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EFFECT OF TILLAGE SYSTEMS ON WINTER CEREALS PRODUCTIVITY UNDER RAINFED CONDITIONS AT RAS EL-HEKMA, EGYPT

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ABSTRACT

Eight field trials were conducted under rainfed conditions at Ras El-Hekma (10 km inland), 56 Km east of Marsa Matrouh at the Northwest coastal zone of Egypt, during four rainfall winter seasons (2003/04, 2004/05, 2005/06 and 2006/07). This study aimed to find out the optimum tillage system to develop and sustainable of rainfed cultivation of wheat and barley. The obtained results could be summarized as follows:

Results of the present experiments evaluated the yield and yield attributes for each of barley and wheat in experimental area follow the amount of rainfall precipitation. Since, barley used rain water more efficiency than wheat. Barley had a higher yield and its attributes as compared with wheat. Also, tillage systems of traditional tillage after rain precipitation (TTAR) and conservational tillage after rain precipitation (CTAR) had higher water use efficiency (WUE) than the other tried tillage systems. Accordingly, the highest values of yield and yield attributes for both cases of wheat and barley and the sustainability production of winter cereal crops could be secured in varied rainfall seasons with the application of CTAR or TTAR system. Economically, barley recorded the highest values of gross return (GR), net return (NR) and average rate of return (ARR) than wheat overall seasons of this study. Also, the highest these values were recorded when CTAR was applied throughout the four seasons in the case of barley and in the latter three seasons in case of wheat. However, the partial budget analysis concluded that conservation tillage system applied after rain precipitation (CTAR) was favorable tillage system economically for barley and for wheat particularly in the rainy seasons. Therefore, barley could be the favorable winter crop economically more than wheat under rainfed conditions such as the region of Ras El-Hekma at the Northwest coast of Egypt.

Keywords: Tillage systems, yield components, conservation, traditional tillage, water use efficiency, partial budget analysis.

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INTRODUCTION

The Northwest coastal (NWC) zone of Egypt extends about 500 km from west of Alexandria to the Egyptian - Libyan border. The rainfed areas of this zone are characterized by harsh agro-ecological conditions. There are several principal physical, biotic and socioeconomic problems to sustainable development. The major constraint for cereal production under rainfed conditions is the insufficient soil moisture content in the root zone to meet crop water requirements. Therefore, the physical limitations of land and water resources indicate that horizontal expansion of wheat cultivation is limited option in such rainfed areas.

Heavy grazing pressure on natural forage resources has increased and leading to deterioration of nature vegetation. Since, livestock largely still the main source of Bedouin's income, establishment and conservation of rainfed forage crops, especially barley are important to reduce feeding gap (Moselhy, 2001). Watts and El-Mourid (1988) cited that the main feeding resources in the semi-arid regions are cereal residues including straw and field stubble. Among cereal crops, barley (*Hordium vulgare*, L.) proved to be withstanding the adverse conditions.

Barley is grown on the northern plateau, the arable land is about 16% of the total area, approximately 7% cultivated and 9% fallow. Whereas, 48% of total area is rangeland, and 35% of it is barren land that facilitates water catchments and generates run-offs. Barley is sown on over 83000 ha in wet years, but in the dry years this area reduces with 40-50%. Meanwhile, bread wheat (*Triticum astivum* L.) is sown on 25000 ha only in higher rainfall seasons through small batches and depression areas. The average of annual rainfall during the last ten years is 140 mm /year. However, continuous conventional cultivation of wheat and barley led to deterioration of the native plant resources and exposed the soil surface to wind erosion. Jones and Singh (1995) reported that wide expanse of cultivated rainfed areas without windbreaks are strongly affect by wind erosion. Tillage practices may have direct or indirect impact on plant growth. Conservation tillage practices are very important in arid and semi-arid zones, where water is the limiting factor for crop development under rainfed

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conditions (Bond *et al*., 1971, Wilhelm *et al.*, 1989 and Wilhelm, 1998).

Farmers in the NWC are making pressure on available land in the time of low level of mechanization and risky rainy seasons. These farming systems seem to be vulnerable to continuous degradation environmental conditions. Indigenous conservation tillage systems are prevalent in areas with water-deficit conditions. A traditional tillage practice has led to advanced soil erosion which has decreased crop productivity. Direct seeding in dry soil is widely used in the NWC. The technique consists of handle broadcasting the seeds in dry soil and covered with one chisel plowing (15 cm depth) using a tractor and they wait the rain precipitation. This practice is carried out by farmers in order to meeting their production objectives rather than protecting the soil from hazards. Where, disturbed soil surface is exposed to wind erosion which may be occurred before rain precipitation.

The present study aimed to find out the optimum tillage practices, which can be sustained cultivation of wheat and barley under rainfed conditions. Also, to shows the main advantages derived from the long term application of optimum tillage on crop performance and to formulate recommendations in order to improve farm ecological conditions for enhanced sustainability.

