixing farmyard manure (FM) with soil increased the aggregate percentage but was not significantly different ($P < 0.05$). Application of the FM as mulch on soil surface enhanced the aggregate percentage significantly. The percentage of aggregates bigger than 2 mm in non-mulched chisel plow (CP) was higher than non-mulched MP. The application of FM as mulch in CP increased the percentage of aggregates significantly ($P < 0.05$). Mixing the FM with soil in the CP increased aggregates percentage but it was not statistically significant. The percentage of aggregate bigger than 2 mm in deep plow (DP) was more than MP and CP. Mulched DP had highest percentage of aggregate. Mixing of FM with DP soil increase the aggregate percentage compared to non-mulched DP but it was not significant.

Application of FM as a mulch on all kind of plowing increased the percentage of soil aggregates in soil surface. This result is in agreement with result of Shirani et al. (2002) who showed that the mixing of 30 and 60 Mg ha^{-1} of FM increased the aggregate stability. However, there is no reported data on the application of FM as a mulch and aggregate stability. As mentioned in the materials and methods section, the thickness of FM mulch was 3 cm and if we calculate the weight of FM per ha, it is around 5 Mg ha^{-1}. Although the amount of FM applied was low, it increased the aggregate stability drastically and improved the soil structure.

3.2 Soil cone index

Soil compaction is normally determined by measuring its penetration resistance with a penetrometer and the value obtained is referred to as a soil cone index. The soil cone indices of the treatments are shown in Figure 3. There was significant difference ($P < 0.05$) in soil cone index among treatments. The soil cone indexes in mulched treatments were much lower than either non-amended treatments or treatments of FM mixed with the soil. Lowest cone index was observed in mulched-DP and non-mulched MP which had the highest cone index. Mixing FM with the soil decreased soil cone index compare to the same tillage without application of FM. The percentage of soil aggregate bigger than 2 mm was negatively correlated with the cone index (Figure 4.). Soil cone index decreased with increasing amount of aggregates bigger than 2 mm.

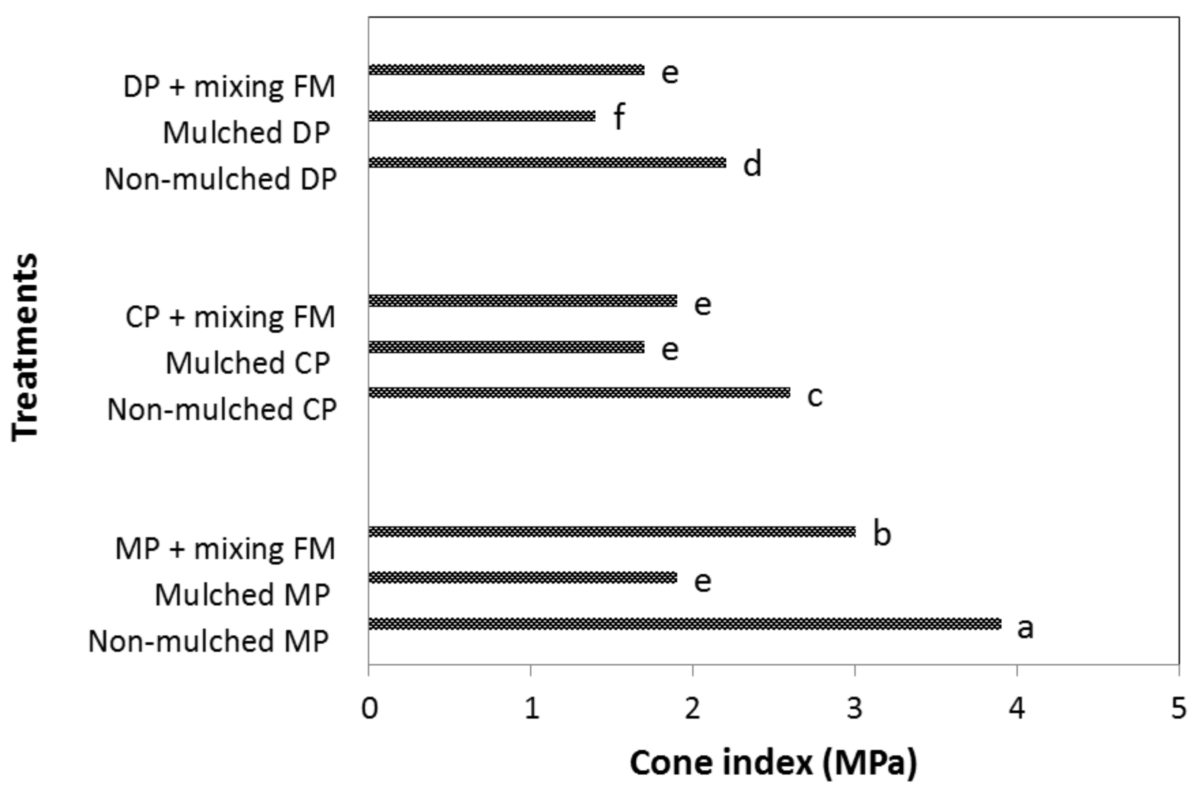


Fig. 3. Cone index of treatments in April (2004). Treatments followed by the same letter are not significantly different ($P < 0.05$).

