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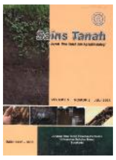

Studying The Effect of Tillage Depth combined with Organic Amendments and Different Nitrogen Fertilization on Improving Calcareous Soil Properties and Wheat Productivity

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ABSTRACT

Calcareous soil suffers from deprived organic materials, structural properties, increased water holding capacity, deep percolation, crusts and cracks formation, which hinders the roots dispersion and decreases permeation speed. This inhibits the soil physical, hydraulic properties, and its nutritional status. The research objective is to enhance the calcareous soil status and its productivity using eco-friendly conditioners. A Split-split plot field experimental study has been laid at El-Nubaria Agri. Res. Stat., in 2018 and 2019 winter seasons with three replications. The main factor was two depths of tillage: (T_1) surface tillage (0 – 15 cm) and (T_2) deep tillage (0 – 60 cm). The sub-main factor was three types of mineral nitrogen (N) fertilization, control (C1) without N application, ammonium nitrate (F1) and urea formaldehyde (F2), while the sub-sub main factor was the types of soil amendments: no amendment (cont.), sugar beet waste (W), K-Humate (KH), Sulphur (S) and compost (Comp). Results have indicated that greater values of organic matter OM and aggregate measured were gained by the surface tillage treatment and using both sugar beet wastes (W) and compost applications. The combination between the deep tillage (T2) and ammonium nitrate (F1) and sugar beet waste (W) has increased the wheat grains and straw yield (ton ha^{-1}) and 1000-grains weight (g). Sugar beet waste can be recommended as an economic conditioner enhances the calcareous soil to make it more productive.

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1. INTRODUCTION

Soil is the main player that is responsible for the food providing worldwide. The reclaimed soils are usually desert areas being sandy or calcareous soils and cultivation of such types needs optimization of suitable soil management strategies. Calcareous soils' structure are often having high capacity to retain water with extreme deep percolation that causes ineffective water use in addition to a low content of the organic matter (OM) along with crusting and cracking. So, the soil hydraulic permeation rates as well as the roots dispersion are inhibited limiting the productivity of such soil (FAO, 2016). Consequently, the nutritional status and productivity of this soil type necessitates a continuous improvement (Ahmed, 2018).

Studies have indicated that amending soil via single and combined application of biochar and hydrogel have enhanced the soil hydro-physical properties. They have been significantly increased the fodder crop cowpea (*Vignaun guiculata* L.) yield parameters (El-Hassanin, Samak, El-Hady, et al., 2022). Compost and vermicompost synthesis procedures utilizing bio-accelerators and vermi worms could be utilized to take out the heavy metals from sewage sludge. Such method was promising for the production of high-quality environment friendly organo-fertilizers for the local and global handling (El-Hassanin, Samak, Ahmed, et al., 2022). Amending the calcareous soil by organo-supplements such as the compost and wastes by-products for example Sugar beet leftovers can improve its physical and chemical characteristics (Ahmed et al., 2022). On another hand, the humic acid and K-humate salt are widely applied within the organic fertilization programs because they are efficient for enhancing the soil properties, macro- and micro-nutrients availability and growth promotion.

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Sulphur (S) compounds can be applied as soil conditioners because they neutralize the alkaline effect of the $CaCO_3$ present in soil giving acidification effect for soil that is reducing the soil pH and improving the nutrients' availability. In addition, the S element is capable to bind soil particles with the organic species like a bridge forming stronger soil aggregates. It is associated with the nitrogen (N) metabolism and an essential nutrient in the proteins and vitamins synthesis as well as the essential amino acids (El-Gamal et al., 2020).

The chemical nitrogenous fertilizers are costly so that the majority of farmers decrease their sufficient application that decreases the crop production. The controlled-release N-fertilizer called Urea formaldehyde (40%) possibly enhance the N-uptake by crops and reduces the environment contamination effects resulted from the N leaching loss. It provides the nitrate form to crops compared to the ammonium nitrate 33.5%. Replacement of the conventional mineral urea fertilizer and ammonium nitrates by the coated N-fertilizers has been studied. Coating materials are including the sulfur, gypsum, calcium sulfates, zeolites, and the filter cake/Mud of sugar cane or sugar beet. Such controlled-released N-fertilizers have maximized the yield and yield parameters of green Iceberg lettuce cabbage plants (El-Hassanin et al., 2021).

Tillage practices impact the soil physically, chemically, and biologically, and thus can shift the plants growth and yield (Ali et al., 2018). Choosing the most suitable tillage technique is crucial to optimize the crops productivity. Wheat is a worldwide cereal crop having a unique protein for human consumption and can grow in miscellaneous environmental conditions. The total Egyptian production of wheat was 8.4 million tons by 1.28-1.43 million hectare soil area (El-Gamal et al., 2020). Research studies regarding natural amendments like the K-humates, sugar beet wastes, compost, and divers N-fertilizers (controlled-releasing Formaldehyde fertilizers) compared to the traditional ammonium nitrate are limited. This study aims to optimize the wheat yield by optimization of the calcareous soil chemically and physically through application of eco-friendly conditioners from natural sources rather than the synthetic chemical soil conditioners under the effect of different tillage depth.

2. MATERIAL AND METHODS

2.1. The experimental field soil

The field experimental soil was at El-Nubaria Agricultural Research Station-Agricultural Research Center (Al-Beheara Governorate-Egypt). Surface (0-30 cm) soil samples were dried in oven (24 h at 105°C) before sowing and tested for its general soil chemical and physical characteristics (Piper, 2019) that are shown in Table 1.

