Evaluation of Tillage Systems on Wheat Crop Production Under Surface and Sprinkler Irrigation Methods: Application for Rural Areas Close to Baghdad, Iraq

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ABSTRACT: This study investigated the effect of soil conservation tillage systems on the growth and productivity of wheat crops under surface and sprinkler irrigation. Field trials were conducted in 2016–2017 and 2017–2018 using three tillage systems under a split-plot design by a systematic arrangement with three replicates. Experimental plots included two irrigation methods (surface and sprinkler), within which were sub-plots for conventional tillage (CT), minimum tillage (MT), and zero tillage (ZT). The results show that surface irrigation treatment produced the greatest wheat crop growth (plant height, length of spike and biomass) in both seasons compared to sprinkler irrigation. The CT treatments resulted in better growth than ZT and MT. However, ZT recorded a decrease in biomass and grain yield of less than 10% compared to CT during both seasons, although superior plant height resulted from CT during the second season. Even so, ZT reduced the water use to 17% and 16% for the first and second seasons, respectively. These results indicate that ZT or MT may slightly reduce wheat yield under sprinkler and surface irrigation, but will consume less irrigation water, providing a sustainable strategy in water-deficient conditions.

KEYWORDS: Agricultural management, rural areas, wheat, surface irrigation, water resources

TYPE: Original Research

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Introduction

Tillage is an important agricultural practice in crop production because of its role in soil fragmentation, ventilation, soil porosity, and preparation of a good seed cradle (Alesso et al., 2020; Bogunovic et al., 2019). In addition, it plays an important role in activating Collinestal microbiology in the soil and increasing the availability of nutrients (Al-Kaisi et al., 2005; El-Shater et al., 2020). However, the regular use of tillage processes may adversely affect the physical and chemical properties of soil due to the stacking of the soil surface layer (Bartimote et al., 2017). This negative impact can occur because of the frequent use of agricultural machinery during the preparation of land for farming and crop servicing, especially when soil moisture levels are higher than those suitable for the cultivation process (Halopka, 2017; Niari et al., 2012). This problem is highly evident in heavy-texture soils and less content of organic matter (Lafond et al., 2006). As a result, there are stacked layers of soil that causes reduced output and moisture content, weaken the growth of roots, and prevent access to nutrients. To avoid this problem, subsurface tillage needs to be conducted, which increases production costs but reduces the bulk density of soil and, subsequently, the infiltration (Bennett et al., 2017; Kaspar et al., 2001).

Conservation agriculture is a trending agricultural system adopted in many non-developed countries because it preserves the physical and chemical properties of soil and, subsequently, quality and health (Dumanski et al., 2006; Van Pelt et al., 2017). Conservation farming or zero tillage can be defined as planting the land without stirring and moving the soil to protect it from degradation and erosion and retaining moisture and organic matter (Al-Grbawi et al., 2017). Recently, global research has tended to minimize soil tillage processes to reduce their negative effects on soil properties, construction, and fertility (Alesso et al., 2020; Gómez et al., 2009; Marques et al., 2020). Undoubtedly, this practice can reduce soil erosion but could also connect some hydrological pathways from the shoulders to foot slopes as other authors observed in vineyards (Cerdà & Rodrigo-Comino, 2020; Rodrigo-Comino et al., 2020).

Tillage can also increase moisture loss and, subsequently, the amount of irrigation water required, which leaches elements away from the roots (Bartimote et al., 2017; Tekaya et al., 2016). Some authors confirmed that continuous tillage might increase soil temperature and contribute to reducing the amount of organic carbon in the soil (Paustian et al., 2019) as well as an increase in soil retention of annual weeds seeds and spread the rhizomes of perennial species (Muslim Al-Eqaili et al., 2017). The effects of different tillage systems may be attributed to the type, structure and properties of soil and the method of irrigation (Muslim Al-Eqaili et al., 2017), and this may be influencing soil moisture content and the growth of weeds. Bhattacharyya et al. (2006) confirmed that applying zero tillage could conserve moisture compared to traditional farming systems. The zero tillage system is a simplified way of water harvesting while improving soil cohesion and lack of erosion that could increase crop productivity (Lankoski et al., 2006; Lu et al., 2018). This process is economically feasible as it reduces working hours in the farming treatment and

Figure 1. Sprinkler irrigation at season 2017–2018 (left side) and surface irrigation at season 2017–2018 (right side).

