Effects of different tillage methods on soil physical properties, grain and forage yield of two cultivars maize

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ABSTRACT

One of the factors affecting the physical properties of soil and crops is tillage systems. The experiment was conducted in the summer of 2012 at the research farm of Islamic Azad University. This study was performed by experiment a split plot in a randomized complete block design with three replications. The main factors in this study are four different tillage methods and sub factors which includes two maize varieties; single cross 704 and maxima. Also for soil physical properties statistical analysis, randomized complete block design was used. Based on the results, different tillage methods on soil physical properties and yield of plants have shown significant differences at 1%. Most of the yield was related to corn single cross 704 and twice of disc tillage in depth of 15-10 cm, with 88/18 tons per hectare. The greatest amount of soluble sugars and protein was obtained from corn single cross 704 using cultivator with blade and light disk with depth of 8 to 10 cm.

Key words: Soil, corn, tillage methods.

INTRODUCTION

When peoples were dependent on a group of animals to supply some of their own necessary nutrients, producing some useful and valuable forage plants for animal feeds, was more noteworthy. One of these plants is corn. This valuable product of agriculture provides nearly 70% of the poultry feed. It is a useful grain that is use to produce edible oil, starch, glucose, and raw material in the industry and many other products (Hosseini and Abedi, 2007). Studies have shown that each year a large area of arable land in the world disappears due to compaction and soil erosion. For this reason, application of appropriate strategies is necessary to reduce nutrient loss and soil erosion. Conservation tillage which includes reduced tillage and no-tillage is one of the useful methods to avoid these problems (Limousin and Tessier, 2007). On the other hand, adopting special measures seems necessary to address the concerns regarding lack of food, for growing world population. In this regard, proper land preparation and tillage operations are the two important issues for increasing production. Research results indicate that tillage systems are effective on yield of the different crops. Wright et al. (2007) reported that cotton yield in reduced tillage system increases compared with conventional tillage system. They stated that phosphorus and nitrogen availability increases in the soil of reduced tillage systems which lead to higher performance. Another study conducted in 5 years, observed that cotton yield in the first three years in conservation tillage systems was significantly higher than conventional tillage while in the last two years, cotton yields in the system of protective tillage was equivalent to conventional tillage (Blaise and Ravindran, 2003). Conservation tillage can lead to increased performance yield of corn by increasing soil moisture and reducing its temperature (Afzalinia et al., 2011). Keeping soil in good physical condition is one of the protective aspects of it that depends heavily on the proper use of agricultural machinery management and soil conditions. The tillage systems affect the rate of previous crop residue on soil surface and pores soil. Thus, they play a prominent role in maintaining moisture and yield in arid and semiarid regions (De Vita et
Table 1. Physical and chemical soil analysis.

<table>
<thead>
<tr>
<th>Type of test</th>
<th>pH</th>
<th>Clay (%)</th>
<th>Silt (%)</th>
<th>Sand (%)</th>
<th>Texture</th>
<th>N (%)</th>
<th>K (ppm)</th>
<th>P (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimum range</td>
<td>6.5</td>
<td>25</td>
<td>25</td>
<td>50</td>
<td>Loam</td>
<td>&gt; 0.2</td>
<td>400</td>
<td>15</td>
</tr>
<tr>
<td>Results</td>
<td>7.78</td>
<td>22</td>
<td>36</td>
<td>42</td>
<td>Loam</td>
<td>0.06</td>
<td>406.6</td>
<td>12.8</td>
</tr>
</tbody>
</table>

MATERIALS AND METHODS

This research was conducted in year 2012 at agricultural research station crop, the University of Varamin located in Varamin city (tehran province), with longitude 51° 39’ and latitude 35° and 19’ and elevation 1000 m above sea level and features loam soil - clay loam (Table 1). During this research, effect of different methods of tillage on soil physical properties, yield and forage maize cultivars were evaluated. This research was conducted by split-plot. The design of experiments was a randomized complete block with three replications. The main factors of this project are four different tillage methods including: 1- tillage with rotary tiller in depth of 8 to 10 cm (S1), 2- cultivator with blade and light disk with depth of 8 to 10 cm (S2), 3- twice disk with depth of 10 to 15 cm (S3), 4- moldboard plow and light disk with depth of 8 to 10 cm (S4). Moreover, two cultivars of silage corn were considered as sub-factors in this research which are as follows: corn with single cross of 704 (SC 704) and corn with cultivar of Maxima. For statistical analysis of physical properties of soil, completely randomized block design was utilized.