2.2. Treatments and experiment layout

The field experiment layout was a split-split plot in which each treatment was replicated three times. The main factor was two depths of tillage: (T_1) surface tillage (0– 15cm) and (T_2) deep tillage (0– 60cm).The sub-main factor was three types of mineral nitrogen (N) fertilization, control (C1) without N application, ammonium nitrate (F1) and urea formaldehyde (F2), while the sub-sub main factor was the types of soil amendments: no amendment (cont.), sugar beet waste (W), K-Humate (KH), Sulphur (S) and compost (Comp).The analysis of amendments was carried out in the lab according to the recommended chemical methods of analysis and has included the pH (in suspension) and total soluble salts (in extract) using 1:10 compost: water ratio, total OC% using the loss on ignition method, moisture content (%), humic acid (%) and total N, P, K, Fe, Zn and Mn and tests results were presented in Table 2.

2.3. Field practices and Plant analysis

Wheat grains (*Triticum activism* L., Giza 168 var.) were sown on all plots (120 kg ha^{-1}) on the 15th of November (winter seasons of the years 2018/2019). The wheat fertilization was following the Agricultural Ministry Annual Bulletin recommendations (El-Basioni et al., 2015). The N-fertilization was 100 units equivalent to 720 kg N as ammonium nitrate: 33.5% (F_1) and 600 kg as urea formaldehyde form (F_2) under flute irrigation at the field capacity.

Table 1. Some characteristics of the experimental soil

Soluble ions (meq L^{-1})						
K^+	Na^+	Ca^{2+}	Mg^{2+}	Cl^-	HCO_3^-	SO_4^-
0.22	10.05	4.87	3.36	16.82	0.73	0.95
EC (dS m^{-1})	pH (1:2.5)	$CaCO_3$ (%)	OM (%)	BD Mg m^{-3}	TP (%)	Ksat (cm h^{-1})
1.85	7.89	28.31	0.83	1.49	43.8	3.6
Particle size distribution (%)				**Aggregate size distribution (%)**		
Sand	Silt	Clay	Texture	<2mm	2 -1.5mm	<1.5
61.47	31.88	6.65	sandy loam	17.33	36.41	46.26
Available nutrients (mg kg^{-1})						
Macronutrients				**Micronutrients**		
N	P		K	Fe	Mn	Zn
47.2	3.6		112	82	41	35

Table 2. Some properties of the compost, sugar beet wastes and K-humate

pH (1:10)	EC(dS m-^{1})‡	OC (%)	OM (%)	C/N ratio	Macronutrients (%)			Micronutrients (mg kg^{-1})		
					N	P	K	Fe	Mn	Zn
Compost										
7.14	6.35	32.5	55.93	13.01	2.50	0.40	3.14	160.0	113.0	86.0
Sugar beet wastes										
7.20	2.95	34.30	59.0	10.24	3.35	0.38	3.80	210.0	155.0	117.00
K-humate										
	OC (%)			**Humic acid**		**Moisture content**			**K_2O (%)**	
	80.0			65.0%		15.0%			8-10	

Harvesting of the mature wheat plants was followed by separation into grains and straw, then drying in air and in oven at 70°C to weight and calculate the yield (ton ha^{-1}). They were extracted by the wet digestion method (Piper, 2019) for determination of its total N content (%), Uptake (kg ha^{-1}) and the relative increasing yield (RIY) calculated by Equations 1 and 2, respectively.

$$\mathrm{N-Uptake\ (kg\ ha^{-1})} = \frac{\mathrm{N\ (\%) in\ grains \times grains\ yield\ (kg\ ha^{-1})}}{100} \ldots\ldots [1]$$

$$\text{Relative increase of yield (RIY)} = \frac{\text{Treatment Grains yield (ton ha}^{-1}\text{)} - \text{Control grains yield (ton ha}^{-1}\text{) x 100}}{\text{Control grains yield (ton ha}^{-1}\text{)}} \ldots [2]$$

2.4. Soil chemical and physical analysis

All plots have been subjected to soil sampling to be analyzed (Piper, 2019) for their pH (1:2.5 soil:water suspension), electric conductance EC, dS m^{-1} (in soil paste extract), $CaCO_3$% (volumetrically, the Collins Calcimeter), and organic matter content (OM%, Walkley-Black′s titration method). The concentrations of soluble ions were estimated including the CO_3^-, HCO_3^-, Cl^-, Ca^{+2}, and Mg^{+2} by titration and the Na^+ and K^+ by flame photometer.

A 2 N KCl solution has been used for extraction of the available N in soil samples and measuring by micro-Kjeldahl steam distillation system (UDK 139 - code F 30200 130). A 0.5 M $NaHCO_3$ has been used for extraction of available P and measuring by sulpho molybdic acid colorimetric method using SPECTRONIC 21D NARP 100034 spectrophotometer. The available potassium (K) was measured by CORNING 400 flame photometer, while the DTPA-extracted available micro-nutrients Fe, Mn, and Zn were measured by the atomic absorption spectrophotometer.

Soil aggregate stability has been estimated using the wet sieving method, soil texture (mechanical analysis, by the pipette method using Na-Hexa meta phosphate dispersing agent after removing the $CaCO_3$), and bulk density (g cm^{-3}) at the field moisture content (by core method: 5 cm inner diameter × 5 cm height, Piper (2019)). The soil total porosity (%) was calculated using the bulk density (ρb) and particle density (ρp, 2.65 g cm^{-3}) by Equation 3.

$$Porosity\ (\%) = \left(1 - \frac{\rho b}{\rho p}\right) \times 100 \ldots\ldots\ldots\ldots [3]$$

Hydraulic conductivity (cm hr^{-1}) has been estimated using undisturbed soil samples collected by metallic rings (4.6 cm inner diameter, 15 cm height) by the constant head method Equation 4.

$$\mathrm{HC} = \frac{\mathrm{(QL)}}{\mathrm{(At\ \Delta H)}} \ldots\ldots\ldots\ldots [4]$$

Where HC = Water amount flowed through saturated soil column per area per unit time; Q = Water volume flowed through saturated soil column per unit time (L^3/t); A = Cross-sectional area of the flow (L^2); L = Length of the soil column; ΔH = Difference in hydraulic head over the soil column (L); t = Time (h).

