

## Tillage Practices in Wheat Production under Rainfed Conditions in Jordan: An Economic Comparison

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**Abstract:** Wheat (*Triticum durum* L.) is widely grown under rainfed conditions in Jordan. The predominant traditional or conventional tillage system depletes soil resources and results in low crop yields. Conservation tillage increases efficiency of soil moisture storage and is expected to increase crop yield. A field study was conducted during the growing season of 2004/2005 in Northern Jordan, to investigate economic performance of wheat grown under conventional tillage, using a moldboard plow, conservation tillage, using a chisel plow and no-tillage. Costs and returns of the production process were calculated. No tillage was superior to conventional and conservation tillage systems as it maintained the highest total revenue and highest net benefits. According to the results, no tillage system appears to be a viable option for wheat production under rainfed conditions in Jordan. However, for more sound economic judgments, the experiment needs to be conducted at several sites for more than one season.

**Key words:** Wheat • no tillage • chisel • moldboard • cost • returns • net profit

### INTRODUCTION

Wheat (*Triticum durum* L.) is one of the most widely grown cereal crops in Jordan. During the period 1998-2004 the average area planted with wheat was 35.7 thousand hectares, producing about 40,803 tons of grains. In the period 2000-2004 Jordan imported an average amount of 575.6 thousand tons of wheat annually [1]. Low soil moisture was identified as the major constraint limiting crop growth and production under rainfed conditions in Jordan [2].

Development of suitable tillage practices for dryland crop production has been a dynamic process. The traditional and exploitive cropping systems, which have been practiced in Jordan and other Middle Eastern countries, depleted soil resources and resulted in lower crop yields [3].

Traditional crop rotations practiced in Jordan were based on fallows and conventional tillage practices. This system performed reasonably well in the past. However, with the increased population pressure and mechanization of dry land farming, improved tillage practices are needed to conserve soil resources and increase crop productivity [4].

The traditional (conventional) tillage practices being used in Jordan consist of land preparation using moldboard plow or disk harrow during October-December to allow growth of weeds after heavy rains followed by hand broadcasting of seeds late November-January and covering seeds by disk harrow. No fertilizers or herbicides are applied in this tillage practice [5]. Another tillage practice that has been used in Jordan is the conservation or minimum tillage. This tillage practice has been defined as reducing tillage only to those operations that are timely and essential to producing the crop and avoiding damage to the soil. Advantages of this tillage practice include reduced soil compaction; better soil conservation due to soil roughness, more crop residues are left on the soil surface and reduced energy requirements. In some instances, yield increases were obtained as a result [4].

No-tillage system refers to a method of planting crops in previously unprepared soil by opening a narrow slot, trench, or band only of sufficient width and depth to obtain proper seed coverage. No other soil preparation is required and herbicides are used for weed control. Advantages of no-tillage system include: reduced production cost, reduced runoff, less wind and water

erosion, better moisture retention and less soil compaction from machinery. No-tillage may result in yield increases compared with conventional or minimum tillage.

Comparisons of no tillage or direct seeding and conventional or conservation tillage in many studies have indicated that the main benefit of no tillage is erosion protection through maintenance of surface residue cover. Other benefits include water conservation and reduced labor and fuel costs [6].

Fuel cost is a variable cost that decreases with the elimination of tillage practices when adopting no tillage. The labor cost also decreases when switching to no-tillage production. The number of hours and acres that will be used will also decrease with a switch to no tillage production. Repair is a variable cash cost that is expected to decrease with the adoption of no tillage [7].

Recent research results have confirmed that no till production costs can be lower and profitability higher than conventional tillage systems. Several studies have shown “no-tillage” to be labor saving and fuel economizing techniques of crop production besides being useful in checking wind and water erosion [8-14]. Labor and fuel savings also accrue by eliminating fall tillage [15].

