 Egyptian J. Desert Res., **72**, No. 1, 89-105 (2022)

COMPARATIVE STUDY BETWEEN CERAMIC WASTE DUST AND FARM YARD MANURE FOR IMPROVING PROPERTIES AND PRODUCTIVITY OF SANDY SOIL

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A field experiment was carried out on sandy soils located at south of El-Qantara East station, North Sinai, Egypt. The study aimed at investigating the effect ceramic waste dust (CWD) or farmyard manure (FYM) on some soil's physical and chemical properties and the yield of cultivated wheat. The treated materials were used at the rates of 0, 25, 50, 100 and 150 Mg ha^{-1}. The obtained data revealed that soil pH, EC, bulk density, penetration resistance, and hydraulic conductivity decreased with increasing application rates of either CWD or FYM, while, the OC, maximum water holding capacity was increased. The obtained results showed that wheat grain yield increased with increasing either CWD or FYM at rates up to 150 Mg ha^{-1}. The average yields were 1.61, 2.79, 4.28, 6.28, and 7.65 Mg ha^{-1} for CWD addition rates of 0, 25, 50, 100, and 150 Mg ha^{-1}, respectively. While, they reached 1.61, 2.71, 3.84, 4.87, and 6.10 Mg ha^{-1} for FYM additions at the same rates, respectively. Statistical analysis showed that a quadratic function fitted the relationships between CWD, FYM rates, and wheat grain (r = 0.99^{**} and 0.99^{**}, respectively). Differential's method of the quadratic equation obtained was used to find the predicted values of a critical level of rate amendments which were 239 and 221 Mg ha^{-1} for CWD and FYM, respectively.

Keywords: ceramic waste dust, farmyard manure, soil amendments, soil chemical, sandy soil, physical properties

INTRODUCTION

Soil is a dynamic natural system that lies at the interface between earth, air, water, and life, providing critical ecosystem service for the sustenance of humanity (Needelman, 2013). Soil quality may quickly deteriorate because of the intensive management, stabilizing with time under proper management, and improving in a long time by supplying organic matter. A decline in soil organic matter under intensive farming systems is a major cause of soil fertility loss worldwide. Organic matter plays a critical role in the soil ecosystem because it provides substrates for decomposing soil microbes improving soil structure and water holding capacity (Abiven et al., 2009 and Bonanomi et al., 2010), and reducing heavy metal toxicity (Park et al., 2011). In this scenario, a recovery of depleted soil organic matter and its maintenance to an adequate level is a needed task. It has been shown that the application of organic amendments such as compost is a reliable and effective tool to ameliorate soil structure and both chemical (Scotti et al., 2013) and biological fertility of soils (Ros et al., 2003), as well as to suppress soil-borne pathogens (Zaccardelli et al., 2013).

The global production of ceramic waste dust during the surface leveling of the ceramic before the final polishing phase of ceramic tiles is around 22 billion tonnes, the application of ceramic waste dust in waste sites could create major environmental issues for soil, water, and climate, it has been calculated that about 30% of the daily growth in the ceramic industry goes to waste (Iravanian and Saber, 2020). The ceramic products are produced from natural materials containing a high proportion of clay content. Following a process of dehydration and controlled firing at temperatures between 700ºC and 1000ºC, these minerals acquire the characteristic properties of fired clay (Chen and Felix, 2015). Ceramic waste dust is rich in organic and inorganic plant nutrients (Elias et al., 2014) and addition of ceramic waste in sand soil reduced maximum dry density value and increases optimum moisture content value (Sharma, 2020). Previous research has shown that the clay amendment has been recommended to be quite effective. Also, the clay amendments have a very significant effect to ameliorate the physicochemical character in sandy soil. The application of clay amendment in sandy soil increases fertility with the essential element when the percentage of bentonite is over greater than 5% in sandy soil (Karbout et al., 2015). Rajamannan et al. (2013) investigated the effect of the addition of ceramic waste to clay materials and concluded from chemical, mineralogical, and morphological analyses, that water absorption and compressive strength tests show that ceramic waste can be added to the clay material without detrimental effect, thus enhancing the possibility of its reuse safely and sustainably. Therefore, this study focuses on the effects of ceramic waste dust and farmyard manure applications on some physical properties of sandy soil and evaluates their effects on wheat yield.

MATERIALS AND METHODS

This study was conducted in El-Qantara East, North Sinai, located between latitudes of 30º 46' 32" - 30º 51' 25" N and longitudes of 32º 22' 31" - 32º 27' 38" E. Soil analysis of the experimental site and the tested soil amendment materials of ceramic waste dust (CWD) or farmyard manure (FYM) were carried out and and presented in table (1). Ceramic waste dust was produced of ceramic industry and brought from a factory in 10th Ramadan City, Egypt.

Table (1). Selected chemical and physical characteristics of the studied sandy soil and the tested amendments.