Figure 2. The geographic map for the location of the research station.

associated expenses (fuel, employment, machine consumption, etc.) (Lankoski et al., 2006; Mastrandrea & Schneider, 2008; Rodrigo-Comino et al., 2016). In addition, Page et al. (2020) observed an improvement in permeability, highlighting its role in improving the nutrient cycle and, thus, a clear increase in yield production and quality.

The application of conservation tillage systems in rural areas close to big populated cities has increased considerably within wet and semi-humid areas under rain irrigation systems. However, this system has not been thoroughly tested in dry rural lands from non-developed countries like Iraq, where soil and water resources are essential for rural economies (Afzalinia & Ziaee, 2014). It is well-known that tillage efficiency under rain or surface irrigation largely depends on soil properties, such as texture, depth, electrical conductivity, drainage, calcium carbonate content, bulk density, and movement of nutrients (Rezania et al., 2009). However, it is unknown whether zero or minimum tillage systems under surface irrigation compared to rain irrigation practices (sprinkler irrigation) would be suitable. Therefore, goal of this research is to evaluate the effectiveness of soil conservation tillage systems on the growth and productivity of the wheat crop. To achieve this goal, we assessed surface and sprinkler irrigation systems at the Al-Suwaira research station of the Agricultural Research Office/Ministry of Agriculture as part of the National Wheat Plant Development Program in Iraq (50 km from Baghdad) in representative clay loam soils. Field trials were conducted during two seasons (2016–2017 and 2017–2018) using three tillage systems under a systematic split-plot design with three replicates. We considered the use of conventional tillage (CT), minimum tillage (MT), and zero tillage (ZT) as sub-plots, while the whole plots included two irrigation methods (surface and sprinkler) and determined the effect on the growth and production of wheat crops.

Materials and Methods

Study area and sampling strategy

Field experiments were carried out at the Al-Suwaira research station of the Agricultural Research office belonging to the Ministry of Agriculture (Figure 1) as part of the National Wheat Plant Development Program in Iraq, located 50 km south of Baghdad (44.82E, 33.1N) (Figure 2). The research was conducted during the winter seasons in 2016–2017 and

Table 1. Soil Physical and Chemical Properties.

VARIABLE	2016–2017	2017–2018	UNIT
pH	7.41	7.24	
Electrical conductivity	7.62	5.32	dS m^{-1}
Bulk density	1.34	1.32	
Volumetric moisture content 33 kilopascal	0.33	0.34	$cm^3.cm^{-3}$
Volumetric moisture content (150 kilopascal)	0.12	0.12	$cm^3.cm^{-3}$
Available water	0.21	0.22	$cm^3.cm^{-3}$
Sand	208.67	206.41	$g.kg^{-1}$
Loam	400.13	402.22	$g.kg^{-1}$
Clay	391.2	392.2	$g.kg^{-1}$
Ca	15.8	14.32	$mm.L^{-1}$
Mg	7.3	7.61	$mm.L^{-1}$
Na	40.5	38.4	$mm.L^{-1}$
K	2.68	2.66	$mm.L^{-1}$
SO_4	11.46	10.37	$mm.L^{-1}$
CL	52. 18	48.25	$mm.L^{-1}$
HCO_3^{-1}	2.97	2.73	$mm.L^{-1}$
CO_3^{-2}	0	0	$mm.L^{-1}$

2017–2018 using the most extended soil types of this region with a soil clay loam texture (USDA classification). Soils sample were taken from 0 to 30 cm in depth to estimate physical and chemical properties (Table 1). The soil texture was estimated according to the method developed by Black et al. (1965). pH was measured in a 1:1 suspension of soil to water using a pH meter, and electrical conductivity was measured using a conductive meter. Bicarbonate (HCO^{3-}) and carbonate ($CO^{3=}$) were estimated according to Richards (1954) using the method described in Page et al. (1982). Potassium and sodium content were estimated using a flame photometer device and sulfates following Chesnin and Yien (1951) with the use of barium chloride through a spectrophotometer with a wavelength of 490 nm.

