Menoufia J. Soil Sci., Volume 10 Issue 5 (2025): 77 - 89

MENOUFIA JOURNAL OF SOIL SCIENCE

https://mjss.journals.ekb.eg

IMPACT OF TILLAGE AND NITROGEN FERTILIZER ON SOIL HEALTH AND PRODUCTION OF WHEAT

El-Gamal, B. A.; El-Khamisy, Rasha R.; Abou Alfotoh, M.S.M. and Akl, A. A. A.

Soils, Water and Environmental Research Institute; ARC, Giza, Egypt.

Received: Apr. 22 , 2025 Accepted: May 21, 2025

ABSTRACT: A Field experiment was carried out at the El-Gemmeiza Agricultural Research Station Farm, affiliated with the Agricultural Research Center (ARC), El-Gharbia Governorate, during two winter growing seasons of 2022/2023 and 2023/2024. The study assessed the impact of different tillage methods and nitrogen fertilizer application rates on soil properties and wheat productivity. A split-plot experimental design with three replications was used. The main plots were assigned to two tillage treatments: no-tillage (T1) and conventional tillage to a depth of 0–40 cm (T2). Sub-plots received five nitrogen application levels: 0 (N1), 44.62 (N2), 89.25 (N3), 133.88 (N4), and 178.50 (N5) kg.ha^{-1}. Results demonstrated that the combination of no-tillage (T1) and the highest nitrogen rate (N5) significantly improved soil chemical characteristics, including the availability of nitrogen, phosphorus, and potassium, as well as organic matter content, electrical conductivity (EC), and pH, compared to conventional tillage (T2) in both seasons. Additionally, no-tillage treatments showed higher water consumption, productivity, and efficiency. Conversely, conventional tillage enhanced soil physical attributes such as bulk density, total porosity, hydraulic conductivity, and cumulative infiltration rate. Overall, no-tillage systems promote better synchronization between nitrogen availability and plant uptake, improve fertilizer use efficiency, and reduce potential environmental impacts of nitrogen loss.

Keywords: Tillage, Nitrogen, Soil properties, and Wheat

INTRODUCTION

Tillage is one of the essential practices in terms of agricultural management that leads to disturbing, overturning, and rearranging the soil particles and providing great soil physical properties. That might affect the plants' growth and yield (Karuma *et al.,* 2014). At the soil surface, the no-tillage system exhibited higher bulk density, gravimetric moisture content, and aggregate stability compared to the tilled system, although it resulted in lower saturation or total porosity. Regardless of the tillage method, bulk density tended to increase with soil depth. Among the various soil properties, chemical characteristics were the most influenced by the tillage regime. Notably, total organic carbon content was significantly greater under no-tillage conditions, particularly within the uppermost soil layer. (Sokolowski *et al.,* 2020). Zero tillage (ZT) reduces soil erosion, which helps control soil structural degradation, potentially increasing the organic matter content and the presence of microorganisms in the soil (Bottinelli *et al.,* 2015). In addition, Jat *et al.* (2012) reported that the longer the duration of adoption of ZT (Zero Tillage), the higher is the buildup of the soil OM. No-till with NPK management, therefore, may allow farmers to maintain high yields while reducing soil and nutrient losses in this soil condition. In the no-tillage system, at least 30% of the ground is covered by plant residues, which improves the soil properties and water resources, saves energy and time, decreases the production cost of crops, and reduces fuel consumption (Afzalinia *et al.,* 2011). Tillage practices have a notable impact on soil infiltration rates, moisture retention, and temperature regulation, and they play a critical role in altering the soil's physical, chemical, and biological characteristics (Eileen, 2001; Nunes *et al.,* 2018). Kustermann *et al.* (2013) investigated the impact of three tillage systems on wheat (Triticum aestivum L.) yield within a crop rotation that included potatoes. The treatments included conventional tillage (CT) to a depth of 25 cm, reduced tillage at 18 cm (RT1), and shallow reduced tillage at 8 cm (RT2), each combined with varying nitrogen application

*Corresponding author: basher.elgamal12@gmail.com

rates. Their findings indicated that conventional tillage (CT) resulted in higher wheat yields under low to moderate nitrogen levels compared to both reduced tillage treatments. Similarly, Rafi *et al.* (2021) reported that zero tillage (ZT) significantly reduces wheat sowing costs by approximately 50–60% compared to conventional methods, a key factor driving the widespread adoption of ZT practices in rice–wheat cropping systems. Furthermore, different tillage systems notably influence soil physical properties, plant-available water, organic matter content, nutrient status, rice residue management, wheat yield, and overall farm economics. Rafi *et al.* (2012) highlighted that tillage methods and crop residue management critically affect plant growth and productivity, with residue accumulation under zero tillage improving soil health and enhancing yield. Additionally, Hemmat and Eskandari (2006) found that combining zero tillage with straw mulching significantly improved soil moisture retention, benefiting crop performance during dry periods.

Wheat (*Triticum aestivum L.)* is the leading staple food and a vital energy source in the human diet. Wheat contributes about 30% of the grain and 44% of cereal worldwide (Food and Organization, 2009). It also provides around 55% and 20% of carbohydrates and food calories consumed across the globe, respectively. Nitrogen fertilizer rate and time of application significantly influence wheat grain yield (Sohail *et al.,* 2013). Nitrogen fertilizer application is one of the main factors that affect wheat grain quality. Therefore, N fertilizer management is key to producing high-quality wheat (Abedi *et al.*, 2010). Moraru and Rusu (2012) examined the influence of CT (conventional tillage), RT (reduced tillage), and sowing with no-tillage (NT) and suggest that the differences in wheat yield with these systems are non-significant. Khorami *et al.* (2018) noted that, the effects of CT (conventional tillage), RT (reduced tillage) and NT (no tillage) on several wheat genotypes and concluded that the highest yields were achieved in the RT system, followed by the CT system, while the lowest yields occurred in the NT system. Nitrogen fertilization strategies for cereal crops must consider the type and the appropriate application rate, as nitrogen requirements fluctuate throughout different growth stages. Nitrogen plays a vital role in supporting plant development, promoting biomass accumulation, and ensuring grain quality. However, it is also one of the most mobile nutrients in the soil, making it susceptible to leaching. Improper nitrogen management, particularly excessive application, can lead to significant nitrate losses, contributing to the eutrophication of nearby surface water bodies (Myrbeck, 2014).