Parameter	pH	EC_e (dS m^{-1})	OC (g kg^{-1})	Bulk density (Mg m^{-3})	$CaCO_3$ (g kg^{-1})	Particle size distribution: Fine sand %	Coarse sand %	Silt %	Clay %	Texture class
Soil at depth 0-20 cm	7.98	7.56	1.97	1.66	11.0	45.28	46.72	4.8	3.2	Sand
CWD	7.54	1.73	29.93	1.08	5.50	1.97	1.73	27.8	68.5	Clay
FYM	6.84	1.16	278.5	0.78	2.56	--		--		--
Total content of some elements of soil amendments										
Parameter	**N (g kg^{-1})**	**P (g kg^{-1})**	**K (g kg^{-1})**	**Fe (mg kg^{-1})**	**Mn (mg kg^{-1})**	**Zn (mg kg^{-1})**	**Cu (mg kg^{-1})**	**Pb (mg kg^{-1})**	**Cd (mg kg^{-1})**	**Ni (mg kg^{-1})**
CWD	13.20	5.78	13.16	210	4.12	4.23	1.37	0.69	0.004	0.02
FYM	17.10	3.57	11.22	89	2.73	1.55	1.23	0.55	0.003	0.03

Explanations: CWD: ceramic waste dust; FYM: farmyard manure; pH in soil suspension and EC_e in soil paste extract

The experimental design was a randomized complete block, with 5 replicates. Each block (3 × 3 m^2) was split for randomized two soil amendments either CWD or FYM at use rates of 0, 25, 50, 100, and 150 Mg ha^{-1}. Either ceramic waste dust or farmyard manure (FYM) was incorporated with the surface soil layer (0-10 cm). The field experiment comprised 2 soil amendments at different 5 rates for each amendment with 5 replicates of each rate.

Wheat grains (*Triticum a esitivum* L.) c.v. Giza 171 were sown on November 22th in the 2019/2020 season; at the rate of 144 kg ha^{-1} by hand drilling in rows. The recommended rates of N, P and K were applied for all plots; also the cultivation practices were followed as the recommendation of the Ministry of Agriculture and Land Reclamation, Egypt.

Wheat was harvested at end of June. Whole plants were taken at harvest from each plot to determine grain yield. The disturbed and undisturbed soil sample from each plot was taken from 0-10 cm depth to determine some physical and chemical soil properties. Particle size distribution was determined by the pipette method, using sodium hexametaphosphate as a dispersing agent (Kroetsch and Wang 2007). Bulk density (BD) at 0-10 cm depth was determined using the core methods as described by Blake (1986). For the measurement of penetration resistance (Pen.), a standard cone penetrometer was used. Pen. measurements were repeated six times in each plot (ASAE, 1993). Saturated hydraulic conductivity (HC) for the undisturbed soil samples was determined according to Klute (1986). Maximum water holding capacity was determined according to the technique described by Stolte et.al. (1992). The soil water extract components were determined in the soil paste extract, and the following determinations were carried out by using the standard methods of analysis according to Jackson (1973). The total soluble salts were determined using the EC meter. Soil reaction (pH) was determined in the soil paste according to Richards (1954). Organic matter was determined by the modified Walkley and Black method (Jackson, 1973).

RESULTS AND DISCUSSION

1. Soil Chemical Properties

1.1. Soil pH

The ceramic waste dust and the FYM had a neutral reaction (Table 1). Table (2) and fig. (1) show that soil pH very slightly decreased (from 7.91 to 7.82) adding ceramic waste dust compared to the soil control (without soil amendments). Also, soil pH slightly decreased (from 7.91 to 7.75) for FYM compared to the soil control. This may be attributed to the production of organic acids, CO_2 and hydrogen ions (H^+). These results are in agreement with those obtained by Babbu et al. (2015) and Abdel-Aal (2015), who found that the pH values decreased with applying organic fertilizers.

Table (2). Effect of CWD and FYM rates on some soil chemical properties.

Treatments	Rate (Mg ha^{-1})	pH	ECe (dS m^{-1})	OC (g kg^{-1})
Control	0	7.91	6.26	1.82
CWD	25	7.89	5.76	2.23
	50	7.88	5.48	2.39
	100	7.86	5.08	2.55
	150	7.82	4.69	2.79
FYM	25	7.84	5.91	2.54
	50	7.82	5.64	2.87
	100	7.79	5.33	3.22
	150	7.75	4.96	3.71
LSD $_{(0.05)}$		0.025	0.029	0.026

