International Journal of Recycling of Organic Waste in Agriculture (2021)10: 427-438
Doi: 10.30486/IJROWA.2021.1922816.1199

ORIGINAL RESEARCH

Influence of compost and canal clay scouring on sandy soil properties and wheat productivity under irrigation water regime

Sayed Abdelrahman Abdeen[1*], Mahmoud Mohamed EL-Sayed[2]

Received: 06 February 2021 / Accepted: 17 July 2021 / Published online: 06 November 2021

Abstract

Purpose Improving physio-chemical properties under irrigation regime by using natural conditioners to achieve the highest possible crop yield and water productivity.

Method A field experiment was conducted in a split-plot design with three replicates by addition of canal clay scouring (CS) and compost (CO) during two consecutive growing winter seasons of 2018/19 and 2019/20. The treatments were: control (100% and75% of water requirements), 20 and 40 (ton. ha^{-1}) of CO and 40 and 80 (ton. ha^{-1}) of CS as alone or mixed with each other under drip irrigation.

Results The results showed that soil organic matter and cation exchange capacity increased by increasing the application rates of CO and CS. The lowest values of bulk and hydraulic conductivity were observed at 80 ton. ha^{-1} CS +40 ton. ha^{-1} CO. Also, field capacity, wilting point and available water were 20.94,5.97 and5.07%, respectively. The lowest values of ETa were observed at 80 ton. ha^{-1} CS +40 ton. ha^{-1} CO under 75% water irrigation requirement in all growth stages. The highest rates of the studied materials as a mixture gave a significant increase in nitrogen, phosphorus and potassium contents of grains and straw of wheat crop. The highest yield of straw and grain were 9523.81 and 6428.57 kg ha^{-1}, respectively. Also, it could be observed that the highest percentage of CWP and IWP were 21.05 and 14.53%, respectively, under 75% irrigation water requirement.

Conclusion Application of clay and compost can improve soil physio-chemical properties, water productivity and crop yield under irrigation water regime.

Keywords Water productivity, Sandy soil, Clay scouring, Compost, Wheat yield

Introduction

The challenge for food security is based on escalating demand as Egypt population grew to 95 million people in 2017 (CAPMAS 2019). This growing population will aggravate food insecurity not only by increasing the demand for food but also worsen the burden and access to agricultural resources considering development pressure (housing and urbanization), which has historically resulted in the loss of limited fertile lands, and the degradation of limited water resources (Abdelaal and Thilmany 2019). Sandy soil has very low nutrients and poor water holding capacity, which makes it hard for the plant's roots to absorb water. The addition of organic matter can help give plants an additional boost of nutrients by improving the nutrient and water holding capacity of sand soil (Young et al. 2004). By 2025, Egypt is expected to suffer from physical water scarcity and grains productivity is predicted to decrease by 11% compared to 1995 due to irrigation water scarcity (WWAP 2019). Moreover, there are many challenges to combat the decreasing in Egypt share of the Nile water flow (Power 2019).

Deficit irrigation (DI) is a watering strategy that can be applied by different types of irrigation application methods. The correct application of DI requires understanding of yield response to water (crop sensitivity to drought stress) and the economic impact on harvest reductions. In regions where water resources are restrictive, it can be more profitable for a farmer to max-

✉ Sayed Abdelrahman Abdeen
dr.sayedabdeen@azhar.edu.eg

[1] Soils and Water Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt
[2] Soils and Water Department, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt

imize crop water productivity instead of maximizing the harvest per unit land. The saved water can be used for other purposes or to irrigate extra units of land (Fereres and Soriano 2007). Salvador et al. (2011) found that drip irrigation has a greater efficiency compared to surface irrigation. Masri et al. (2015) revealed that drip irrigated sugar beet plants with 75% of irrigation water requirements (IWR) recorded the highest significant leaf area index, sucrose%, purity% and extractable sugar% in both seasons. Also, application of compost (5 ton/fed) with drip irrigation system increased root yield of sugar beet. Fang et al. (2018) stated that drip irrigation system increased wheat yield under limited water availability by enhancing soil moisture compared to basin irrigation. Surface drip irrigation promotes soil water extraction in deep soil by improving root length density below the 80 cm soil layers and increases yield by 9.8–14.2% and improves water productivity by 12.3–17.7% compared to surface irrigation (Li et al. 2018). Subsurface drip irrigation increased wheat crop water productivity by 24.95% and irrigation water productivity by19.59% compared to flood irrigation (Umair et al. 2019).