This study aimed to assess the individual and combined effects of tillage practices and nitrogen fertilizer application on soil physicochemical properties and wheat productivity. Additionally, it aimed to evaluate the impact of these treatments on water applied (WA), water use efficiency (WUE), and water productivity (WP).

MATERIALS AND METHODS

This study was conducted as a field experiment at the Experimental Farm of El-Gemmieza Agricultural Research Station, Agricultural Research Center (ARC), El-Gharbia Governorate, Middle Nile Delta region (30°43′ latitude and 31°47′ longitude). It was carried out over two consecutive winter growing seasons (2022/2023 and 2023/2024) to investigate the individual and combined effects of tillage practices and nitrogen fertilization on the properties and fertility of clay soil and wheat productivity.

A split-plot experimental design with three replications was employed. The main plots were assigned to two tillage treatments: no-tillage (T1) and conventional tillage to a subsoil depth of 0–40 cm (T2). The sub-plots received five nitrogen application levels: 0 (N1), 44.62 (N2), 89.25 (N3), 133.88 (N4), and 178.50 (N5) kg N ha^{-1}. Each plot measured 3 × 3.5 meters. Certified seeds of wheat (Triticum aestivum L., cv. Sakha 95) were obtained from the Field Crops Research Institute, ARC, and sown at a seeding rate of 143 kg ha^{-1} in both seasons. Sowing dates were November 15th, 2022, and November 12th, 2023.

Before planting, both undisturbed and disturbed soil samples were collected from the 0 – 30 cm depth to assess initial soil characteristics, as detailed in Tables 1 and 2. Nitrogen fertilizer was applied as urea (46% N) in two equal splits. The first was before the initial irrigation, and the second was before the subsequent irrigation. Phosphorus and potassium fertilizers, such as ordinary superphosphate (15.54 % P_2O_5) and potassium sulphate (48 % K_2O) were applied at rates of 71 kg P_2O_5 ha^{-1} and 115 kg K_2O ha^{-1}, respectively, before planting. All other agronomic practices followed the recommendations provided by the Egyptian Ministry of Agriculture and Land Reclamation. Table 3 shows the meteorological data of the study area. It was downloaded from https://power.larc.nasa.gov/data-access-viewer/.

Wheat was harvested on May 17th, 2023, and May 10th, 2024. After harvesting, grain and straw yields were recorded for each plot. Undisturbed soil samples were collected from the plot's 0–30 cm layer post-harvest, air-dried in the shade, ground, and passed through a 2 mm sieve. Soil physical properties, including bulk density, total porosity, infiltration rate, and hydraulic conductivity, were measured and analyzed concerning crop productivity, following the procedures described by Klute (1986). Disturbed soil samples were also taken from the same depth and analyzed for selected chemical properties according to A.O.A.C. (2012).

Table 1: Chemical and physical properties of the experimental soils.

Season	pH (1:2.5)	EC ds cm^{-1}	Available NPK (mg kg^{-1})			OM %	CEC (Cmol kg^{-1})
			N	P	K		
2022/2023	8.14	0.87	38.05	4.05	405.20	1.19	49.05
2023/2024	8.11	0.76	40.05	5.35	348.30	1.11	46.33

Season	Particle size distribution (%)				Tex. class	HC $cmhr^{-1}$	IR $mmhr^{-1}$
	C. sand	F. sand	Silt	Clay			
2022/2023	8.91	11.63	29.11	50.35	Clay	1.21	13.05
2023/2024	7.73	12.05	32.19	48.03	Clay	1.10	10.39

EC=Electrical conductivity, OM=Organic matter, CEC= Cation Exchange Capacity, HC= Hydraulic conductivity and (IR) Infiltration rate

Table 2. Bulk density and some hydrodynamic constants of the experimental soils.

Depth (cm)	Season 2022/2023					Season 2023/2024				
	FC	WP	AW	Bd (gcm-3)	Tp (%)	FC	WP	AW	Bd (gcm^{-3})	Tp (%)
0 – 30 cm	41.97	21.50	20.47	1.28	51.70	40.27	21.02	19.25	1.32	50.19

FC = Field capacity, Wp = Water point, Aw = Available water, Bd = Bulk density, and Total porosity = Tp.

Water Applied (WA).

It is the total amount of irrigation water delivered to the field. Water was calculated according to Allen *et al.* (1998) as follows.

$$WA = \frac{Q * t}{A}$$

WA = Water applied (m^3ha^{-1}).

Q = flow rate of the system (in m^3/hour)
t = irrigation time (in hours)
A = field area (in hectares)

Flow rate (Q) was calculated according to Chadwick *et al.* (2013) as follows

$$Q = CA(2gH)^{0.5}$$

Where:
Q = Discharge or flow rate (m^3/s).
C = discharge coefficient t = 0.6 Range (0.6 & 0.8).
A = Cross-sectional area of orifice or pipe.
g = Acceleration due to gravity (≈ 9.81 m/s^2).
H = Hydraulic head or fluid height above the orifice (m).