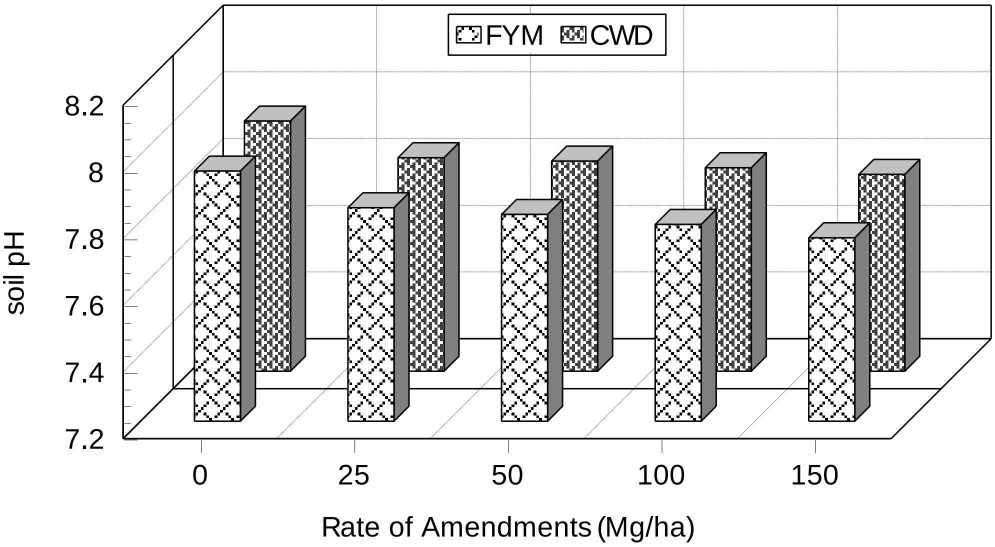

Fig. (1). Effect of CWD and FYM on pH in soil surface layer.

1.2. Soil salinity EC_e

The effect of ceramic waste dust and FYM rates on EC_e of the soil is shown in fig. (2). The EC_e values decreased from 6.26 dS m^{-1} to 4.69 dS m^{-1} for ceramic waste and from 6.26 dS m^{-1} to 4.96 dS m^{-1} for FYM, respectively. The EC_e values were decreased with increasing the applied rates of ceramic waste dust and FYM, compared to the control.

The percentage of decrement in EC_e values relative to the control reached 7.98, 12.46, 18.84 and 25.07% due to the applying ceramic waste dust to the soil at the rates of 25, 50, 100 and 150 Mg ha^{-1}, respectively, while the respective decrement relative the control reached 5.59, 9.04, 14.85 and 20.70% due to FYM application rates (Table 2). The positive effect of ceramic waste dust and FYM in decreasing the soil salinity may be due to their effectiveness in increasing the ability of the soil to hold water. Therefore, more soluble salts will have the chance to be leached out from the soil surface layer by the following irrigation.

In this respect, ElCossy (2021) found that the soil EC_e values were decreased from 7.56 dS m^{-1} to 5.13 dS m^{-1} with increasing the applied rates FYM, compared to the control.

1.3. Soil organic carbon (OC)

Data in table (2) and fig. (3) show that the soil OC increased as ceramic waste dust or FYM rate increased. The percentage of increment reached 22.52, 31.31, 40.19 and 53.29% for ceramic waste dust and 39.56, 57.69, 76.92 and 103.84% for FYM relative to the soil control value due to the increase in ceramic waste dust and FYM rates of 25, 50, 100 and 150 Mg ha^{-1}, respectively. These results are in agreement with those obtained by

ElCossy (2021), who found that the soil OC increased by increasing the juice pomegranate waste (JPW) and FYM rates. The percentages of increment reached 28, 44, 51 and 60% for JPW and 15, 33, 39 and 53% for FYM due to the increase in JPW and FYM rates from 0 to 25, 50, 100 and 150 Mg ha^{-1}, respectively.

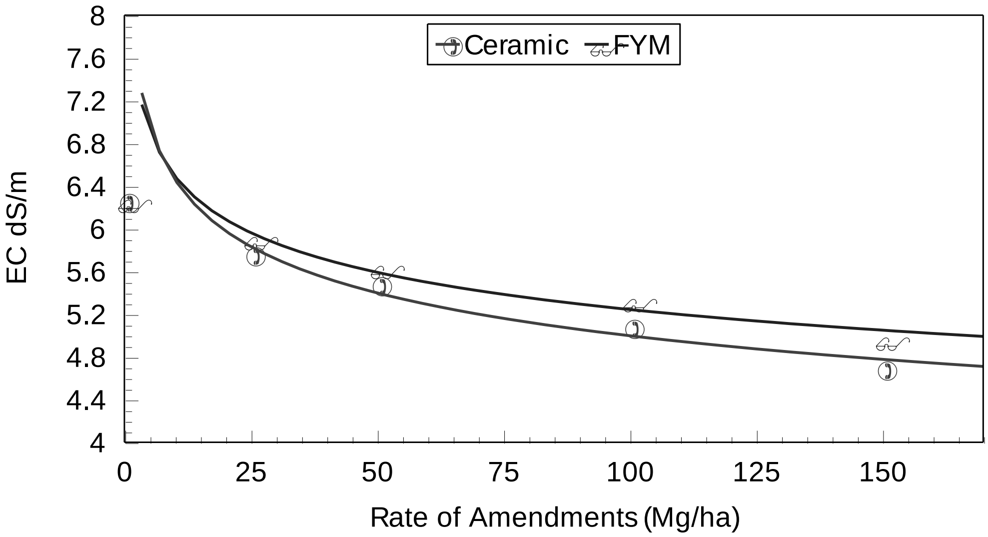

Fig. (2). Effect of CWD and FYM rates on soil salinity (EC_e) in soil surface layer.