A split-plot design was used by a systematic arrangement distribution of the treatments. After preparing each soil and planting wheat, the field was divided into main plots that represented the irrigation treatment as a whole plot. The sub-plots were exposed to different tillage practices, including sprinkler irrigation with conventional tillage (aCT), sprinkler irrigation with zero tillage (aZT), sprinkler irrigation with minimum tillage (aMT), surface irrigation with conventional tillage (bCT), surface irrigation with zero tillage (bZT), and surface irrigation with minimum tillage (bMT). All treatments had three replicates (Figure 3).

Land preparation and statistical analysis

Chemical fertilizers (NPK—nitrogen, phosphorus, and potassium-) were added at three stages. One-third of nitrogen (40 kg $N.ha^{-1}$) and potassium (33 $kg.ha^{-1}$) and all phosphate fertilizers as P_2O_5 (30 kg $P.ha^{-1}$) were used during the pre-planning phase. After that, the second, third part of nitrogen and potassium fertilizer was applied 50 days after planting (during the tillage stage). The last third of nitrogen and potassium fertilizers were added 75 days after planting (elongation stage). The wheat sowing dates were 22/11/2016 and 1/12/2017, and harvesting was done on 2/5/2017 and 4/5/2018 using a square meter sample from the experimental units. The number of spikes per square meter and grain weight per spike were randomly calculated for each unit treatment. The weight of 1,000 grains was determined by separating the spike from the straw the weighting the grains and straws separately. A Mouldboard plow was used (30 cm depth of plow) to conduct traditional tillage with softening soil and a rotary plow. Minimum tillage was done using a disk plow (5–7 cm depth of plowing). The water requirement of the crop was calculated according to the following equation (1) (FAO, 1998)

$$ETC = ET_o X\ Kc \tag{1}$$

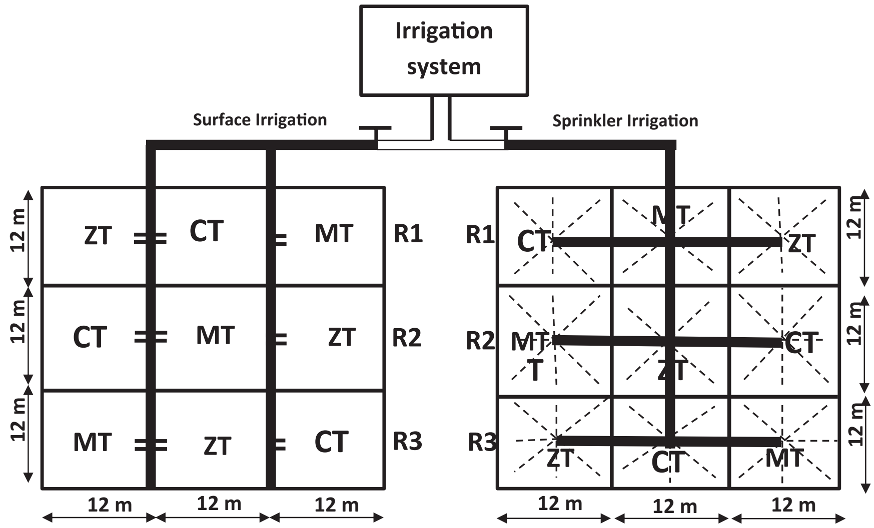

Figure 3. Layout of the experimental design and distribution of the treatments.
Note. CT = conventional tillage; ZT = zero tillage; MT = minimum tillage.

Where
ETc = crop evapotranspiration;
ET_o = reference evapotranspiration;
KC = seasonal crop coefficient.

Evapotranspiration (ET_o) was calculated according to equation (2) (FAO, 1977) using the meteorological data collected 3 years ago, including temperature, wind speed, hours of radiation, evaporation, and relative humidity using a meteorological station in the studied plots (Table 2).

After that, the total field irrigation requirement (FIR) was calculated according to Al-Taif and Al-Hadithy (1988) :

$$FIR = \frac{ETc}{(1 - LR)\, E_i} \tag{2}$$

Where
FIR = field irrigation requirement;
Etc = crop evapotranspiration;
E_i = efficiency of water adding.