Water consumptive use (WCU)

In establishing the crop (WCU), soil samples were taken before and after 48 hours for each irrigation from each plot. The consumption of crop water between two consecutive irrigations was calculated with the equation given by Israelsen and Hansen (1962) as follows:

$$\text{WCU (cm)} = \frac{\text{Q2} - \text{Q1}}{100} \text{ X Bd X ERZ}$$

Where:
WCU = Water consumptive use (cm).
ERZ = Effective root zone depth (cm) at 60 cm for wheat.
Bd = Bulk density of soil layer (g cm^{-3}).
Q2 = Soil moisture content (%, wt/wt) 48 hours after irrigation.
Q1 = Soil moisture content (%, wt/wt) just before the next irrigation.

Water use efficiency (WUE)

Water use efficiency was calculated according to Jensen (1983) as follows:

$$\text{WUE} = \frac{\text{Y}}{\text{WCU}}$$

Where:
WUE = Kg grain m^{-3} water consumed.
Y = Grain yield (Kg ha^{-1}).
WCU = Water consumptive use (m^3 ha^{-1}).

Water productivity (WP)

Water Productivity (WP) was calculated according to Ali *et al.* (2007) as kg grains/m^3 water applied:

This parameter WP = Gy/I
Where:
Gy = Grain yield (Ton ha^{-1})
I = Irrigation water applied m^3 ha^{-1}.

Statistical analysis

According to the computer program Costate statistical software, the data were statistically analyzed using a split-plot design with three replicates. Mean values were compared using the least Significant Difference (LSD) and Duncan (Costat, 2005).

Climatic Condition the meteorological data including: (T- max) maximum temperatures (°C), (T- min) minimum temperatures (°C), (T-mean): mean of temperatures, (RH): relative humidity (%), (WS) wind speed (m/s) and rainfall (mm/day) during the two years of study were recorded daily and their monthly mean values are presented in Table 3.

Table 3. Meteorological data in the 2022/2023 and 2023/2024 growing seasons.

Month	T- max		T- min		T-mean		RH		Wind speed (ms^{-1})		R.F	
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
November	26.84	25.55	11.17	11.85	19.01	18.70	60.51	62.01	8.33	8.85	0.089	0.11
December	24.18	23.01	10.51	11.01	17.35	17.01	67.23	69.08	7.96	8.05	0.41	0.36
January	22.45	21.09	8.95	8.63	15.70	14.86	62.25	66.27	6.69	6.61	0.36	0.96
February	22.05	20.88	7.96	7.70	15.00	14.29	60.91	67.69	6.09	5.96	0.61	0.69
March	24.09	23.65	8.74	8.09	16.42	15.87	58.95	56.05	5.95	5.25	0.37	0.25
April	28.27	29.09	9.98	10.25	19.13	19.67	51.09	52.13	6.03	5.86	0.03	0.04
May	35.71	34.61	10.05	10.79	22.90	22.71	41.01	42.36	6.73	6.39	0.00	0.01

* Source: https://power.larc.nasa.gov/data-access-viewer/.

RESULTS AND DISCUSSION

Soil physical properties

Table 4 presents the measured soil physical properties such as bulk density (Bd), total porosity (Tp), hydraulic conductivity (HC), and cumulative infiltration rate (IR) recorded after wheat harvest during both growing seasons, as influenced by tillage treatments and nitrogen fertilization. The results indicate that tillage practices and nitrogen application rates significantly affected all measured parameters. Specifically, soil subjected to conventional tillage exhibited lower bulk density and higher values of total porosity, infiltration rate, and hydraulic conductivity in the surface layer (0–30 cm) when compared to the no-tillage treatment. These findings suggest that tillage enhances soil physical conditions by loosening the surface layer and promoting better water movement and air circulation. Wherever, Nitrogen application N2, N3, N4 and N5 severally decreased bulk density values by 2.38, 3.17, 3.97 and 6.35%, in the first season and decreased by 2.34, 3.13, 3.91 and 6.25% in the second season, consequently, total porosity increased by 2.27, 2.99, 3.47 and 5.86% in the first season as compared to control (N1), while their increases were 2.53, 3.29, 4.00 and 5.59% in the second season. In addition, hydraulic conductivity increased by 7.25, 14.49, 20.29, and 44.93% in the first season and by 25.51, 30.61, 50.00, and 64.29% in the second season. Also, the cumulative infiltration rate increased by 7.44, 9.45, 10.84, and 18.14% in the first season and by 8.25, 15.08, 14.93, and 22.23% in the second season. The application of chemical fertilizers increased cumulative infiltration and infiltration rate with time. Nitrogen fertilizer application improves SOC concentration, soil physical properties, and infiltration rate (Bhattacharyya *et al.* 2007). A positive correlation exists between SOC and infiltration rate (Brar *et al.* 2015), as soil aggregation is closely related to soil bulk density. As chemical fertilizers don't have a noticeable effect on soil aggregation and flocculation, no significant results were observed on the bulk density of soil (Kumar *et al.* 2011). In contrast, a marginal reduction is also reported in bulk density at nitrogen, phosphorus, and potassium application, possibly because of improved biomass production and the consequential upsurge in soil organic matter content (Bhatt *et al.* 2019). Nitrogen application contributes to enhancing the benefits of perennial pasture root development, which in turn improves soil macro-porosity. Root growth management is a key strategy for enhancing soil structure and increasing porosity. When comparing systems over the two study years, saturated hydraulic conductivity (HC) under conventional tillage (CT) showed a decrease of approximately 6% relative to no-tillage (NT) and vertical tillage (VT). Across treatments, changes in Ks ranged from 0.04 mm h^{-1} to 6.43 mm h^{-1}. However, these variations were not statistically significant, indicating that the differences observed among tillage systems did not have a strong enough effect to be considered conclusive at a conventional significance level. (Ordonez-Morale *et al.,* 2019). At 0 - 30 cm soil depth, while the highest Tp and HC were recorded under CT, the lowest were under ZT, also found higher Tp and HC at the soil surface under conventional tillage compared to zero tillage. Similar to Bd and Tp, the trend of Tp and HC at the subsurface depths (20 - 40 cm, 40 - 60 cm) was reversed. The highest TP and HC were recorded under ZT, and the lowest were under CT (Abagandura *et al.,* 2017). The hydraulic properties of the soils are subject to temporal changes in response to tillage and natural factors such as rainfall, increase and decrease of biological activity, root development, and the drying and wetting cycle (Schwen *et al.,* 2011). Vogeler *et al.* (2009) detected higher HC values under NT than CT in a German soil, while no differences were reported under unsaturated conditions. Zero tillage (ZT) has been shown to enhance soil physical, chemical, and biological properties; however, it may also lead to certain drawbacks, such as increased bulk density. Because of the maintained mulch loads, conservation tillage, also known as minimum tillage, considerably decreased soil loss and runoff compared to conventionally tilled plots (Bhatt and Khera, 2006). According to Castellini *et al.* (2019), no-tillage can reduce aggregate stability, potentially resulting in surface crusts and relatively flat cumulative infiltration curves, indicative of lower infiltration rates. Nitrogen fertilization has been observed to promote root growth and expansion while reducing the nitrogen-to-carbon (N:C) ratio. This shift supports greater microbial activity, which enhances organic matter decomposition, thereby improving soil structure and reducing bulk density (Al-Bayati *et al.*, 2021). Moreover, no-tillage systems are effective in conserving soil moisture, as crop residues left on the surface reduce evaporation and promote water infiltration (Shittu *et al.*, 2017). In contrast, conventional agricultural practices often create pore spaces that facilitate water loss through evaporation following rainfall events (Faris and Sarbast, 2022)