Soil crust appeared when soil aggregates are broken down into smaller particles (Bissonnais, 1996; Le Bissonnais et al., 1989). The high cone index values observed in non-mulched MP could be due to the restriction factor for wheat emergence and water infiltration; hence, higher soil cone index could be a potential limiting factor for plant growth and it is expected that precipitation water will be lost as surface runoff.

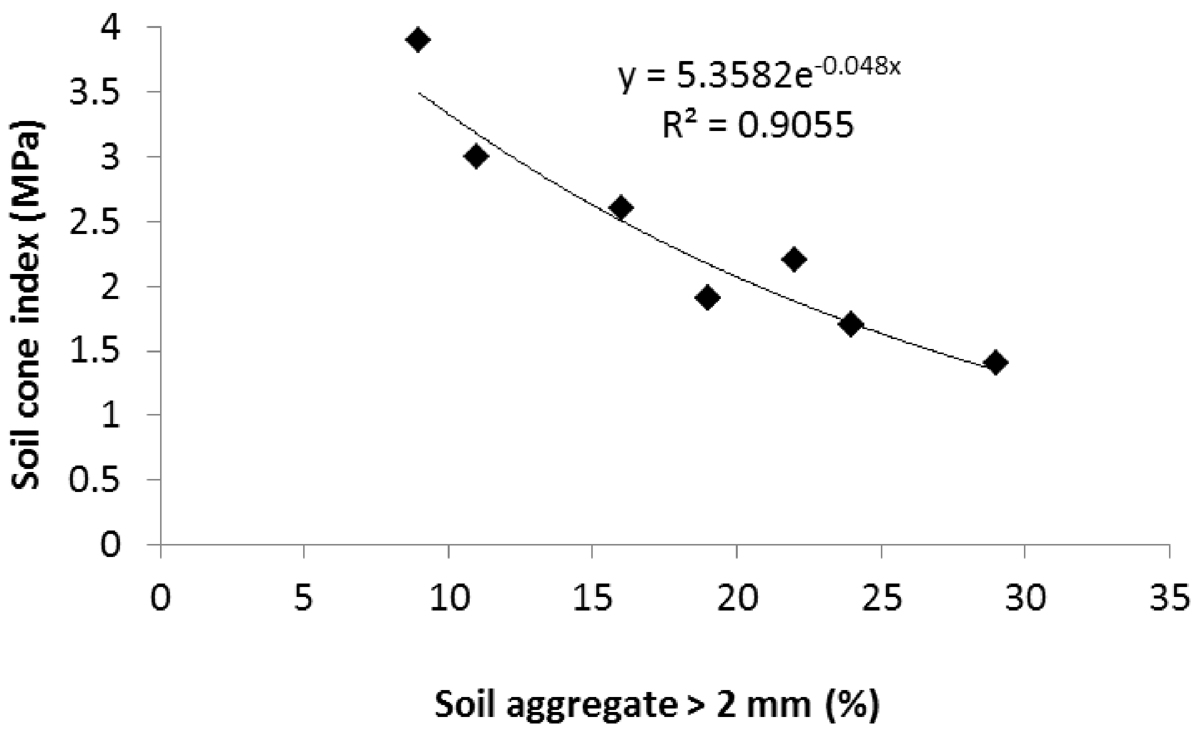


Fig. 4. Correlation between percentage of soil aggregate bigger than 2 mm and soil cone index.

3.3 Soil bulk density

The soil bulk densities measured at different depths of treatments are shown in Figure 5. There was no difference in soil bulk density between non-mulched MP, mulched MP and mixed FM with MP treatments at depths lower than 10 cm. However, mulched MP had the lowest bulk density at the soil surface (5 cm depth). Mixing FM with soil decreased the soil bulk density at the upper depths (5 and 10 cm depths) compared to same non-mulched MP treatment. The highest bulk density in non-mulched MP was observed at 25 cm depth and this is possibly due to the presence of hardpan at that depth. The bulk densities in the MP treatments increased at depths lower than 20 cm. This is reasonable because MP is able to loosen the upper 20 cm soil layer and below this depth, the soil can be compacted by moldboard during tillage operation. Chisel plow treatments had lower bulk density at 25 cm depth in contrast to MP treatments. This data shows that hardpan was broken by the CP operation. Bulk density was lowest in the DP treatments. This plowing method decreased soil bulk density atall depths except at 50 cm. The addition of FM as mulch helped to lower the surface soil bulk density in all tillage systems. This result is consistent with the finding of Lampurlanés, (2003) who showed that deep tillage could keep soil to be porous. This result also in agreement with Shirani et al. (2002) who reported that farmyard manure significantly decreased soil bulk density on the row tracks of field.