Organic sources are release nutrients over a fairly long period; the potential drawback is that they may not release enough of their principal nutrient at a time to give the plant what it needs for best growth (Timsina 2018). However, they perform other important functions. These functions include increasing soil organic matter content, improving physical structure of the soil. Mixing different types of soil conditioners together was more efficient in improving physical soil properties than applying each of them alone. Application rate of mixtures' components is considered as the important factors that highly affect soil ecosystem (Tadesse et al. 2013).

Clay is dominated to sandy soil and considered to be one of the strategies to hold water; clay surfaces have a high capacity for cation exchange and can bind phosphorus (Yaghi and Hartikainen 2014). Amendment of sandy soils with clay minerals is an important practice for improving water conservation and increasing crop production (Dempster et al. 2012). Ibrahim et al. (2013) indicated that the use of polymers, organic, and clay deposits enhanced the water retention of sandy soils. Application of organic materials affected soil pH, decreased soil bulk density, increased organic carbon, total nutrients, total soil porosity, water holding capacity and plant water availability (Mojarad et al. 2019).

Wheat (*Triticum aestivum* L.) is the most important food crop in Egypt. It provides an almost 20 % of food calories for people in the world as well as in Egypt. High production of wheat is the ultimate goal needed to meet the increasing population and growing demand for food. Wheat is among the crops whose yield is limited by low nutrients' availability in sand soils (Bameri et al. 2012). As a result, excessive chemical fertilizers are used to supply wheat plants with the nutrients which in turn induce soil and ground water pollution (Manal et al. 2016).

The current study aims to improve sandy soil properties and water productivity by adding some natural soil conditioners (canal clay scouring and compost) as well as to find the suitable application level for optimum utilization of such soils for wheat crop production under drip irrigation system.

Materials and methods

An experimental field study was carried out on a private farm, at El-Saff, Giza governorate, Egypt during two consecutive growing winter seasons of 2018/19 and 2019/20. The relevant physical and chemical properties of the experimental site and tested materials are shown in Table 1.

The experiment was laid out in a split plots design with three replications. The main plots were assigned to irrigation scheduling with two treatments (100 and 75% of water requirements) with a buffer zone (2 m width) to avoid the horizontal seepage. The water requirements were measured based on the average water requirements of wheat crop for the study area (720m^2). The sub-main treatments (ton. ha^{-1}) were as followed; 20 and 40 (ton. ha^{-1}) of compost and 40 and 80 (ton. ha^{-1}) of canal clay scouring as alone or mixed with each other. Canal clay scouring (CS) and compost (CO) were added during soil preparation as natural conditioners. Compost was purchased from Beni Suef company for organic manures, El-Haram, Giza, Egypt. Also, canal clay scouring was collected from the canals nearest to the studied region. The drip system is set up of glass fiber reinforced plastic (GR) polyethylene pipe 16 mm in diameter auto emitter every 30 cm with flow rate of 4 liter /hour at 150 kPa. In the winter seasons of 2018/19 and 2019/20, wheat seeds (*Triticum aestivum L. Masr 2*) were sown in rows 8 m long and 0.15 m apart under drip irrigation methods (each plot included 33 rows). The lateral lines were at 50 cm away and the drippers

Table 1 Physio-chemical properties of the experimental site and tested materials

The experimental site	Parameter	pH	EC_e $dS.m^{-1}$	CEC $cmolc\ kg^{-1}$	OM %	MWD mm	HC md^{-1}	Particle size distribution % Sand	Silt	Clay
	Value	7.60	1.80	2.80	0.30	0.55	5.90	88.00	7.00	5.00
			Soil water content (%)							
	Parameter	Depth (cm)	FC	PWP	Available water	BD Mgm^{-3}				
	Value	0 – 25	14.58	4.10	10.48	1.58				
		25 – 50	12.85	3.80	9.05	1.61				
Canal clay scouring	Parameter	FC	PWP	Available water	BD Mgm^{-3}	Sand	Silt	Clay		
	Value	33.50	15.00	18.50	1.42	16.00	25.50	58.50		
	Parameter	pH	EC_e $dS.m^{-1}$	OM %	Real density $Mg\ m^{-3}$	Porosity %				
	Value	7.90	2.40	1.65	2.60	45.38				
Compost	Parameter	pH	EC dSm^{-1} (1:10)	OM %	OC %	C/N ratio	Total macronutrients % N	P	K	
	Value	6.90	2.70	36.98	21.50	11.62	1.85	1.10	1.65	

