Effect of Tillage Systems on the Growth and Productivity of Eight Wheat Cultivars

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Abstract. A field experiment was carried out in one of the agricultural fields in Abu Ghraib region during the winter season of 2018-2019 in order to study the effect of plowing systems on the growth and productivity of eight cultivars of wheat crop in a silty clay loam, field land which was not sown in the previous season. Two tillage systems were used (no-tillage and tillage) to grow the wheat crop, moldboard plows and harrow (local made). The cultivars were (Wafia, Adena, Araz, Erratum, Pura, Spelta, Doru, and Cymto). Randomized complete blocks design (RCBD) was used in a split plot arrangement with three replications. Results revealed that Adena predominated in plant height (87.77 cm), spike length (10.68 cm) tillers (4.695 tiller plant^{-1}), whereas Cymto was superior in plant dry weight (80.00 g), thousand grains weight (54.80 g), grains yield per unit (5.535 Kg). Genetic material of Azar, Adena and Cymto cultivars was the best, as it was clearly manifested in the phenotypic components of wheat.

1. Introduction

The increasing need for food by humans or animals has increased in recent years as a result of the increase in population density (global food security). This leads to the introduction of agricultural mechanization in various agricultural operations, including the plowing process. Wheat (*Triticum aestivum* L.) is one of the most important strategic grain crops that are relied upon to reduce the food gap, which has become the problem of the world. The world population is expected to reach 9 billion in 2050, up from 5.5 billion in 1994. This problem began to manifest itself in Iraq clearly because the rate of self-sufficiency in the wheat crop did not exceed 41.21% in 1994 [1]. In order to meet the growing food need, it is necessary to think about increasing the productivity of this crop, which is still very low in Iraq. Researchers tried to increase wheat yield via improving soil and crop management operations and genetic improvements, and it seems that half of the increase in wheat production at the global level is due to interest in soil and crop management operations through the use of agricultural mechanization of plowing, softening, seeding, hoeing, fertilizing, harvesting and other crop practices of agricultural crops. The other half of the increase came through genetic improvements by developing cultivars with high yield and good quality. Based on the foregoing, soil and crop management operations and genetic improvements were highlighted to be the basis for developing the productivity of this crop. In light of the current conditions of high fuel prices and the increase in the cost of agricultural production requirements on the one hand and the scarcity of water sources and low rainfall rates on the other hand, these problems persists. It was found that conservative agriculture would save farmers' expenses at least, reduce weeding, remove harmful plants, raise soil moisture and reduce erosion in areas prone to erosion, as a result of the presence of crop residues, leading to an increase in production in the long run. However, conservation agriculture does not succeed in heavy clay soils due to the decrease of soil porosity and cracks in it. In the

developing countries such as Iraq, traditional plowing methods are still used due to the lack of efficient information on the minimum level of tillage, no-till technologies or conservation agriculture that reduce energy requirements and soil erosion and loss of moisture, especially in areas with desert soils, as the crop yield increases when there is little rain [2]. The economic yield of wheat, while maintaining the productive state of the soil, is needed and it is necessary to apply several technologies, including regulating the use of agricultural mechanization. [3] found that tillage systems have an important role in the growth and yield of wheat cultivars, as five cultivars responded differently to two tillage systems. The use of unconventional and appropriate plowing processes reduces surface eruption and increases infiltration rates. This causes soil moisture to be preserved. Researchers have indicated that no-tillage or minimal tillage techniques have the ability to hold water to a greater degree than traditional soil technologies [4][5], and reduce pesticide use [6], and energy consumption [7]. Conservation tillage represents a wide range of tillage operations that are intended to conserve soil moisture and reduce soil erosion by keeping more than one third of the soil surface covered with crop residues (as farmers do in southern Iraq by broadcasting seeds of barley or wheat in rice fields), which increases organic carbon. [8][9], as the organic matter under zero tillage helps to increase the yield [10] [11]. Conservation tillage may include effective shallow depth without turning the soil, i.e. no-tillage, reduction, or shallow with spring tooth harrow or disc harrows [12]. In general, conservation tillage systems (no or minimum tillage) improve soil organic carbon, water capacity available to plants, and water transport in soil and its aggregates [13] [14]. Soil porosity and total (N) were high in soils subject to conservation tillage (no or minimum tillage). They also indicated that wheat yield was affected by tillage systems and different cultivars, the Panifor cultivar under conservative tillage outperformed by giving the highest grain yield. Zero tillage caused an increase in porosity, field capacity and NPKS elements in availability to the plant form, so it is concluded that zero tillage is suitable for preserving soil elements and achieving an ideal yield in the farming system [15]. The minimum tillage with plant residues caused a significant increase of 78.0% in the yield of wheat grains compared to conventional tillage, and the minimum tillage reduces irrigation by 70.7%. The reason may be attributed to the suitability of the soil temperature due to the coverings and the high soil moisture in the upper part of the soil. Therefore, it is concluded that the minimum tillage in the presence of plant residues and reduced irrigation were more beneficial in the production of winter wheat after maize in northern China [16]. [17] found that no-till system and disc harrows improved the qualitative characteristics of winter wheat and may represent an alternative to conventional tillage. Therefore, this research was carried out with the aim of evaluating the effect of two tillage systems on the growth and yield of eight cultivars of bread wheat.