No-tillage soil management has been adopted by many farmers in the US to reduce monetary and external energy inputs, increase profit, conserve soil water and increase soil organic matter [16]. Grain production, which is related to the quantity of crop root and residue inputs to the soil, has been shown to increase with no tillage [17].

**No tillage: economic consideration:** Conservation tillage eliminates moldboard plowing and uses less erosive methods, including chisel plowing or disking, to prepare the soil for planting. No-tillage, the strictest form of conservation tillage, uses no tillage of the soil. The result is that most of the surface of a planted field is covered with crop residue from the previous season. Increased surface residue helps to increase or maintain organic matter, to increase moisture retention and to decrease soil erosion.

**Economic comparison between conventional and no-tillage systems:** Tillage systems that reduce the number of cultivation steps have been adopted by many farmers [18]. These reduced-tillage systems - called NT, low till, reduced till, limited till, or conservation till - can, according to soil scientists, save soil moisture, fuel, labor and machinery costs, as well as reduce wind and water erosion. However, producers are reluctant to adopt NT

practices without more information about the risks and benefits [19].

No-tillage is beneficial because the soil and its overlaying residue are not disturbed [20]. With reduced tillage and/or NT, less organic matter is oxidized and lost as comes with frequent moldboard and chisel tillage [21]. The long-range benefits of conservation tillage include increase in soil organic matter and favorable types of microbes and earthworms. The latter are soil builders that improve soil structure and increase its capacity to hold soil moisture and nutrients to enable root proliferation [21].

In order to determine which tillage system is most suitable and more economical for growing wheat in the rainfed areas of Jordan, an experiment was conducted to compare the effect of three different tillage systems on the yield components and profitability of wheat grown under rainfed conditions in Jordan. The three tillage systems used were: traditional (conventional) tillage using a moldboard plow, conservation tillage using a chisel plow and no-tillage systems.

The objective of this research was to evaluate the economics of no-till in wheat production under rainfed conditions in Jordan compared to conventional and conservation tillage systems.

## MATERIALS AND METHODS

**Site and tillage treatments:** The experiment was started in November 2004 at Maru Station (32° 35'N, 35° 40'E, elevation 620 m), of the National Center for Agricultural Research and Technology Transfer (NCARTT), Ministry of Agriculture, Maru, Jordan, where the mean annual precipitation is about 400 mm. The soil at the site is a fine, montmorillonitic, thermic, entic chromoterert. The experiment consisted of nine plots, each plot 20 X 10 m (three treatments with three replicates per treatment) and layed out in Randomized Complete Block Design (RCBD).

The three tillage treatments were: 1- traditional or conventional tillage (TT) using a moldboard plow, 2- conservation tillage (CT) using a chisel plow and 3- no-tillage system (NT). A chisel plow (duck foot) was used for seedbed preparation for all plots two months before planting (October 15, 2004). All plots were planted with “Um Qais” cultivar (a newly released wheat cultivar in Jordan) using a seed drill at the rate of 120 kg ha<sup>-1</sup> on December 15, 2004. For weed eradication, the herbicide 2, 4-D was applied to all plots on January 10, 2005 at the rate of 1 liter ha<sup>-1</sup>. All plots were fertilized using urea at the rate of 50 kg ha<sup>-1</sup> on February 27, 2005.

Table 1: The grain and straw yields (kg ha<sup>-1</sup>), revenues (JD ha<sup>-1</sup>), total variable cost (JD ha<sup>-1</sup>) and the net profit (JD ha<sup>-1</sup>) for wheat production under different tillage systems in rainfed areas in Jordan

Tillage treatments	TT	CT	NT
Grain			
Yield	2060.0	1980.0	2280.0
Revenue	473.8	455.4	524.4
Straw			
Yield	1540.0	1490.0	1760.0
Revenue	154.0	149.0	176.0
TR	627.8	604.4	700.4
TVC	98.9	87.9	72.1
NP	528.9	516.5	628.3

<sup>a</sup>Data are means of 3 replicates

**Data collection:** The numbers of seedlings/m<sup>2</sup> were counted inside three 1 m<sup>2</sup> quadrates randomly taken from each plot for each tillage system on January 14, 2005. Wheat plant inside three 1 m<sup>2</sup> area were harvested on June 22, 2005 from each plot in order to measure grain yield and yield components. The total seed weight and the weight of straw for each plot were determined and recorded in g/m<sup>2</sup>. The average of three plots for all measured parameters was determined for each tillage system.

