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The Effect of Tillage Practices on Barley Production under Rainfed Conditions in Jordan

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Abstract: Barley (*Hordeum vulgare* L.) is the most widely grown cereal crop under semi-arid conditions in Jordan. The traditional or conventional tillage systems practiced in Jordan depleted soil resources and resulted in lower crop yields. The use of conservation tillage systems increases the efficiency of soil moisture storage. Therefore, the conservation tillage system is expected to increase crop yield as compared with the traditional tillage systems. A field study was conducted during the growing season of 2002/2004 in Northern Jordan, to investigate the performance of barley under traditional or conventional tillage using a disk plow, conservation tillage using a chisel plow and no-tillage systems in a fallow barley rotation. During the experiment, the soil moisture content for each tillage system was determined at different sampling dates. Number of seedlings m^{-2}, plant height, straw yield and grain yield were determined. The results showed that the conservation tillage system gave the best results concerning soil moisture content, number of seedlings m^{-2}, straw and grain yield compared to the other tillage practices used in the experiment. However, for more sound judgments, the experiment needs to be done for more than one growing season.

Key words: Barley · no-tillage · disk · chisel · conservation · conventional

INTRODUCTION

Barley (*Hordeum vulgare* L.) is the most widely grown cereal crop in Jordan and other West Asian countries. The barley-based farming system exists in wide areas along the dry margins (200-300 mm annual rainfall) of cultivation in Syria, Jordan and Iraq [1]. During the period of 2000 to 2004 the average harvested area of barley in Jordan was 33.13 thousand hectares producing the average amount of 35.4 thousand tons of grain [2]. Lack of soil moisture was identified as the major factor limiting crop growth and production under rainfed conditions [3].

The development of tillage practices for dryland crop production has been and will be a dynamic process. The traditional and exploitive cropping system, which has been practiced in Jordan and other Middle Eastern countries, depleted soil resources and resulted in lower crop yields [4].

Traditional crop rotations practiced in Jordan were based on the fallow system and conventional tillage practices. This system performed reasonably well in the past. However, with the increased population pressure and mechanization of the dryland farming, new highly improved tillage practices are needed to stabilize both soil resources and crop production [5].

The conventional (traditional) tillage systems 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 system [6]. Another tillage system that has been used in Jordan is the conservation tillage or minimum tillage. This tillage system 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 system include reduced soil compaction; better soil conservation due to soil roughness and more residue left on the surface and reduced energy requirements. In some instances, yield increases were obtained as a result [5].

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

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preparation is required and herbicides are used for weed control.

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 [7]. Grain production, which is related to the quantity of crop root and residue inputs to the soil [8], has been shown to increase with no tillage owing to water conservation [9].

Comparisons of zero tillage or direct seeding with conventional or conservation tillage in many studies have indicated that the main benefit of zero tillage is erosion protection through maintenance of surface residue cover. Other benefits include water conservation and reduced labor and fuel costs [10].

In order to determine the tillage practice that is suitable for growing barley in the rainfed areas of Jordan, an experiment was conducted to compare the effect of three different tillage systems on the soil moisture content, yield and yield components of barley grown under rainfed conditions in Jordan. The three tillage systems used are conventional tillage using a disk plow, conservation tillage using a chisel plow and no-tillage systems.

MATERIALS AND METHODS

Site and tillage treatments: The experiment was started in August 2002 at Ramtha Station for Agricultural Research and Technology Transfer, Ramtha (32°30'N, 36°00'E, elevation 590 m), where mean annual precipitation is 250 mm. The soil at the site is a fine, mixed, thermic soil (Typic xerochrepts). The experiment was devised as a Randomized Complete Block Design (RCBD). The experiment consisted of nine plots (three treatments with three replicates per treatment). Each plot was 200 m^2 (10×20 m).

The three tillage treatments were: 1-conservation tillage (CT) using a chisel plow, 2-traditional or conventional tillage (TT) using a disk plow and 3-no-tillage system (NT). The first tillage operation (for tilled plots) was done on August 20, 2002, the second operation on April 12, 2003 and the third one was on August 15, 2003. All plots were planted with "Rum" cultivar using a seed drill at the rate of 100 kg ha^{-1} on November 30, 2003. Germination started on December 14, 2003 in all plots. All plots were fertilized using urea at the rate of 50 kg ha^{-1} on February 18, 2004. For weed eradication, the herbicide 2, 4-D was applied to all plots on January 10, 2004 at the rate of 1 L ha^{-1}.

