World Applied Sciences Journal 14 (10): 1555-1558, 2011
ISSN 1818-4952

Effect of Different Tillage Methods on Some Physical and Mechanical Properties of Soil in the Arid Lands of Iran

Majid Rashidi and Fereydoun Keshavarzpour

Department of Mechanical Engineering, East Tehran Branch,
Islamic Azad University, Tehran, Iran

Abstract: Field experiments were conducted to investigate the effect of different tillage methods on some physical and mechanical properties of soil, i.e. moisture content (MC), bulk density (BD) and penetration resistance (PR). Tillage treatments in the study were moldboard plow followed by two passes of disk harrow (MDD) as conventional tillage, two passes of disk harrow (DD) as reduced tillage, one pass of disk harrow (D) as minimum tillage and no-tillage (NT). The statistical results of the study indicated that tillage method significantly ($P \leq 0.05$) affected physical and mechanical properties of soil. The highest MC (20.6%) and the lowest BD (1.34 g cm^{-3}) and PR (487 kPa) was observed in case of MDD treatment; while the lowest MC (17.6%) and the highest BD (1.44 g cm^{-3}) and PR (1087 kPa) was noted in case of NT treatment. Therefore, conventional tillage method was found to be more appropriate and profitable tillage method in enhancing selected physical and mechanical properties of soil in the arid lands of Iran.

Key words: Soil · Tillage · Moisture content · Bulk density · Penetration resistance · Arid lands · Iran

INTRODUCTION

Soil tillage is among the important factors affecting soil physical and mechanical properties [1]. Tillage method affects the sustainable use of soil resources through its influence on soil properties [2]. The proper use of tillage can improve soil related constrains, while improper tillage may cause a range of undesirable processes, e.g. destruction of soil structure, accelerated erosion and depletion of organic matter and fertility [3]. Use of excessive and unnecessary tillage operations is often harmful to soil. Therefore, currently there is a significance interest and emphasis on the shift to the conservation and no-tillage methods [4].

Conventional tillage practices modify soil structure by changing its physical and mechanical properties such as moisture content, bulk density and penetration resistance. Annual disturbance and pulverizing caused by conventional tillage produces a finer and loose soil structure as compared to conservation and no-tillage methods which leave the soil intact [5]. This difference results in a change of number, shape, continuity and size distribution of the pores network, which controls the ability of soil to store and transmit air, water and agricultural chemicals. This in turn controls erosion, runoff and crop performance [6]. Conversely, conservation tillage methods often result in decreased pore space [7], increased soil mechanical strength [8] and stable aggregates [9]. Whereas, conventional tillage decreases soil mechanical strength and soil bulk density [10]. It also improves porosity and water holding capacity of the soil. This all leads to a favorable environment for crop growth and nutrient use [6].

Currently, different tillage methods are being used in Iran without evaluating their effects on physical and mechanical properties of soil. Thus, this study was conducted to determine the effect of different tillage methods on some selected physical and mechanical properties of soil (moisture content, bulk density and penetration resistance) in the arid lands of Iran.

MATERIALS AND METHODS

Research Site: This study was carried out at the Agricultural Research Site, Garmsar, Iran on a clay loam soil for two successive growing seasons (2009 and 2010). The research site is located at latitude: 35° 13' N, longitude: 52° 19' E and altitude: 873 m in arid climate (136 mm rainfall annually) in the center of Iran.

Corresponding Author: Dr. Majid Rashidi, Ph.D., Department of Mechanical Engineering, East Tehran Branch, Islamic Azad University, Tehran, Iran.