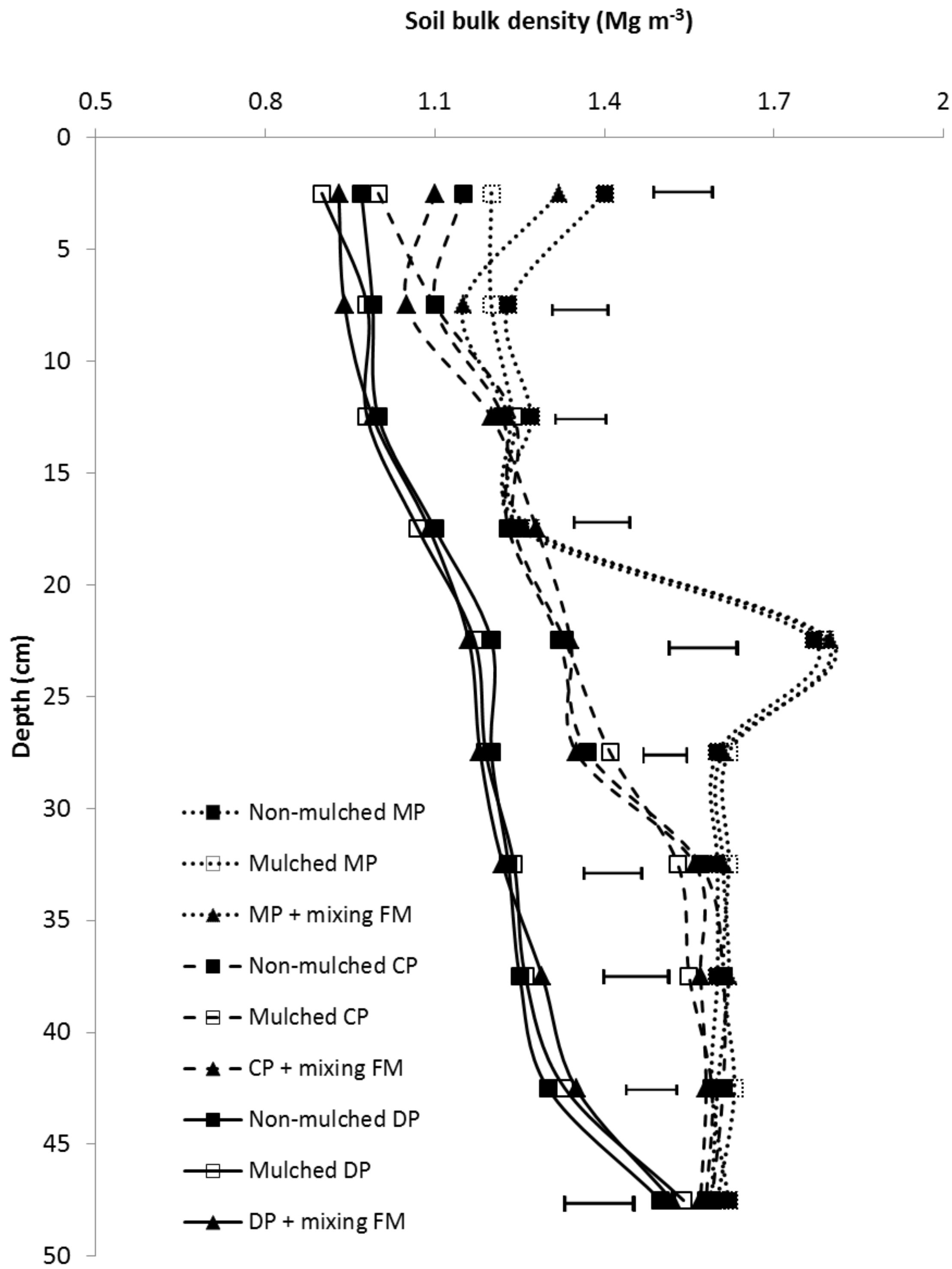


Fig. 5. Soil bulk density of treatments versus depths measured during April 2004. Horizontal bars represent the common LSD ($P < 0.05$) by depth for all treatments.

3.4 Infiltration rate

The infiltration rates of the treatments are shown in Figure 6. The infiltration rate in mulched DP was the highest, while non-mulched MP had lowest rate. The infiltration rates of the treatments were in the following order: mulched DP > mulched CP > DP + mixing FM

= mulched MP > non-mulched DP = CP + mixing FM > non-mulched CP > MP + mixing FM > non-mulched-MP. The results indicate that infiltration rates increased with the application of mulch on soil surface in all tillage systems. Among the tillage systems studied, the DP which has the lowest bulk density and cone index has the highest infiltration rate followed by CP and MP. Application of FM as mulch in the all tillage treatments increased infiltration rate. Mixing FM with soil increased infiltration rate but it was not as effective as the FM mulch. This indicated that the addition of FM as a mulch helped improved soil structure and increase water infiltration. This can be attributed to the fact that FM mulch can increase aggregate stability, increase soil water content and decrease runoff. This finding is in accordance with the results of Shirani et al. (2002), which showed that mixing 30 and 60 Mg ha^{-1} of farmyard manure increased soil hydraulic conductivity. However, there is no reported study on the application of FM as mulch on soil surface in various tillage systems after sowing. Only 3 to 4Mg ha^{-1} of FM is required to cover the soil for FM to be used as a mulch which is affordable to the farmers in the large area of dryland production of Iran. This application method is also suitable for dry land production in other parts of world.