Data collection: Soil moisture content was measured 17 times during the growing season (October 2003-May 2004). Three soil samples from each plot were taken randomly to the depth of 20-cm for soil moisture content analysis at the following dates: October 14, 2003; December 8, 2003; December 16, 2003; December 21, 2003; December 29, 2003; January 12, 2004; January 18, 2004; January 29, 2004; February 8, 2004; February 17, 2004; February 25, 2004; March 8, 2004; March 30, 2004; April 14, 2004; May 4, 2004; May 12, 2004; and May 30, 2004. Soil moisture content was determined using the gravimetric method.

The numbers of seedlings m^{-2} were taken randomly from each plot on December 18, 2003. The average of three plots count for each tillage system was determined. Plant height in centimeters was measured for five plants randomly selected from each plot on May 12, 2004. Three samples of plants per square meter were harvested on May 17, 2004 from each plot, to measure the yield and yield components of barley. Total biological yield, straw and grain yield were measured in grams m^{-2} for each plot. The average biological yield, straw and grain yield of three plots was determined for each tillage system.

RESULTS AND DISCUSSION

Weather data: Maximum and minimum temperatures and the rainfall during the growing season of the experiment and the average of 24 years for the area are shown in Fig. 1. The maximum temperature was higher than the average for the area in all months of the growing season. The maximum temperature did not differ from the average during the month of December 2003. The minimum temperature was also either more than or equal to the average for the area during the months of the growing season. At the beginning and the end of the season, the rainfall was much below the average for the area. Except for the months of October 2003, January and February 2004, which received the same or little more rainfall than average, the rest of the months (November and December 2003, March, April and May 2004) received lower than the average rainfall of the area for the same period. Figure 1 shows that the amount of rainfall received was not well distributed over the months of the growing season. This means that terminal drought stress occurred during the season.

Soil moisture content: The soil moisture content for the three tillage systems was analyzed using the analysis of variance (ANOVA) method as shown in Fig. 2. The Figure

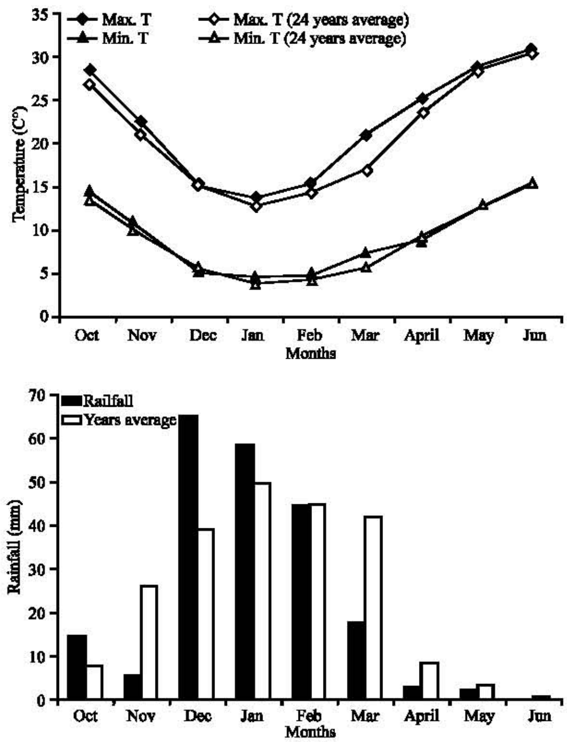

Fig. 1: Maximum and minimum temperatures and rainfall during the growing season of 2003/2004 and the averaged maximum, minimum temperature and rainfall for 24 years

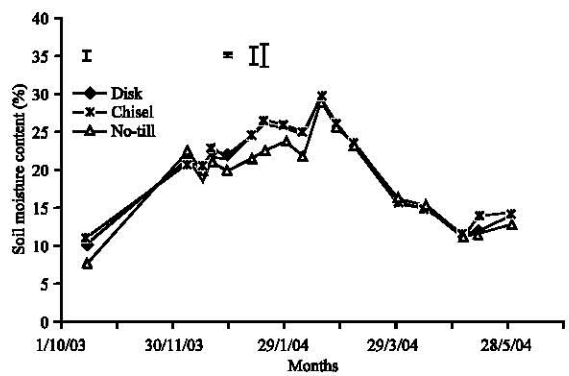

Fig. 2: Soil moisture content at sampling dates for barley fields exposed to three tillage systems in Northern Jordan. Vertical bars indicate the LSD (0.05) when the difference between means was significantly different in ANOVA

shows that the soil moisture content was significantly higher for plots under conservation and conventional tillage systems than non-tilled plots at four sampling dates (October 14, 2003, December 29, 2003, January 12, 2004 and January 18, 2004). There was no significant