According to soil tests, rate of nitrogen fertilizer, was calculated as 350 kg per hectare. Nitrogen fertilizer was given to the plant in three phases: growing phase (50%), three to five leaves (25%) and the crown of flowers (25%). The first irrigation was performed after tillage and before planting drip method. This procedure continued until complete plant establishment after planting. Subsequently, once every 6 to 10 days they were done with conventional methods and practices of local farmers. Plantation was performed by worker and planting with hand. In this method, a furrow by foca along the longitudinal of each plot with depth of 2.5 cm was induced. Then, the seeds were poured in furrow and compacted. Humidity was measured twice, after tillage and after harvest, in depth of 10-15 cm and three points of each main plot. The sampling was performed by a special cylinder that also was used to calculate the bulk density. In all cases, soil samples were dried at 105°C in oven for 24 h. Meanwhile, wet and dry weight of soil before and after placing the sample in the oven was measured. Weighing by digital scale it was accurately calculated 0.01. Afterwards, moisture content measurement was derived from Equation 1.

\[ \Theta_m = \frac{A - B}{B - C} \]  

Equation 1

Where \( \Theta_m \): is moisture content, \( A \): stands for weight of empty container and wet soil weight, \( B \): denotes weight of empty container and dry soil weight and \( C \): is weight of the empty container.

For sampling and determination of bulk density of the soil after tillage, samples were taken from three points of each main plot randomly in depth of 10-15 cm as undisturbed soil, by special cylinders. In order to calculate the bulk density Equation 2 was utilized.

\[ \rho_b = \frac{\text{Weight of dry soil}}{\text{Undisturbed soil volume}} \]  

Equation 2

Soil fragmentation measurements were done at the end of tillage before planting. The index, which is commonly used in the case, is mean weight diameter (MWD) hunk. In order to measure it, a frame with dimensions of 15 × 15 × 30 cm in depth of 15 cm was inserted in the soil. The frame was removed and after pouring, the soil was transported to the laboratory in plastic bag. This work was carried out randomly in each plot three times. We used Equation 3 to calculate the mean weight diameter (MWD) hunk.

\[ \text{MWD} = (1/W) \left( 0.25A + 0.75B + 1.25C + 1.25D + 1.75E \right) \]  

Equation 3

Where \( W \): is weight of soil comminuted in per sample from experiment, \( A \): shows weight of soil transmission from sieve 0.5 inch, \( B \): denotes weight of clod between sieve of 0.5 and 1 inch, \( C = \) is weight of the clod between sieve of 1 and 1.5 inch, \( D \):
represent weight of clod between sieve of 1.5 and 2 inch, E: stands for weight of the clod on sieve of 2 inch and N: is mean of clod diameter on the upper sieve in term of millimeters.

Weight of 100 seeds was measured averaging from sampling 10 sample of each sub plot. Also, Equation 4 was used in order to calculate the total number of grains per year.

\[
\text{Total number of seeds} = \text{Average number of rows per ear} \times \text{Number of seeds per row}
\]

To measure fresh forage yield, whole shoot, leaf and corn from the soil surface were harvested, and weight of the fresh forage was considered as yield of forage fresh weight. For this purpose, ten plants per subplot were cut from the soil surface, and were immediately transported to the laboratory. In the laboratory, each of them was measured separately by separating the leaves and stalks of corn, and the yield of forage fresh weight was calculated.

Statistical analysis was performed for all traits using SAS software. For the drawing of the graphs and tables, excel software was utilized. Also, all mean comparisons were performed using Duncan's multiple range tests. For the analysis of traits related to yield and yield components of maize varieties, tested split plot was used in a randomized complete block design. But for the analysis of soil physical properties, randomized complete block design was used. Data were collected and analyzed separately.