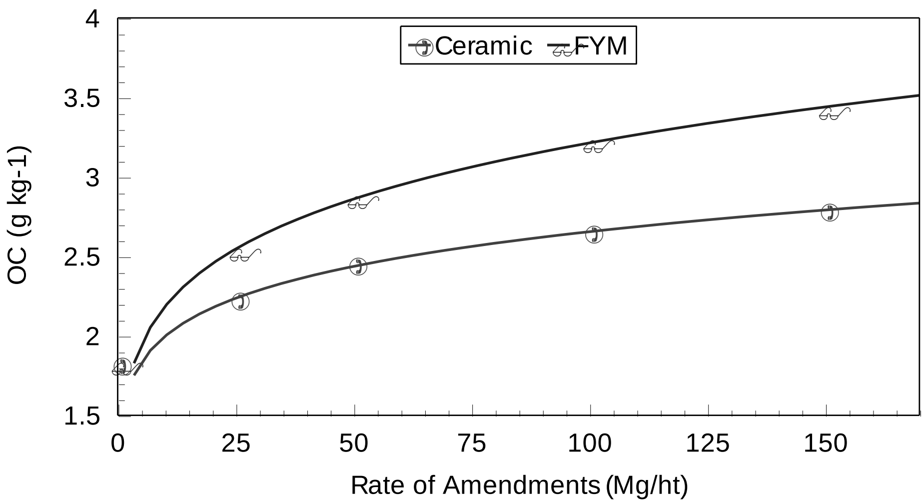

Fig. (3). Effect of CWD and FYM rates on OC in soil surface layer.

In this respect, Ali and Mubarak (2013) concluded that the amelioration process of nutrients poor sandy soil through mixing with organic amendments could be useful whereas; mixing of mud with nutrient-poor sandy soil had increased its organic matter content, water holding capacity, cation exchange capacity, and N content. Also, they recommended that since mixing sandy soils with mud proved to be a good amendment, attention should be directed towards utilizing this material in the improvement of sandy soils.

Moreover, Tahir and Marschner (2016) confirmed that clay addition to sandy soil increases soil organic carbon retention compared to sandy soil alone. The newly formed peds can also influence nutrient cycling and bind organic C, which may explain why ped size did not have a consistent effect on soil respiration and nutrient availability.

2. Selected Soil Physical Properties

2.1. Bulk density

Results show that soil bulk density values of soil surface layer for the treatments of CWD and FYM were significantly lower than the control treatment (Table 3 and fig. 4). This could be attributed to the effect of the low bulk density of both ceramic waste dust and FYM. These results are in agreement with those obtained by Khan et al. (2019), who found that the applied farmyard manure decreased the bulk density of soil.

Moreover, data show that the mean bulk densities were decreased with increasing application rates of ceramic waste dust and FYM. The reduction percentages in Bd values of soil surface layer relative to the soil control were 11.90, 14.28, 18.45 and 22.61% for ceramic waste dust rates 25, 50,100 and 150 Mg ha^{-1}, respectively, while, they were 18.33.10.11, 14.28, and 18.45% at FYM rates 25,50,100 and 150 Mg ha^{-1}, respectively. This clearly shows the adverse effect of increasing application rates of ceramic waste dust and FYM on soil bulk density.

2.2. Soil penetration resistance

The soil penetration resistance is a good indicator of the soil's physical properties, the decrease in penetration resistance allows the plant roots for easy penetration into the soil. The results show that a significant decrease in soil penetration resistance was accompanied by an increase in the rates of CWD and FYM (Table 3 and fig. 5). These results are in agreement with those obtained by Abou Yuossef and El-Eweddy (2010), who found that the application of amendments (Bokashi and FYM) significantly decreased soil penetration resistance, which accompanied by an increase in the rates of amendments.

2.3. Maximum water holding capacity, MWHC

Incorporating ceramic waste dust and FYM with surface soil could enhance soil's physical properties. Data in table (3) and fig. (6) illustrate that the effects of CWD and FYM rates on maximum water holding capacity were significant as they increase with increasing CWD and FYM rates. The relative increases in the maximum water holding capacity were 30.59,51.05, 96.17 and 155.44% for CWD additions rates of 25, 50, 100 and 150 Mg ha^{-1}, respectively. While they were 4.01. 17.20, 60.42. and 108.98% for FYM additions at the same rates, respectively. These results are in agreement with those obtained by Bassouny and Abuzaid (2017), who found that application rates of biogas slurry increase the water holding capacity in sandy soil increased by increasing the rate of biogas slurry.

2.4. Saturated hydraulic conductivity

Concerning the effect of CWD and FYM rates on soil saturated hydraulic conductivity, data presented in table (3) and fig. (7) show a decrease in the hydraulic conductivity with the increase of soil amendments application rates.