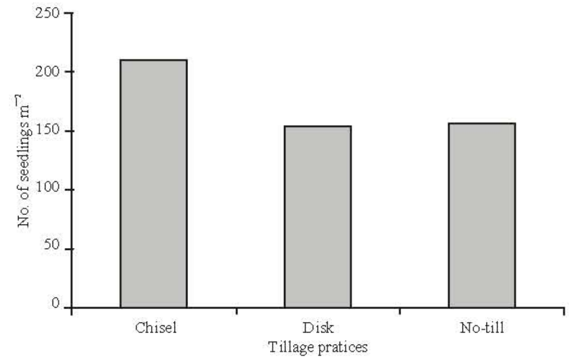

Fig. 3: Number of seedlings for barley grown in fields exposed to three tillage systems in Northern Jordan. Vertical bar indicates the LSD (0.05)

difference in the soil moisture content for the rest of the sampling dates for all tillage systems used in the experiment.

The effect of tillage regime on soil moisture content depended on the time of sampling, soil depth and crop [11]. During the growing season, soil moisture content under conventional tillage (disking) exceeded that under no tillage at the 50-125 mm depth. Rainfall may have percolated in a preferential manner through cracks or root channels beyond this depth under no tillage [12], whereas, soil disturbance with conventional tillage may have resulted in more uniform water movement. In our study, conservation tillage system resulting in higher soil moisture retention, especially early in the season, when rainfall was received most. Soil chiseling appears to promote structure in topsoil, owing to better break-up of large clods and improved resultant water retention characteristics [13].

Seedling establishment: The number of seedlings was measured for all plots under the different tillage systems on January 19, 2004. Figure 3 shows that the number of seedlings per square meter in chisel-plowed plots was significantly higher than those in disked and non-tilled plots.

Some of the concerns with NT, such as delayed emergence, reduced plant population [14] and increased weed and pest populations [15] could be overcome by using a conservational tillage system. In conservation tillage, the improvement in seedling number might be due to improvement in soil structure, seedbed condition and moisture retention.

Plant height: Plant height was significantly higher in plots tilled with a disk plow, followed by plots tilled with

Table 1: Plant height, yield and yield components of barley grown exposed to three tillage practices in Northern Jordan

Tillage systems	Plant height (cm)	Yield components ($g\ m^{-2}$)		
		Total yield	Grain yield	Straw yield
Chisel	66b	291a	151a	140a
Disk Plow	72a	267a	134ab	133a
No-till	58c	150b	70b	81b

a chisel plow (Table 1). The data in Table 1 supported by previous results, show that conservation and conventional tillage systems improved early establishment and plant growth, resulting in taller plants. Non-tilled plots showed the lowest plant height among all plots.

Soil temperature is an important environmental factor in influencing plant growth. Surface residues in conservation tillage systems decrease soil water evaporation, thus furnishing a more moist and cooler environment [16]. Dao and Nguyen [17] demonstrated that the cool soil temperatures under conservation tillage systems reduced the rate of wheat growth in the early spring. Hay [18] claimed that surface residues lower soil temperature by 2 to 6°C during early spring.

Yield: The total biological yield was significantly higher for plants grown in chisel plowed plots than disked plots and non-tilled plots (Table 1). This is supported by the findings of Al-Issa [19] who found that the use of conservation tillage system produces more wheat yield than the use of conventional tillage system in Northern Jordan. When compared to TT, NT has been found to increase, decrease, or have no effect on the growth and yield of crops [20-24]. The difference in crop responses occur through tillage effects on soil physical, chemical and biological processes and occurrence of crop diseases and may also differ among crops and soils [25-28].

No tillage has been found to diminish soil erosion, but has not always been found to be beneficial for grain yield. Rao and Dao [29] found the no tillage system to occasionally reduce yield through decreased N availability. According to Rasmussen [30], high levels of cereal residues on the soil surface can reduce wheat yield, with reduction variously attributed to disease, weed competition, or decreased light intensity.

CONCLUSIONS

The results of the experiment showed that the conservation tillage system using a chisel plow gave higher soil moisture content, better growth and higher yield of barley than the conventional (disking) and no tillage systems under rainfed conditions. These results indicate that using the conservation tillage system (chisel plow) is the best tillage practice that should be applied to planting barley in the rainfed areas of Jordan. The traditional tillage system using the disk plow and the no-tillage system, were not effective tillage practices for the semiarid region of Jordan.

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