RESULTS AND DISCUSSION

The results showed that tillage methods had significant effect on seed weight and number of grains per ear, wet weight of leaf, stem and grain quality traits such as soluble sugars and protein. Also the effect of tillage on soil physical properties such as soil moisture after tillage and after harvest, soil bulk density and the mean weight diameter (MWD) was meaningful. The Results for the analysis of variance for the study is reported in Tables 2 and 3.

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**Table 2.** Analysis of variance, yield and yield components of two maize varieties under different tillage methods (mean square).

<table>
<thead>
<tr>
<th>Sources of change</th>
<th>Degrees of freedom</th>
<th>The total number of grains per ear</th>
<th>100 Seed weight</th>
<th>wet weight of leaves</th>
<th>wet weight of stem</th>
<th>wet weight of corn</th>
<th>yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeat (R)</td>
<td>2</td>
<td>34455.792</td>
<td>2.040</td>
<td>4.530</td>
<td>4.530</td>
<td>9.960</td>
<td>0.179</td>
</tr>
<tr>
<td>Tillage (S)</td>
<td>3</td>
<td>13744.50**</td>
<td>9.854**</td>
<td>5131.250**</td>
<td>86678.125**</td>
<td>12460.250**</td>
<td>420.000**</td>
</tr>
<tr>
<td>Error (E)</td>
<td>6</td>
<td>22.125</td>
<td>0.327</td>
<td>0.163</td>
<td>0.163</td>
<td>3.702</td>
<td>0.0001</td>
</tr>
<tr>
<td>cultivar (v)</td>
<td>1</td>
<td>3901.50**</td>
<td>46.204**</td>
<td>2109.375**</td>
<td>119709.375**</td>
<td>1683375**</td>
<td>565.996**</td>
</tr>
<tr>
<td>Interaction of tillage and cultivar (s×v)</td>
<td>3</td>
<td>54832.50**</td>
<td>26104**</td>
<td>465.625**</td>
<td>6753.125**</td>
<td>1184625**</td>
<td>62.962**</td>
</tr>
<tr>
<td>Error (E)</td>
<td>8</td>
<td>33.875</td>
<td>0.245</td>
<td>0.245</td>
<td>0.245</td>
<td>2.506</td>
<td>0.0001</td>
</tr>
<tr>
<td>The coefficient of variation (c.v%)</td>
<td>-</td>
<td>10.74</td>
<td>4.17</td>
<td>6.71</td>
<td>10.06</td>
<td>8.87</td>
<td>9.01</td>
</tr>
</tbody>
</table>

* and**: Significant at 0.05 and 0.01 Probability level respectively.

**Table 3.** Statistical analysis of soil physical properties under different tillage methods (mean square).

<table>
<thead>
<tr>
<th>Sources of change</th>
<th>Degrees of freedom</th>
<th>Soil bulk density in depth of 10-15 cm</th>
<th>Soil moisture after tillage</th>
<th>soil moisture after harvest</th>
<th>Mean weight diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeat (R)</td>
<td>2</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.007</td>
<td>0.0001</td>
</tr>
<tr>
<td>Tillage (S)</td>
<td>3</td>
<td>0.210**</td>
<td>5.289**</td>
<td>0.110**</td>
<td>0.962**</td>
</tr>
<tr>
<td>Error (E)</td>
<td>6</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.005</td>
<td>0.0001</td>
</tr>
<tr>
<td>The coefficient of variation (c.v%)</td>
<td>-</td>
<td>5.75</td>
<td>1.05</td>
<td>2.82</td>
<td>4.77</td>
</tr>
</tbody>
</table>
According to the results of mean comparisons (Figures 1, 2, 3 and 4), the highest fresh weight of leaf, stem and corn, which was obtained from the cultivation of maize single cross 704 with Type 3 tillage methods (S3), equals 113.43, 521.81 and 166.45 g respectively and the corn yield with Type 3 tillage methods and cultivation of maize single cross 704 with 88.18 tons per hectare. With reduced tillage methods, the crop water requirement can be provided during the growing season and especially at the end of the growing season (Robert et al., 2006). Generally, water is the main limiting factor for agriculture in arid and semi-arid regions. Tillage and crop rotation, and storage management methods are effective in moisture absorption impact. In reduced tillage methods, performance will increase possibly due to more reserve soils moisture and reduction of evaporation.

