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Impact of Rice Straw and Biochar Compost Treated with Olive Mill Wastewater on some Sandy Soil Properties, Nutritional Status and Yield Productivity

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ABSTRACT

Create highly nutritious compost. Four compost piles were constructed from farmyard manure (FY) with either biochar (Bc) in piles B and D or rice straw (RS) in piles C and E. All piles received urea, rock phosphate and feldspar, while their humidity's were maintained at 60% using either tap water (TW) {B and C} or olive mill waste water (OMWW) {D and E}. Compost piles were enriched with *Trichoderma harzianum, Pleurotus eryngii, Bacillus polymyxa* and *Bacillus megatherium*. During composting process piles containing RS reached maturity parameters sooner than those containing Bc. The mature compost from pile (E) {FY+RS+ OMWW} was superior in nutrients content (N, P, K) and humification parameters, includes humic acid content (HA%), humification ratio (HR) and humification index (HI), as compared to other compost piles. The mature composts were applied as organic fertilizer in sesame and soybean field experiments carried out in sandy soil. Composts application of RS (C and E) or Bc (B and D) using two application rates increased soil moisture content compared to control treatment (without compost application A). Soil pH values nearly decreased while salinity (EC) values increased by applying the composts at the higher rate of 10.0 Ton ha^{-1} in descending order E > C > D > B >A. Soil organic matter (OM) content increased with the high rates of compost application as compared to control. Among both crops, rice straw compost was significantly superior in N, P and K availability and crop yield component (straw and seeds).

Keywords: Compost, Rice Straw, Biochar, Olive Mill Waste Water, Yield.

INTRODUCTION

Several types of organic wastes had been generated from intensive agriculture practices. Great demand on recycling those agricultural wastes in order to generate organic fertilizers and to increase soil organic matter content which could improve the physical, chemical, and biological properties of soil as well minimize environmental pollution (Westerman and Bicudo, 2005).

Composting was clarified as transformation of organic matter, as bulking agent, by the aid of microbial populations' rapid growth under aerobic conditions. A portion of the organic matter got mineralized into carbon dioxide during that process, while the majority changed into humic compounds, as an important indicator of organic matter stabilization. Furthermore, humic acid content and the rate at which compost quality improved were found to be correlated with compost maturity which had either direct or indirect impact on the chemical, physical and biological characteristics of the soil (Senesi and Plaza, 2007).

In Egypt, rice straw was found to be the primary agricultural waste produced, difficult to degrade due to its lignin content beside cellulose and hemicellulose (Abdel-Rahman et *al*., 2016). Inoculants from microorganisms such as *Trichoderma spp.* did effective degradation and conversions in cellulose, hemicellulose, lignin and starch when added to compost constructed from rice straw. As the most effective microbial inoculants used the more efficiency of manure composting leading to increasing N, P, and K contents (Cong et *al.* 2021).

Biochar is the relatively stable carbon compound that is made from organic materials by heating them to over 400 degrees Celsius in limited oxygen environment. Biochar is characterized by high sorption properties due to its ability to exchange cations and anion added to its large surface area and porosity (Chen et *al.* 2014). According to Teodoro et *al.* (2020), soil amendment with compost embedding biochar during composting process were found to improve soil conditions for plant establishment and increase nutrient availability than ordinary compost. Farid et *al.* (2022) succeeded in adding biochar during composting process producing a fully-matured soil amendment suitable for improving broad-spectrum of soils, as plant growth characteristics were markedly improved after adding composted biochar to a light-textured, low-fertile soil. Thao et *al.* (2023) observed that by adding biochar manure co-composts to soil, it showed positive effects on soil health beside lessening loss of essential nutrients leading to increased uphold crop water use efficiency and yield productivity.

Olive mill wastewater (OMWW) had been generated in significant quantities during the olive oil extraction. Its high organic carbon load (COD) and phenolic components made it resistant to biological degradation and considered as an environmentally hazardous by-product (Aktas et *al*., 2001). Direct application of OMWW as an organic fertilizer caused negative consequences on the soil and plants (Cereti et *al*.,

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2004). Otherwise, McNamara et *al.* (2008) reported that the edible fungus *Pleurotus sp.* can degrade phenols and reduce the COD of olive mill wastewater. According to Paredes et *al.* (1999), OMWW was found to be rich in potassium and other essential soil fertility elements such as nitrogen, phosphorus, calcium, magnesium, and iron. The composting process reduced the polyphenol content of olive mill wastes and their concentration in the mature compost was almost imperceptible (Rigane et *al.*, 2015). Therefore, composting is an alternate solution to the environmental problem of OMWW.

Noor et al. (2020) found that the physical and chemical characteristics of the soil were enhanced when compost was used as an amendment. This improvement was noted in the wilting point, field capacity, porosity, and bulk density measurements. In addition, the productivity of sesame yields is improved by increasing the dose of compost.

Consequently, the present study aimed to create highly nutritious compost piles with highly water retention from farmyard manure (FY) with either biochar (Bc) or rice straw (RS) treated with tap water and olive mill wastewater. As well as evaluate their effects on some sandy soil properties beside their impact on crop yield productivity of sesame and soybean.

MATERIALS AND METHODS

To achieve the objectives of this study, four compost piles (B, C, D and E) were constructed at Soil Water and Environment Research Institute; Agriculture Research Center. Giza, Egypt, followed by a field experiment at Ismailia Agric. Res. Station under sandy soils conditions during the summer season (2018).