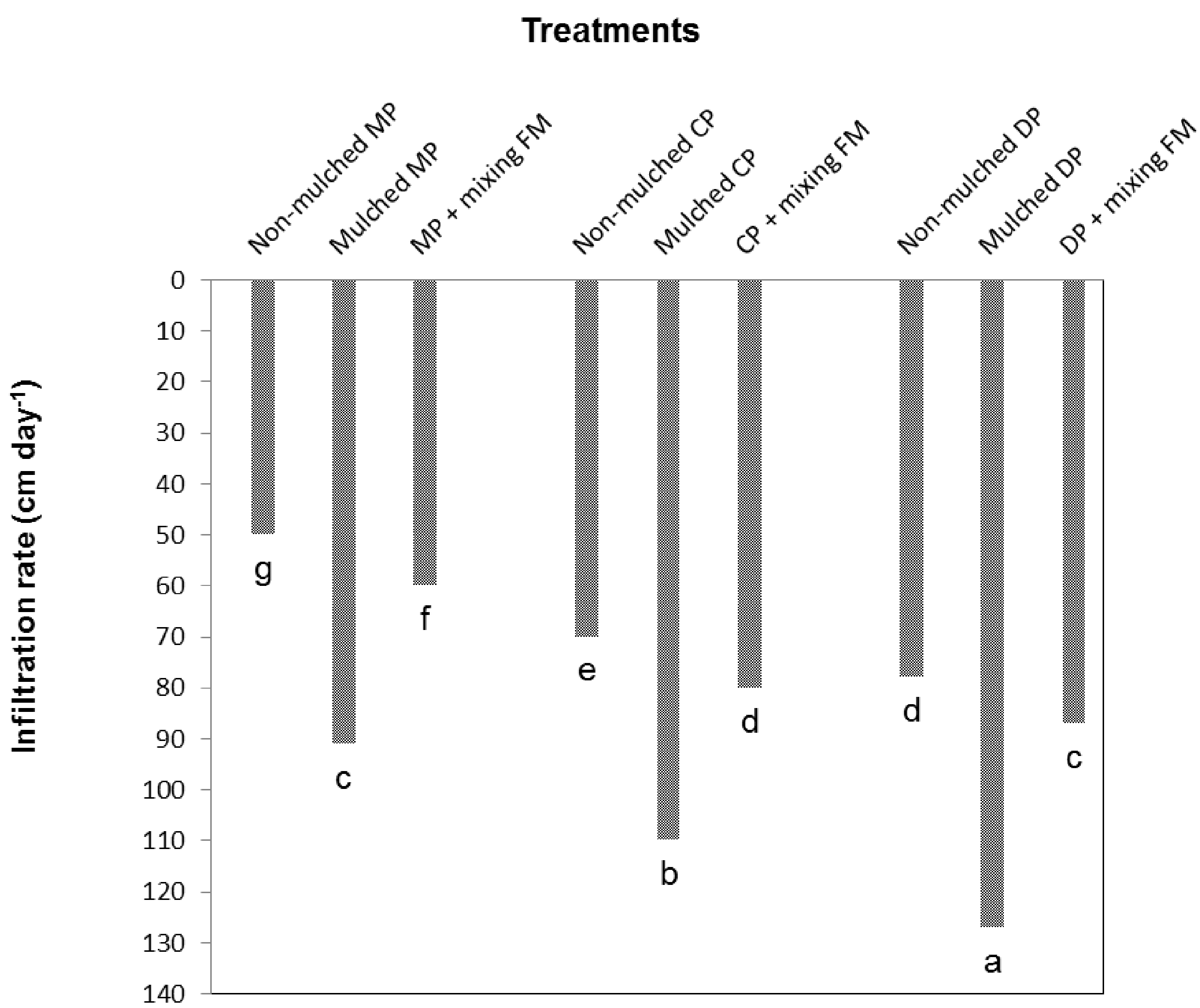


Fig. 6. Infiltration rate of the treatments during April (2004). Treatments followed by the same letter are not significantly different (P < 0.05).