## RESULTS AND DISCUSSIONS

Regarding grain yield, the present investigation demonstrated the superiority of NT system over the TT and CT systems. The no tillage system gave the highest grain yield (2280 kg ha<sup>-1</sup>), followed by the traditional or conventional tillage system using the moldboard plow (2060 kg ha<sup>-1</sup>) Table 1. These results are in consistence with the findings of Campbel *et al.* [17], who found that grain production increased with no tillage. The conservation tillage system using the chisel plow gave the lowest grain yield (1980 kg ha<sup>-1</sup>). Also the straw yield was highest under no tillage system (1760 kg ha<sup>-1</sup>). The traditional or conventional tillage system was second (1540 kg ha<sup>-1</sup>), while the lowest straw yield was produced under the conservation tillage system (1490 kg ha<sup>-1</sup>).

The total revenue for wheat grown in no till plots was the highest among all applied tillage systems (700 JD ha<sup>-1</sup>). The traditional or conventional tillage system was next (628 JD ha<sup>-1</sup>), while the conservation tillage system was the last (604 JD ha<sup>-1</sup>).

The total variable cost for plants grown in no-till plots was the least (72 JD ha<sup>-1</sup>), because there was no tillage wage and no fuel cost; however, the total variable cost for plants grown under traditional or conventional tillage system was the highest (99 JD ha<sup>-1</sup>), followed by the total variable cost for plants grown under

conservation tillage system (88 JD ha<sup>-1</sup>). These findings are supported by Young [8], who reported that recent research results have confirmed that no till production costs can be lower and profitability higher than conventional tillage systems.

The highest net profit (628 JD ha<sup>-1</sup>) was obtained by the no-tillage system, which is about 100 JD ha<sup>-1</sup> more than that of the traditional or conventional tillage system (529 JD ha<sup>-1</sup>). The conservation tillage system using a chisel plow gave the lowest net profit (516 JD ha<sup>-1</sup>). The major factors that make the net profit for wheat grown in no till plots much higher than that for wheat grown in moldboard and chisel plowed plots are the high total revenue and the low total variable cost for no till plots.

Most studies agree that conservational and/or NT systems reduce input costs such as fuel, labor and machinery repair and depreciation costs [18, 19, 21, 22]. However, in most cases, there is an increase in herbicide costs and/or a decrease in yield when conservation tillage systems are used [23].

This study has focused on the economics of no tillage system used in wheat production under rainfed conditions in Jordan compared to traditional or conventional and conservation tillage systems. Cost and returns of the production process were calculated for the three systems: traditional or conventional tillage system using a moldboard plow, conservation tillage system using a chisel plow and no tillage system. All systems showed positive net profit. The no tillage system showed the highest net profit and superiority to the moldboard plow and the chisel plow. However, in order to pass a more sound economic judgment, these tillage systems should be tested using farm level data. A thorough economic study on these technologies and their level of adoption by farmers will be very useful in the future.

Appendix: TVC (JD ha<sup>-1</sup>) components according to tillage system during the time of the study

Item	TT	CT	NT
Um Qais wheat	27.6	27.6	27.6
Urea	11.0	11.0	11.0
2,4 D	3.5	3.5	3.5
Tillage wage	25.0	25.0	0.0
Fuel	1.8	0.774	0.0
Seed drill	10.0	10.0	10.0
Harvesting	20.0	20.0	20.0
Total	98.9	87.9	72.1

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