MATERIALS AND METHODS

The present on-farm trials were carried out under rainfed conditions at Ras El-Hekma (10 km inland), 56 Km east of Marsa Matrouh, NWC of Egypt, during four rainfall seasons (2003/04, 2004/05, 2005/06 and 2006/07). This study aimed to find out the optimum tillage system to develop the conventional rainfed cultivation of wheat and barley.

The treatments were six tillage systems applied on wheat and barley in two separated field experiments. These treatments were as follows:

LTBR: Limited tillage before rain (one chisel plow as a cover to broadcast grains).

CTBR: Conservation tillage before rain (one chisel plow before grains grains broadcasting and another one after sowing grains as a cover).

TTBR: Traditional tillage before rain (two perpendcular plows before grainsbroadcasting and one plow to cover the grains).

LTAR: Limited tillage after rain (one chisel plow as a cover to broadcasted grains).

CTAR: Conservation tillage after rain (one chisel plow before grains broadcasting and another one after sowing grains as a cover).

TTAR: Traditional tillage after rain (two perpendcular plows before grains broadcasting and one plow to cover the grains).

The tried tillage systems were defined as any tillage system that reduces loss of soil or water relative to conventional tillage (MRMP 2002).

Chisel disc plowing was made at 15 cm depth to prepare the seed beds. Wheat and barley grains at a rate of 72 Kg/ha were used before or after rain precipitation. Giza 168 c.v. and Giza 126 c.v. were used for wheat and barley, respectively. The sowing date of wheat and barley was differed from season to season according to the onset of effective rainfall. In case of cultivation before rain precipitation, the grains of two crops were sown on 1 Nov. for each season. Whereas, the sowing dates after effective rain precipitation were 15, 5, 10, 20 of Nov. for the first, second, third and fourth season, respectively.

The average rainfall of ten -years in the NWC is 140 mm/year. However, the amount and distributions of rainfall during the on-farm trials period were as shown in Figure (1). The amount of rainfall was less than the general average overall the seasons of the study. Rainfall distribution was balanced with siutable amount only in the last season as compared with the rest winter seasons. The total amount of rainfall were 91.0, 122.0, 113.2 and 140.1 mm for 2003/04, 2004/05, 2005/06 and 2006/07 winter seasons, respectively.

The soil of the on-farm trials was loamy-sand in texture, which is called Nous in Bedouin terminology. It has 0.022-0.025 % available nitrogen, 22-27 ppm phosphorous and high Ca Co_3 content (23-26 %). The EC of this soil type ranged between 1.47 to 1.60 dS/ m.

The experiments of each wheat and barley were laid out in randomized complet block (RCB) design with six replicates. The plot size was 200 m^2 (10 m width x 20 m long). At harvesting time, 20 m^2 from each plot was used to determine yield and yield components for each of wheat and barley as well as field stubble in each experiment.

The collected data were analyzed statistically according to

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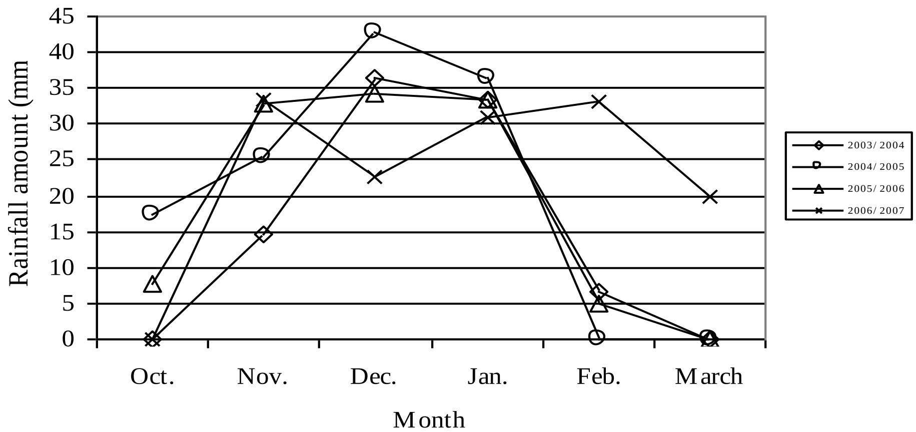

Fig.1. Monthly rainfall amount (mm) during four winter seasons.

Snedecor and Cochran (1967). For comparison the differences among means, Duncan's multiple range tests were used (Duncan, 1955). The variable costs and total sales of each wheat and barley products were estimated with five interviewed farmers each year by using of participatory approach to evaluate the tried treatments economically. Field stubble was estimated as Scandinavian feed units (SFUs) where, one Kg of barley grain equals one SFU, while one Kg of dry matter equals 0.45 SFU (Le Houerou, 1986). Economic analysis using partial budget was made according to Perrin, *et al* (1983).