EC_e: Electrical conductivity in soil extract (1:2.5), CEC: Cation exchange capacity, BD: Bulk density, MWD: Mean weight diameter, HC: Hydraulic conductivity, FC: Field capacity and PWP: Permanent wilting point.

were at 30 cm apart. The plot was 8 m in length and 5 m in width with an area of 40 m^2. All the agriculture practices were applied as commonly used for growing wheat and carried out according to the recommendations set by the Ministry of Agriculture. Ammonium nitrate (33.5% N) was applied at a level of 286 kg ha^{-1}. Calcium super phosphate (15.5% P_2O_5) was added at a level of 238 kg ha^{-1} during soil preparation. Potassium sulphate (48% K_2O) was supplemented at a level of 119 kg ha^{-1}.

At harvest (140 days after planting for each season), soil samples were collected from each treatment as well as the control one at depths of 0-25 and 25-50 cm, air dried, gently crushed and sieved through a 2 mm sieve and kept for analyses. The soil chemical properties were measured according to Page et al. (1982). Bulk density was determined using the core methods according to Blake and Hartge (1986). Field capacity and permanent wilting point were determined according to Kulte (1986) by using a pressure cooker apparatus (cores 2.5 cm height, 4.5 cm diameter), the samples were saturated using water and placed in the pressure plate at 33 and 1500 kPa, respectively, and left until equilibrium. The core samples were weighted at each pressure stage; and then water content gravimetrically. Hydraulic conductivity was measured in the undisturbed soil cores using the constant head method according to Kulte and Dirksen (1986). The amount of water consumptive use (WCU) from the root zone between two successive irrigations as a water depth in cm was calculated according to the equation of Israelsen and Hansen (1962) as follows: -

$$WCU = \frac{(\theta 2 - \theta 1)}{100} \times Bd \times D. \quad \text{...} (1)$$

Where: Θ2 = soil moisture percentage at field capacity in %,

Θ1 = soil moisture percentage at wilting point in %,

Bd = Bulk density in Mg m^{-3}, and

D = Effective depth in m.

The actual evapotranspiration (ET_a) as a cubic meter per hectare is equal to WCU as a water depth in m multiply by 10000. To obtain ET_a, the soil moisture percentage was determined gravimetrically on dry basis just before and after irrigation. Soil samples for moisture determination were taken from each 25 cm depth for a depth of 50 cm from the soil surface by a regular auger.

The reference evapotranspiration ET_o values were computed from weather data (Source: Meteorology Station of Giza, Egypt) by using FAO Penman-Monteith method: ET_o of individual agro-ecological units is calculated according to FAO Penman-Monteith method (FAO 1998). The FAO CROPWAT (CROPWAT 8.0 developed) program incorporates procedures for ET_o and crop water requirements that allow the simulation of crop water use under various climate, crop and soil conditions (FAO 2009). The crop coefficient (K_c) is calculated as the dimensionless ratio of crop ET_a and the potential ET_o.

$$Kc = \frac{Eta}{ETo} \quad \text{...} (2)$$

Where: Et_a = actual evapotranspiration in mm/day/month, and

ET_o = potential evapotranspiration in mm/day/month.

The irrigation water productivity of the marketable yield (seed wheat yield) as kg seed/ m^3 of water were calculated according to Ghane et al. (2010) as follows:

$$WP\ (kg\ m^{-3}) = \frac{\text{Seed yield}\ (kg\ ha^{-1})}{\text{WCU}\ (m^3\ ha^{-1})} \quad \ldots\ldots\ldots\ldots (3)$$

$$IWP\ (kg\ m^{-3}) = \frac{\text{Seed yield}\ ((kg\ ha^{-1})}{\text{IW}\ ((m^3\ ha^{-1})} \quad \ldots\ldots\ldots\ldots (4)$$

Where: WP = water productivity, IWP = irrigation water productivity and IW = irrigation water

At harvest time, ten plants were chosen randomly from each plot to measure seed index (weight of 1000 grains), NPK in grains and straw. Four square meters (2m x 2m) from the centric area of each plot were used to estimate the grain and straw yields, then the recorded values were converted to ton. ha^{-1}. The statistical analysis was analyzed by Statistical Package for Social Science (SPSS) version 20. Values were presented as mean. Statistical differences between treatments were performed using one-way ANOVA, the mean difference was significance at ($P \leq 0.05$) level according to Levesque (2007).