2.5. Statistical Analysis

The obtained data were statistically analyzed to calculate the least significant difference (LSD) of the treatment effect at a significance level of $P \leq 0.05$ by the two-way analysis of variance (ANOVA) using computerized MSTAT software.

3. RESULTS

3.1. Influence of the applied tillage, N-fertilizers, and amendments on some soil physical and chemical characteristics

3.1.1. Organic matter (OM, %)

The surface tillage (T1) treatment has led to a significant increase in the soil OM (%) mean values shown in Table 3 after wheat harvest more than the deep tillage (T2). The types of fertilizers have increased the soil OM mean values significantly compared to the control C1 (1.02 Cont, 1.07 F1, 1.08 F2%) T1 and (0.96 Cont, 1.02 F1, 1.01 F2%) T2, respectively.

The application of amendments under study to the soil has resulted in significant variations between soil OM values for both surface and deep tillage treatments. The best waste (W) application combined with T1 and/or T2 has produced the maximum mean values (1.26 and 1.14%), respectively. Also, another maximum OM mean value (1.29 %) has resulted from the interaction effect of the combined treatment surface tillage T1 + ammonium nitrate F1 + Sugar beet waste (W) (T1×F1×W). Intensive tillage practicing perhaps breaks the soil OM down.

3.1.2. Soil aggregates size distribution

Application of the compost as well as sugar beet waste has resulted in the utmost influence on the average wet aggregates after one year more than other additives as exhibited in Figures 1 and 2 as well as in Table 4 for the least significant difference ($LSD_{0.05}$) values of the statistically tested data.

Table 3. Soil OM (%), total porosity (%), hydraulic conductivity (cm^3 h^{-1}), and available N (mg kg^{-1}) in soil after wheat harvesting as affected by factors under study

Treatments		Control	KH	W	Compost	S	Mean
				Soil OM (%)			
Tillage (T1)	C1	0.77	1.06	1.24	1.19	0.83	1.02
	F1	0.87	1.07	1.29	1.24	0.90	1.07
	F2	0.90	1.12	1.26	1.18	0.96	1.08
Mean		0.85	1.08	1.26	1.20	0.90	1.06
Tillage (T2)	C1	0.71	1.03	1.10	1.04	0.92	0.96
	F1	0.82	1.01	1.21	1.11	0.93	1.02
	F2	0.88	1.03	1.11	1.07	0.94	1.01
Mean		0.80	1.02	1.14	1.07	0.93	0.99
LSD $_{0.05}$	T =0.016	F =0.018	A =0.023	T×F = 0.025	T×A= 0.032	F×A =0.039	T×F×A =0.056
				Soil Total Porosity (%)			
Tillage (T1)	C1	47.17	51.70	55.66	55.66	49.44	51.93
	F1	47.36	51.70	55.29	55.48	50.19	52.0
	F2	47.36	51.70	55.10	55.10	49.81	51.81
Mean		47.30	51.70	55.35	55.41	49.81	51.91
Tillage (T2)	C1	46.42	53.97	57.93	57.93	50.19	53.28
	F1	46.80	54.72	58.68	58.12	50.76	53.81
	F2	46.98	54.15	58.68	56.79	51.32	53.58
Mean		46.73	54.28	58.43	57.61	50.76	53.56
LSD $_{0.05}$	T =0.278	F =0.289	A =0.171	T×F =0.409	T×A = 0.528	F×A =0.646	T×F×A =0.914
				Soil Hydraulic Conductivity (Cm^3 h^{-1})			
Tillage (T1)	C1	8.12	12.12	15.37	14.14	9.46	11.84
	F1	8.25	12.24	15.33	14.14	9.46	11.88
	F2	8.50	12.81	15.67	14.65	9.88	12.30
Mean		8.29	12.39	15.45	14.31	9.60	12.01
Tillage (T2)	C1	8.41	11.91	16.07	14.18	11.68	12.45
	F1	8.76	14.11	15.94	15.00	11.27	13.01
	F2	9.49	14.11	16.31	15.00	11.78	13.34
Mean		8.88	13.38	16.10	14.73	11.58	12.93
LSD $_{0.05}$	T = 0.188	F = 0.202	A = 0.260	T*F = 0.285	T*A = 0.368	F*A =0.451	T*F*A = 0.637
				Soil Available N (mg Kg^{-1})			
Tillage (T1)	C1	34.37	47.38	52.97	52.53	46.33	46.72
	F1	53.67	59.03	65.14	63.45	56.71	59.60
	F2	52.88	56.89	59.95	58.39	53.34	56.29
Mean		46.97	54.43	59.35	58.12	52.13	54.20
Tillage (T2)	C1	26.27	34.48	38.55	38.31	30.31	33.58
	F1	45.23	54.11	57.69	54.75	49.31	52.22
	F2	41.49	49.53	56.10	51.89	48.99	49.60
Mean		37.66	46.04	50.78	48.32	42.87	45.13
LSD $_{0.05}$	T =0.726	F =0.728	A =0.940	T×F = 1.030	T×A = 1.330	F×A =1.628	T×F×A =2.303

Remarks: T1: surface tillage, T2: deep tillage, C1: control without N, F1: Ammonium nitrate, F2: urea formaldehyde, S: Sulphur, Comp: compost, KH: potassium humate, W: Sugar beet waste, T: tillage, F: Mineral fertilizers, A: amendment

Both surface and deep tillage have shown an impact on the wet aggregate distribution that ensures the significant effect of the studied amendments, including the K-humate, beet waste, compost, and Sulphur, on the soil physico-chemical characteristics. The amending materials have promoted the particles' aggregation as the greater aggregates sizes than 2.0 (S1), 2.0-1.0 (S2), 1.0-0.5 (S3), mm diameter were increased, while 0.5-0.25 (S4), 0.25-0.063 (S5), and smaller than 0.063 (S6) mm were decreased by adding the beet waste (W).

