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# Effect of Conservation Tillage on the Soil Properties and Cotton Yield

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**Abstract:** In order to investigate the effect of conservation tillage on the soil properties, fuel consumption, time required for tillage and planting operations, cotton yield, and cotton yield components, an experiment was performed with three treatments and four replications. The research was conducted in the form of a randomized complete block experimental design in Darab region of Fars province, Iran. Three different tillage methods including conventional tillage (CT), reduced tillage (RT), and zero tillage (ZT) were considered in this study. Parameters such as soil moisture content, soil bulk density, fuel consumption, time required for tillage and planting operations, cotton yield, and cotton yield components were measured to compare the tillage methods considered in this research. Data collected from this study were analyzed using SAS software, and Duncan's multiple range tests was used to compare the treatments means. Results showed that there was no significant difference between the treatments for soil bulk density and soil moisture retention. Results showed that reduced and zero tillage methods saved fuel consumption during seed bed preparation and planting operations for 59.6 and 77.3%, respectively. These methods also saved time required for seed bed preparation and planting operations for 61.8 and 71.9%, respectively compared to the conventional tillage method. Results also revealed that conservation tillage slightly increased the number of boll per plant, and decreased cotton yield by 15.7% on average compared to conventional tillage.
**Key words:** reduced tillage, zero tillage, conventional tillage, soil properties, cotton yield

## INTRODUCTION

Conservation tillage system is a method in which at least 30% of soil surface remains covered by crop residues. Minimum and zero tillage systems are important methods of conservation tillage. Conservation tillage improves soil and water resources, saves energy and time, and reduces the costs of agricultural products. According to the results of a research conducted by Chen and Baillie (2009), changing the tillage method from conventional to minimum in cotton could save the overall fuel consumption by about 10%. Jalota et al. (2008) compared conservation and conventional tillage methods in cotton and found that minimum tillage method had the lower yield and water productivity compared to the conventional tillage. Erenstein and Laxmi (2008) stated that on time planting, weed control, water saving, reducing production costs, and increasing farmers' income were the advantages of wheat direct drilling in the rice residue. De Vita et al. (2007) found that zero tillage decreased the evaporation from the top soil. Rusu (2005) reported that minimum tillage reduced fuel consumption by 12.4 to 25.3 liter per hectare and power requirement by 23.6 to 42.8 % compared to conventional tillage method. Liu et al. (2005) reported that zero tillage increased soil bulk density and soil cone index compared to conventional tillage. Weed population was also reduced in the zero tillage method compared to the conventional method (Liu et al., 2005).

Karamanos et al. (2004) showed that conservation tillage methods (no-tillage and minimum tillage methods) provided higher soil water content, cotton root growth, and cotton yield compared to the conventional tillage. Blaise and Ravindran (2003) reported that using the reduced tillage method instead of the conventional tillage method in cotton caused a higher soil organic Carbone, weed density, plant dry matter, yield, and yield components. Hobbs et al. (1997) reported that conservation tillage saved 98 L/ha fuel and 20% water consumption in wheat production compared to the conventional tillage method.

Merrill et al. (1996) showed that wheat root development increased up to 112% in the no-tillage system in comparison to the conventional method. Peruzzi et al. (1996) found that conservation tillage reduced fuel and energy consumption and increased system field efficiency compared to conventional tillage. Ahmad et al. (1994) reported that wheat direct drilling in the rice residue increased wheat yield for 24% in comparison to the control treatment. Chopart (1987) suggested that direct drilling method could be used for planting cotton followed a corn crop. Touchton et al. (1984) reported that the winter legumes made no considerable variations in the soil nitrogen and bulk density, but increased the water infiltration rate when cotton was no-till planted into winter legumes compared to the cotton direct seeding in the fallowed soil. Objective of this study was to determine the effect of conservation tillage on the soil properties, cotton yield, and cotton yield components.

## MATERIALS and METHODS

The effect of conservation tillage on the soil physical properties, fuel consumption for seed bed preparation and planting, time required for tillage and planting operations, cotton yield, and cotton yield components was evaluated in this research. Three tillage methods including conventional tillage (CT), reduced tillage (RT), and zero tillage (ZT) were considered in this study. Research was performed in the form of a randomized complete block experimental design with three treatments and four replications. In the conventional tillage method, primary tillage was performed using a mold board plow and secondary tillage operation was done using disk harrow and land leveler. Seed bed was prepared in the reduced tillage method using a tine and disc cultivator (TerraMix) which was able to complete the primary and secondary tillage operations simultaneously. Cotton seed was directly planted using SEMEATO (SEMEATO Factories, Passo Fundo, Brasil) direct planter without any seed bed preparation in the zero tillage method. Tests were conducted in a bare fallow field and the cotton variety used in this study was a local variety called Bakhtegan. Soil bulk density was measured at two levels of soil depth including 0 to 10 and 10 to 20 cm using core samplers and drying samples at 105 degrees centigrade for 24 hours in the oven. The following equation was used to calculate the soil bulk density:

$$BD = \frac{W_d}{V} \quad (1)$$

where:
$BD$ = soil bulk density (g/cm$^3$),
$W_d$ = sample dry weight (g), and
$V$ = Sample total volume (cm$^3$).

Soil moisture content was measured by taking samples from the soil depth of 0 to 20 cm and drying samples at the temperature of 105 degrees centigrade for 24 hours. The following equation was used to calculate the soil moisture content:

$$MC = \frac{W_w - W_d}{W_w} \times 100 \quad (2)$$

Where:
$MC$ = soil moisture content (%wb),
$W_w$ = sample wet weight (g), and
$W_d$ = sample dry weight (g).