Table 4: Effect of tillage and nitrogen fertilizer on some soil physical properties after wheat harvesting.

Tillage	Nitrogen treatments Kg ha^{-1}	1st season				2nd season			
		Bd (gcm^{-1})	Tp (%)	HC (cmhr^{-1})	IR (cmhr^{-1})	Bd (gcm^{-1})	Tp (%)	HC (cmhr^{-1})	IR (cmhr^{-1})
No-tillage(T1)	N1	1.29	51.32	0.95	12.08	1.30	50.94	0.73	9.89
	N2	1.26	52.45	1.14	13.06	1.28	51.70	0.93	11.16
	N3	1.25	52.83	1.23	13.45	1.26	52.45	0.95	12.23
	N4	1.24	53.21	1.31	13.53	1.26	52.45	1.11	12.22
	N5	1.21	54.34	1.58	14.78	1.23	53.58	1.23	13.77
Tillage(T2)	N1	1.23	53.58	1.82	16.69	1.26	52.45	1.22	15.57
	N2	1.19	55.09	1.82	17.86	1.21	54.34	1.53	16.40
	N3	1.18	55.47	1.93	18.05	1.21	54.34	1.61	17.07
	N4	1.18	55.47	2.02	18.36	1.19	55.09	1.82	17.03
	N5	1.14	56.98	2.42	19.21	1.18	55.47	1.98	17.53
LSD $_{0.05}$ T*N		ns	ns	ns	ns	ns	ns	ns	1.06
N-tillage		1.25a	52.83b	1.24b	13.38b	1.26a	52.28b	0.99b	11.85b
Tillage		1.19b	55.27a	2.00a	18.03	1.21b	54.31a	1.64a	16.72a
LSD $_{0.05}$ T		0.040	1.42	0.20	0.67	0.01	0.38	0.30	0.99
Miner fertilizer	N1	1.26a	52.52c	1.38c	14.39c	1.28a	51.70d	0.98d	12.73c
	N2	1.23b	53.71b	1.48bc	15.46b	1.25b	53.01c	1.23c	13.78b
	N3	1.22b	54.09b	1.58bc	15.75b	1.24bc	53.40bc	1.28bc	14.65b
	N4	1.21b	54.34b	1.66b	15.95b	1.23c	53.77b	1.47ab	14.63b
	N5	1.18c	55.60a	2.00a	17.00a	1.20d	54.59	1.61a	15.56a
LSD $_{0.05}$ N		0.03	1.03	0.21	0.57	0.014	0.51	0.22	0.97

- N1, N2, N3, N4, and N5 = 0, 44.63, 89.25, 133.88, and 178.50 kg N ha^{-1}.