Table 1: Soil chemical properties and particle size distribution of the research site (mean of 2009 and 2010)

Soil characteristics	Values
Texture	Clay loam
Sand (%)	23.6
Silt (%)	37.0
Clay (%)	39.4
EC (dS m^{-1})	3.10
pH	7.35
OC (%)	0.92
P (ppm)	45.2
K (ppm)	270
Fe (ppm)	2.95
Zn (ppm)	1.48
Cu (ppm)	1.21
Mn (ppm)	13.1

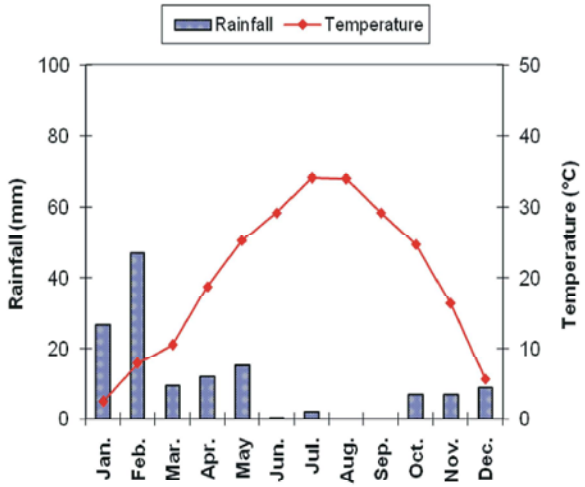

Fig. 1: Mean monthly rainfall and temperature (mean of 2009 and 2010)

Fig. 2: CP40-II cone penetrometer

Fig. 3: Small cone size (diameter: 12.83 mm; area: 130 mm^2; angle: 30°)

Soil Sampling and Analysis: The soil of the research site is classified as an Aridisol (fine, mixed, active, thermic, typic haplocambids). A composite soil sample (from 12 points) was collected from 0-30 cm depth 10 days before tillage treatments (10th June) during the years of study and was analyzed in the laboratory for P, K, Fe, Zn, Cu, Mn, EC, pH, organic carbon and particle size distribution. Details of soil chemical properties and particle size distribution of the research site are given in Table 1.

Weather Parameters: The mean monthly rainfall and temperature data of the research site during the years of study (2009 and 2010) are given in Fig. 1.

Field Methods: The experiments were laid out in a Randomized Complete Block Design (RCBD) having three replications. The size of each plot was 10.0 m long and 6.0 m wide. A buffer zone of 5.0 m spacing was provided between plots. The treatments were applied to the same plots during the two year (2009-2010) on farm study. Tillage treatments included one pass of moldboard plow followed two passes of disk harrow (MDD) as conventional tillage, two passes of disk harrow (DD) as reduced tillage, one pass of disk harrow (D) as minimum tillage and no-tillage (NT).

Observation and Data Collection: Standard procedures were adopted for recording the data on selected physical and mechanical properties from 0-30 cm depth 90 days after tillage treatments (20th September). For determining soil bulk density (BD) five undisturbed samples were taken from each plot by core sampler and dried 24 h at 105°C in an oven. Also, soil moisture content (MC) was determined during soil BD determination. Moreover, soil

penetration resistance (PR) was measured by five insertions in each plot. For measuring PR a CP40-II cone penetrometer (Fig. 2) was used with small cone size (Fig. 3) based on ASAE standard S313.3 FEB04.

Statistical Analysis: The data collected were analyzed statistically using Randomized Complete Block Design (RCBD) as described by Gomez and Gomez [11]. Duncan's Multiple Range Test (DMRT) at 5% probability was also performed to compare the means of different treatments by using the computer software SPSS 12.0 (Version, 2003).

RESULTS

Soil Moisture Content (MC): Different tillage treatments significantly affected soil MC during the study years. The highest soil MC of 20.6% was obtained in case of MDD treatment and lowest (16.9%) in case of NT treatment (Table 2).

Soil Bulk Density (BD): A significant effect of different tillage treatments on soil BD was also found during both the years of study. The highest soil BD of 1.44 g cm^{-3} was recorded in case of NT treatment and lowest (1.34 g cm^{-3}) in case of MDD treatment (Table 2).

Soil Penetration Resistance (PR): Different tillage treatments significantly affected soil PR during the years of study. The highest soil PR of 1087 kPa was obtained in case of NT treatment and lowest (487 kPa) in case of MDD treatment (Table 2).