RESULTS

Wheat

Yield attributes

Data pertaining yield attributes of wheat as affected by different tillage systems over four seasons are presented in Table 1. The results showed that there were significant differences between different tillage systems in the four seasons. It is evident that the tried tillage systems had a significant effect on all traits of yield attributes of wheat. This was typically the same in the four seasons. Moreover, the results confirmed the superiority of traditional tillage after rain (TTAR) system followed by conservation tillage after rain (CTAR) system as compared with other tried tillage systems with plant height and 1000-grain weight overall seasons, number of tillers/ m^2 in the first thee seasons and tillering index (TI) in the first two seasons. Meantime, TTAR and CTAR systems were similar in having higher number of tillers/ m^2 in the latter season and higher number of spikes/ m^2 and number of grains/ spike in the all seasons, higher values of tillering index (TI) in the latter two seasons and longer spikes in the first two seasons. It was cleared that TTAR system followed by CTAR system gave the tallest plants in the all seasons, furthest number of tillers/ m^2 in the first three seasons and number of spikes/ m^2 in the first two seasons, while, LTBR system recorded the shortest plants and lowest values of all traits during the four seasons. Moreover, TTAR system had the heaviest 1000-grain weight followed by CTAR system in the all seasons of the study.

Yield

Results in Table 2 indicate a significant effect of applied tillage systems on grain, straw, biological and field stubble yields of wheat as well as, water use efficiency (WUE) during all seasons. However, there were insignificant effect of tillage systems on harvest index (HI) overall seasons. In the first three seasons, TTAR system had the highest grain, straw and biological yields as well as WUE followed by CTAR then LTAR and TTBR systems. Meanwhile, TTAR and CTAR systems had the highest grain, straw and biological yields as well as, WUE as compared with the other tillage systems in the latter season. While, LTBR system recorded the lowest values of the aforementioned traits overall seasons. On the contrary, LTBR system produced the highest field stubble yield followed by LTAR system over all seasons, while TTAR produced the lowest field stubble/ ha. It seem that the weak ineffective tillers is the higher field stubble yield/ ha and vice verso. Ultimately, it is cleared that the highest WUE was secured with TTAR in the first three seasons and with TTAR or CTAR in the latter season which received high amount of precipitation. Whereas, LTBR system had the lowest WUE throughout the four seasons (Table 2). Generally, there were no significant differences between TTAR and CTAR systems with wheat yields in the case of good/ or average amount of

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Table 1. Effect of tillage systems on yield attributes of wheat during the four seasons

rainfall and good distribution during the winter

Tillage systems	Plant height (cm)	No. of tillers/ m^2	No. of spikes/ m^2	Tillering index (%)	Spike length (cm)	No. of grains/ spike	1000-grain wt. (gm)
				2003/ 04			
LTBR	44.4 e	210.8 f	123.6 d	58.63 c	3.44 d	22.00 d	22.28 e
CTBR	53.4 d	223.0 e	139.4 bc	62.47 b	4.32 c	25.06 c	23.60 d
TTBR	58.4 c	226.8 d	144.6 b	63.74 ab	5.14 b	27.14 b	24.06 cd
LTAR	55.6 cd	235.4 c	134.8 c	57.29 c	4.44 c	25.74 c	24.46 c
CTAR	63.4 b	249.8 b	160.2 a	64.03 ab	6.08 a	29.96 a	25.48 b
TTAR	67.4 a	253.6 a	166.6 a	65.59 a	6.26 a	31.00 a	26.94 a
F. test	*	*	*	*	*	*	*
				2004/ 05			
LTBR	51.6 e	218.6 f	129.6 c	59.29 d	4.24 d	23.74 d	23.68 e
CTBR	60.8 d	230.4 e	145.6 b	63.14 c	5.04 c	26.90 c	24.80 d
TTBR	65.0 c	238.0 d	150.8 b	63.35 bc	5.54 b	28.44 b	25.48 cd
LTAR	60.6 d	245.6 c	146.4 b	59.67 d	5.16 c	26.26 c	25.74 c
CTAR	68.4 b	256.4 b	168.8 a	65.82 ab	6.44 a	31.52 a	27.22 b
TTAR	72.6 a	261.4 a	173.0 a	66.17 a	6.70 a	32.22 a	29.14 a
F. test	*	*	*	*	*	*	*
				2005/ 06			
LTBR	49.6 e	217.0 f	127.2 d	58.62 c	3.90 e	20.58 c	22.26 e
CTBR	58.2 d	229.2 e	142.4 c	62.11 b	4.48 d	23.20 b	23.46 d
TTBR	63.4 c	235.0 d	149.0 b	63.40ab	5.14 c	24.62 b	24.06 c
LTAR	56.4 d	244.4 c	143.8 c	58.84 c	4.66 d	23.20 b	24.34 c
CTAR	66.6 b	257.6 b	166.6 a	54.64 a	5.92 b	27.70 a	25.72 b
TTAR	69.8 a	261.0 a	169.2 a	64.80 a	6.28 a	28.30 a	27.12 a
F. test	*	*	*	*	*	*	*
				2006/ 07			
LTBR	60.8 e	249.0 c	153.6 d	61.69 c	5.36 e	24.76 c	23.94 e
CTBR	70.0 d	263.8 b	165.6 c	62.78bc	6.10 d	27.16 b	24.92 d
TTBR	74.4 c	268.8 b	173.6 b	64.60 b	6.52 c	27.90 b	25.82 c
LTAR	69.4 d	267.0 b	169.4bc	63.44bc	6.10 d	26.64 bc	26.02 c
CTAR	78.6 b	294.2 a	198.6 a	67.57 a	7.16 b	31.24 a	27.40 b
TTAR	82.0 a	299.6 a	203.4 a	67.94 a	7.46 a	31.68 a	28.96 a
F. test	*	*	*	*	*	*	*

* Significant at 0.05 level of probability.
Values followed by similar letters are not significantly different at P < 0.05 by Duncan's multiple range tests.