Soil chemical properties

The application of nitrogen fertilization as urea and tillage showed a slight improvement in soil chemical properties (Table 5). The best values of soil chemical properties were recorded with the treatment of tillage than with no tillage. The lowest value of determined parameters was recorded from the treatments with no nitrogen fertilizer application. Also, it could be noted from the results that the application of N5 led to a decrease in soil pH of 0.87 and 0.75% in the first and second seasons, respectively, compared to the control (N1). Treatment of N5 gave the most significant increase in percent of EC, which were 7.89 and 15.15% in the first and second seasons, respectively, compared to the control. The rate of N increases was 68.08 and 53.31%, and for available P, it was 30.39 and 19.90%, and also for available K, it was 17.38 and 15.63%, and for OM content, it was 21.26 and 24.78% with treatment of N5 in the first and the second season, respectively, as compared to the control. Which reported that the decrease in pH with N-fertilizer might be attributed to the nitrification of NH4+, which produces H+ ions, thus increasing soil acidity and H^+ released by roots. ZT plots reportedly suffer from significantly higher weed pressure because of surface-placed seeds and better availability of water and nutrients. Higher organic carbon status was reported under zero-tilled plots compared to conventional tilled plots. Thus, under ZT, nutrient availability increases near the soil surface, which might be available to the seeds, whether an economic crop or weeds (Bhatt, 2015). Also, these results may be due to the application of N levels increasing soluble ions, especially in the upper depth, consequently promoting values of EC. The plant residual may help build C and N contents in soils, particularly the soils with low levels of inherent C and N, which have potential supplies of nutrients. Kustermann *et al.* (2013) examined the effects of a conventional and reduced treatment with different N rates on wheat (*Triticum aestivum L.*) yield in a crop rotation with potatoes; they collected data that indicated that traditional tillage (CT) at low and medium N rates produced higher wheat yields than (RT). This may be due to the higher mass of harvest residues (roots and stubble) remaining on plots fertilized with high doses of nitrogen. Similar observations were made for total N content in the soil. According to Wozniak and Gos 2014 the available phosphorus content in the soil was lower in the plots with the CT (conventional tillage), compared to that found with NT (no-tillage) and RT (reduced tillage), while tillage systems or nitrogen doses did not determine potassium and magnesium contents.

Water properties and wheat grain yield measurements

The results in Table 6 show water applied (WA), WCU, WUE, WP, and wheat grain yield with N application under tillage systems. No-tillage decreased WP, WCU, and grain yield; consequently, WUE and WP were increased in the two seasons. Treatments of N5 resulted in a decrease of WA by 5.13 and 5.19%, and a WCU decrease of 6.20 and 9.12% in the first and the second season, respectively. On the other hand, N5 improves WP and WUE by 55.38 and 42.06% in the first season and increases by 48.17 and 42.73% in the second season, respectively, as compared to the control (N). Treatment under the No Tillage (NT) system compared with CT pertains to the enhanced water movement in the soil and improved soil aggregate development.

It is essential to consider economic indicators to optimize the rational use of nitrogen fertilizers for topdressing winter wheat. Achieving higher yields is necessary; however, it is equally crucial to ensure that the costs associated with fertilizer application are offset by the economic returns from the increased grain production (Zhichkina *et al.*, 2022). The beneficial effect of ZT is not only the reduction in the water loss (e.g. evaporation) but it also increases soil moisture availability and decreases tractor time with an average of 8.9 h ha^{-1} or an average 81% and diesel use in the range of 15-60 ha^{-1} or an average 81% saving in the form of farm energy consumption (Erenstein and Laxmi, 2008). No tillage increases the soil water retention in rain-fed environments (Colecchia *et al.*, 2015). The no-tillage system is essential to improve soil water storage by reducing evaporation from the upper layer of soil (Afzalinia *et al.*, 2011). Applying a no-tillage system reduces water evaporation and increases water availability and OM for the plants to grow. (Al-Wazzan and Muhammad, 2022).

Table 5: Effect of tillage and nitrogen fertilizer on some soil chemical properties after wheat harvesting.

Tillage	Nitrogen Treatments	1st season						2nd season					
		pH (1:2.5) Suspension	EC (dSm^{-1})	Available NPK (mg Kg^{-1}) N	P	K	Organic matter (%)	pH (1:2.5) Suspension	EC (dSm^{-1})	Available NPK (mg Kg^{-1}) N	P	K	Organic matter (%)
No-tillage(T1)	N1	8.03	0.79	28.30	4.54	427.00	1.31	7.97	0.66	30.82	6.03	398.33	1.14
	N2	8.02	0.84	34.65	5.06	456.67	1.41	7.95	0.70	36.96	6.58	431.67	1.26
	N3	7.99	0.84	39.48	5.40	460.00	1.51	7.91	0.74	41.12	6.44	436.67	1.33
	N4	7.96	0.83	43.37	5.62	491.67	1.58	7.91	0.77	47.40	6.96	441.67	1.40
	N5	7.92	0.86	45.80	5.97	526.67	1.62	7.91	0.77	51.81	7.23	461.67	1.45
Tillage(T2)	N1	7.99	0.73	24.70	4.07	415.00	1.23	7.99	0.65	30.13	5.62	380.00	1.12
	N2	8.00	0.74	32.02	4.19	439.33	1.29	7.96	0.68	35.44	6.16	405.00	1.22
	N3	7.98	0.74	37.40	4.56	436.67	1.35	7.95	0.71	38.60	6.40	423.33	1.23
	N4	7.96	0.76	40.52	4.92	441.67	1.35	7.94	0.71	0.65	6.55	428.33	1.26
	N5	7.95	0.77	43.28	5.27	461.67	1.47	7.93	0.74	41.65	6.75	438.33	1.37
LSD $_{0.05}$ T*N		ns	ns	ns	ns	19.03	ns	ns	ns	1.35	ns	ns	ns
NO-tillage		7.98a	0.83a	38.32a	5.32a	472.40a	1.49a	7.95b	0.72a	41.62a	6.65a	434.00a	1.32a
Tillage		7.98a	0.74b	35.58b	4.60b	438.87b	1.34b	7.93a	0.70a	37.30b	6.30a	415.00b	1.24b
LSD $_{0.05}$ T		ns	0.31	2.54	0.42	22.67	0.080	0.035	ns	1.90	ns	7.450	0.07
Miner fertilizer	N1	8.01a	0.76c	26.50e	4.31e	421.00d	1.27d	7.98a	0.66d	30.48e	5.83c	389.17d	1.13d
	N2	8.01a	0.77bc	33.33d	4.63d	448.00c	1.35c	7.95b	0.69c	36.20d	6.37b	418.33c	1.24c
	N3	7.99b	0.79ab	38.44c	4.98c	448.33c	1.43b	7.93c	0.73b	39.86c	6.42b	430.00b	1.28bc
	N4	7.96c	0.80a	41.94b	5.27b	466.67b	1.47b	7.93c	0.72b	44.02b	6.76a	435.00b	1.33b
	N5	7.94d	0.82a	44.54a	5.62a	494.17a	1.54a	7.92c	0.76a	46.73a	6.99a	450.00a	1.41a
LSD $_{0.05}$ N		0.016	0.026	1.94	0.30	17.58	0.053	0.017	0.026	1.13	0.28	11.50	0.050

Table 6: Effect of tillage and nitrogen fertilizer on WA, WCU, WUE, WC, and grain yield after wheat harvesting.