The beet waste addition has increased the fraction size > 0.5 mm while other amending additives have decreased the aggregates sizes in the fractions S5, S6, and S7 more than the control C1 in cases of surface and deep tillage. Small aggregate fractions that had ancient carbon perhaps formed macro aggregates. The macro aggregates keep soil OM compared with the mineral fertilizers or cont without OM and increased macro-aggregates (%) decreased the micro-aggregates (%) at the same time.

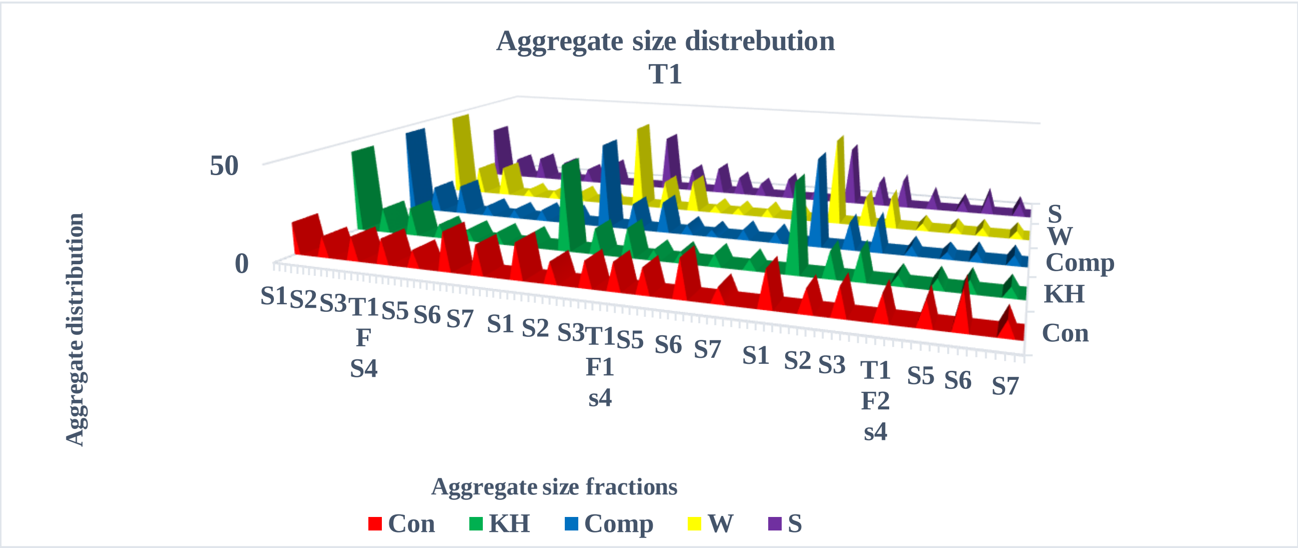

Figure 1. Aggregates size distribution after experiment as affected by surface tillage T1

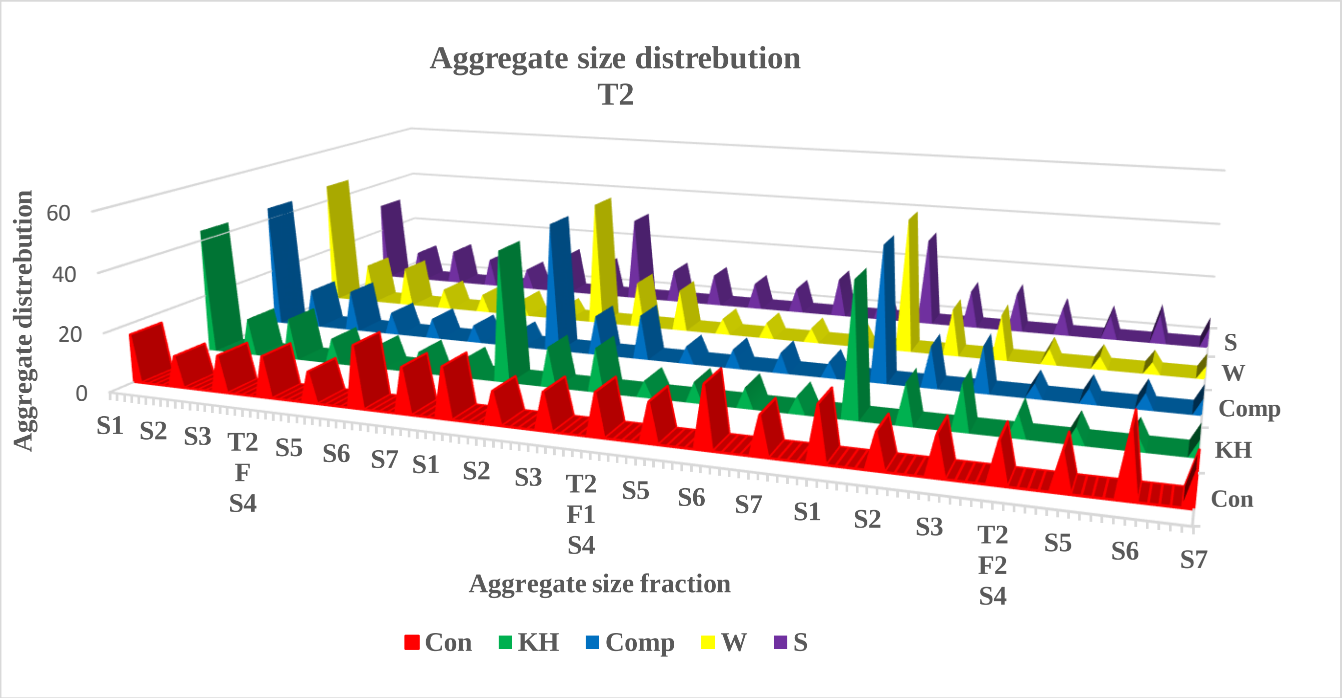

Figure 2. Aggregate size distribution after the experiment as affected by deep tillage T2