Table 2. Effect of tillage systems on yields of wheat as well as harvest index, field stubble and water use efficiency (WUE) during the four seasons

Tillage	Grain yield	Straw yield	Biological yield	Harvest index	Field stubble	WUE (kg grains/

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systems	(t/ha)	(t/ha)	(t/ha)	(HI)	(kg/ha)	mm)
			2003/ 2004			
LTBR	**0.472 f**	**0.690 e**	**1.161 e**	**40.55**	**163.2 a**	**5.19 f**
CTBR	**0.555 e**	**0.859 d**	**1.414 d**	**39.27**	**155.2 b**	**6.10 e**
TTBR	**0.623 d**	**0.930 c**	**1.553 c**	**40.15**	**146.0 d**	**6.85 d**
LTAR	**0.657 c**	**0.954 c**	**1.611 c**	**40.77**	**156.2 b**	**7.22 c**
CTAR	**0.836 b**	**1.209 b**	**2.045 b**	**40.86**	**148.6 c**	**9.19 b**
TTAR	**0.948 a**	**1.350 a**	**2.298 a**	**41.24**	**141.8 e**	**10.41a**
F. test	*	*	*	**N.S**	*	*
			2004/ 2005			
LTBR	**0.767 f**	**1.171 f**	**1.937 f**	**39.59**	**169.0 a**	**6.29 f**
CTBR	**0.899 e**	**1.281 e**	**2.180 e**	**41.24**	**161.6 b**	**7.37 e**
TTBR	**0.953 d**	**1.370 d**	**2.323 d**	**41.03**	**153.2 c**	**7.81 d**
LTAR	**1.019 c**	**1.443 c**	**2.462 c**	**41.36**	**162.4 b**	**8.35 c**
CTAR	**1.136 b**	**1.577 b**	**2.713 b**	**41.91**	**153.2 c**	**9.31 b**
TTAR	**1.258 a**	**1.714 a**	**2.971 a**	**42.33**	**144.0 d**	**10.31a**
F. test	*	*	*	**N.S**	*	*
			2005/ 2006			
LTBR	**0.675 e**	**0.958 e**	**1.633 e**	**41.35**	**161.0 a**	**5.97 e**
CTBR	**0.780 b**	**1.109 d**	**1.889 d**	**41.27**	**153.8 b**	**6.89 d**
TTBR	**0.863 c**	**1.175 c**	**2.038 c**	**42.36**	**143.0 c**	**7.63 c**
LTAR	**0.875 c**	**1.214 c**	**2.089 c**	**41.87**	**153.8 b**	**7.73 c**
CTAR	**1.080 b**	**1.369 b**	**2.449 b**	**44.07**	**143.4 c**	**9.54 b**
TTAR	**1.149 a**	**1.458 a**	**2.608 a**	**44.08**	**134.2 d**	**10.15a**
F. test	*	*	*	**N.S**	*	*
			2006/ 2006			
LTBR	**0.906 d**	**1.150 d**	**2.056 d**	**44.03**	**160.4 a**	**6.47 d**
CTBR	**1.034 c**	**1.252 c**	**2.286 c**	**45.23**	**154.4 b**	**7.38 c**
TTBR	**1.086 b**	**1.282bc**	**2.368bc**	**45.89**	**142.4 c**	**7.75 b**
LTAR	**1.043 c**	**1.364 b**	**2.407 b**	**43.42**	**153.4 b**	**7.44 c**
CTAR	**1.130 a**	**1.457 a**	**2.587 a**	**43.69**	**138.6 d**	**8.07 a**
TTAR	**1.153 a**	**1.463 a**	**2.616 a**	**44.11**	**129.8 e**	**8.23 a**
F. test	*	*	*	**N.S**	*	*

* Significant at 0.05 level of probability.
Values followed by similar letters are not significantly different at P < 0.05 by Duncan's multiple range tests.

season which occurred in the latter season.

These results indicated that the higher rainfall precipitation gave the higher yield and yield attributes of wheat. Meanwhile, the highest field stubble yield was obtained by applied limited tillage particularly before rain precipitation (LTBR), this may be due to the harmful effect of continuous cultivation of wheat on the indigenous natural plants rather than the effect of amount rainfall precipitation. In the fourth season, rain water was used in grain production of wheat with the same efficiency with applied TTAR and/ or CTAR system. WUE for grains production was lowest when LTBR system was applied in the all seasons.