Tillage	Nitrogen Treatments	1st season WA	WCU	WUE	WP	Grain	2nd season WA	WCU	WUE	WP	Grain
		(m^3 ha^{-1})	(m^3 ha^{-1})	(Kg m^{-3})	(Kg m^{-3})	Kg ha^{-1}	(m^3 ha^{-1})	(m^3 ha^{-1})	(Kg m^{-3})	(Kg m^{-3})	Kg ha^{-1}
No-tillage(T1)	N1	5078.33	4236.7	1.308	1.09	5541.60	4823.33	3975.00	1.39	1.15	5525.25
	N2	4976.67	4133.3	1.4827	1.23	6128.44	4749.33	3873.33	1.48	1.21	5732.53
	N3	4940.00	4110	1.6506	1.37	6783.97	4740.00	3813.33	1.68	1.35	6406.39
	N4	4943.33	4065	1.8209	1.50	7401.96	4656.67	3783.33	1.88	1.53	7112.66
	N5	4818.33	4008.3	2.0693	1.72	8294.38	4536.67	3594.00	2.14	1.70	7691.16
Tillage(T2)	N1	5750.00	4673.3	1.2917	1.05	6036.50	5700.00	4460.00	1.34	1.05	5976.40
	N2	5613.00	4570	1.394	1.13	6370.58	5626.67	4386.67	1.44	1.12	6316.80
	N3	5533.33	4523.3	1.5278	1.25	6910.70	5593.33	4310.00	1.57	1.21	6766.70
	N4	5490.00	4476.7	1.7154	1.40	7679.33	5530.00	4323.33	1.68	1.31	7263.19
	N5	5456.67	4349.7	1.9716	1.57	8575.87	5443.33	4071.67	1.92	1.43	7817.61
LSD 0.05 T*N		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
No-tillage		4951.33a	4110.67b	1.67a	1.32a	6830.07b	4701.20b	3807.80b	1.71a	1.39a	6493.60b
Tillage		5568.67b	4518.60a	1.58b	1.23b	7114.60a	5578.67a	4310.33a	1.59b	1.22b	6828.14a
LSD 0.05 T		150.39	41.45	0.059	0.035	176.19	110.56	47.35	0.06	0	12.08
miner fertilizer	N1	5414.17a	4455.00a	1.30e	1.07e	5789.05e	5261.67a	4217.5a	1.37e	1.10e	5750.38e
	N2	5295.00b	4351.67b	1.44d	1.14d	6249.51d	5188.00ab	4130.00b	1.46d	1.16d	6024.67d
	N3	5236.67bc	4316.67b	1.59c	1.26c	6847.33c	5166.67bc	4061.67c	1.63c	1.28c	6556.55c
	N4	5216.67c	4270.83b	1.77b	1.38b	7540.64b	5093.33c	4053.33c	1.78b	1.42b	7187.93b
	N5	5137.50d	4179.00c	2.02a	1.52a	8435.12a	4990.00d	3832.83d	2.03a	1.57a	7754.38a
LSD 0.05 N		63.03	83.25	0.084	0.047	333.84	86.24	54.54	0.062	0.063	224.32

CONCLUSIONS

No-tillage and N levels greatly influence soil properties, which can explain their effects on plant growth and grain production. No-tillage and N application at (N5) significantly improved soil pH, EC, OM, NPK available, water applied, Water consumptive use, water use efficiency, and Water Productivity. Meanwhile, tillage and N5 improve physical properties Bd, TP, HC, and the cumulative infiltration rate.

REFERENCES

A.O.A.C. (2012). Official Methods of Analysis of AOAC International. 19th ed. Gaithersburg, MD, USA, Association of Analytical Communities.

Abagandura, G. O.; Eld-Deen, M.; Nasr, G. and Moumen, N. M. (2017). Influence of Tillage Practices on Soil Physical Properties and Growth and Yield of Maize in Jabal al Akhdar, Libya. Open Journal of Soil Science, 7: 118-132.

Abedi, T.; Alemzadeh, A. and Kazemeini, S. A. (2010). Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. Aust. J. Crop Sci., 4: 384-389.

Afzalinia, S.; Karami, A.; Talati, M. H. and Alavimanesh, S. M. (2011). "Effect of Conservation Tillage on the Soil Properties and Corn Yield", The Canadian Society for Bioengineering, 11(204): 1-8.

Al-Bayati, A. H.; Ziydan, B. A. and Al-Enz, A. F. M. (2021). The Effect of Some Nitrogen Fertilization Practices and Tillage Systems on Growth and Yield of Wheat Crop within The Conditions of the Sedimentary Plain in Iraq. Earth and Environmental Science 761 (2021) 012006.

Ali, M. H.; Hoque, M. R.; Hassan, A. A. and Khair, A. (2007). Effect of deficit irrigation on yield water productivity, and economic returns of wheat. Agric. Water Management. 92(3): 151-161.