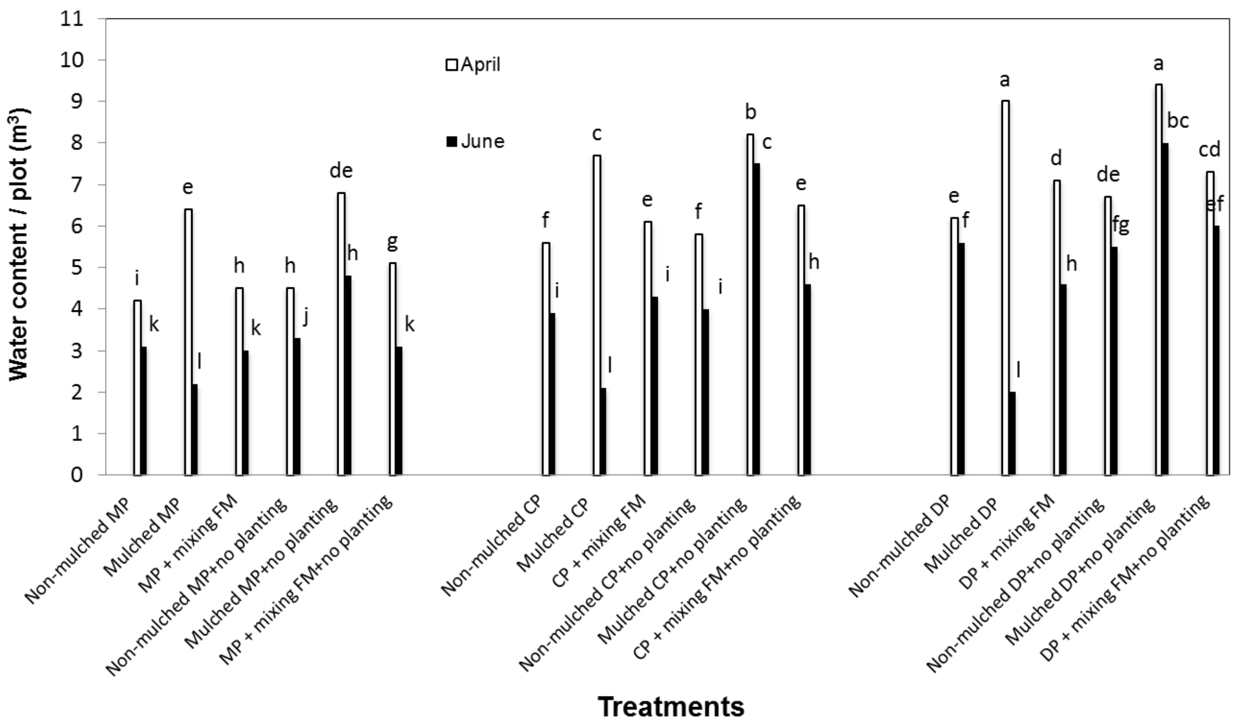


Fig. 7. Soil water content of treatments in April and June (2004). Treatments followed by the same letter are not significantly different ($P < 0.05$).

3.5 Soil water content

Effects of mulch and tillage treatments on water content in the soil profile, evaporation, and availability of water for plant growth could not be studied in winter and autumn because biomass production started in the April and plants needed water since beginning of April to end of June. Soil water contents of treatments during April and June (2004) are shown in Figure 7. There was a significant difference in soil water content among MP, CP and DP in April. Soil water content was significantly ($P < 0.05$) higher in DP than CP and MP during April. The lowest water content was observed in MP treated soils in April. There was higher water content in soils treated with mulch compared to same treatment without mulch. Soil water content of non-cultivated plot of DP with mulch was the highest among the tillage treatments. The soil water content of non-cultivated plot of CP with mulch was lower than the non-cultivated DP with mulch. However, non-cultivated plot of CP with mulch had higher water content than non-cultivated plot of MP with mulch. The water content in all planted treatments which had mulch was lowest. Higher biomass in the mulch treated plots implied the higher water consumption in these treatments. Conversely, in the non-planted mulch treatments for all tillage operations (MP, CP and DP) water content were higher than same tillage systems without mulch. The differences in water content in the non-planted treatments with planted treatments could be due to reduced transpiration in the non-planted treatments. The water contents of all treatment during June were decreased in comparison to April. The decrease in water content could be ascribed to evaporation and possible drainage of water to a depth greater than 100 cm. Our data suggest that FM mulch on soil surface was effective in conservation of water and thus retaining more water in the soil than that in the other treatments. This result is in agreement with previous result which showed the addition of municipal sewage sludge increased available water in the root zone mainly due to reduction in evaporation (Agassi et al., 2004).

3.6 Runoff

Annual runoff for each treatment is presented in Table 2. Almost all precipitations occurred in autumn 2003 and winter 2004 and then continued in April 2004. Precipitations were extremely low after April 2004. Lack of rainfall in May and June (2004), i.e., during the plant growth period, was considered as a vital aspect of water conservation and runoff control in this area during the previous autumn and winter. Spreading FM mulch on the soils resulted in decreased runoff of MP, CP and DP compared to the same tillage systems without mulch. For example, in the case of MP, mulching could decrease 300 m^3 ha^{-1} of runoff per year compared to the non-mulched MP.

The amount of runoff in the CP and MP treatments was negligible and it was zero in the mulched CP and DP (Table 2). Addition of FM as a mulch decreased the runoff of CP and DP compared to the non-mulched CP and DP (Table 2). Therefore, it can be concluded that the decrease in runoff is one of beneficial effects of FM mulch especially in the conventional tillage system (MP). A decrease in runoff was related to the higher infiltration rate in mulched treatments and this finding is in agreement with other studies which showed that mulching was effective in controlling runoff in soils susceptible to sealing (Poesen and Lavee, 1991; Saxton et al., 1981).

3.7 Soil loss

The trend of soil loss was similar to the trend of runoff among the treatments (Table 2). Soil loss ranged from 0 kg $plot^{-1}year^{-1}$ for mulched CP and MP to 193 kg $plot^{-1}year^{-1}$ for non-mulched MP. (Table 2). Less soil loss was measured on mulched MP treatment compared to the non-mulched MP treatment. Mulching also decreased soil loss in CP and DP. However, in some cases the differences between the mulched and non-mulched treatments was not significant ($P < 0.05$). Overall, soil loss in all treatments of CP and DP was negligible. Mulching significantly decreased the soil loss in some treatments by preventing the impacts of raindrops on the soil aggregates (Figure 2) hence conserving the soil structure (Figure 3) and as a result infiltration rates were higher in mulched treatments compared to the non-mulched treatments (Figure 6). From theresults it can be concluded that mulching was very useful to control soil erosion. This result is in agreement with the findings of Döring et al. (2005) who reported that soil erosion was reduced by more than 97% in a rain simulation experiment on a potato field of 8% slope with 20% crop cover compared to sils without crop cover.