Barley

Yield attributes

Yield components of barley as affected by different tillage systems over four seasons are presented in Table 3. It is evident that the tried tillage systems had a significant effect on all traits of yield attributes of barley. This was typically the same in the four seasons, except tillering index in the latter season. Meantime, TTAR and CTAR systems were similar in having tallest plants, higher number of tillers and spikes/ m^2, longest spikes, furthest grain numbers/ spike and heaviest 1000-grain weight in the all seasons as well as, highest value of tillering index in the first three seasons. Moreover, the results confirmed the superiority of traditional tillage after rain (TTAR) system or conservation tillage after rain (CTAR) system as compared with other tried tillage systems with all yield attributes of barley. However, LTBR system recorded the lowest values of all traits during the four seasons. Generally, under the different varied rainfall seasons, yield attributes of barley were showed similar response to traditional and conservation tillage systems particularly when applied after effective rain precipitation.

Yield

Data presented in Table 4 indicated a significant effect of tried tillage systems on grain, straw, biological yields of barley as well as field stubble and WUE for barley grains at all seasons. However, there were insignificant effects of tillage systems on HI, this was true in all seasons. Meanwhile, TTAR and CTAR systems showed similar trend in having highest yields as well as,

Table 3. Effect of tillage systems on yield attributes of barley in the studied four seasons

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Tillage systems	Plant height (cm)	No. of tillers/ m^2	No. of spikes/ m^2	Tillering Index (%)	Spike length (cm)	No. of grains/ spike	1000-grain wt. (gm)
				2003/ 04			
LTBR	56.0 d	244.6 c	164.6 d	67.29 c	4.04 e	24.12 e	22.46 c
CTBR	62.4 c	257.6 b	187.8 c	72.85 b	4.60 d	27.20 d	23.30 bc
TTBR	66.8 b	262.8 a	198.4 b	75.48 b	5.76 b	29.28bc	24.26 b
LTAR	64.0 c	256.6 b	188.6 c	73.48 b	5.10 c	28.28cd	24.56 b
CTAR	71.6 a	265.4 a	211.6 a	79.73 a	6.36 a	30.64ab	26.86 a
TTAR	72.2 a	265.2 a	211.4 a	79.71 a	6.40 a	30.92 a	27.32 a
F. test	*	*	*	*	*	*	*
				2004/ 05			
LTBR	62.8 d	250.8 c	156.4 d	62.34 d	4.60 d	24.80 d	23.82 d
CTBR	68.0 c	263.8 b	177.8 c	67.35 c	5.14 c	28.30 c	24.64 cd
TTBR	71.4 b	270.0 a	191.4 b	70.84 b	6.16 b	30.82 b	25.58 bc
LTAR	70.4 b	262.4 b	181.8 c	69.28 bc	5.48 c	29.82bc	25.96 b
CTAR	77.4 a	271.2 a	203.0 a	74.82 a	6.60 a	32.60 a	28.44 a
TTAR	77.8 a	271.2 a	203.2 a	74.69 a	6.62 a	32.26 a	28.52 a
F. test	*	*	*	*	*	*	*
				2005/ 06			
LTBR	60.8 d	248.6 d	163.8 e	65.89 d	4.32 e	22.50 d	23.40 c
CTBR	66.4 c	263.4 bc	189.2 c	71.80 c	4.78 d	25.92 c	24.10 c
TTBR	71.4 b	267.2 ab	198.4 b	74.24 b	5.98 b	27.84 b	25.30 b
LTAR	69.6 b	259.2 c	181.0 d	69.84 c	5.28 c	27.28 bc	25.54 b
CTAR	75.6 a	270.2 a	207.6 a	76.66 a	6.54 a	29.38 a	27.76 a
TTAR	76.4 a	270.8 a	207.6 a	76.83 a	6.60 a	29.68 a	27.84 a
F. test	*	*	*	*	*	*	*
				2006/ 07			
LTBR	74.0 d	263.0 d	168.4 d	64.08	5.70 d	25.60 d	24.40 d
CTBR	79.2 c	292.8 c	206.2 c	70.38	6.28 c	28.74 c	25.52 c
TTBR	82.6 b	313.4 b	215.6 b	68.76	7.10 b	30.86 ab	26.44 b
LTAR	81.4 b	304.0 b	206.8 c	68.01	6.52 c	30.10 b	26.80 b
CTAR	91.2 a	323.8 a	227.2 a	70.16	7.68 a	31.96 a	29.52 a
TTAR	92.0 a	325.8 a	227.6 a	69.86	7.82 a	32.14 a	29.74 a
F. test	*	*	*	N.S	*	*	*

* Significant at 0.05 level of probability.
Values followed by similar letters are not significantly different at $P < 0.05$ by Duncan's multiple range tests.