Allen, R. G.; Pereira, L. S.; Raes, D. and Smith, M. (1998). Crop Evapotranspiration – Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper No. 56.

Al-Wazzan, F. A. and Muhammad, S. A. (2022). Effects of Conservation and Conventional Tillage on some Soil Hydraulic Properties. IOP Conf. Series: Earth and Environmental Science. 1060 (2022) 012002 doi:10.1088/1755-1315/1060/1/012002.

Bhatt, R and Khera, K. L (2006). Effect of tillage and mode of straw mulch application on soil erosion losses in the submontaneous tract of Punjab, India. Soil Till. Res. 88: 107-115.

Bhatt, R. (2015). Soil water dynamics and water productivity of rice-wheat system under different establishment methods (Master's thesis). Punjab Agricultural University, Ludhiana, India.

Bhatt M, Singh AP, Singh V, Kala DC, Kumar V (2019). Long-term effect of organic and inorganic fertilizers on soil physico-chemical properties of a silty clay loam soil under rice-wheat cropping system in Tarai region of Uttarakhand. J Pharmacog Phytochem 8(1): 2113–2118

Bhattacharyya, R; Chandra, S; Singh, R; Kundu, S; Srivastva, A and Gupta H (2007) Long-term farmyard manure application effects on properties of a silty clay loam soil under irrigated wheat-soybean rotation. Soil Tillage Res. 94: 386–396

Bottinelli, N.; Jouquet, P.; Capowiez, Y.; Podwojewski, P.; Grimaldi, M and Peng, X (2015). Why is the influence of soil macrofauna on soil structure only considered by soil ecologists? Soil Tillage Res, 146: 118–124.

Brar, B. S; Singh, J; Singh, G and Kaur, G (2015). Effects of long-term application of inorganic and organic fertilizers on soil organic carbon and physical properties in maize-wheat rotation. Agronomy 5:220–238. https://doi.org/10.3390/agronomy5020220.

Castellini, M.; Francesco, F; Pasquale, G; Luisa, G; Michele, R.; Domenico, V.; Carolina, V. and Alessandro, V. V (2019). Effects of No-Tillage and Conventional Tillage on Physical and Hydraulic Properties of Fine Textured Soils under Winter Wheat. Water 2019, 11, 484; doi:10.3390/w11030484.

Chadwick, A; Morfett, J and Borthwick, M (2013). Hydraulics in Civil and Environmental Engineering (5th ed.). CRC Press.

Colecchia, S. A; Rinaldi, M.; De Vita, P. (2015). Effects of tillage systems in durum wheat under rainfed Mediterranean conditions. Cereal Res. Commun. 43: 704–716.

Costat statistical software (Version 6.311) [Computer software]. CoHort Software, 798 Lighthouse Ave, PMB 320, Monterey, CA 93940, USA. (2005) http://www.cohort.com.

Eileen, J. K (2001). Tillage systems and soil ecology. Soil and Tillage Research 61, 61-76.

Erenstein, O. and Laxmi, V (2008). Zero tillage impacts in India's rice-wheat systems: A review. Soil and Tillage Research 100(1-2): 1-14.

Faris, A. A. and Sarbast, A. M (2022). Effects of Conservation and Conventional Tillage on some Soil Hydraulic Properties. IOP Conf. Series: Earth and Environmental Science 1060, 012002. doi:10.1088/1755-1315/1060/1/012002.

Food and Organization (2009). FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS Rome, 2009 http://www.fao.org.

Hemmat, A. and Eskandari, I (2006). Dryland winter wheat response to conservation tillage in a continuous cropping system in northwestern Iran. Soil and Tillage Research 86(1): 99-109.

Israelsen, O. W. and Hansen, V. E. (1962). Irrigation Principles and Practices, 3rd edit. John Wiley and Sons, Inc., New York, USA.

Jensen, M. E. (1983). Design and operation of farm irrigation systems. Am. Soc. Ag. Eng. Mitchigan, USA. Fp. 827.

Jat, R. A; Wani, P. S and Sahrawat, K. L. (2012). Conservation agriculture in the semi-arid tropics: prospects and problems. Adv. Agron. 117: 191- 273.

Karuma, A; Mtakwa, P; Amuri, N; Gachene, C.K. and Gicheru, P (2014). "Tillage Effects on Selected Soil Physical Properties in a Maize-Bean Intercropping System in Mwala District, Kenya", International Scholarly Research Notices, 2014, pp. 1-12.

Khorami, S. S; Kazemeini, S. A; Afzalinia, S and Gathala, M. K. (2018). Changes in soil properties and productivity under different tillage practices and wheat genotypes: a short-term study in Iran. Sustainability 10:3273(1-17).

Klute, A (1986). Water Retention: Laboratory Methods. In: Methods of Soil Analysis In Methods of Soil Analysis, ed. A Klute. Madison, Wisconsin: Am. Soc. Agron. pp. 635–662.

Kumar S, Dahiya R, Kumar P, Jhorar BS, Phogat VK (2011). Long-term effect of organic materials and fertilizers on soil properties in pearl millet-wheat cropping system. Ind J Agric Rese 46(2):161–166.

Kustermann, B; Munch, J. C and Hunsberger, K. J (2013). Effects of soil tillage and fertilization on resource efficiency and greenhouse gas emissions in a long-term field experiment in Southern Germany. European Journal of Agronomy 49:61-73

Moraru, P. I and Rusu, T (2012). Effect of tillage systems on soil moisture, soil temperature, soil respiration and production of wheat, maize and soybean crops. Journal of Food, Agriculture and Environment 10(2):445-448.