3.8 Wheat emergence, dry weight of roots and grain yield

Wheat emergence was significantly influenced by mulching and tillage (Table 2). Wheat emergence in April (2004) was low under tillage systems without mulch. Mulching increased the wheat emergence in all tillage systems (Table 2). The highest and the lowest rates of wheat emergence were observed in mulched MP and non-mulched DP, respectively. Although conservation tillage (non-mulched CP and non-mulched DP) were able to decrease water and soil loss as runoff and sediment and prevented soil structure from being degradation, there was less wheat emergence compared to the conventional tillage (non-mulched MP). The decrease in wheat emergence rate in non-mulched CP and DP could be due to cracking of seeds at the end of autumn when the water freeze into ice . However, mulching seems to decrease seed cracking in the mulched-CP and DP treatments. A possible explanation for a decrease in wheat emergence in non-mulched MP is crusting was induced by raindrops in this treatment.

Effects of tillage systems and mulching on dry weight of roots and grain yield were significant (Table 2). Weight of roots and grain yield under all the tillage systems generally increased with the application of mulch. Mulched MP had higher weight of roots and grain yield than the non-mulched MP which could be explained by the higher wheat emergence and higher water content for feeding the plant during the growth period.

The grain yield was the highest in the mulched DP. Mulched CP had lower grain yield than the mulched MP. Although non-mulched DP had high water content, the grain yield and weight of roots were low probably because the absence of enough wheat emergences (Table 2). The existence of enough moisture in the soil profile (Figure 7) is not a sufficient condition to have high amounts of yield. High wheat emergence is also necessary to have enough plant population and economical grain yield. In the non-mulched CP and DP there was not enough plant population to obtain an economical yield. This is the reason why farmers do not prefer conservation tillage in this area. However, the addition of FM as mulch to the tillage systems increased the yield drastically (approximately two folds) and solved the problem of low grain yield often associated with the conservation tillage. The FM mulch helped the soils to store enough water in the soil profile but at the same time did not reduce the wheat emergence. Therefore, the FM mulch method is highly recommended for conserving water in the arid and semi-arid regions without jeopardizing the grain yield of wheat.

	Treatments								
	Non-mulched MP	**Mulched MP**	**MP + mixing FM**	**Non-mulched CP**	**Mulched CP**	**CP + mixing FM**	**Non-mulched DP**	**Mulched DP**	**DP + mixing FM**
Runoff (m^3/ plot year)	1.8 a†	0.6 c	1.3 b	0.2 d	0 e	0.15 de	0.14 de	0 e	0.10 de
Soil loss (kg / plot year)	193 a	53 c	114 b	67 c	0 e	29 d	59 c	0 e	11 e
Wheat emergence per plot	7600 d	12072 a	9480 b	6037 f	8360 c	7320 d	5722 g	9317b	6681e
Dry weight of roots (kg / plot)	6.96 e	10.26 c	7.99 d	6.79 e	11.89 b	7.19 de	7.57 d	15.63 a	7.90 d
Grain yield (kg / plot)	4.87 g	8.78 c	6.40 e	5.93 ef	11.95 b	7.61 d	6.30 de	15.28 a	7.24 d

† Means in a row followed by a different letter differ significantly based on the LSD at $P < 0.05$.

Table 2. Runoff, soil loss, wheat emergence, dry weight of roots and grain yield in various treatments

4. Conclusions

The objective of this study was to develop appropriate tillage and farm yard mulching systems for conserving water and soil with the aim of improving the grain yield of wheat (Triticum aestivum L.) of the cultivar Sardary. Three plowing treatments (MP, CP, and DP) and three FM applications (no application, mixing with soil and application as mulch on soil surface) were employed. From the results it can be concluded that:

- Conservation tillage systems (CP and DP) increased soil water content in the soil profile and decrease runoff and soil loss. However, the yield was not economical due to the effect of ice damage on the winter wheat seed.
- Application of FM as a mulch to the conservation tillage systems increased grain yield. The mulched DP had the highest yield of wheat among the treatments.
- Mulching increased infiltration, soil water content and yield in the conventional tillage system (MP).
- Mulching enhanced the wheat yield in all tillage systems and at the same time conserves water and soil. Therefore, it is a good strategy to be adopted not only with the conventional tillage system but also with the conservation tillage system which is usually associated with low yield.

5. References

Agassi M., Levy G., Hadas A., Benyamini Y., Zhevelev H., Fizik E., Gotessman M., Sasson N. (2004) Mulching with composted municipal solid wastes in Central Negev, Israel: I. effects on minimizing rainwater losses and on hazards to the environment. Soil and tillage research 78:103-113.

Allison L., Moodie C. (1965) Carbonate volumetric calcimeter method. Methods of analysis. Agronomy Monogr:1389-1392.

Alvarez R., Steinbach H. (2009) A review of the effects of tillage systems on some soil physical properties, water content, nitrate availability and crops yield in the Argentine Pampas. Soil and tillage research 104:1-15.

Arshad M., Gill K. (1997) Barley, canola and wheat production under different tillage-fallow-green manure combinations on a clay soil in a cold, semiarid climate. Soil and tillage research 43:263-275.

Bahremand M., Afyuni M., Hajabbasi M., Rezainejad Y. (1999) Short and mid-term effects of organic fertilizers on some soil physical properties. pp. 288-289.

Barzegar A., Asoodar M., Khadish A., Hashemi A., Herbert S. (2003) Soil physical characteristics and chickpea yield responses to tillage treatments. Soil and tillage research 71:49-57.