Table 4. Effect of tillage systems on yields of barley as well as water use efficiency (WUE) in the four studied seasons

illage systems	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Field stubble (kg/ha)	WUE (kg grains/ mm)
			2003/ 04			
LTBR	**0.670 c**	**0.954 d**	**1.624 d**	**41.24**	**160.6 a**	**7.36 c**
CTBR	**0.935 b**	**1.261 bc**	**2.196 c**	**42.73**	**153.6 b**	**10.28 b**
TTBR	**0.987 b**	**1.316 ab**	**2.303 bc**	**42.92**	**144.2 c**	**10.85 b**
LTAR	**0.947 b**	**1.203 c**	**2.150 c**	**44.05**	**154.0 b**	**10.40 b**
CTAR	**1.037 ab**	**1.359 a**	**2.397 ab**	**43.3**	**145.0 c**	**11.40 ab**
TTAR	**1.172 a**	**1.365 a**	**2.536 a**	**45.62**	**136.8 d**	**12.88 a**
F. test	*	*	*	**N.S**	*	*
			2004/ 05			
LTBR	**0.920 d**	**1.264 d**	**2.184 d**	**42.11**	**167.0 a**	**7.54 d**
CTBR	**1.208 b**	**1.374 c**	**2.582 c**	**46.79**	**159.4 b**	**9.90 b**
TTBR	**1.251 b**	**1.528 b**	**2.779 b**	**45.04**	**152.0 c**	**10.25 b**
LTAR	**1.083 c**	**1.455 bc**	**2.537 c**	**42.69**	**159.4 b**	**8.87 c**
CTAR	**1.303 a**	**1.640 a**	**2.944 a**	**44.28**	**149.2 c**	**10.68 a**
TTAR	**1.307 a**	**1.638 a**	**2.945 a**	**44.37**	**142.2 d**	**10.71 a**
F. test	*	*	*	**N.S**	*	*
			2005/ 06			
LTBR	**0.862 d**	**1.145 c**	**2.006 d**	**42.95**	**162.4 a**	**7.61 d**
CTBR	**1.085 c**	**1.449 b**	**2.534 c**	**42.76**	**154.8 b**	**9.58 c**
TTBR	**1.159 b**	**1.569 a**	**2.728 b**	**42.49**	**144.2 c**	**10.24 b**
LTAR	**1.046 c**	**1.471 b**	**2.517 c**	**41.55**	**155.2 b**	**9.24 c**
CTAR	**1.235 a**	**1.627 a**	**2.861 a**	**43.18**	**143.4 c**	**10.91 a**
TTAR	**1.236 a**	**1.629 a**	**2.865 a**	**43.18**	**135.6 d**	**10.92 a**
F. test	*	*	*	**N.S**	*	*
			2006/ 07			
LTBR	**1.023 d**	**1.272 d**	**2.295 d**	**44.55**	**160.8 a**	**7.30 d**
CTBR	**1.248 c**	**1.421 c**	**2.670 c**	**46.74**	**152.8 b**	**8.91 c**
TTBR	**1.343 b**	**1.543 b**	**2.886 b**	**46.53**	**143.4 c**	**9.59 b**
LTAR	**1.297 bc**	**1.479 bc**	**2.776 c**	**46.71**	**153.0 b**	**9.26 bc**
CTAR	**1.436 a**	**1.642 a**	**3.079 a**	**46.65**	**141.0 c**	**10.25 a**
TTAR	**1.431 a**	**1.628 a**	**3.060 a**	**46.77**	**133.0 d**	**10.22 a**
F. test	*	*	*	**N.S**	*	*

* Significant at 0.05 level of probability.
Values followed by similar letters are not significantly different at $P < 0.05$ by Duncan's multiple range tests.

WUE compared to other tillage systems in the all seasons as occurred with above mentioned yield attributes traits of barley. However, LTBR system recorded the lowest values of the

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aforementioned traits in the four seasons. On reversely, the highest field stubble yield was produced by applied LTBR system followed by LTAR system over all seasons, while TTAR produced the lowest ones. It seem that the weak ineffective tillers is the higher field stubble yield/ ha and vice verso. Ultimately, it is indicated that the highest values of WUE was recorded by TTAR and CTAR at equal part in the four seasons, whereas, LTBR system had the lowest values.

These results confirmed that there were no significant differences between TTAR and CTAR systems in yield traits of barley under different varied rainfall seasons. Also, the case was the same trend with yield attributes (Table 3). Meanwhile, the highest field stubble yield was obtained by applied limited tillage particularly before rain precipitation (LTBR). This may be due to the harmful effect of continuous barley cultivation on the indigenous natural plants rather than the effect of amount rainfall precipitation.