Remarks: Control: Cont.; Sugar beet waste: W; Compost: Comp.; S: Sulphur; KH: K-humate

3.1.3. Total soil porosity (%)

It has been found in Table 3 that deep tillage T2 led to a significant increase in the total pores' mean values in a comparison with the control C1: Con=51.28%, F1=51.81%, F2=51.58%, respectively. Oppositely, the surface tillage T1 didn't affected total pores significantly relative to the control C1 even with different types of fertilizers, i.e. mean values for T1: Con=51.93%, F1=52.0%, F2=51.81%, respectively.

However, the surface tillage T1 could produce a significant increase in the soil total porosity in comparison with the control C1 under the amending effect of soil-applied amendments as the compost (Comp) and Sugar beet waste (W) resulting in the most significant increase of mean values. Similar results were observed for the deep tillage T2 and they can be ordered based on their effect as follows: W> Comp > KH > S > Cont.

Consequently, the most significant increase of total soil porosity mean value (58.68%) has resulted from the complementary interactive effect of the deep tillage treatment T2 with the sugar beet waste W application for both cases; ammonium nitrate F1 and the urea-formaldehyde F2 (T2×F1×W andT2×F2×W).

3.1.4. Soil hydraulic conductivity

The deep tillage T2 has also exhibited a significant increase in the hydraulic conductivity mean values more the surface tillage T1 as shown in Table 3.

Additionally, the hydraulic conductivity values showed a slight and significant increase under the effect of the urea formaldehyde F2 in a comparison with the control in both cases of the surface and deep tillage T1 and T2 treatments, respectively. On the contrary, the deep tillage has

Table 4. The least significant difference ($LSD_{0.05}$) for the aggregate size distribution (size S1-S7) as affected by the studied treatments

Particles size	$LSD_{0.05}$ F	$LSD_{0.05}$ T	$LSD_{0.05}$ C
≥2mm(S1)	1.100	1.110	1.276
2 – 1mm (S2)	0.291	0.292	0.336
1 – 0.5mm (S3)	0.250	0.251	0.287
0.5 – 0.25mm (S4)	0.240	0.241	0.282
0.25 – 0.125mm (S5)	0.225	0.230	0.271
0.125 – 0.063mm (S6)	0.241	0.240	0.276
<0.063 mm (S7)	0.008	0.008	0.011

Remarks: F: Mineral fertilizers; T: Tillage; C: Compost

significantly affected the hydraulic conductivity with the application of the ammonium nitrate F1 and urea formaldehyde F2, which exhibited greater values in a comparison with the control where C1=12.45, F1=13.01, F2=13.34 cm3 h-1, respectively. The amending materials under study have produced a significant increase in the soil hydraulic conductivity mean values relative to the control for both surface tillage T1 and deep tillage T2 following the direction: Cont < S < KH < Comp < W.

Hence, the interactive effect that produced the maximum mean value of soil hydraulic conductivity (=16.31 cm^3 h^{-1}) has been obtained by the deep tillage T2 accompanied by the urea formaldehyde F2 and Sugar beet waste application (W) T2×F2×W.

3.2. Nitrogen N availability in soil as affected by different treatments

The mean values listed in Table 3 for the soil available N showed a significant increase due to the surface tillage T1 more than the deep tillage T2.

Also, a significant increase in the available N relative to the control due to the fertilization by the ammonium nitrate (F1) higher than the urea formaldehyde one (F2) in both surface (T1) and deep (T2) tillage treatments being: Con=46.72, F1=59.60, F2=56.29 mg kg^{-1} and Cont=33.58, F1=52.22, F2=49.60 mg kg^{-1} for T1 and T2, respectively. This may be due to the faster dissolution of the nitrate mineral salt in soil solution than the slow dissociation of the organic urea formaldehyde that provides the available N form more readily for the plant. So, the nitrate salt may be a more efficient N-fertilizer than the urea formaldehyde.

The soil available N values were significantly different affected by amendments in a comparison with the control for both surface and deep tillage treatments. The maximum significant increased mean value was resulted from the sugar beet waste treatment W = 59.35 mg kg^{-1} and 50.78 mg kg^{-1} in case of T1 and T2, respectively.

The overall maximum mean value has been observed due to the complementary interaction effect of the combined treatment surface tillage T1 plus ammonium nitrate F1 plus sugar beet wastes W (T1×F1×W = 65.14 mg kg^{-1}).

3.3. Nitrogen N concentration (%) and uptake by wheat plant as affected by the studied factors

Table 5 indicates a significant increase of the N content (%) and uptake (kg ha^{-1}) by the wheat plant greater than the control due to the treatments' applications.

The surface tillage T1 has resulted in a more significant increase of the N content and uptake than the deep tillage. Additionally, the combination of the ammonium nitrate application with the surface tillage has produced the maximum mean values of N content and uptake equal to 2.21% and 118.8 kg ha^{-1}, respectively relative to the control. This can be attributed to the additional N nutrient amount present in the type of N-fertilizer. The sugar beet waste combined with the surface tillage showed also a maximum mean value of N (%) equals 2.22% among the applied amendments. The triple combined treatment: surface tillage practice T1 plus ammonium nitrate F1 plus sugar beet waste (T1×F1×W) has resulted in the most significant increase in the N content equal to 2.31% due to the interaction between the three factors under study.