The value of Ei was 80% for surface irrigation and 90% for sprinkler irrigation, which were considered an approach to the values previously obtained from experiments conducted in central Iraq (Al-Hadithy, 1983). To determine the date and quantity of irrigation, the weight method was adopted during the stages of growth before starting the irrigation process. The irrigation date was also adopted when 50% to 55% of available water was lost from the soil layer (0–30 cm). The amount of water added was calculated according to the following equation (Al-Taif & Al-Hadithy, 1988):

$$d = \frac{(\mu\, FC - \mu\, I)\, \beta\, \beta}{100} \times D \tag{3}$$

Where;
d = depth of water irrigation;
μ FC = soil moisture with field capacity;
μ I = soil moisture with irrigation;
β β = bulk density ($mg.m^{-3}$);
D = depth of soil (cm).

The statistical analysis was performed using GenStat software (Edition 4). The number of points used for each analysis corresponded to all measurements conducted at each plot. Statistically significant differences between the means of independent (unrelated) groups were identified using an analysis of variance (ANOVA systematic design). Normality testing was conducted and a post-hoc test to detect which specific groups were different by comparing all the possible paired means.

Results

Amount of water irrigation (m^3 per plot)

The ANOVA identified significant differences in the water requirements of the wheat crop during the different growth stages, needs of the field, depth of irrigation water, and amount of water added (Figure 4). The results revealed differences in irrigation required among the tillage systems where larger amounts of water were required in the conventional tillage plot to reach a specific wetting level (50%–55% of available water in the soil), compared to the zero tillage (ZT) or minimum tillage (MT), in both seasons (2016–2017 and 2017–2018). This was reflected in the increasing amount of irrigation water required per plot, including the water supplied by different irrigation and tillage methods. Under the sprinkler irrigation method, traditional tillage needed 28.18 m^3 per plot, while ZT and MT required 26.24 and 27.92 m^3, respectively. By comparison, the board in traditional tillage under surface irrigation used 32.17 m^3. ZT and MT required 30.48 and 31.35 m^3 under surface irrigation during the first season, respectively. Values differed from the first season in the second season, but the same trend for irrigation and tillage practices was observed.

Table 2. Values of ET_o (Reference Evapotranspiration) and ETc (Crop Evapotranspiration) for the Wheat Crop During the Two Growth Monitoring Seasons (2016–2017 and 2017–2018).

SEASON		JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	TOTAL
2016–2017	ET_o	21.0	63.0	62.0	89.0	168.0	214.0	
	K_c	0.35	0.75	1.20	1.10	0.85	0.45	
	ET_C	7.35	47.25	74.40	97.90	142.80	96.30	466
2017–2018	ET_o	13.0	63.0	52.0	89.0	168.0	214.0	
	K_c	0.35	0.75	1.2	1.1	0.85	0.45	
	ET_C	4.55	47.25	62.40	97.90	142.80	96.30	451.2

Note. ET_o = reference evapotranspiration; ETc = crop evapotranspiration; K_C = seasonal crop coefficient.