2. Materials and Methods

2.1. Experiment laying out and design

Field trial was laid out in one of the private farms in Abu-Ghraib District- Hameed Shaaban Town, 35km west of Baghdad during the winter season of 2018-2019. For the chemical and physical properties of experimental soil, random samples were taken at a depth of 0-30 cm before planting and analyzed in the Central Laboratory for Soil, Water and Plant Analysis / Department of Soil Sciences and Water Resources - College of Agriculture - University of Baghdad, the results of which are shown in Table (1).

Table1. Chemical and physical properties of experimental soil

Soil properties	Value
Sand	112.2
Clay	336.2
Silt	551.6
Soil texture	silty clay loam
pH	8.15
EC_e ($dS.m^{-1}$)	5.42
N mg kg^{-1}	25
P mg kg^{-1}	40.2

K mg kg^{-1}	360
OM %	8.2

Randomized complete blocks design (RCBD) was used in a split plot arrangement with three replications. Tillage systems (no tillage, traditional tillage) were allocated to the main plot and cultivars (Wafia, Adena, Araz, Erratum, Pura, Spelta, Doru, and Cymto) were allocated to sub-plots. The field was watered to the limits of saturation (flooding) and the narrow and broad leaf weeds were controlled with Paraquat 20% SL. Soil management operations were carried out before planting, plowing, smoothing and leveling, and the experimental land was divided into plots (4 x 5 m). Furrows for irrigation were opened, and terraces were worked between the plots. Fertilizer was applied according to the fertilizer's recommendation.

2.2. Statistical analysis

The results were analyzed according to the split plot in RCBD design with the statistical software Genstat v12.1, and the least significant difference L.S.D was used under the probability level of 0.05 to test the treatments means.

3. Results and Discussions

3.1. Plant height (cm)

Table 2 illustrates that individually, these cultivars were different where Adena gave the highest height of 87.77 cm, followed by Doru of 86.65 cm, Pura of 86.48 cm and Cymto of 85.02 CM, whereas, spelta had the lowest height of 72.47 cm. As for the tillage system, no-tillage practice yielded numerically maximal plant height of 82.51 cm, while till process achieved minimal height of 77.87 cm. The Italian cultivar Pura X no-till has outperformed in the plant height as it gave (92.67 cm), followed by the Doru X no-till (87.46 cm), then Adena X no-till (85.30 cm), while the Australian cultivar (Erratum) gave the lowest average plant height (69.47 cm) under No-till system. Under the tillage system, Adena cultivar outperformed, giving the highest average of 90.23 cm, followed by cymto (85.87 cm) and Doru 85.83 cm, while the Erratum cultivar gave the lowest average of 62.43 cm.