Results and discussion

Soil chemical properties

Generally, soil chemical properties (soil pH, EC, OM and CEC) were affected by the application rates of either compost (CO) or clay scouring (CS) under 100 and 75% of irrigation requirements (Table 2). Soil pH slightly increased with increasing the application rate of CS and the opposite was true for compost application as compared to control treatment. This illustrates that the changes in soil reaction (pH) depends on its buffering ability, so compost that is routinely applied preserves or improves soil pH (Butler et al. 2008 and Soheil et al. 2012).

The data also explained that ascending the applications' rate of compost were associated with increasing in soil EC. For instance, the control value of the sandy soil received recommended dose only displayed EC value of 1.85 dSm^{-1} and increased to 2.28 dSm^{-1} at 40 ton. ha^{-1} compost under 75% IR (Table 2). Soil

Table 2 Soil chemical properties as affected by the addition rates of compost and clay scouring after wheat harvest as average values of both seasons 2018/19 and 2019/20

Treatments ton. ha^{-1}	IR %	pH	ECe $dS.m^{-1}$	OM %	CEC $cmol_c\ kg^{-1}$
Control	100	7.60	1.85	0.33	2.90
	75	7.58	1.88	0.31	2.90
CS 40	100	7.62	1.80	0.35	3.50
	75	7.60	1.85	0.35	3.47
CS 80	100	7.66	1.82	0.37	3.90
	75	7.63	1.83	0.36	3.80
CO 20	100	7.51	1.95	0.35	3.30
	75	7.50	1.98	0.36	3.35
CO 40	100	7.40	2.28	0.38	3.60
	75	7.37	2.33	0.40	3.73
CS + 20 CO 40	100	7.55	1.90	0.39	3.80
	75	7.51	1.95	0.40	3.85
CS + 40 CO 40	100	7.45	2.00	0.40	4.20
	75	7.44	2.21	0.42	4.26
CS + 20 CO 80	100	7.55	2.00	0.43	4.60
	75	7.56	2.18	0.43	4.60
CS + 40 CO 80	100	7.42	2.20	0.47	5.90
	75	7.40	2.23	0.50	5.93
LSD	CS (A)	0.50	0.16	0.13	1.12
	CO (B)	0.50	0.25	0.13	1.25
	AB	0.16	1.02	0.16	1.69

organic matter and CEC were increased significantly by increasing the addition rates of clay scouring or compost. This might be attributed to the high CEC of compost and clay scouring. The highest values were observed at the highest rates of CS and CO as a mixture. This may be attributed to addition of clay scouring and compost which led to increasing microorganism activity and enhance CEC and soil fertility (Natsheh and Mousa 2014). These findings are in line with those obtained by Urbaniak et al. (2017) who found that application of organic resources improved soil chemical properties.

Soil moisture content

Data presented in Table 3 show the influence of compost and clay scouring under irrigation treatments on soil moisture coefficient as average values of both seasons (2019/20). Field capacity (FC) and wilting point (WP) showed almost no change through both growing seasons in all treatments. The results recorded an increase in the FC and WP values by increasing the applied amounts of compost and clay scouring. The results indicated that the highest FC and WP value was recorded at 80 CS + 40 CO (ton. ha^{-1}) under 75% irrigation requirements while the lowest one was recorded under 100% of irrigation requirement. Organic wastes (hazelnut husk compost) led to increasing water holding capacity, porosity, filed capacity and wilting point, and decrease in bulk density (Aşkın and Selahattin 2018).

Bulk density (BD)

Data presented in Table 3 showed that there is a slight change on soil bulk density with different water irrigation requirements through both growing seasons. Soil bulk density (BD) was influenced by adding the amended materials. It observed a decreasing trend in soil bulk density with increasing the amount of adding clay scouring or compost. The results indicated that the highest BD value was recorded for control treatment that received 75% water irrigation requirement. The lowest one was recorded under 80 CS +40 CO (ton. ha^{-1}) at 100% water irrigation requirement. In this concern, Aşkın and Selahattin (2018) and Gulser et al. (2015) reported that application of organic wastes led to increasing soil organic matter, stable aggregation, and decrease bulk density.