The relative decreases in hydraulic conductivity were 13.63, 23.69, 39.16 and 46.55% on an average base due to the increase in ceramic waste dust application rates from 0 to 25, 50, 100 and 150 Mg ha^{-1}, respectively. While, the relative decreases in hydraulic conductivity were 9.97, 20.17, 30.71 and 41.53% on an average base due to the increase of FYM application rates from 0 to 25, 50, 100 and 150 Mg ha^{-1}, respectively.

In this respect, Abd El-Hady and Eldardiry–(2016) found that the application of bentonite deposits to sandy soil decrease hydraulic conductivity from 9.75 to 1.75 cm h^{-1} and intrinsic permeability improved from 11.63 to 2.09 m^2.

Table (3). Effect of CWD and FYM rates on soil bulk density (Bd), penetration resistance (Pen.), maximum water holding capacity (MWHC), and saturated hydraulic conductivity (K_{sat}) in soil surface layer.

Type of amendment	**Rate (Mg ha^{-1})**	**Bd (Mg m^3)**	**Pen. (Kpa)**	**MWHC (%)**	**HC (cm h^{-1})**
Control	**0**	1.68	9.87	5.23	21.16
CWD	**25**	1.48	7.74	6.83	18.27
	50	1.44	6.59	7.90	16.14
	100	1.37	5.23	10.26	12.87
	150	1.30	3.90	13.36	11.31
FYM	**25**	1.54	8.59	5.44	19.05
	50	1.51	7.27	6.13	16.89
	100	1.44	589	8.39	14.66
	150	1.37	4.44	10.93	12.35
***LSD* (0.05)**		0.029	0.118	0.320	0.215

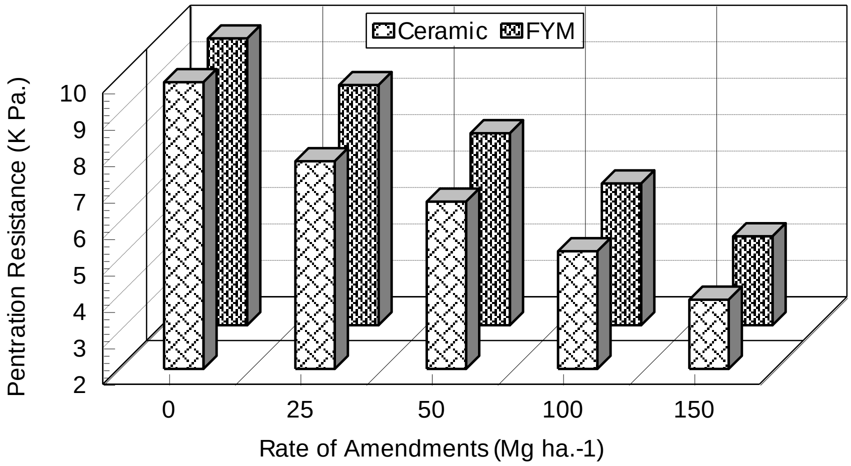

Fig. (4). Effect of CWD and FYM rates on bulk density of soil surface layer.

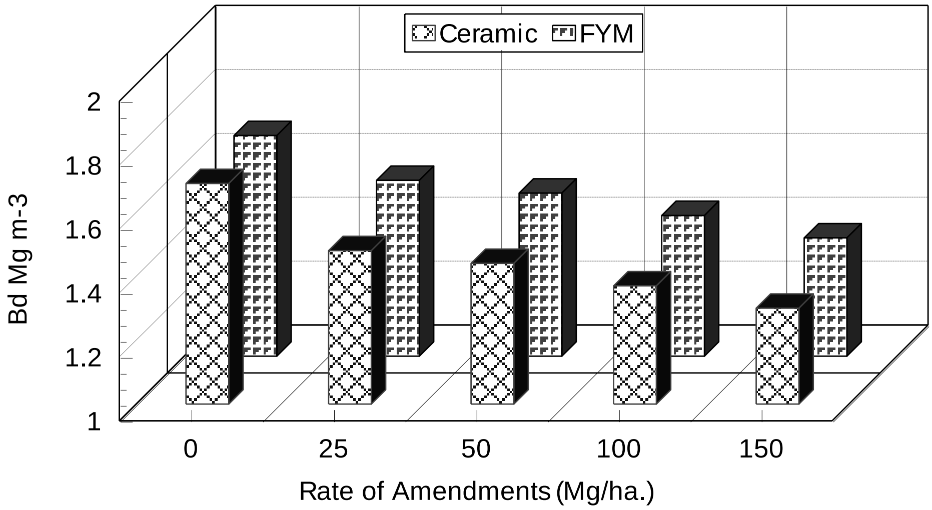

Fig. (5). Effects of CWD and FYM applications on penetration resistance of soil surface layer.