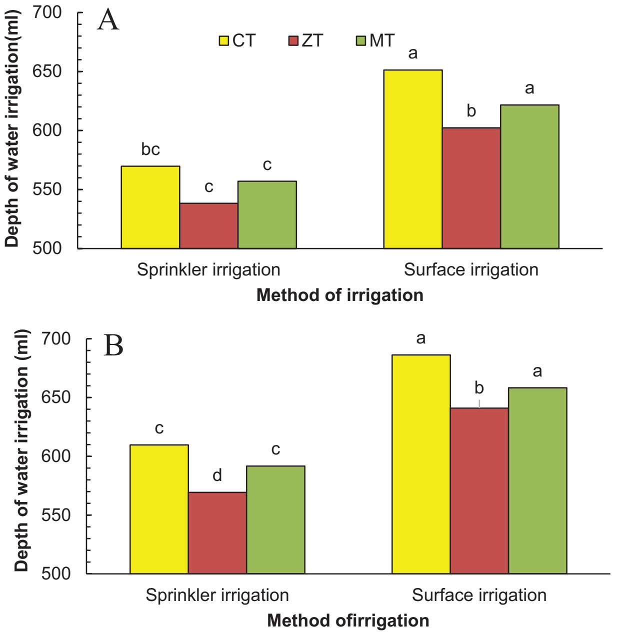

Figure 4. Depth of water irrigation of field: (A) first season (2016–2017) and (B) second season (2017–2018).
Note. CT = conventional tillage; ZT = zero tillage; MT = minimum tillage.
The letters on the columns refer to the last significant different among means (LSD).
ETc of sprinkler irrigation was 609.15 and ETc of surface irrigation was 685.
Means within a column followed by the same letter are not significantly different (p-value ⩽.05).

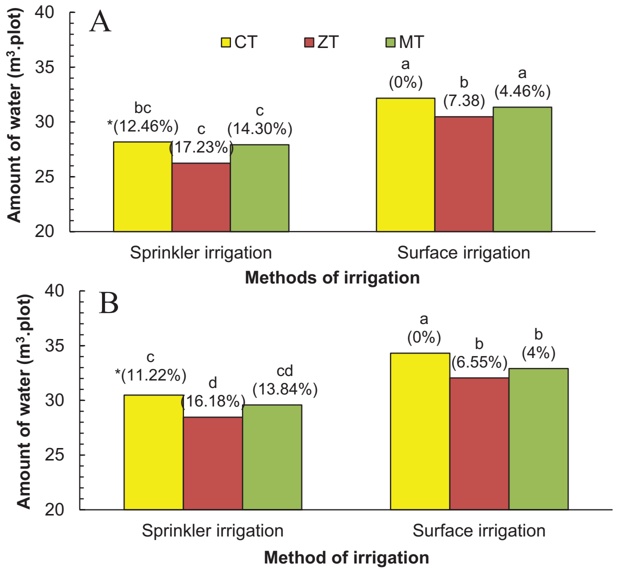

Figure 5. Amount of water necessary to be added per plot: (A) first season (2016–2017) and (B) second season (2017–2018).
Note. CT = conventional tillage; ZT = zero tillage; MT = minimum tillage.
The letters on the columns refer to the last significant different among means (LSD).
ETc of sprinkler irrigation was 609.15 and ETc of surface irrigation was 685.
Means within a column followed by the same letter are not significantly different (p-value ⩽.05).
*Water Reserve compared with CT (%).

From this amount added per plot, the irrigation water reserved for each treatment was calculated relative to the traditional treatment of surface irrigation and tillage. The sprinkler irrigation in the ZT system gave the best results for water irrigation (17.2% during the first season and 16.2% during the second one). The reserve of irrigation water decreased by more than half under irrigated conditions in the same treatment (17.2% and 6.6% for the two seasons, respectively). The MT treatment also recorded a reserving rate reaching 14.3% and 13.8% for the two seasons under sprinkler irrigation compared to the surface irrigation for the same treatment, which amounted to 4.4% and 4.08%, respectively (Figure 5). These results highlight the important role that tillage plays in increasing soil water retention and rapid saturation. We observed that as deep tillage increases, the soil becomes more porous and drains water away from the plant's root area.

Growth of wheat

There were significant differences in wheat crop growth indicators with changing methods of irrigation and tillage. Traditional tillage treatments recorded a moral superiority in plant height at the first season under sprinkler and surface irrigation systems, while the treatment of ZT or minimum tillage did not differ during the first season (Table 3). In the second season, ZT and MT treatments recorded a higher plant height than the conventional tillage under the sprinkler and surface irrigation. No significant differences in spike length were found between any of the treatment groups for both seasons.

Table 3. Effect of Irrigation Treatment and Tillage on Some Growth Parameters of Wheat Crop.