Table 3 Soil moisture coefficient, bulk density (BD) and hydraulic conductivity (HC) as affected by compost and clay scouring under irrigation treatments after wheat harvest as average values of both seasons 2018/19 and 2019/20

Treatments ton. ha^{-1}	IR %	FC%	WP%	FC%	WP%	BD Mgm^{-3}		HC m d^{-1}
		0 – 25 cm		25-50 cm		0 – 25 cm	25-50 cm	0- 50 cm
Control	100	17.62	4.37	16.75	4.17	1.59	1.60	5.64
	75	17.97	4.46	17.06	4.23	1.56	1.68	5.72
40 CS	100	20.59	5.37	17.17	4.57	1.53	1.58	5.14
	75	18.79	5.08	17.34	4.16	1.54	1.60	5.16
80 CS	100	20.71	5.29	17.47	4.60	1.48	1.56	4.99
	75	19.46	5.06	17.49	4.45	1.49	1.59	4.90
20 CO	100	18.53	5.32	18.09	4.42	1.53	1.58	5.17
	75	18.84	4.87	17.98	4.24	1.57	1.62	5.04
40 CO	100	20.12	5.31	18.41	4.52	1.49	1.56	5.04
	75	18.77	4.80	18.32	4.40	1.51	1.60	4.54
40 CS + 20 CO	100	18.96	5.28	18.54	4.41	1.47	1.52	4.99
	75	18.36	4.78	18.48	4.16	1.50	1.54	4.92
40 CS + 40 CO	100	20.66	5.44	19.98	4.58	1.46	1.53	4.68
	75	19.86	5.50	20.10	4.21	1.49	1.57	4.58
80 CS + 20 CO	100	20.31	5.75	20.25	4.63	1.43	1.50	4.28
	75	20.07	5.55	19.98	4.58	1.47	1.53	4.20
80 CS + 40 CO	100	20.94	5.97	20.71	5.07	1.41	1.47	3.95
	75	20.80	5.85	20.58	4.96	1.43	1.48	3.94

Hydraulic conductivity (HC)

Data presented in Table 3 shows that the hydraulic conductivity (HC) values slightly changed by different water irrigation requirements through both growing seasons. The Hydraulic conductivity (HC) was decreased with increasing the amount of adding clay scouring or compost. This may be due to the effect of organic matter on the pore-size distribution of the soil through soil structure development which also influences hydraulic conductivity. The modification of soil structure caused by an increase in OM content may replace larger pores more aggregated material and thin pathways to occur change in water movement (Nemes et al. 2005). The results indicated that the highest HC value was recorded for control treatment that received 75% water irrigation requirement. The lowest one was recorded under 80 CS +40 CO (ton. ha^{-1}) for 75% water irrigation requirement.

Water relationships

Actual evapotranspiration (ETa)

Actual evapotranspiration (ETa) as affected by application rates of compost and clay scouring through wheat growth stages as average values of both seasons under irrigation regime is presented in Table 4. The highest values of ETa were recorded in the mid growth followed by development and end stages, while the lowest values were recorded in the initial stage. The results recorded a decrease in ETa values with low water irrigation requirements. Also, the results indicated that the highest seasonal ETa value was recorded for control treatment that received 100% water irrigation requirement. The lowest one was recorded under 80 CS +40 CO (ton. ha^{-1}) for 75% water irrigation requirement. The results recorded a decrease in the ETa values by increasing the applied amounts of compost or clay scouring in all growth stages. These results are consistent with those obtained by Hassan et al. (2017) who reported that Eta values decreased as water utilization rate decreased.