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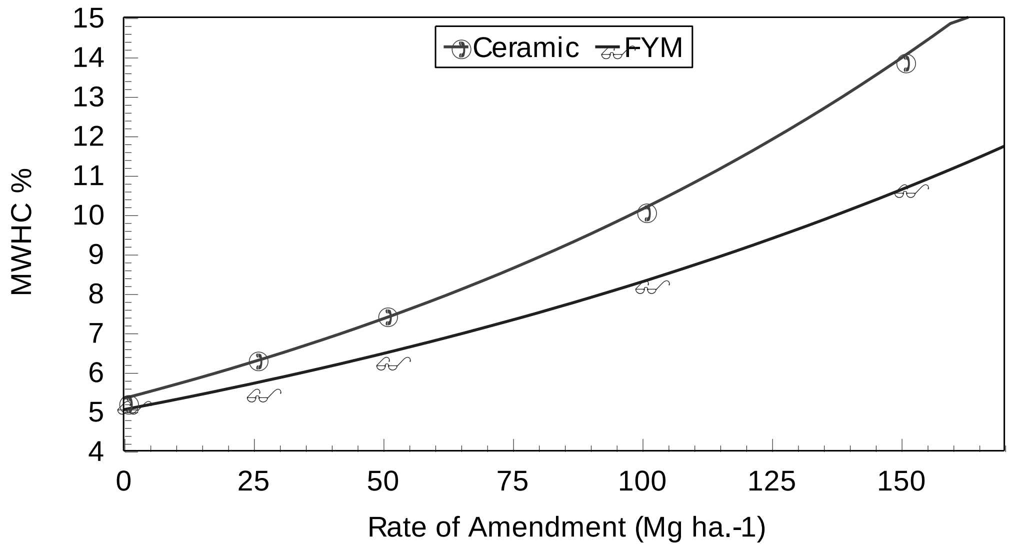

Fig. (6). Effects of CWD and FYM applications on MWHC of soil surface layer.

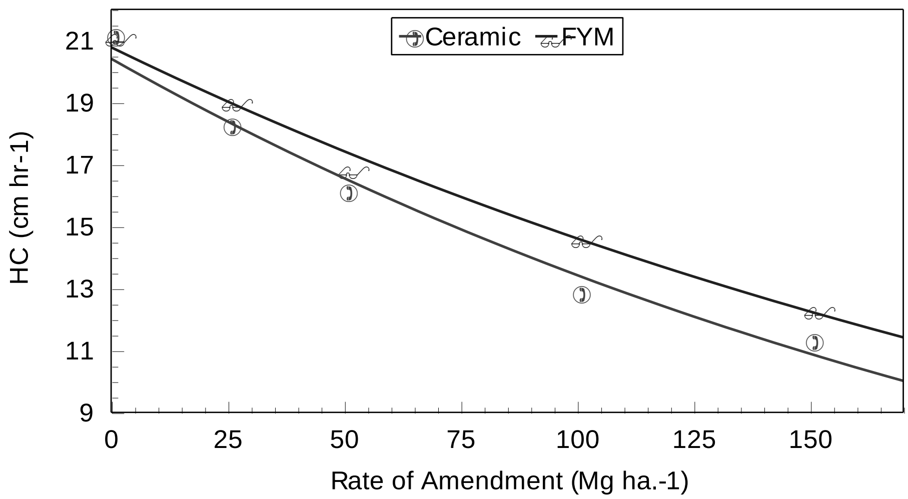

Fig. (7). Effect of CWS and FYM applications on saturated hydraulic conductivity of soil surface layer.

3. Wheat Grain Yield

Data in table (4) represent the response of wheat grain yield to CWD and FYM applications. The applications of CWD and FYM at studied rates of 25, 50, 100 and 150 Mg ha^{-1} significantly increased the wheat grain yield.

Maximum yield was achieved with the application of 150 Mg ha^{-1} of CWD. These results are in agreement with those obtained by ElCossy (2021), who found that the average yields reached 2.44, 3.29, 4.07 and 4.99 Mg ha^{-1} for FYM addition rates of 25, 50, 100 and 150 Mg.ha^{-1}, respectively.

Referring to the data presented in table (4) and visualized in fig. (8), the difference between CWD and FYM as used was significant and increased with increasing application rates. Moreover, all-ceramic waste dust treatments increased grain yield by an average of 73.14, 165.70, 289.66 and 374.36% relative to control with the application of CWD at rates of 25, 50,100 and 150 Mg ha^{-1}, respectively. While, an increase in grain yield was observed by an average of 67.97, 138.01, 202.27 and 278% relative to control with the application FYM at rates of 25, 50,100 and 150 Mg ha^{-1}, respectively.

Statistical analysis of the data in table (4) and fig. (8) shows a highly significant effect of application rates of CWD and FYM at the grain yield. Such effect was more pronounced with the CWD as compared to the FYM at all application rates.

The relationships between CWD and FYM rates and wheat grain production were fitted using the best fitting equation in table (5).

Table (4). Wheat grain yield (Mg ha^{-1}) as affected by application rates of studied soil amendments.