Baumhardt R., Jones O. (2002) Residue management and tillage effects on soil-water storage and grain yield of dryland wheat and sorghum for a clay loam in Texas. Soil and tillage research 68:71-82.

Bissonnais Y. (1996) Aggregate stability and assessment of soil crustability and erodibility: I. Theory and methodology. European Journal of Soil Science 47:425-437.

Blake G.R., Hartge K. (1986) Bulk density. Agronomy (USA).

Bouwer H. (1986) Intake rate: Cylinder infiltrometer. Agronomy.

Bouyoucos G.J. (1962) Hydrometer Method Improved for Making Particle Size Analyses of Soils1. Agronomy Journal 54:464.

Bower C., Reitemeier R., Fireman M. (1952) Exchangeable cation analysis of saline and alkali soils. Soil science 73:251.

Box Jr J.E., Langdale G. (1984) The effects of in-row subsoil tillage and soil water on corn yields in the Southeastern coastal plain of the United States. Soil and tillage research 4:67-78.

Busscher W., Bauer P. (2003) Soil strength, cotton root growth and lint yield in a southeastern USA coastal loamy sand. Soil and tillage research 74:151-159.

Busscher W., Frederick J., Bauer P. (2000) Timing effects of deep tillage on penetration resistance and wheat and soybean yield.

Busscher W., Bauer P., Frederick J. (2002) Recompaction of a coastal loamy sand after deep tillage as a function of subsequent cumulative rainfall. Soil and tillage research 68:49-57.

Busscher W., Bauer P., Frederick J. (2006) Deep tillage management for high strength southeastern USA Coastal Plain soils. Soil and tillage research 85:178-185.

Carter L.M. (1967) Portable penetrometer measures soil strength profiles. Agric. Eng 48:348-349.

Derpsch R., Sidiras N., Roth C. (1986) Results of studies made from 1977 to 1984 to control erosion by cover crops and no-tillage techniques in Paraná, Brazil. Soil and tillage research 8:253-263.

Diaz F., Jimenez C., Tejedor M. (2005) Influence of the thickness and grain size of tephra mulch on soil water evaporation. Agricultural Water Management 74:47-55.

Döring T.F., Brandt M., Heß J., Finckh M.R., Saucke H. (2005) Effects of straw mulch on soil nitrate dynamics, weeds, yield and soil erosion in organically grown potatoes. Field crops research 94:238-249.

Gardner W.H., Klute A. (1986) Water content. Methods of soil analysis. Part 1. Physical and mineralogical methods:493-544.

Glsb T., Kulig B.. (2008) Effect of mulch and tillage system on soil porosity under wheat (Triticum aestivum). Soil & tillage research 99:169-178.

Hajabbasi M., Hemmat A. (2000) Tillage impacts on aggregate stability and crop productivity in a clay-loam soil in central Iran. Soil and tillage research 56:205-212.

Hemmat A., Taki O. (2001) Grain yield of irrigated winter wheat as affected by stubble-tillage management and seeding rates in central Iran. Soil and tillage research 63:57-64.

Hemmat A., Eskandari I. (2004a) Conservation tillage practices for winter wheat-fallow farming in the temperate continental climate of northwestern Iran. Field crops research 89:123-133.

Hemmat A., Eskandari I. (2004b) Tillage system effects upon productivity of a dryland winter wheat-chickpea rotation in the northwest region of Iran. Soil and tillage research 78:69-81.

Hemmat A., Eskandari I. (2006) Dryland winter wheat response to conservation tillage in a continuous cropping system in northwestern Iran. Soil and tillage research 86:99-109.

Hemmat A., Ahmadi I., Masoumi A. (2007) Water infiltration and clod size distribution as influenced by ploughshare type, soil water content and ploughing depth. Biosystems engineering 97:257-266.

Hobbs P.R., Sayre K., Gupta R. (2008) The role of conservation agriculture in sustainable agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences 363:543.

Hoogmoed W., Stroosnijder L. (1984) Crust formation on sandy soils in the Sahel I. Rainfall and infiltration. Soil and tillage research 4:5-23.

Inbar M., Llerena C.A. (2000) Erosion processes in high mountain agricultural terraces in Peru. Mountain Research and Development 20:72-79.

Kemper W., Rosenau R. (1986) Aggregate stability and size distribution.

Khan A.A.H., Ong C.K. (1997) Design and calibration of tipping bucket system for field runoff and sediment quantification. Journal of soil and water conservation 52:437.

Laddha K., Totawat K. (1997) Effects of deep tillage under rainfed agriculture on production of sorghum (Sorghum biocolor L. Moench) intercropped with green gram (Vigna radiata L. Wilczek) in western India. Soil and tillage research 43:241-250.

Lampurlanés J. (2003) Soil bulk density and penetration resistance under different tillage and crop management systems and their relationship with barley root growth. Agronomy Journal 95:526.

Le Bissonnais Y., Bruand A., Jamagne M. (1989) Laboratory experimental study of soil crusting: Relation between aggregate breakdown mechanisms and crust stucture. Catena 16:377-392.

Locke M.A., Bryson C.T. (1997) Herbicide-soil interactions in reduced tillage and plant residue management systems. Weed Science:307-320.

Mahboubi A., Lal R., Faussey N. (1993) Twenty-eight years of tillage effects on two soils in Ohio. Soil Science Society of America journal (USA).