3.4. Yield (ton ha^{-1}) and some yield components of the wheat crop as affected by the studied factors

Table 5 reveals significant increases in the recorded values of the wheat 1000-grains wt. (g), grains and straw yields (ton ha^{-1}), and the relative increase of yield (RIY) greater than the control as a result of all treatments' applications.

The deep tillage treatment T2 has shown a more significant effect on the mentioned parameters than the surface tillage treatment T1. This can be attributed to the nature of the wheat roots distribution along with the increased OM% content and N-availability with the improved hydraulic conductivity. The enhanced structure status at the deep layers and breaking down the impervious soil layer was obtained by the subsoiler tillage that increases the aggregates susceptibility to formation so that they can keep and provide the nutrients released from decomposing the applied organic materials (El-Sedfy et al., 2023).

The combination between the fertilization by the ammonium nitrate with the deep tillage has produced the most significant increase in the mean values of the 1000-grains wt. (g), grains and straw yield (ton ha^{-1}), and RIY of the wheat crop being equal to 58.36 g, 5.88 ton ha^{-1}, 11.90 ton $ha^{-1,}$ and 28.95%, respectively. Such results are perhaps caused by the partially leached ammonium nitrate mineral fertilizer from the surface to the layer of soil to be accumulated in the deep soil layers. It contributes to the significantly enhanced grain yield of the wheat plant that, in turn, enhances the RIY compared to the control. The urea formaldehyde as a slow-release fertilizer may need some time to decompose and release the N nutrient as an available form easily absorbed by the plant during the 1st season.

In addition, the studied amendments caused significant increases in the mentioned yield parameters in comparison with the control. The greatest mean values of the 1000-grains wt. (g), grains and straw yield (ton ha^{-1}) as well as the RIY of wheat have been obtained by combined application of the sugar beet waste plus the deep tillage being equal to 63.29 g, 5.88 ton ha^{-1}, 11.69 ton $ha^{-1}$and 23.12%, respectively.

As expected, the most significant values obtained for the 1000-grains wt., (g), grains and straw yield (ton ha^{-1}) as well as the R.I.Y of wheat were due to the triple combined treatment applied: deep tillage T2 plus the ammonium nitrate F1 plus the sugar beet waste W (T2×F1×W) giving the values:

Table 5. The N content (%), uptake (kg ha^{-1}), 1000-grains wt. (g), grains and straw yield (ton ha^{-1}) of wheat crop as affected by factors under study

Treatments			**N (%)**	**N-uptake (kg ha^{-1})**	**1000-grains wt. (g)**	**Yield (ton ha^{-1})**		**RIY (%)**	
						Grains	**Straw**	**Grains**	**Straw**
T1	C1	Cont	1.76	75.6	46.83	4.30	7.46	-	-
		KH	1.96	87.96	53.90	4.49	8.35	4.47	11.90
		W	2.13	110.42	55.23	5.18	9.65	20.67	29.26
		Comp	2.05	100.37	54.42	4.90	9.36	13.97	25.40
		S	1.96	85.61	52.22	4.37	8.28	1.68	10.93
	Mean		1.97	91.99	52.52	4.57	8.62	8.16	15.50
	F1	Cont	2.11	91.66	50.96	4.39	10.18	-	-
		KH	2.25	125.28	54.80	5.57	10.58	26.78	4.01
		W	2.31	133.61	60.35	5.78	11.11	31.69	9.20
		Comp	2.25	125.28	57.90	5.57	10.73	26.78	5.42
		S	2.15	117.14	51.65	5.45	10.54	24.04	3.54
	Mean		2.21	118.8	55.13	5.35	10.63	21.86	4.43
	F2	Cont	2.02	95.50	47.96	4.73	8.98	-	-
		KH	2.10	109.87	53.99	5.23	10.30	10.66	14.71
		W	2.23	126.84	56.67	5.69	11.23	20.30	25.13
		Comp	2.15	117.14	56.33	5.45	10.68	15.23	18.98
		S	2.06	107.28	49.88	5.21	10.20	10.15	13.64
	Mean		2.11	111.34	52.97	5.26	10.27	11.27	14.50
T2	C1	Cont	1.47	65.98	47.87	4.49	8.54	-	-
		KH	1.55	74.04	53.96	4.78	9.46	6.42	10.67
		W	1.58	84.94	62.10	5.38	10.61	19.79	24.16
		Comp	1.55	80.35	60.02	5.18	10.25	15.51	19.94
		S	1.53	71.98	49.70	4.70	9.36	4.81	9.55
	Mean		1.54	75.46	54.73	4.90	9.65	9.31	12.86
	F1	Cont	1.74	79.34	53.63	4.56	11.16	-	-
		KH	1.76	106.87	58.34	6.07	11.90	33.16	6.67
		W	1.84	120.55	64.19	6.55	12.72	43.68	13.98
		Comp	1.78	112.34	61.74	6.31	12.34	38.42	10.54
		S	1.74	102.72	53.90	5.90	11.38	29.47	1.94
	Mean		1.77	104.38	58.36	5.88	11.90	28.95	6.63
	F2	Cont	1.81	86.45	50.93	4.78	10.30	-	-
		KH	1.81	102.53	54.08	5.66	10.82	18.59	5.13
		W	1.90	111.72	63.59	5.88	11.69	23.12	13.52
		Comp	1.90	108.98	60.65	5.74	10.92	20.10	6.06
		S	1.81	102.10	51.15	5.64	10.78	18.09	4.66
	Mean		1.84	102.36	56.08	5.54	10.90	15.98	5.87
	LSD$_{0.05}$	**(N %)**	T = 0.039	F = 0.043	A = 0.055	T×F×A = 0.136			
	LSD$_{0.05}$	**(N uptake)**	T = 0.939	F = 0.953	A = 1.230	T×F×A = 3.014			
	LSD$_{0.05}$	**(1000 weight)**	T =0.237	F = 0.244	A= 0.316	T×F×A =0.773			
	LSD$_{0.05}$	**Grains yield**	T=0.005	F = 0.011	A = 0.015	T×F×A =0.036			
	LSD$_{0.05}$	**Straw yield**	T = 0.036	F =0.046	A =0.059	T×F×A =0.145			

64.19 g, 6.55 ton ha^{-1}, 12.72 ton ha^{-1}, and 43.68%, for the mentioned parameters, respectively.