Wheat crop coefficient (K_c)

Wheat crop coefficient (K_c) as affected by compost and clay scouring at different wheat growth stages under 100% and 75% of irrigation requirements is presented

Table 4 Actual evapotranspiration (mm) as affected by compost or clay scouring application for different water irrigation requirements through wheat growth stages as average values of both seasons 2018/19 and 2019/20

Treatments ton. ha^{-1}	IR %	ETa (mm) during Growth stages of wheat crop				
		Initial (20 day)	Development (50 day)	Mid (45 day)	End (25 day)	Gross season (140 day)
Control	100	41.44	147.11	155.99	78.55	423.10
	75	26.24	110.10	120.75	59.59	316.67
CS 40	100	38.88	144.19	152.47	76.60	412.14
	75	24.01	106.03	120.03	58.02	308.10
CS 80	100	38.27	142.66	151.10	75.83	407.86
	75	24.40	105.50	117.65	56.25	303.81
CO 20	100	39.59	146.98	154.08	76.49	417.14
	75	24.35	108.88	118.80	58.44	310.48
CO 40	100	38.88	143.19	153.47	76.60	412.14
	75	23.64	105.10	119.19	57.55	305.48
CS + 20 CO 40	100	38.30	142.75	151.17	75.87	408.10
	75	23.23	105.08	117.27	57.04	302.62
CS + 40 CO 40	100	38.13	142.32	150.79	75.66	406.90
	75	23.20	104.99	117.19	57.00	302.38
CS + 20 CO 80	100	37.55	140.88	149.49	74.94	402.86
	75	22.62	103.55	115.89	56.27	298.33
CS + 40 CO 80	100	37.01	137.52	149.27	75.26	399.05
	75	22.28	103.70	114.13	55.85	295.95
Reference evapotranspiration (ET_o)		79.73	114.09	134.46	88.04	416.32

in Table 5. The K_c value started to increase at the initial stage to reach its maximum value (K_c devolvement) at mid stage. During the late season, the K_c started to decline till the lower values at the end of the growing period. The K_c values were less at low water requirements than that at high one. The highest seasonal K_c value was recorded for control treatment that received 100% water irrigation requirement, while the lowest one was recorded under 80 (t/ha) CS +20 (t/ha) CO and 80 CS +40 CO (ton. ha^{-1}) for 75% water requirement. Also, it was noticed to be a decrease in the K_c values by increasing the application rate of compost and clay scouring in all growth stages. Similar results were reported by EL-Sayed and Abd El-Monem (2017).

Crop water productivity (CWP) and irrigation water productivity (IWP)

Data presented in Table 6 show the influence of compost or clay scouring and irrigation water requirements for wheat on crop water productivity (CWP) and irrigation water productivity (IWP) as average values of both seasons. An increase in CWP and IWP at 75% irrigation water requirements was observed.

The highest CWP and IWP value was recorded under 80 CS +40 CO (ton. ha^{-1}) for 75% irrigation water requirement. This may be due to the improvement of soil fertility, which led to increasing the growth and productivity of wheat plants. Shenglan et al. (2020) reported a marked effect of organic fertilizers which can improve water use efficiency (WUE) and grain crops. The lowest CWP was recorded under control at 100% irrigation water requirement as well as for IWP under 40 CS +40 CO (ton. ha^{-1}) at 100% water irrigation requirement treatment. An increase in the CWP and IWP values was noticed by increasing the application rate of compost or clay scouring. These results are in agreement with those obtained by Teran et al. (2005), Munoz-Perea et al. (2007) and Hassan et al. (2017).

Wheat yield (straw and grain)

Straw and grain yield of wheat crop as affected by canal clay scouring and compost under irrigation regime are presented in Table 7. The highest increase in straw or grain yield was obtained by high application rate of clay scouring and compost. Straw yield increased significantly

Table 5 Wheat crop coefficient (K_c) as affected by compost or clay scouring application for different water irrigation requirements through wheat growth stages as average values of both seasons 2018/19 and 2019/20

Treatments ton. ha^{-1}	IR %	Growth stage: Initial (20 day)	Development (50 day)	Mid (45 day)	End (25 day)	Seasonal K_c
Control	100	0.52	1.29	1.16	0.89	0.97
	75	0.33	0.96	0.90	0.68	0.72
40 CS	100	0.49	1.26	1.13	0.87	0.94
	75	0.30	0.93	0.89	0.66	0.70
80 CS	100	0.48	1.25	1.12	0.86	0.93
	75	0.31	0.92	0.88	0.64	0.69
20 CO	100	0.50	1.29	1.15	0.87	0.95
	75	0.31	0.95	0.88	0.66	0.70
40 CO	100	0.49	1.26	1.14	0.87	0.94
	75	0.30	0.92	0.89	0.65	0.69
40 CS + 20 CO	100	0.48	1.25	1.12	0.86	0.93
	75	0.29	0.92	0.87	0.65	0.68
40 CS + 40 CO	100	0.48	1.25	1.12	0.86	0.93
	75	0.29	0.92	0.87	0.65	0.68
80 CS + 20 CO	100	0.47	1.23	1.11	0.85	0.92
	75	0.28	0.91	0.86	0.64	0.67
80 CS + 40 CO	100	0.46	1.21	1.11	0.85	0.91
	75	0.28	0.91	0.85	0.63	0.67