Type of amendment	**Rate of added amendment (Mg ha^{-1})**	**Grain yield (Mg ha^{-1})**
Control	0	1.61
CWD	25	2.79
	50	4.28
	100	6.28
	150	7.65
FYM	25	2.71
	50	3.84
	100	4.87
	150	6.10
LSD	0.146	

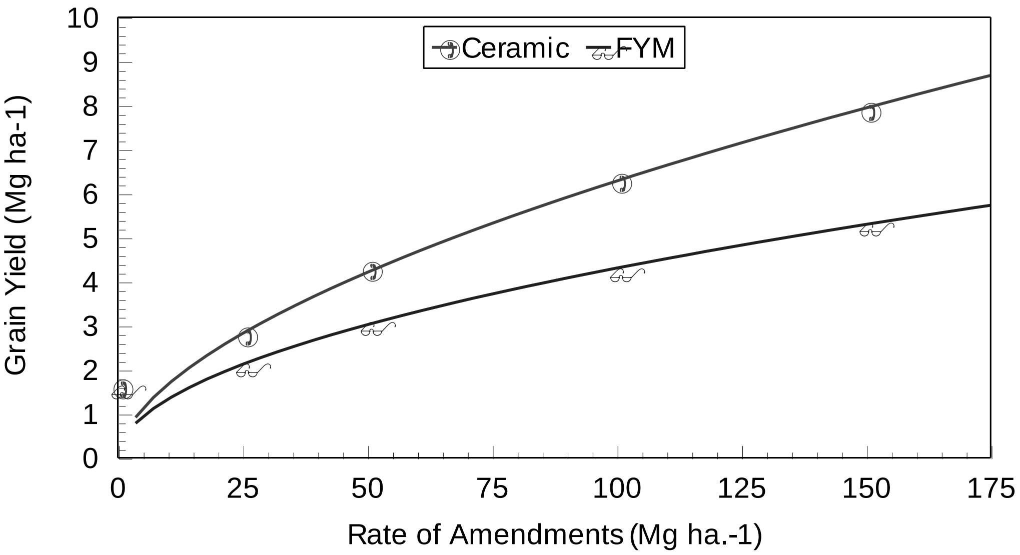

Fig. (8). Effect of CWD and FYM applications on grain yield.

Table (5). Regression equations and correlation coefficients (r) between CWD and FYM rates and yield of wheat grain.

Type	**Equation**	**r**
Quadratic	Grain = 1.506 +0.0598 x CWD rate – 1.251e^{-4} x CWD ratre^{2}	0.99^{**}
	Grain = 1.650 + 0.021 x FYM rate + 4.97e^{-5} x FYM rate^{2}	0.99^{**}
Square-root	Grain = 1.002+0.501x CWD rate $^{1/2}$	0.96^{**}
	Grain = 1.016+ 0.349 x FYM rate $^{1/2}$	0.92^{**}
Inverse	Grain = 7.884-138.374/ CWD rate	0.94^{**}
	Grain =5.768 – 99.152/ FYM rate	0.87^{**}
Power	Grain = 0.422 x CWD rate $^{0.583}$	0.98^{**}
	Grain = 0.351 x FYM rate $^{0.555}$	0.98^{**}
Exponential	Grain =2.034 x e$^{(0.0099 \text{ x CWD rate})}$	0.94^{**}
	Grain = 1.752 x e$^{(0.008\text{x FYM rate})}$	0.96^{**}
Logarithmic	Grain = - 6.306 + 2.756 x ln (CWD rate)	0.97^{**}
	Grain = - 4.691 + 2.044 x ln (FYM rate)	0.95^{**}
Liner	Grain = 1.849 + 0.040 CWD rate	0.97^{**}
	Grain = 1.514+ 0.029 FYM rate	0.97^{**}

****:** Significant at 1%

The analysis showed that a quadratic function fitted the relationship between either CWD or FYM rates and wheat grain yield ($r = 0.94^{**}$) as compared to the other equations. The correlation obtained for the quadratic relationship between either CWD or FYM rates (Mg ha^{-1}) and wheat grain (Mg ha^{-1}) is as follows:

Grain Yield = 1.506 + 0.0598 x CWD rate -0.000125 x CDW rate$^{\wedge 2}$, [1]
Grain Yield = 1.650 + 0.021 x FYM rate +0.000049 x FYM rate$^{\wedge 2}$, [2]

This indicates that yield increase was attributable to additional amendment additions. Differential's method of quadratic regression (equation [1] and [2]) was used to find the predicted values of the critical rate of the amendment, as the critical level represents the rate where a further change in the yield results in a reduction in the yield. In this respect, the differential quadratic regression (equation [1] and [2]) is as follows:

dy/dx = 0.0598 - 0.00025 CWD rate [3]
dy/dx = 0.02173 + 0.000098 FYM rate [4]

The value for the critical level reached 239 and 221 Mg ha^{-1} for CWD and FYM, respectively, increasing this rate of addition the yield will decline. Moreover, by observation of this data set, it can be said wheat grain yield increased up to 8.66 and 8.38 Mg ha^{-1} in either ceramic waste dust or FYM treatment, respectively, and then decreased with further increase in amendment rates value.