4. DISCUSSION

This research article presents a greatly important output ensures that organic conditioning additives obtained from agricultural wastes like the sugar beet cultivation are superior to inorganic conditioners to maintain the calcareous soil fertility status during the agronomic practices, which agree with previous studies (Tiwari, 2021).

The combined effect of the tillage treatments along with the role played by the decomposed organic materials and their decomposition products as binding agent has increased the aggregates re-formation and enhances the aggregation process and production with suitable structure parameters (El-Sedfy et al., 2023).The significant interactive effect of the tillage with thesugar beet waste and/or compost application were complementary to each other for enhancement of the soil OM content, aggregation, hydraulic conductivity, nitrogen availability, wheat yield and yield components compared to the control. The calcareous soil that is improved chemically and physically at the root zoon distribution has enhanced plant growth and development. The deep tillage and applied beet waste or compost helped to break the hard soil layers, enhanced the water movement within the soil, and increased the stored water for a longer time to be available for the plant roots. Consequently, the availability of soil nitrogen (N) increases. The sugar beet wastes, followed by the compost and then the K-humate, were the best-studied amendments that have exhibited the maximum significant enhancement of wheat yield (ton ha^{-1}) as well as the soil OM, aggregate size distribution (%), porosity (%), and hydraulic conductivity. A maximum OM mean values equal 1.26 and 1.14% could be produced via soil application of sugar beet waste W for surface and deep tillage. This has been reflected in the optimized N-nutrient availability and uptake by the wheat plant.

The mechanism of action through which the studied factors gave the obtained results can be defined in the light of previous studies output. There is a relationship between the soil aggregation and the OM content, biological activities, and soil processes (for example water infiltration, water holding capacity, aeration, and available nutrients). Aggregates size distribution: amount of large, medium, and small macro-aggregates (> 250 mm) and micro-aggregates (< 250 mm) affect the pores sizes and stability. Macro-aggregates usually contain greater amounts of OM and nutrients, resist erosion, and form large pores to enhance water infiltration and aeration compared to microaggregates. A soil containing stabilized macro-aggregates is usually better quality than the soil containing stablized micro-aggregate. Macro-aggregates formation and stabiliation is via biological processes, for instance roots and fungal hyphae and side-products of microbial synthesis and decay. So, above ground management such as tillage practicing, crops' rotations/sequence, fertilization, pesticides additions, and water managing affect macro-aggregation greater than micro-aggregation (Nichols & Toro, 2011). Several studies have been ensured that the incorporation of plant and/or organic wastes either processed like the compost or in raw form into the soil provided a stabilized form of the OM that are cementing agent bind the soil particles together so that enhances the soil physically. They enhance the soil water movement, holding capacity and hence enhanced water drain, and consequently; the available and uptake of nutrients by plants. This can be attributed to a slow OM decomposition that lead to soil restoration (Affandi et al., 2019). The humic substances addition also enhances the soil chemically, which can raise the contents of the organic carbon (C), available phosphorous (P) and total nitrogen (N) (Herviyanti et al., 2022; Rahayu et al., 2019). Economically, the sugar beet wastes can be recommended being more efficient to optimize the calcareous soil poor structure, low organic content, infertility, and low water retention and poor nutrient cycling because they are locally available and need to be eliminated to save the environment (Sukartono et al., 2022).

Organic conditioners and amendments from natural sources like beet waste and compost, being environment friendly, can encourage good microbial activity more than the K-humate as a favored long-term action enhances soil fertility and nutrient availability. When compared with inorganic, organic conditioners are ideal and effective in improving the calcareous soil fertile status for agricultural sustainability (Larney & Angers, 2012; Tiwari, 2021).

5. CONCLUSION

This study has indicated that the productivity of wheat under the calcareous soil conditions can be enhanced by enhancing the soil chemically and physically. Factors of this study were directed to enrich the OM (%) by application of different soil amendments, enhance the nitrogen N nutrient availability (being quickly depleted from soil) by application of two types of N-fertilizers, and improve the soil physical characteristics that control the cycle of water and nutrients during the plant growth season by testing two depths of tillage. It has been found that the combined application of the sugar beet waste with both surface (0 – 15 cm) and deep (0 – 60 cm) tillage and either with the ammonium nitrate or the urea formaldehyde as N fertilizers has significantly enhanced the estimated properties of the calcareous soil together with its wheat yield (ton ha^{-1}) compared to the application of the K-humate, compost and Sulphur. The soil organic content, total pores, hydraulic conductivity, and aggregates size distribution were significantly improved in a comparison with the control treatments. The dual effective utilization of the sugar beet waste as an organic conditioner to enhance the calcareous soil physical and chemical characteristics can be promising as an economic and environment friendly partial alternative for the mineral fertilizers needed under such soil conditions. The optimized tillage practicing along with such wastes can be more effective than the traditional application of the K-humate and compost.

Declaration of Competing Interest

The authors declare that no competing financial or personal interests may appear to influence the work reported in this paper.