Table2. Effect of tillage and cultivar on plant height (cm)

cultivars	No-till	till	average
Wafia	81.12	79.30	80.21
Adena	85.30	90.23	87.77
Pura	92.67	80.30	86.48
Spelta	79.27	65.67	72.47
Doru	87.46	85.83	86.65
Cymto	84.17	85.87	85.02
Erratum	69.47	62.43	65.95
Araz	80.67	73.30	76.98
L.S.D(0.05)	11.72		7.92
average	82.51	77.87	
L.S.D (0.05)	N.S		

3.2. *Spike length* (cm)

Table 3 shows the response of spike length (cm) for the eight cultivars of wheat for two tillage systems. Individually, the results show the superiority of Adena in spike length of 10.68 cm, while Pura gave the lowest length of 8.42 cm. Interactively, Wafia cultivar under the no-till system, gave the spike length of 10.43 cm, followed by the Iranian cultivar Araz (10.17 cm), then the Doru cultivar (10.03 cm), while the wild cultivar spelta gave the lowest value of spike length of 7.13 cm, each under no-till system. When the eight cultivars were subjected to plowing, the Adena and Araz cultivars outperformed in spike length, each of them gave 11.4 and 10.53 cm in length of the spike, respectively, followed by the Wafia cultivar (9.60 cm), and then the cultivar Doru (9.13 cm), while the Italian Pura gave the lowest average (8.33 cm) under the tillage system.

Table3. Effect of tillage and cultivar on spike length (cm)

cultivars	No-till	till	average
Wafia	10.43	9.60	10.02
Adena	9.97	11.40	10.68
Pura	8.50	8.33	8.42
Spelta	7.13	8.43	7.78
Doru	10.03	9.13	9.58
Cymto	8.77	8.50	8.63
Erratum	9.27	8.73	9.00
Araz	10.17	10.53	10.35
L.S.D(0.05)	2.73		1.98
average	9.28	9.33	
L.S.D (0.05)	n.s		

3.3. Tiller number per plant

Results presented in Table 4 represent the number of tillers under two plowing systems for the eight cultivars of wheat. The results show that the Italian cultivar Cymto tillered the highest tillers of 5.535 tillers plant^{-1}, whereas Pura possessed the lowest tillers of 3.541 tillers plant^{-1}. As for tillage system, tillage practice achieved maximal tillers of 5.161 tillers plant^{-1}, while no-till achieved minimal tillers of 4.229 tillers plant^{-1}. Interactively, Cymto scored the highest number of tillers under the no-till system, which amounted to 4.885, followed by the Iranian cultivar Araz (4.380), then Wafia cultivar (4.350), and the Turkish cultivar Adena (4.229). However, the Italian cultivar Pura produced only 2.926 tiller under this no-till, while under the tillage system, the Italian cultivar Cymto outperformed, giving the highest average of 6.185 tillers, followed by the Adena cultivar (5.161), and then the Erratum cultivar (5.003), while the cultivar spelta gave 3.542 tiller.

Table 4. Effect of tillage and cultivar on number of tillers per plant.

cultivars	No-till	till	average
Wafia	4.350	4.966	4.658
Adena	4.229	5.161	4.695
Pura	2.926	4.156	3.541
Spelta	3.737	3.542	3.639
Doru	4.188	4.498	4.343
Cymto	4.885	6.185	5.535
Erratum	4.380	5.003	4.691
Araz	3.915	4.915	4.415
L.S.D(0.05)	0.810		0.612
average	4.229	5.161	
L.S.D (0.05)	0.031		

3.4. Length of flag leaf (cm)

Table 5 shows the length of the flag leaf (cm) for the eight cultivars of wheat under two plowing systems. Results show that the cultivar Araz gave the highest length of flag leaf of 26.20cm, whereas, Wafia possessed the lowest length of flag leaf of 20.90 cm. As for the tillage system, no tillage practice achieved maximal length of flag leaf of 24.58 cm, while till achieved minimal length of 23.73 cm. It may be concluded that the Adena cultivar recorded the longest length of the flag leaf (26.13 cm), followed by the Cymto cultivar (25.67 cm), then the Doru (25.47 cm) cultivar, and the Iranian cultivar Araz (25.40 cm). However, the Wafia cultivar recorded the lowest average length of the flag leaf (20.80 cm). When planting these cultivars under the tillage system, the Iranian cultivar Araz gave the highest average length of the flag leaf of 27.00 cm, followed by the Italian cultivar Pura (25.53 cm), then the Italian cultivar Cymto (25.07 cm), while the cultivar Erratum recorded the lowest length of flag leaf (19.87 cm).