Table 6 Water productivity as affected by compost or clay scouring application at different water irrigation requirements for wheat yield as average values of both seasons 2018/19 and 2019/20

Treatments ton. ha^{-1}	IR %	IW (m^3 ha^{-1})	WCU (m^3 ha^{-1})	CWP (Kg m^{-3})		IWP (Kg m^{-3})	
				Value	% Increase	Value	% Increase
Control	100	4800	4231	1.33	-	1.17	-
	75	3600	3167	1.74	-	1.53	-
40 CS	100	4800	4121	1.37	3.00	1.18	0.85
	75	3600	3081	1.81	4.02	1.55	1.31
80 CS	100	4800	4079	1.43	7.52	1.22	4.27
	75	3600	3038	1.85	6.32	1.56	1.96
20 CO	100	4800	4171	1.36	2.26	1.18	0.85
	75	3600	3105	1.79	2.87	1.55	1.31
40 CO	100	4800	4121	1.38	3.76	1.19	1.71
	75	3600	3055	1.86	6.90	1.58	3.27
40 CS + 20 CO	100	4800	4081	1.43	7.52	1.22	4.27
	75	3600	3026	1.85	6.32	1.55	1.31
40 CS + 40 CO	100	4800	4069	1.41	6.02	1.19	1.71
	75	3600	3024	1.88	8.05	1.58	3.27
80 CS + 20 CO	100	4800	4029	1.42	6.77	1.19	1.71
	75	3600	2983	1.88	8.05	1.56	1.96
80 CS + 40 CO	100	4800	3990	1.61	21.05	1.34	14.53
	75	3600	2960	2.09	20.11	1.72	12.42

by increasing the application rate of clay scouring and compost. The findings also revealed that compost treatment had a positive influence on wheat yield and yield components. The enhancing effect of compost may be due to a higher concentration of plant nutrients such as N, P, K, and Mg, as well as root strengthening caused by compost (Donn et al. 2014).

The straw and grain yields were 9523.81 and 6428.57 kg ha^{-1} at 80 CS +40 CO (ton. ha^{-1}) under 100% and they were 9250.00 and 6190.48 kg ha^{-1} under 75% IR, respectively. The relative increase of straw yield was observed at the highest mixture of compost and canal scouring clay (80 CS ton. ha^{-1} +40 CO ton. ha^{-1}). The highest increment was 34.23 and 46.6 % at 100 % and 75% IR, respectively. Also, the highest rates of compost and canal clay scouring gave the highest weight of 100 grain yield. On the other side, the relative increase of grain yield was 14.55 and 12.31% at 100% and 75% IR, respectively under 80 CS ton. ha^{-1} +40 CO ton. ha^{-1}. In this respect, Ali et al. (2020) found that addition of different organic manures enhances grain quality and wheat productivity under deficit irrigation with little impact on the quality and quantity of the harvested yield.

Macronutrients in straw and grain yield

Concerning the effect of canal clay scouring and compost on macronutrients' content under different levels of moisture content, the obtained data revealed that higher application induced higher nutrient content as compared to control (Table 8). The data show a significant increase in N, P and K content of wheat grain and straw by adding clay scouring or compost alone or in mixture for 100 and 75% IR compared to control treatment. Such promoting the effect of compost can be linked to its ability to increase the availability and content of nutrients such as nitrogen, phosphorus, and potassium in the soil and in plants. In turn, this promotes growth and yield production

Table 7 Wheat yields as affected by compost or clay scouring application for different water irrigation requirements as average values of both seasons 2018/19 and 2019/20