References

Affandi, Z., Purnomo, D., & Supriyono, S. (2019). A Study of Light Intensity and Fertilizer on Soybean in Albizia chinensis Agroforestry System. *Sains Tanah Journal of Soil Science and Agroclimatology*, *16*(1), 46-56. https://doi.org/10.20961/stjssa.v16i1.25872

Ahmed, A. R. (2018). An attempt for ameliorating the calcareous soil behaviour and its productivity. *Nature and Science*, *16*(8), 16-25. https://www.sciencepub.net/nature/ns160818/03_33697nsj160818_16_25.pdf

Ahmed, A. r., Ismail, A. O. A., & Helmi, M. Y. (2022). Raising the Efficiency of Calcareous Sandy Loam Soil Production by Applying Organic Low Economic Value. *Middle East Journal of Applied Sciences*, *12*(02), 125-135. https://www.curresweb.com/index.php/MEJAS1/article/view/93

Ali, A., Usman, M., & Adaikwu, A. O. (2018). Effect of Tillage Methods on Soil Properties, Growth and Yield of Maize (Zea mays L.) in Makurdi, Nigeria. *International Journal of Science and Healthcare Research*, *3*(1), 48-55. https://ijshr.com/IJSHR_Vol.3_Issue.1_Jan2018/IJSHR008.pdf

El-Basioni, S., Hassan, H., & Rashad, R. T. (2015). Effect of magnetic iron oxide combined with some additives on the yield of groundnut, wheat and nutrient availability in sandy soil. *Egyptian Journal of Soil Science*, *55*(4), 441-452. https://doi.org/10.21608/ejss.2015.1561

El-Gamal, B. A., Khalafallah, N. E., & El-Kafrawy, M. M. (2020). Impact of sulphur and biochar applications on soil properties and productions of wheat and soybean yields in soils having texture. *Menoufia Journal of Soil Science*, *5*(9), 235-265. https://doi.org/10.21608/mjss.2020.172391

El-Hassanin, A. S., Samak, M. R., Ahmed, S. M., Afifi, M. M. I., & Abd El-Satar, A. M. (2022). Bioaccumulation of heavy metals during composting and vermicomposting processes of sewage sludge. *Egyptian Journal of Chemistry*, *65*(132), 1155-1162. https://doi.org/10.21608/ejchem.2022.162620.6973

El-Hassanin, A. S., Samak, M. R., El-Ashry, S. M., Azab, N. A., & Abou-Baker, N. H. (2021). Comparative Performance of some Slow Release Coated Nitrogen Fertilizers on Lettuce and Cabbage Plants Grown in Sandy Soil. *Plant Cell Biotechnology and Molecular Biology*, *22*(23-24), 146-159. https://ikprress.org/index.php/PCBMB/article/view/6154

El-Hassanin, A. S., Samak, M. R., El-Hady, O., El-Dewiny, C., & Mostafa, F. E.-S. (2022). Impact of Biochar and Hydrogel Amendments on Hydrophysical Properties of Sandy Soil and Cowpea Yield (*VignaUnguiculata* L.) Under Different Water Regimes. *Egyptian Journal of Chemistry*, *65*(4), 487-497. https://doi.org/10.21608/ejchem.2021.97083.4542

El-Sedfy, O. F., Abd El-Rahman, Z. M., & Rashad, R. T. (2023). The Combined Effect of the Tillage Depth and Compost Application on Calcareous Soil Aggregates and The Yield of Intercropped Faba Bean with Wheat. *Plant Physiology and Soil Chemistry*, *3*(2), 40-48. https://doi.org/10.26480/ppsc.02.2023.54.62

FAO. (2016). *Management of calcareous soils*. https://www.fao.org/soils-portal/soil-management/management-of-some-problem-soils/calcareous-soils/ar/

Herviyanti, Maulana, A., Lita, A. L., Prasetyo, T. B., Monikasari, M., & Ryswaldi, R. (2022). Characteristics of inceptisol ameliorated with rice husk biochar to glyphosate adsorption. *Sains Tanah Journal of Soil Science and Agroclimatology*, *19*(2), 11. https://doi.org/10.20961/stjssa.v19i2.61614

Larney, F. J., & Angers, D. A. (2012). The role of organic amendments in soil reclamation: A review. *Canadian Journal of Soil Science*, *92*(1), 19-38. https://doi.org/10.4141/cjss2010-064

Nichols, K. A., & Toro, M. (2011). A whole soil stability index (WSSI) for evaluating soil aggregation. *Soil and Tillage Research*, *111*(2), 99-104. https://doi.org/10.1016/j.still.2010.08.014

Piper, C. S. (2019). *Soil and plant analysis. Scientific Publishers*. https://www.scientificpubonline.com/bookdetail/soil-plant-analysis/9788172336202/0

Rahayu, Syamsiyah, J., Cahyani, V. R., & Fauziah, S. K. (2019). The Effects of Biochar and Compost on Different Cultivars of Shallots (Allium ascalonicum L.) Growth and Nutrient Uptake in Sandy Soil Under Saline Water. *Sains Tanah Journal of Soil Science and Agroclimatology*, *16*(2), 13. https://doi.org/10.20961/stjssa.v16i2.34209

Sukartono, Kusumo, B. H., Suwardji, S., Bakti, A. A., Mahrup, M., Susilowati, L. E., & Fahrudin, F. (2022). Influence of biochar amendments on the soil quality indicators of sandy loam soils under cassava–peanut cropping sequence in the semi-arid tropics of Northern Lombok, Indonesia. *Sains Tanah Journal of Soil Science and Agroclimatology*, *19*(2), 6. https://doi.org/10.20961/stjssa.v19i2.65452

Tiwari, A. K. (2021). Comparative Analysis of Organic Farming Practices: Impacts on Soil Health, Crop. *Plant Science Archives*, *6*(1). https://doi.org/10.51470/PSA.2021.6.1.01