IRRIGATION TREATMENT	TILLAGE TREATMENT	PLANT HEIGHT (CM)	LENGTH OF SPIKE (CM)	YIELD BIOMASS (MG.HA^{-1})
Season 2016–2017				
Sprinkler irrigation	CT	92.40 a	9.70 a	7.61 b
	ZT	82.33 b	9.3 0 a	6.51 c
	MT	79.33 b	9.13 a	6.48 c
Surface irrigation	CT	93.67 a	10.3 a	8.20 a
	ZT	88.73 a	9.73 a	5.76 d
	MT	82.77 b	9.47 a	6.37 c
L.S.D		5.321	NS	0.53
Season 2017–2018				
Sprinkler irrigation	CT	90.13 bc	10.70 a	11.80 a
	ZT	95.47 bc	11.20 a	9.72 c
	MT	103.37 a	10.37 a	8.91 d
Surface irrigation	CT	86.33c	10.57 a	11.08 b
	ZT	90.07 c	10.77 a	9.41 c
	MT	97.07 b	10.60 a	9.30 c
L.S.D		6.00	NS	0.71

Note. Means within a column followed by the same letter are not significantly different (p-value ⩽.05). CT = conventional tillage; ZT = zero tillage; MT = minimum tillage.

Conversely, the conventional tillage treatment recorded higher values in crop biomass under sprinkler and surface irrigation. However, conventional tillage under surface irrigation systems recorded larger crop biomass (8.20 Mg.ha^{-1}) than the sprinkler irrigation system (7.61 Mg.ha^{-1}) for the first season. The same treatment did not show any difference during the second season. Zero tillage and MT had lower total biomass than conventional tillage treatment, reaching about 20% to 30% during the first season and 12% to 16% during the second season.

Grain yield and yield component

The surface irrigation method showed clear superiority for yield production and its components compared to the sprinkler irrigation for both seasons (Table 4). In addition, traditional tillage also resulted in higher productivity compared to ZT and MT. However, it is worth noting that the ZT under surface irrigation showed no, or minimal, significant differences compared to the traditional tillage treatment under sprinkler irrigation. In the second season (2017–2018), the same trend was obtained between tillage and irrigation treatments. The ZT treatment recorded a grain weight similar to the traditional tillage under surface irrigation and spraying systems in both planting seasons, while the weight of grains in the treatment with MT decreased. Traditional tillage treatment recorded the highest number of spikes per square meter under surface irrigation (381 spikes.m^{-2}) in the first season, while the same treatment under the sprinkler irrigation system recorded a decrease of 328.7 spikes.m^{-2}. Zero tillage treatment recorded fewer spikes than conventional tillage in both years. The ZT group with under surface irrigation recorded several spikes (322.7 and 370.7 spikes.m^{-2}) and did not differ significantly from traditional tillage under sprinkler irrigation (328.7 and 369.3 spikes.m^{-2}) during the first and second seasons, respectively. Minimum tillage recorded a lower number of spikes than the other treatments in both study seasons. Tillage significantly affected the number of grains per spike in the first season but not in the second. Traditional tillage under surface irrigation recorded the highest number of grains per spike, with 72.2.

The economic yield of grain varied according to the different components. The treatment of surface irrigation in traditional tillage in grain yield was higher than the same treatment under sprinkler irrigation. Grain yield in ZT and MT treatments decreased by 10.8% and 11.1%, respectively, compared to the traditional tillage treatment under the sprinkler irrigation system. The ZT and MT treatments also produced 1.4% and 19% lower grain yields, respectively, than the traditional tillage under surface irrigation during the first season. In the second season, the traditional tillage under sprinkler and surface irrigation methods were significantly superior to the other treatments and did not differ between them. Therefore, ZT and MT did not result in significant differences in grain yield.

Table 4. Effect of Irrigation Treatment and Tillage on Yield and Yield Components of Wheat Crop.