Fuel consumption was obtained using full tank method for both seed bed preparation and planting operations. Total time required for seed bed preparation and planting operations in each treatment was measured to determine the effective field capacity for each method. Cotton yield and yield components including number of bolls per plant and weight of 20 bolls were measured during the harvesting process.

## RESULTS and DISCUSION

Results of this study showed that there was no significant difference between the treatments for soil bulk density at the both soil depths (Table 1). Soil bulk density of conventional tillage was slightly higher than that of the reduced tillage, and bulk density of the reduced tillage was higher than that of the zero tillage method at the soil depth of 0 to 10 cm. Since tillage operation effect on the soil properties was a

long term process, significant difference between the soil bulk densities of different tillage methods was not found for the first year of project performance. Soil bulk density in all the tillage methods at the depth range of 10 to 20 cm was equal to or higher than that of the soil depth range of 0 to 10 cm which was expected. Results also showed that there was no statistically significant difference between the tillage methods from the view point of moisture retention in the soil (Table 1). Since there was not enough crop residue left on the soil surface in the starting year of this experiment, conservation tillage methods (reduced and zero tillage) could not increase the moisture retention in the soil.

**Table 1. Effect of tillage methods on the soil bulk density and moisture content**

| Tillage methods | Bulk density ($g/cm^3$) | | Moisture content (%wb) |
|---|---|---|---|
| | 0-10 cm | 10-20 cm | 0-20 cm |
| CT | 1.36 a | 1.36 a | 18.93 a |
| RT | 1.33 a | 1.37 a | 18.81 a |
| ZT | 1.29 a | 1.37 a | 18.45 a |

The effect of tillage methods on the fuel consumption during the seed bed preparation and planting process is shown in Figure 1. Conventional tillage consumed the highest amount of fuel (47 L/ha) during the seed bed preparation process because of larger number of operation needed in this method. Results indicated that using minimum tillage reduced fuel consumption by 59.6% compared to the conventional method. The fuel consumption saving was 77.3% when using zero tillage method because the seed bed preparation process was not necessary in this method. In the conventional method, 209.9 minutes were required for seed bed preparation and planting operations while, these times were 80.2 and 54.8 minutes for the reduced and zero tillage methods, respectively (Fig. 2). The reduced tillage method also saved time required for the seed bed preparation and planting operations by 61.8% in comparison to the conventional method. Since there was no seed bed preparation operation in the zero tillage method, time saving during the seed bed preparation and planting operations in this method was 73.9%. Time saving is the most important advantage of conservation tillage in the intensive planting systems which enables farmers to plant their crops on time.

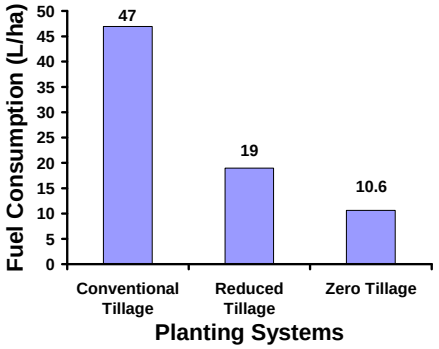


**Figure 1. Fuel consumption for different planting systems**

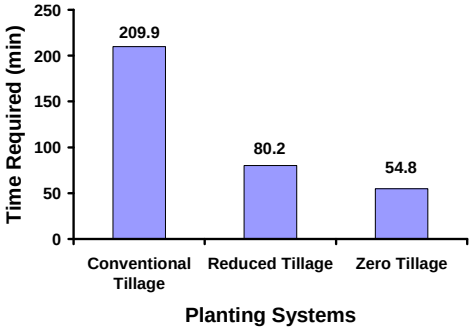


**Figure 2. Time required for seed bed preparation and planting in different planting systems**

As shown in Figure 3, the effective field capacity for seed bed preparation and planting operations in the zero tillage method was approximately 4 times as high as that of the conventional method which could significantly reduce the costs of agricultural products.

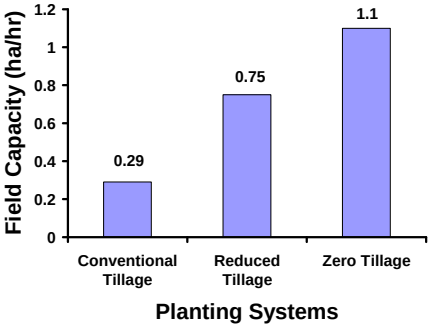


**Figure 3. Effective field capacity for different planting Systems**

Results of this research revealed that there was a significant difference between the treatments in cotton yield. Conventional tillage method had the

highest cotton yield and the zero tillage method had the lowest (Table 2). The difference between the yield obtained from the reduced and zero tillage methods was not significant. In contrast, tillage method had no considerable influence on the cotton yield components (bolls per plant and weight of 20 bolls). However the yield obtained for conservation tillage (reduced and zero tillage) methods was lower than that of the conventional method for the first year, it is expected that improving soil physical properties and organic matter in the conservation tillage methods will improve cotton yield in the coming years of this experiment performance.

**Table 2. Effect of tillage methods on the cotton yield and yield components**

| Tillage methods | Bolls per plant | Weight of 20 bolls (g) | Yield (kg/ha) |
|---|---|---|---|
| CT | 17.83 a | 130.5 a | 2286.4 a |
| RT | 16.79 a | 131.5 a | 1981.9 b |
| ZT | 18.08 a | 128.0 a | 1848.8 b |

## CONCLUSIONS

The results of this study indicated that:

1. Conservation tillage methods saved fuel consumption and time required for the seed bed preparation and planting operations by at least 59.6% and 61.8%, respectively.
2. There was no significant difference in cotton yield between the reduced and zero tillage methods but conventional tillage increased cotton yield by 23.7% compared to the zero tillage method.
3. There was no significant difference between the tillage methods from the soil physical properties point of view.

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