Table 5. Effect of tillage and cultivar on length of flag leaf (cm)

cultivars	No-till	till	average
Wafia	20.80	21.00	20.90
Adena	26.13	24.03	25.08
Pura	25.13	25.53	25.33
Spelta	23.83	24.77	24.30
Doru	25.47	22.57	24.02
Cymto	25.67	25.07	25.37
Erratum	24.23	19.87	22.05
Araz	25.40	27.00	26.20
L.S.D(0.05)	4.584		3.318
average	24.58	23.73	
L.S.D (0.05)	ns		

3.5. dry weight of plant (gm)

The results presented in Table 6 show the average vegetative dry weight of wheat under two plowing systems. Results show that cultivar Cymto gave the highest dry weight of 80.00 gm, whereas, Erratum possessed the lowest dry weight of 37.80 gm. As for the tillage system, no tillage practice achieved maximal dry weight 59.50 gm, while till achieved minimal dry weight of 51.30 gm. Superiority was for cultivar Doru as it achieved the highest value of 82.3 gm per plant under the no-till system, followed by the Italian cultivar Cymto (80.9 gm), then Adena cultivar (73.7 gm), and the Iranian cultivar Araz (67.6 gm), while the wild cultivar spelta produced the lowest value of 38.3 gm. Under the tillage system, the Italian cultivar Cymto outperformed, reaching 79.1 gm, followed by the Iranian cultivar Araz (63.8 gm), then the Turkish cultivar Adena (58.1 gm), while the lowest value recorded by the Australian Cultivar Erratum was 31.0 gm.

Table 6. Effect of tillage and cultivar on dry weight (gm)

cultivars	No-till	till	average
Wafia	41.7	34.9	38.3
Adena	73.7	58.1	65.9
Pura	47.0	41.7	44.3
Spelta	38.3	40.4	39.3
Doru	82.3	61.1	71.7
Cymto	80.9	79.1	80.0
Erratum	44.6	31.0	37.8
Araz	67.6	63.8	65.8
L.S.D(0.05)	12.76		9.59
average	59.50	51.30	
L.S.D (0.05)	3.22		

3.6. Weight of 1000 grain **(**gm)

The results presented in Table 7 show the average weight of 1000 grain of wheat under two plowing systems. Results show that cultivar Cymto gave the highest thousand grain weight of 54.80 gm, whereas, Pura filled the lowest thousand grain weight of 33.42 gm. As for the tillage system, no tillage practice possessed maximal grain weight 47.15 gm, while till achieved minimal grain weight of 40.36 gm. Furthermore, results indicate the superiority of the Italian cultivar Cymto, as it achieved the highest value of the weight of 1000 grains (61.23 gm) under the no-till system, followed by the Turkish cultivar Adena (51.10 gm), then the Australian cultivar Erratum (49.53 gm), and the Wafia cultivar (49.17 g), while the wild cultivar Spelta gave the lowest value under this system of 35.07 gm. However, under the plowing system, the Italian cultivar Cymto achieved the highest weight of 1000 grains (48.37 gm), followed by the Australian cultivar Erratum (43.37 gm), then the Wafia cultivar (43.07 gm), and the Turkish cultivar

Adena (41.87 gm), while Spelta cultivar gave the lowest value of 37.00 gm.

Table 7. Effect of tillage and cultivar 1000 grain weight (gm)

cultivars	No-till	till	average
Wafia	49.17	43.07	46.12
Adena	51.10	41.87	46.48
Pura	37.87	28.97	33.42
Spelta	35.07	37.00	36.03
Doru	44.53	41.47	43.00
Cymto	61.23	48.37	54.80
Erratum	49.53	43.37	46.45
Araz	48.67	38.77	43.72
L.S.D(0.05)	9.84		7.37
average	47.15	40.36	
L.S.D (0.05)	2.98		

3.7. Yield of Experimental Unit **(**kg exp. unit^{-1})

It is noted from Table 8 that cultivar Cymto gave the highest yield per experimental unit of 5.535 kg exp.unit^{-1}, whereas, Pura yielded the lowest yield of 3.541 kg exp.unit^{-1}. As for the tillage system, tillage practice yielded maximal yield 4.803 kg exp.unit^{-1}, while no-till achieved minimal yield of 4.076 kg exp.unit^{-1}. The Italian cultivar Cymto was superior in seed yield, as it gave 4.885 kg per exp. unit^{-1} under the no-till system, followed by the Iranian cultivar Araz (4.380 kg), then the Wafia cultivar with a slight difference (4.350 kg), then the Turkish cultivar Adena (4.229 kg), while the Italian cultivar Pura gave the lowest seed yield of 2.926 kg exp. unit^{-1}. When these cultivars were subjected to plowing, the Italian cultivar Cymto achieved the highest seed yield of 6.185 kg, followed by the Turkish cultivar Adena (5.161 kg), then the Australian cultivar Erratum (5.003 kg), and the Iranian cultivar Araz (4.915 kg), while Spelta gave the lowest average seed yield (3.542 kg).