DISCUSSION

In this study, effect of different tillage methods on some selected physical and mechanical properties of soil, i.e. moisture content (MC), bulk density (BD) and penetration resistance (PR) was investigated. The statistical results of the study indicated that tillage method significantly ($P \leq 0.05$) affected all studied properties (Table 2). The highest MC (20.6%) and the lowest BD (1.34 g cm^{-3}) and PR (487 kPa) was observed in case of MDD treatment. On the other hand, the lowest MC (17.6%) and the highest BD (1.44 g cm^{-3}) and PR (1087 kPa) was noted in case of NT treatment (Table 2). A significant higher MC in case of MDD treatment was assumed to be owing to effect of primary and secondary tillage implements used which improved porosity and consequently water holding capacity of the soil. These results are in agreement with those of Khurshid *et al.* [1] who reported that conventional tillage practices increased tortuosity of the soil. Moreover, significant lower BD and PR in case of MDD treatment were judged to be due to soil loosening effect of primary and secondary tillage implements used. These results are in line with the results reported by Iqbal *et al.* [4] that conventional tillage practices increased MC and decreased BD and PR. Higher PR in case of conservation tillage methods may also be owing to lower MC. This is in line with the results reported by Hill [7] that PR increased with decrease in MC.

Table 2: Means comparison for selected physical and mechanical properties of soil among different tillage methods (mean of 2009 and 2010)

Treatment	MC* (%)	BD* (g cm^{-3})	PR* (kPa)
MDD	20.6 a	1.34 c	487 c
DD	19.3 b	1.40 b	709 b
D	18.0 c	1.43 ab	961 a
NT	17.6 c	1.44 a	1087 a

* = Significant at 0.05 probability level

Means in the same column with different letters differ significantly at 0.05 probability level according to DMRT.

(MC: moisture content; BD: bulk density; PR: penetration resistance)

CONCLUSION

Conventional tillage method (moldboard plow + two passes of disk harrow) was found to be more appropriate and profitable tillage method in improving selected physical and mechanical properties of soil in the arid lands of Iran.

ACKNOWLEDGMENT

The authors are very much grateful to the "East Tehran Branch, Islamic Azad University, Iran" for giving all types of support in publishing this study.

REFERENCES

1. Khurshid, K., M. Iqbal, M.S. Arif. and A. Nawaz, 2006. Effect of tillage and mulch on soil physical properties and growth of maize. Int. J. Agri. Biol., 5: 593-596.
2. Hammel, J.E., 1989. Long term tillage and crop rotation effects on bulk density and soil impedance in northern Idaho. Soil Sci. Soc. Amer. J., 53: 1515-1519.
3. Lal, R., 1993. Tillage effects on soil degradation, soil resilience, soil quality and sustainability. Soil and Tillage Res., 51: 61-70.

4. Iqbal, M., A.U. Hassan, A. Ali and M. Rizwanullah, 2005. Residual effect of tillage and farm manure on some soil physical properties and growth of wheat (*Triticum aestivum* L.). Int. J. Agri. Biol., 1: 54-57.
5. Rashidi, M. and F. Keshavarzpour, 2007. Effect of different tillage methods on grain yield and yield components of maize (*Zea mays* L.). Int. J. Agri. Biol., 2: 274-277.
6. Khan, F.U.H., A.R. Tahir and I.J. Yule, 2001. Intrinsic implication of different tillage practices on soil penetration resistance and crop growth. Int. J. Agri. Biol., 1: 23-26.
7. Hill, R.L., 1990. Long-term conventional and no-tillage effects on selected soil physical properties. Soil Sci. Soc. Amer. J., 54: 161-166.
8. Bauder, J.W., G.W. Randall and J.B. Swan, 1981. Effects of four continue tillage systems on mechanical impedance of a clay-loam soil. Soil Sci. Soc. Amer. J., 45: 802-806.
9. Horne, D.J., C.W. Ross and K.A. Hughes, 1992. Ten years of maize/oats rotation under three tillage systems on a silt-loam soil in New Zealand. 1. A comparison of some soil properties. Soil and Tillage Res., 22: 131-143.
10. Khan, F.U.H., A.R. Tahir and I.J. Yule, 1999. Impact of different tillage practices and temporal factor on soil moisture content and soil bulk density. Int. J. Agri. Biol., 3: 163-166.
11. Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agriculture Research. A Wiley-Inter Science Publication, John Wiley and Sons Inc. New York, USA.