A highly significant correlation coefficient was found between wheat grain yield, when amended by CWD, and either pH (r = -0.92**), EC r = -0.98**), OC (r = 0.95**), bulk density (r = -0.92**), penetration resistance (r = -0.97**), hydraulic conductivity (r = -0.99**) or maximum water holding capacity (r = 0.97**). Moreover, A highly significant correlation coefficient was found between wheat grain yield, when amended soil by FYM, and either pH (r = -0.90**), EC r = -0.97**), OC (r = -0.74**), bulk density (r = -0.91**), penetration resistance (r = -0.96**), hydraulic conductivity (r = -0.97**) or maximum water holding capacity (r = 0.97**). Also, the multiple regression relating the wheat grain yield to some soil properties and amending soil by either CWD or FYM rates yields the following equation:

Grain yield = - 17.154 + 0.128 pH - 0.997 EC + 0.0963 OC + 0.1087 Bulk density – 1.127 Penetration resistance – 0.1415 Hydraulic conductivity - 1.11491 Maximum water holding capacity + 1.8719 CWD rate

Grain yield = -19.618 – 0.367 pH - 0.1537 EC + 0.1480 OC – 0.0879 Bulk density – 0.1859 Penetration resistance – 0.1880 Hydraulic conductivity + 0.0678 Maximum water holding capacity + 0.1250 FYM rate

The multiple correlations were highly significant (R = 0.997** and R = 0.993**, respectively) this means that 99.54 and 98.7% of the variations in wheat grain yield, when amended soil by CWD and FYM, could be attributed to the variation in soil pH, EC, OC, bulk density, penetration resistance, hydraulic conductivity, maximum water holding capacity and amendment rate by either CWD or FYM).

Moreover, this means that the variation in wheat grain yield, when soil was amended by CWD was due to 1.16% of soil pH, 12.58% EC, 12.98% OC, 6.09% bulk density, 17.95% penetration resistance, 17.92% hydraulic conductivity, 6.14% maximum water holding capacity and 18.63% CWD rate. While, the variation in wheat grain yield, when soil was amended by FYM was due to 0.98% of soil pH, 0.75% EC, 14.70% OC, 16.68% bulk density, 6.81% penetration resistance, 12.56% hydraulic conductivity, 4.16% maximum water holding capacity and 9.02% FYM rate.

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دراسة مقارنة بين بودرة مخلف السيراميك وسماد المزرعة لتحسين خواص وإنتاجية التربة الرملية

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في تجربة حقلية تم دراسة تأثير إضافة بودرة مخلفات تصنيع السيراميك وسماد مخلفات المزرعة بمعدلات صفر، ٢٥، ٥٠، ١٠٠ و١٥٠ ميجا جرام هكتار-١ على بعض خواص الأرض الرملية وإنتاجية محصول القمح بمنطقة محطة جنوب القنطرة شرق، شمال سيناء، مصر. أظهرت النتائج أنه بزيادة معدلات إضافة بودرة مخلفات تصنيع السيراميك وسماد مخلفات المزرعة انخفضت قيم كلًا من pH وملوحة التربة والكثافة الظاهرية للتربة ومقاومة الاختراق والتوصيل الهيدروليكي للتربة بينما زاد الكربون العضوي والسعة المائية العظمى للتربة. ووجد أنه بزيادة معدلات إضافة بودرة مخلفات تصنيع السيراميك وسماد مخلفات المزرعة زاد محصول حبوب القمح. وتم الحصول على أعلى محصول عند استخدام معدل ١٥٠ م ميجا جرام هكتار-١ بالمقارنة بالمعاملة بدون إضافة. وكان متوسط قيم محصول حبوب القمح ١.٦١، ٢.٧٩، ٤.٢٨، ٦.٢٨، ٧.٦٥ ميجا جرام هكتار-١ عند استخدام بودرة مخلفات تصنيع السيراميك بمعدلات صفر، ٢٥، ٥٠، ١٠٠ و١٥٠ ميجا جرام هكتار-١ على الترتيب بينما كانت متوسط قيم محصول حبوب القمح ١.٦١، ٢.٧١، ٣.٨٤، ٤.٨٧، ٦.١٠ ميجا جرام هكتار-١ عند استخدام سماد مخلفات المزرعة بنفس المعدلات السابقة. وأظهر التحليل الإحصائي أن العلاقة بين المحصول ومعدلات إضافة بودرة مخلفات تصنيع السيراميك وسماد المزرعة معادلة من الدرجة الثانية (r = ٠.٩٩**، ٠.٩٩**) على التوالي . وتم استخدام معادلة التفاضل للحصول على المستوى الحرج لمعدلات الإضافة التى أعلى منها لا يحدث استجابة في كمية المحصول أو يبدأ في الانخفاض وكانت القيمة هي ٢٣٩، ٢٢١ ميجا جرام هكتار-١ من بودرة مخلفات تصنيع السيراميك وسماد المزرعة على التوالي. وتدل النتائج أن استخدام بودرة مخلفات تصنيع السيراميك تعتبر مصدر للمواد المحسنة لخواص التربة الرملية وإنتاجيتها.