Partial Budget Analysis

Data in Table 5 showed partial budget analysis as affected by different tillage systems under different rainfall winter seasons for wheat and barley. Results indicated that TTAR followed by TTBR systems were recorded the highest variable total costs (TC)/ ha in each of wheat and barley over all seasons. Meanwhile, in the case of wheat, the highest values of gross return (GR) / ha, net return (NR) and average rate of return (ARR) were recorded with applied CTAR in the latter three seasons. This may be due to raising wheat grains price in the latter three seasons. On the other hand, in the case of barley, CTAR system was recorded the highest GR followed by TTAR in the four seasons. Whereas, this tillage system was surpassed the rest tillage systems in grain and straw yields of barley (Table 4). Meantime, the highest values of NR and ARR/ ha for barley were recorded when CTAR was applied in all rainfall seasons. However, LTBR system recorded the lowest values of GR, NR and ARR for each of wheat and barley, where this tillage system had the lower

Table 5. Partial budget analysis for each of wheat and barley as affected by different tillage systems in the four seasons

Seasons	Tillage systems	Wheat				Barley			
		GR (LE/ha)	TC (LE/ha)	NR (LE/ha)	ARR	GR (LE/ha)	TC (LE/ha)	NR (LE/ha)	ARR
2003/ 2004	LTBR	797.8	312.8	485.0	1.55	1043.1	297.1	746.0	2.51
	CTBR	975.9	332.3	643.6	1.94	1461.4	327.1	1134.3	3.47
	TTBR	1302.8	366.2	936.5	2.56	1491.0	341.1	1149.9	3.37
	LTAR	1144.6	322.2	822.4	2.55	1238.0	299.5	938.5	3.13
	CTAR	1375.0	338.2	1036.8	3.07	1584.6	321.0	1263.6	3.87
	TTAR	1564.7	376.7	1187.9	3.15	1575.8	351.9	1227.9	3.49
2004/ 2005	LTBR	1336.7	375.2	961.5	2.56	1517.5	345.3	1172.1	3.39
	CTBR	1531.1	395.2	1135.8	2.87	1993.3	376.7	1616.6	4.29
	TTBR	1619.9	435.0	1184.0	2.72	2032.4	415.2	1617.2	3.89
	LTAR	1769.1	387.4	1381.6	3.57	1744.3	349.1	1395.2	4.00
	CTAR	1949.8	402.2	1547.6	3.85	2131.2	371.8	1759.4	4.71
	TTAR	1925.2	444.2	1481.1	3.33	2127.2	413.8	1713.4	4.14
2005/ 2006	LTBR	1518.9	419.2	1099.0	2.62	1867.8	391.7	1476.1	3.77
	CTBR	1738.1	442.8	1295.2	2.92	2452.9	427.3	2025.7	4.74
	TTBR	1856.4	462.0	1374.4	2.97	2501.4	444.1	2057.3	4.63
	LTAR	2006.0	433.2	1572.8	3.63	2147.0	395.5	1751.5	4.43
	CTAR	2207.4	449.9	1757.5	3.91	2621.5	421.3	2200.2	5.20
	TTAR	2177.8	515.8	1661.9	3.22	2618.5	487.3	2131.2	4.37
2006/ 2007	LTBR	2203.1	515.3	1687.8	3.28	2399.5	496.5	1903.0	3.83
	CTBR	2439.6	539.4	1900.2	3.52	2927.6	530.5	2397.1	4.52
	TTBR	2406.1	582.2	1823.9	3.13	2847.9	572.4	2275.6	3.98
	LTAR	2743.6	529.5	2214.1	4.18	2757.7	502.4	2254.8	4.49
	CTAR	2879.7	544.0	2335.7	4.29	3115.3	508.0	2607.3	5.13
	TTAR	2835.5	593.8	2241.7	3.78	2993.0	580.3	2412.8	4.16

Note: GR: Gross return; TC: total costs; NR: net return and ARR: average rate of return.

variable costs than those of the rest tried tillage systems. Generally, the data of partial budget concluded that conservation tillage system applied after rain precipitation (CTAR) was the

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optimum tillage system economically for each of wheat and barley under rainfed conditions. These results are in harmony with those obtained by Al-Issa and Samarah (2006 and 2009). Ultimately, adoption of conservation tillage practices are needs further economic environmental analysis. In this respect, Larney *et al*. (1994) reported that the main benefits of conventional tillage system in many studies are erosion protection through maintenance of surface soil and water conservation.

DISCUSSION

Accordingly to the favorability of the tried tillage systems, to promoting the yield traits either for wheat or barley, tillage systems could be arranged in ascending order as follows: LTBR, LTAR, CTBR, TTBR, CTAR and / or TTAR. It is noticeable that the plowing after wetting turns the soil texture of the experimental area to more friable. In addition to the role of friable texture in water conservation as reflected by WUE for grains of wheat or barley (see Tables 2 and 4), it is improve aeration and facilitate root penetration and ramification. These results are in harmony with those observed under rainfed Mediterranean conditions by Oweis *et al* (1999), Turner (2004) and Wang *et al* (2005). Also, Al-Issa and Samarah (2006) and Cook (2006) were reported that tillage normally assists in increasing the soil moisture holding capacity

These were reasons for the advantages of tillage systems such as TTAR and CTAR systems which had showed favorable effect on yield and yield attributes for each of barley and wheat recorded here. In this respect, many research results concluded that tillage normally assists in increasing the soil moisture holding capacity through increased porosity, increasing the infiltration rates and reducing the surface runoff by providing surface micro-relief or roughness which helps in temporary storage of rain water, thus providing more time for infiltration (Wilhelm *et al,* 1982; Hudson, 1987; Wilhelm, 1998; Al-Issa and Samarah, 2009; Cook, 2006 and Moreno *et al,* 2006).