Morin J., Rawitz E., Hoogmoed W., Benyamini Y. (1984) Tillage practices for soil and water conservation in the semi-arid zone III. Runoff modeling as a tool for conservation tillage design. Soil and tillage research 4:215-224.

Mosaddeghi M., Mahboubi A., Safadoust A. (2009) Short-term effects of tillage and manure on some soil physical properties and maize root growth in a sandy loam soil in western Iran. Soil and tillage research 104:173-179.

Mosaddeghi M., Hemmat A., Hajabbasi M., Alexandrou A. (2003) Pre-compression stress and its relation with the physical and mechanical properties of a structurally unstable soil in central Iran. Soil and tillage research 70:53-64.

Motavalli P., Anderson S., Pengthamkeerati P. (2003a) Surface compaction and poultry litter effects on corn growth, nitrogen availability, and physical properties of a claypan soil. Field crops research 84:303-318.

Motavalli P., Stevens W., Hartwig G. (2003b) Remediation of subsoil compaction and compaction effects on corn N availability by deep tillage and application of poultry manure in a sandy-textured soil. Soil and tillage research 71:121-131.

Nelson D., Sommers L., Page A. (1982) Methods of soil analysis. Methods of soil analysis 9.

Nitant H., Singh P. (1995) Effects of deep tillage on dryland production of redgram (Cajanus cajan L.) in central India. Soil and tillage research 34:17-26.

Peterson G., Halvorson A., Havlin J., Jones O., Lyon D., Tanaka D. (1998) Reduced tillage and increasing cropping intensity in the Great Plains conserves soil C. Soil and tillage research 47:207-218.

Pikul Jr J., Zuzel J. (1994) Soil crusting and water infiltration affected by long-term tillage and residue management. Soil Science Society of America (USA).

Poesen J., Lavee H. (1991) Effects of size and incorporation of synthetic mulch on runoff and sediment yield from interrils in a laboratory study with simulated rainfall. Soil and tillage research 21:209-223.

Rhoades J. (1982) Soluble salts. Methods of soil analysis. Part 2:167-179.

Roger-Estrade J., Richard G., Caneill J., Boizard H., Coquet Y., Defossez P., Manichon H. (2004) Morphological characterisation of soil structure in tilled fields: from a diagnosis method to the modelling of structural changes over time. Soil and tillage research 79:33-49.

Sadegh-Zadeh F., Seh-Bardan B.J., Samsuri A.W., Mohammadi A., Chorom M., Yazdani G.A. (2009) Saline Soil Reclamation By Means of Layered Mulch. Arid Land Research and Management 23:127-136.

Saggar S., Newman R., Ross C., Dando J., Shepherd T. (2001) Tillage-induced changes to soil structure and organic carbon fractions in New Zealand soils. Australian Journal of Soil Research 39:465-489.

Saxton K., McCool D., Papendick R. (1981) Slot mulch for runoff and erosion control. Journal of soil and water conservation 36:44.

Shirani H., Hajabbasi M., Afyuni M., Hemmat A. (2002) Effects of farmyard manure and tillage systems on soil physical properties and corn yield in central Iran. Soil and tillage research 68:101-108.

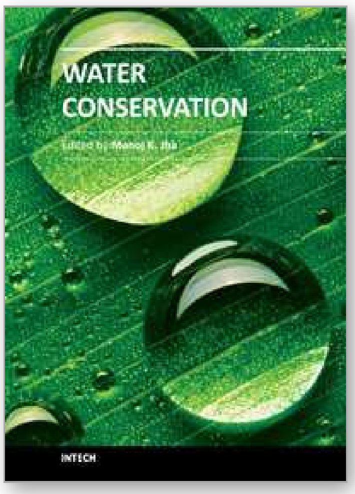
Su Z., Zhang J., Wu W., Cai D., Lv J., Jiang G., Huang J., Gao J., Hartmann R., Gabriels D. (2007) Effects of conservation tillage practices on winter wheat water-use efficiency and crop yield on the Loess Plateau, China. Agricultural Water Management 87:307-314.

Tejedor M., Jiménez C., Díaz F. (2002) Soil moisture regime changes in tephra-mulched soils: implications for soil taxonomy. Soil Science Society of America Journal 66:202-206.

Unger P.W., Fulton L.J. (1990) Conventional-and no-tillage effects on upper root zone soil conditions. Soil and tillage research 16:337-344.

Unger P.W., Jones O.R. (1998) Long-term tillage and cropping systems affect bulk density and penetration resistance of soil cropped to dryland wheat and grain sorghum. Soil and tillage research 45:39-57.

Vittal K., Vijayalakshmi K., Rao U. (1983) Effect of deep tillage on dryland crop production in red soils of India. Soil and tillage research 3:377-384.



Water Conservation

Edited by Dr. Manoj Jha

ISBN 978-953-307-960-8

Hard cover, 152 pages

Publisher InTech

Published online 09, December, 2011

Published in print edition December, 2011

Water is an essential and basic human need for urban, industrial and agricultural use. While an abundance of fresh water resources is available, its uneven distribution around the globe creates challenges for sustainable use of this resource. Water conservation refers to an efficient and optimal use as well as protection of valuable water resources and this book focuses on some commonly used tools and techniques such as rainwater harvesting, water reuse and recycling, cooling water recycling, irrigation techniques such as drip irrigation, agricultural management practices, groundwater management, and water conservation incentives.