Treatments ton. ha^{-1}		IR %	Straw Yield kg. ha^{-1}	Relative increase %	Grain yield		Relative increase %
					100 grain weight (g)	kg. ha^{-1}	
Control		100	7095.24	-	3.93	5609.52	-
		75	6309.52	-	3.66	5511.90	-
40 CS		100	7580.95	6.85	4.25	5666.67	1.02
		75	6880.95	9.06	3.88	5583.33	1.30
80 CS		100	7697.62	8.49	4.80	5845.24	4.20
		75	7380.95	4.27	3.98	5607.14	1.73
20 CO		100	7830.95	10.37	4.15	5654.76	0.81
		75	7571.43	20.00	3.90	5569.05	1.04
40 CO		100	8083.33	13.93	4.30	5690.48	1.44
		75	7642.86	21.13	4.00	5576.19	1.17
40 CS + 20 CO		100	8257.14	16.38	4.56	5833.33	3.99
		75	7750.00	22.83	4.10	5695.24	3.33
40 CS + 40 CO		100	8702.38	22.65	4.85	5723.81	2.04
		75	8226.19	30.38	4.45	5676.19	2.98
80 CS + 20 CO		100	8892.86	25.34	4.97	5707.14	1.74
		75	8285.71	31.32	5.10	5619.05	1.94
80 CS + 40 CO		100	9523.81	34.23	5.40	6428.57	14.55
		75	9250.00	46.60	5.25	6190.48	12.31
LSD	CS(A)		16.50	-	-	19.03	-
	CO (B)		18.90	-	-	23.50	-
	AB		20.22	-	-	30.00	-

(Dhir 2016). The combined application of CS and CO increased yield and yield components than single application. Application of 80 CS +40 CO (ton. ha^{-1}) under 100% IR gave the highest values of N, P and K content in grains and straw. The values being 1.50, 0.28 and 1.45% for the corresponding nutrients for straw and the NPK content were 2.80, 0.35 and 0.85, respectively for grains. This could be due to organic matter and clay scouring application that are acting as good resource or chelating of the nutrients that reduce nutrients' loss by leaching. Soheil et al. (2012) found that available N, P and K increased as the result of compost application.

Conclusion

The application of compost and canal clay scouring improved physio-chemical properties (soil organic matter, cation exchange capacity, field capacity, permanent wilting point and available water) which led to improvement in water productivity and wheat yield. Also, the highest rates of compost and clay scouring (80 ton. ha^{-1} CS + 40 CO ton. ha^{-1}) can reduce water consumption according to improvement of available water in sandy soil. On the other hand, deficit irrigation water had a negative effect on wheat crop. So, the real challenge then is to use a deficit irrigation system that in-

Table 8 Macronutrients' content (%) as affected by compost or clay scouring application for different water irrigation requirements as average values of both seasons 2018/19 and 2019/20

Treatments ton. ha^{-1}		IR %	Straw			Grain		
			N	P	K	N	P	K
Control		100	0.75	0.17	1.15	1.62	0.20	0.57
		75	0.70	0.14	1.10	1.50	0.20	0.55
40 CS		100	0.90	0.17	1.20	1.70	0.22	0.60
		75	0.83	0.15	1.12	1.63	0.20	0.50
80 CS		100	1.25	0.20	1.26	1.70	0.25	0.60
		75	1.10	0.18	1.25	1.70	0.20	0.55
20 CO		100	0.95	0.20	1.25	1.75	0.25	0.64
		75	0.83	0.20	1.20	1.55	0.18	0.55
40 CO		100	1.32	0.20	1.30	1.80	0.28	0.68
		75	1.22	0.18	1.20	1.60	0.25	0.62
40 CS + 20 CO		100	1.20	0.24	1.25	2.15	0.30	0.70
		75	1.18	0.21	1.20	1.95	0.26	0.65
40 CS + 40 CO		100	1.40	0.24	1.33	2.25	0.30	0.70
		75	1.38	0.25	1.35	2.30	0.25	0.70
80 CS + 20 CO		100	1.40	0.25	1.35	2.50	0.35	0.85
		75	1.33	0.23	1.30	2.10	0.30	0.78
80 CS + 40 CO		100	1.50	0.28	1.45	2.80	0.35	0.85
		75	1.42	0.25	1.45	2.85	0.33	0.85
LSD	CS(A)		0.52	0.05	0.43	0.33	0.13	0.17
	CO (B)		0.57	0.05	0.45	0.13	0.11	0.11
	AB		0.85	0.009	1.30	1.58	0.23	0.30

creases or even maintains crop production with reducing irrigation water. For that, canal clay scouring and compost are considered one of the natural conditioners to reduce the side effect of deficit water and improved the productivity of water and wheat crop.

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest associated with this study.

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