Myrbeck, A (2014). Soil Tillage Influences on Soil Mineral Nitrogen and Nitrate Leaching in Swedish Arable Soils. Doctoral dissertation, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Nunes, M. R; Van Es, H. M; Schindelbeck, R; Ristow, A. J and Ryan, M (2018). No-till and cropping system diversification improve soil health and crop yield. Geoderma 328, 30–43.

Ordonez-Morale, K. D.; Martin, C. Z; Alejandro, Z and Santos, C (2019). Effect of Tillage Systems on Physical Properties of a Clay Loam Soil under Oats. Agriculture 2019, 9, 62; doi:10.3390/agriculture9030062.

Rafi, Q; Riaz, A. and Muhammad, I (2012). Response of wheat to tillage and nitrogen fertilization in rice-wheat system. Pakistan Journal of Agricultural Sciences 49(3): 243-254.

Rafi, Q; Atique, U. R; Hafiz, M. R. J; Abdul, R; Muhamed, E. S; Hasnain, A and Shakeel, A (2021). Tillage Systems Affecting Rice-Wheat Cropping System. Sains Malaysiana 50(6):1543-1562.

Schwen, A.; Bodner, G.; Scholl, P.; Buchan, G.D and Loiskandl, W (2011). Temporal dynamics of soil hydraulic properties and the water-conducting porosity under different tillage. Soil Tillage Res., 113, 89–98.

Shittu K. A; Oyedele D. J and Babatunde K. M (2017). "The effects of moisture content at tillage on soil strength in maize production", Egyptian Journal of Basic and Applied Sciences, 4: 139–142.

Sohail, M; Hussain, I; Riaz, S. H; Abbas, M. Q and Noman, M (2013). Effect of split N fertilizer application on physio agronomic traits of wheat (Triticum aestivum L.) under rainfed conditions. Pakistan J. Agric. Res., 26(2): 71-78.

Sokolowski, A. C; McCormick, B. P; De Grazia, J. R; Wolski, J. E; Rodriguez, H. A; Rodriguez-Frers, E. P; Maria C.G; Debelis, S. P; Paladino, I. R and Barrios, M. B (2020). Tillage and no-tillage effects on physical and chemical properties of an Argiaquoll soil under long-term crop rotation in Buenos Aires, Argentina. International Soil and Water Conservation Research 8- 185-194.

Vogeler, I; Rogasik, J; Funder, U; Panten, K and Schnug, E (2009). Effect of tillage systems and P-fertilization on soil physical and chemical properties, crop yield and nutrient uptake. Soil Tillage Res. 103: 137–143.

Wozniak, A. and M. Gos (2014). Yield and quality of spring wheat and soil properties as affected by tillage system. Plant Soil Environ., 60 (4): 141–145.

Zhichkina, L; Zhichkin, K; Vlasov, A. V; Belyaev, A. M; Borobov, V. N and Lyubimova, N. G (2022). The effectiveness of nitrogen fertilizing in the cultivation of winter wheat. Earth and Environmental Science 979 (2022) 012015.

تأثير الحرث والتسميد النيتروجيني على صحة التربة وإنتاجية القمح

بشير أبو بكر الجمل، رشا رفعت الخميسي، محمد سمير محمد أبو الفتوح، أيمن عطفي عقل عقل

معهد بحوث الأراضي والمياة والبيئة – مركز البحوث الزراعية – الجيزة – مصر

الملخص العربى

تم تنفيذ تجربة حقلية بمحطة البحوث الزراعية بالجميزة التابعة لمركز البحوث الزراعية بمحافظة الغربية خلال موسمين شتوي لعامي ٢٠٢٣/٢٠٢٢و ٢٠٢٣/ ٢٠٢٤. هدفت الدراسة إلى تقييم تأثير طرق الحرث المختلفة ومستويات التسميد الآزوتي على خصائص التربة وإنتاجية محصول القمح. استخدم تصميم التجربة بنظام القطع المنشقة مع ثلاث مكررات. خصصت القطع الرئيسية لمعاملتي: عدم الحرث(T1) ، والحرث التقليدي حتى عمق ٠–٤٠ سم .(T2) بينما تلقت القطع الثانوية خمس مستويات من التسميد الآزوتي: N1 بدون تسميد كنترول N2(٤٤,٦٢ كجم نيتروجين للهكتار) و N3(89.25كجم نيتروجين للهكتار) و N4(١٣٣,٨٨كجم نيتروجين للهكتار) و N5(178.50كجم نيتروجين للهكتار).

أظهرت النتائج أن معاملة عدم الحرث (T1) مع أعلى مستوى من التسميد الآزوتي (N5) أدت إلى تحسن ملحوظ في الخصائص الكيميائية للتربة، بما في ذلك توفر النيتروجين والفوسفور والبوتاسيوم، بالإضافة إلى زيادة محتوى المادة العضوية، والتوصيل الكهربائي(EC) ، ودرجة الحموضة(pH) ، مقارنة بالحرث التقليدي (T2) خلال الموسمين. كما أظهرت معاملات عدم الحرث زيادة في الاستهلاك المائي، وإنتاجية المياه، وكفاءة استخدام المياه. في المقابل، كان للحرث التقليدي تأثير إيجابي أكبر على الخصائص الفيزيائية للتربة، مثل الكثافة الظاهرية، والمسامية الكلية، والتوصيل الهيدروليكي، ومعدل التسرب التراكمي.

بوجه عام، يبدو أن نظام عدم الحرث يُعزز التوافق بين توفر النيتروجين وامتصاص النبات، ويحسن كفاءة استخدام الأسمدة، ويُقلل من الأثر البيئي الناتج عن فقدان النيتروجين.

الكلمات المفتاحية: الحرث، النيتروجين، خصائص التربة، والقمح