Table 8. Effect of tillage and cultivar on seed yield per experimental unit (kg)

cultivars	No-till	till	average
Wafia	4.350	4.966	4.658
Adena	4.229	5.161	4.695
Pura	2.926	4.156	3.541
Spelta	3.737	3.542	3.639
Doru	4.188	4.498	4.343
Cymto	4.885	6.185	5.535
Erratum	4.380	5.003	4.691
Araz	3.915	4.915	4.415
L.S.D(0.05)	0.810		0.612
average	4.076	4.803	
L.S.D (0.05)	0.031		

Accordingly, the Italian cultivar Cymto was superior in yield of the experimental unit (table 8), 1000 grain weight (table 7), plant dry weight (table 6), tillers per plant (table 4) and proportional plant height (table 2). This could be due to its genetic potentiality which extracted this potentiality for fullest under a similar environment [3]. No tillage process yielded the highest 1000 grain weight (table 7), plant dry weight (table 6), length of flag leaf (table 5), proportionally spike length (table 3) and numerically plant height, while tillage yield the highest yield per experimental unit (table 8), tillers per plant (table 4) and numerically spike length (table3). This could be due to different potentiality of wheat plants under similar mechanical stress. Consequently, this led to a difference on the next plant growth [3], where it was found that conservative agriculture would save farmers' expenses at least, reduce weeding, remove harmful plants, raise soil moisture and reduce erosion in areas prone to erosion, as a result of the presence of crop

residues, leading to an increase in production in the long run. Conservation agriculture does not succeed in heavy clay soils due to the decrease in soil porosity and cracks in it. In the developing countries such as Iraq, traditional plowing methods are still used due to the lack of efficient information on the minimum level of tillage, no-till technologies or conservation agriculture that reduce energy requirements and soil erosion and loss of moisture, especially in areas with desert soils, as the crop yield increases when there is little rain [2]. Moreover, it seems that among the many factors that alter the differences between treatments in some of the studied traits is the type of soil and the genetic material. So the type of soil may have an important role, especially if its content of moisture and elements such as carbon, magnesium and nitrogen differs. In light soils, the wheat crop absorbs the elements easily under no tillage, which is reflected in the grain. However, [14] obtained the highest 1000-grain weight and grain yield under tillage. The different tillage systems have improved the chemical, physical and mechanical properties of the soil, such as moisture, organic carbon and less weed growth [6][9] [15], which contributes to improving the growth and components of the wheat yield. Traditional plowing provides a good seedbed, which is reflected in the growth of the roots [5], it is the main pump for absorbing elements and water from the soil, which increases the number of grains per spike and the weight of a thousand grains, and thus appears clearly in the grain yield. The difference of cultivars in the above traits may be attributed to the difference in the genetic material of those cultivars, which determines the cultivar's expression of its latent ability to the highest level. This is represented in the phenotypic components, as it was evident in the Azar cultivar, which has a latent ability that differs from the rest of the cultivars. The interaction of the genetic material with environmental factors has an effective role in extracting the potential of the genetic components of a particular cultivar under those conditions, especially the abiotic stresses, including the mechanical tension of the soil. Cultivars may respond in different patterns. The genetic material of Azar, Adena and Cymto cultivars was the best, as it was clearly manifested in the phenotypic components of wheat.

4. Conclusion

From this study, it can be concluded that the Italian genetic material (Cymto) yielded the highest performance. Some yield components were improved under mechanical stress. In general, mechanical stress like no-till did not reduce some traits. On the contrary, no-till system improved some yield components. Thus, cultivars responded via different patterns. Therefore, the genetic material of Azar, Adena and Cymto cultivars was the best, as it was clearly manifested in the phenotypic components of wheat. These genetic materials could be a raw material to be introduced in breeding program to produce tolerant genotypes to abiotic stresses.

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