**The total number of grains per ear and 100 grain weight**

Based on the results (Figures 5 and 6), the most number of grains per ear was obtained, with cultivation of maize single cross 704 and Type 2 tillage methods (S2) which was...
**Figure 3.** Effect of interaction between cultivars and tillage on corn fresh weight (g).

**Figure 4.** Effect of interaction between cultivars and tillage on yield (ton/ha).

**Figure 5.** Effect of interaction between cultivars and tillage on the total number of grains per ear.
901.7 pieces of grains per year. Additionally, the highest weight of 100 seed is achieved with cultivation of maize single cross 704 and Type 2 tillage methods (S2) which equals to 17 g and the lowest amount of this index is obtained from Type 1 tillage methods (S1) and cultivation of maize single cross 704 which was 8 g. This may lead to reduction in soil compaction, improvement of root growth, uniform distribution of nutrients, increase of organic matter and saving and keeping more moisture in the soil (Bauer and Black, 1981). It can be said that reduced tillage methods play effective role in increasing water storage within the soil. It also seems that maize varieties with long growth season have a higher yield in comparison with maize varieties with short growth season.

Changes in soil moisture (after tillage and after harvest)

According to the results (Figures 7 and 8), the maximum amount of moisture after tillage was obtained from Type 4 tillage methods (S4) and lowest amount of moisture was achieved from Type 2 tillage methods (S2). Their amount respectively equals to 16.08 and 13.07%. In addition, the...
highest soil moisture was calculated after harvest with Type 3 tillage methods (S3) and the lowest of soil moisture was derived from Type 4 tillage methods (S4). They are respectively equivalent to 9.10 and 8.69%.

According to the results in dry conditions, reduced tillage, with the maintenance of soil moisture is the best way to prepare the substrate (Rusu et al., 2009). These results indicate that in dry conditions and in areas with limitation of moisture, the less soil is disturbed, the lower moisture losses are because of reduction in evaporation from the soil surface.

**Soil bulk density after tillage**

According to the results (Figure 9), the lowest bulk of density soil was calculated with Type 4 tillage methods (S4) which equals to 0.92 g/cm³ and maximum amounts was calculated for Type 2 tillage methods (S2) which was equivalent to 1.06 g/cm³. This result is consistent with the findings of Jin et al. (2011) in tests that lasted for 10 and 11 years respectively. They reported that plowing by moldboard plow, the bulk density of soil was reduced (Jin et al., 2011). Probably in moldboard plow, bulk density
decreased because of making large of lumps and disarrange of soil. Also the rotary plow results in complete disruption of soil and increases soil porosity.

Mean weight diameter of soil

Based on the results (Figure 10), the highest amount of crushed soil with mean diameter of 1.81 cm was obtained from Type 1 tillage methods (S1) and lowest amount of crushed soil with mean diameter 3.14 cm was achieved by Type 4 tillage methods (S4). Rouzbeh and Loghavi (2006) compared the rotivator with disk in their research. They showed that the rotivator in depth of more than 5 cm, aggregates soil with less mean weight diameter and provides more uniform (Rouzbeh and Loghavi, 2006).

Conclusion

The results of this research show that conventional tillage initially provides more water storage space and greater volume of water due to the low bulk density and greater porosity of soil; however, over time and at the end of growing season the reduced tillage methods cause minimal manipulation and disturbing the soil. As a result, they diminish the rate of moisture evaporation from soil surface and thus are able to prevent the loss of moisture stored in the soil. With conservation tillage practices, water needed to satisfy various products is stored; thus, water consumption in agriculture is reduced.

REFERENCES