IRRIGATION TREATMENT	TILLAGE TREATMENT	WEIGHT OF 1,000 GRAIN (G)	NUMBER OF SPIKES (M^2)	NUMBER GRAIN PER SPIKE	GRAIN YIELD ($MG.HA^{-1}$)	HARVEST INDEX
Season 2016–2017						
Sprinkler irrigation	CT	31.40 b	328.7 b	63.9 b	3.51 a	46.18 a
	ZT	31.67 b	293.3 d	65.01 b	3.13 b	47.79 a
	MT	29.83 b	307.3 cd	59.82 b	3.12 b	48.16 a
Surface irrigation	CT	35.60 a	344.0 a	72.21 a	3.83 a	64.16 a
	ZT	33.80 ab	322.7 bc	62.28 b	3.01 b	50.61 a
	MT	32.10 b	311.3 bc	59.07 b	3.10 b	48.65 a
L.S.D		2.38	18.19	6.971	0.4	NS
Season 2017–2018						
Sprinkler irrigation	CT	37.10 a	369.3 ab	79.42 a	5.22 a	44.25 c
	ZT	36.10 ab	328.0 d	76.87 a	4.47 b	45.97 b
	MT	34.20 c	346.0 c	75.02 a	4.256 c	47.76 a
Surface irrigation	CT	35.40 bc	381.3 a	75.34 a	4.97 a	44.87 bc
	ZT	33.43 c	370.7 ab	73.93 a	4.42 b	47.01 a
	MT	34.27 c	356.7 bc	73.95 a	4.37 b	46.98 a
L.S.D		1.84	16.2	NS	0.2	1.64

Note. Means within a column followed by the same letter are not significantly different (p-value $\leqslant$.05). CT = conventional tillage; ZT = zero tillage; MT = minimum tillage.

Finally, the harvest index represented the quantity of grain that a crop can produce under all biological yields. Table 4 indicated no significant difference between different tillage treatments or irrigation methods during the first season. The ZT and MT recorded a harvest index that exceeded 47% to 50%. The ZT and MT recorded a significant harvest index in the second season that surpassed the traditional tillage treatment.

Discussion

In the agricultural systems of non-developed countries, the reduction of costs, optimization of resources, and conservation of water and soil are becoming requirements due to water deficiency and low reservations. However, the efficiency of irrigation methods and the possibility of enhancing water use for crop production is missing from the current scientific literature (Raheem Lahmod et al., 2019). Generally, our results suggested that irrigation water could be used more economically by reducing or stopping tillage while still maintaining high yield and lower costs. Sprinkler irrigation saved more water than surface irrigation, but MT and ZT increased soil water retention efficiency by 17% and 14%, respectively, compared to 12% with traditional tillage (first season). Although more water was used under surface irrigation conditions, the effect of ZT and MT were similar to the application of sprinkler irrigation in both growing seasons. Conversely, the depth of irrigation water and the amount of water required decreased between treatments, reflecting a greater water supply efficiency. This results are agreement with Beden et al. (2021) on the mung bean crop.

Reducing tillage may increase the volumetric saturation of soil due to lower porosity and the rapid loss of water rapidly to the ground under the soil layers. For instance, McCracken et al. (1993) confirmed that zero tillage retained more moisture when planting maize in sandy loam soil than the conventional system. Bhattacharyya et al. (2006) also confirmed that zero tillage conserved a higher moisture content than the traditional farming system, as did numerous other authors, including Dumanski et al. (2006), Toliver (2010), and Keil et al. (2015). However, other studies investigating tillage procedures and environmental conditions obtained opposite results. For example, Bissett and Oleary (1996) confirmed that the soil permeability in the lower layers could be better under a long period of conservation tillage or sub-surface tillage in clay soils compared to conventional tillage in Australia. These differences may be due to the differences in soil properties.

Our results show that the surface irrigation treatment was the best option for maximum wheat crop growth (plant height and length of spike and biomass) in both seasons compared to the sprinkler irrigation. The traditional tillage treatment also resulted in the best growth indicators, possibly due to the use of large amounts of water. However, zero tillage recorded a decrease in crop growth of less than 10% compared to the biomass of the conventional tillage during two seasons, while plant height was greater than under traditional tillage in the second season. These results highlight the possibility of maintaining a good economic product while reducing tillage practices, their material costs, and reducing water usage. Karlen et al. (1994) found that a system without tillage could result in the best soil aggregate structure and reduce water use, even when using the remnant crop residue on the soil surface. Recently, Rodrigo-Comino et al. (2020) and Cerdà and Rodrigo-Comino (2020) in Spanish olive and citrus plantations insisted that pruned branches and natural mulches helped reduce water losses after extreme rainfall events. However, to be accepted by the farmers, these control measures must be implemented after being subsidized by the governments. Soil conservation must be a priority in every agricultural field since some studies have confirmed that non-sustainable soil management systems in Iraq could directly affect soil and water quality (AL-Dulaimi & Younes, 2017; Karlen et al., 1994).