CONCLUSION

The present results concluded that wheat could be cultivated under rainfed conditions by using traditional or conservational tillage systems only after effective rainfall. However, barley has potentiality to be cultivated under rainfed conditions before and after effective rainfall precipitation with using conservational tillage systems. It can be also concluded that barley is more economically than wheat to cultivate under rainfed conditions at the Northwest coast of Egypt.

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تأثير نظم خدمة الأرض على الانتاجية المستدامة لمحاصيل الحبوب الشتوية تحت ظروف الزراعة المطرية بمنطقة رأس الحكمة- مصر

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أجريت هذه الدراسة تحت ظرو ف الزراعة المطرية بالشريحة المطرية الثانية (٥-١٥ كم جنوب رأس الحكمة)، ٥٦ كم شرق مدينة مرسى مطروح بمنطقة الساحل الشمالي الغربي لمصر. وذلك خلال أربعة مواسم مطرية (٢٠٠٣/ ٢٠٠٤- ٢٠٠٤/٢٠٠٥ – ٢٠٠٥/٢٠٠٦ – ٢٠٠٦/٢٠٠٧) على التوالي. وذلك بهدف دراسة تأثير نظم خدمة الأرض على إنتاجية المحصول ومكوناته فى القمح والشعير، وقد أظهرت النتائج ما يلي:

- أظهرت النتائج تفوق نظام الخدمة التقليدية بعد سقوط الأمطار (TTAR) فى حالة القمح حيث سجل أطول النباتات، وأثقل وزن للألف حبة خلال المواسم الأربعة، وأكبر عدد من الأشطاء/ م٢ فى الثلاث مواسم الأولى. بينما لم يكن هناك فرق معنوى بين نظامى الخدمة التقليدية (TTAR) ، وخدمة الصيانة بعد سقوط الأمطار (CTAR) في عدد السنابل/ م٢، عدد الحبوب/ سنبلة.
- أظهرت النتائج أن أعلى القيم لكل من محصول الحبوب والقش والمحصول البيولوجي فى القمح تم الحصول عليها عند تطبيق نظام خدمة الأرض (TTAR) خلال الثلاث مواسم الأولى مقارنة بباقى نظم الخدمة. ولكن عند زيادة كمية الأمطار فى الموسم الرابع تفوق نظام الخدمة CTAR على باقى النظم. أيضا قد سجل نظام الخدمة (TTAR) أعلى القيم لكفاءة استخدام المياه. فى حين سجل نظام الخدمة LTBR أقل القيم فى محصول القمح ومكوناته خلال مواسم الدراسة.
- بينما فى حالة الشعير لم يكن هناك فرق معنوى بين نظامى خدمة الأرض (CTAR, TTAR) حيث أظهرا تفوقا علي باقى النظم في المحصول ومكوناته خلال مواسم الدراسة الأربعة، ماعدا دليل التشطىء فى الموسم الرابع حيث كان التأثير غير معنوى.
- أوضحت النتائج أن الشعير كان أكثر كفاءة في استخدام مياه الأمطار، حيث سجل أعلى القيم لكفاءة استخدام المياه ، بينما كانت أقل فى حالة القمح خلال الأربعة مواسم تحت ظروف الزراعة المطرية.
- أظهرت نتائج التحليل الاقتصادى أن الشعير قد سجل أعلى القيم من العائد الكلى وصافى العائد ومتوسط معدل العائد مقارنة بالقمح تحت نفس الظروف البيئية. فى حين تم الحصول على أعلى القيم لصافى العائد ومتوسط معدل العائد لمحصول الشعير فى حالة تطبيق نظام خدمة الصيانة والزراعة بعد سقوط المطر الفعال (CTAR) خلال الأربعة مواسم مقارنة بباقى نظم الخدمة، أيضا قد تفوق هذا النظام اقتصاديا فى حالة القمح ولكن خلال الثلاث مواسم الأخيرة فقط حيث كان الموسم الأول أقل المواسم فى معدل الأمطار وبالتالى تفوق نظام الخدمة (TTAR) .
- يستنتج من هذه الدراسة أن أنسب النظم لعمليات خدمة الأرض من الناحية الاقتصادية هى نظام خدمة الصيانة والزراعة بعد سقوط المطر الفعال (CTAR) لكل من الشعير والقمح، ويتمثل هذا النظام فى الحرث سكة واحدة بعد سقوط المطر الفعال ثم نثر التقاوى والتغطية بسكة محراث اخرى تكون متعامدة على الأولى . بينما تكون زراعة الشعير ذات جدوى اقتصادية أعلى من القمح تحت الظروف البيئية المعاكسة بمناطق الزراعة المطرية بالساحل الشمالى الغربى لمصر.