In Brazil, Madari et al. (2005) and Antoneli et al. (2018) showed that minimal tillage help to conserve soil structure and organic carbon and produce a higher volume of grain. Roldan et al. (2003) demonstrated that after 5 years of planting maize with a zero tillage system in Mexico, soil aggregations increased compared to the traditional tillage methods. In addition, they observed an increasing number of enzymes, higher organic carbon content and soil biomass with zero tillage. Under drought conditions, Alqaisi et al.(2018) found that maize growth under zero tillage conditions improved soil conditions and productivity. In addition, some studies indicated that traditional tillage might contribute to the destruction of accumulated soil aggregates and the deterioration of physical properties (Green et al., 2007), although zero tillage may increase the bulk density (Al-Shammary et al., 2018; Cassel et al., 1995). Another positive aspect is that zero tillage or minimum tillage may increase bio-carbon and nitrogen cycles compared to conventional tillage (Erenstein et al., 2007). Traditional tillage can also increase CO_2 emissions from the soil due to increased soil respiration and microbial activity (López-Garrido et al., 2009) resulting in a significant loss of organic matter in the soil. Continuous tillage of the soil may increase the immorality of the organic matter and expose microbial activity (Balesdent et al., 2000). These aspects should also be studied in the future in Iraq to show the policymakers and farmers these important issues.

The yield of wheat grains represents another important economic aspect of the agricultural system, which in this study represents a rural area close to a highly populated city. Our results demonstrated a correlation among the basic components of the crop, such as the weight of seeds, number of seeds per spikes, the number of spikes per m^{-2} and soil quality (Lahmod, 2015). Traditional tillage treatment under surface irrigation and sprinkler systems showed significant differences in grain yield than under zero tillage and minimum tillage. However, zero and minimum tillage recorded 22% lower output for surface irrigation, 11% for sprinkler irrigation during the first season, 9% for surface irrigation and 15% for sprinkler irrigation in the second season. From this, we can determine that zero tillage is a successful strategy under low irrigation conditions using both sprinkler and surface irrigation systems. The use of zero tillage also reduces the costs of agricultural machinery and affects soil compaction, giving positive benefits for farmers and the soil (Miransari, 2013).

When analyzing the increase in wheat grain yield, we find that most of the yield components (number of spikes, number of grains per spike and weight of grain) during the first season showed a significant increase using traditional tillage under irrigation. The number of spikes did not differ from zero tillage. In the second season, the difference in the number of spikes per unit area was not significant between tillage treatment under surface and sprinkler irrigation systems, but the rest of the components (number of grains per spike and the weight of grains) recorded a significant increase when traditional tillage treatment was not used. This result increased with its basic components, possibly due to an increase in one component while the other parameters remained relatively constant (Lahmod & Alsaadawi, 2014). Increasing the number of spikes may reduce the amount of supplied assimilation for the spikes. It would be distributed over a larger number of spikes, which can reduce the share of single spikes, and increase the number of grains per spike, reducing the outputs of photosynthesis processed per grain, which in turn reduces the weight of the grain (Almutrafi et al., 2014).

Finally, the harvest index did not show significant differences during the first season among soil management systems, and only a few differences during the second year of plantation. However, zero or minimum tillage were superior for harvest index compared to traditional tillage. The increase in harvest index in non-tilled or minimum tilled treatments means that the crop invests its activities in producing grain over vegetative growth. However, we need to extend the period of the research monitoring to confirm this at medium- and long-term periods.

Conclusion

The results show that surface irrigation treatment has clear benefits for several biological indicators (plant height, length of spike and biomass) over two seasons compared to sprinkler irrigation. In addition, zero tillage resulted in a decrease of less than 10% in biomass and grain yield compared to conventional tillage during both seasons and superior plant height for conventional tillage in the second season. Zero tillage also reduced water use to 17% and 16% for the first and second seasons, respectively. These results show that zero or minimum tillage may decrease wheat yield under sprinkler or surface irrigation but consumes less water, making it an effective strategy in arid conditions with minimal short water resources. This strategy can be successfully adopted under both rain irrigation and surface irrigation conditions.

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