Piles for compost preparations:

Chopped rice straw (Rs), biochar (Bc), farmyard manure (FY) and olive mill waste water (OMWW) were the main raw materials for establishing the piles. Rice straw and farmyard manure were gathered from Ismailia Agriculture Research Station, Ismailia governorate. Biochar produced through Heat treatment in an oxygen-limited environment of fruit tree branches (El-Wahate El-baharia), while olive mill waste water was collected from olive oil producing factory at Agriculture Research Center - Giza Governorate. The main characteristics of the raw materials used are shown in Table (1).

Table 1. Main characteristics of raw materials used in constructing piles

Chemical properties	Rice straw (RS)	Biochar (Bc)	Farmyard Manure (FY)	Olive mill wastewater (OMWW)
EC, dSm^{-1}	2.50	3.20	3.30	8.2
PH (1:10)	7.60	8.53	7.40	5.40
Moisture (%)	8.3	7.2	14.4	84.0
C (%)	47.8	52.2	19.2	6.97
N (%)	0.60	0.58	1.25	0.89
C/N ratio	79.7	90.0	15.36	7.83
P (%)	0.34	0.17	0.52	0.32
K (%)	1.64	0.68	0.50	2.15
Na (%)	0.12	0.18	0.38	0.24
Fe mg kg^{-1}	189	122	36.0	179
Mn mg kg^{-1}	74.3	34.3	31.2	22.0
Zn mg kg^{-1}	10.0	40.2	18.0	13.0
Cu mg kg^{-1}	3.00	7.10	3.00	4.00
Phenols (%)	0.09	0.17	0.13	0.97

B and D piles were prepared by mixing biochar (Bc) with farmyard manure (FYM) at ratio 3:1 by weight. While C and E piles were prepared by mixing chopped rice straw (Rs) with farmyard manure (FY) at ratio 3:1 by weight. All piles received 2% urea (46% nitrogen), 2% rock phosphate (10.6% Phosphor) and 2% feldspar (9.3% potassium). B and C piles were humidified at 60% moisture with tap water, while D and E piles were maintained at 60% moisture with olive mill wastewater (OMWW). The compost pile types were summarized in the following table.

Pile type	Pile composition
B	FY+Bc+TW
C	FY+RS+ TW
D	FY+Bc+ OMWW
E	FY+RS+ OMWW

To accelerate the decomposition rate of composting process and phenols biodegradation, all of the piles were inoculated by *Trichoderma harzianum* and *Pleurotus eryngii* cultured media, brought from microbiology unite at SWERI, A.R.C., Giza, Egypt, at a rate of 100 ml/100 kg of composted materials. Fungal inoculation was done at beginning of established piles and later after 14 days. At maturity stage, bioactive bacteria namely *Bacillus polymyxa* (nitrogen fixer Bactria) and *Bacillus megatherium* (phosphate dissolver Bactria) obtained from microbiology unite at SWERI, A.R.C., Giza, Egypt were incorporated into piles at rate 100ml of both culture/100kg composted materials. Piles turning were executed every week and moisture content was kept within 50-60 % along the composting period (14 weeks) by tap water and three representative samples from each pile were collected every two weeks for evaluation piles maturation, physical and chemical characteristics.

Analytical methods:

The temperature during the composting period was recorded using long-spilt thermometer. The pH and EC (dSm^{-1}at 25°C) values of compost were determined in 1:10 (w/v) compost: water suspension using pH Meter and Conductivity Meter, respectively. The Moisture contents in used raw materials and pile samples were determined by drying samples at 105 ºC to constant weights and were calculated as a percentage of fresh weight according AOAC (2000). Organic matter contents (OM%) were determined in raw materials and pile samples by the loss weight of dried sample by ignition at 430ºC using muffle furnace for 24h and calculated as follows:

$$\mathbf{OM\%} = \frac{\mathbf{(Dried\ sample\ weight - \ Ignited\ sample\ weight)}}{\mathbf{Dried\ sample\ weight}} \times \mathbf{100}$$

On the other hand, the total organic carbon (TOC) was calculated by multiplying the organic matter by 0.58 (Navarro et *al.*1993). Cation exchange capacity (CEC: meq/100g dry matter) was determined according to (Harada and Inoko, 1980). Total nitrogen (TN) was determined in raw materials and different compost samples using Kjeldahl digestion method, soluble nitrogen forms (NH_4^+ and NO_3^-) in compost samples were determined according to the method outlined by Page et *al.* (1982). Phenolic compounds were determined using the Folin Denis reagent according to AOAC (2000) and the percentage reduction of phenols among the compost samples was also estimated as described by Rigane et.al (2015) while seed germination index was determent by the method of Tiquia et al. (1996).

Humic substances (humic and fulvic acids) were extracted, purified and were determined quantitatively as percentage of humic substances organic carbon extracted by 0.1 M-NaOH {humic acid-like C (CHA) and fulvic acid-like C (CFA)}, the latter after precipitation of the humic acid-like

C (CHA) at pH 2.0. The CHA was calculated by subtracting the CFA from the extracted organic carbon (Sánchez-Monedero et al. 1996).

Humic ratio (HR) and humification index (HI) could be used as indicators to compost maturity and were calculated as follow, where:

$$\mathbf{HR} = \frac{CHA+CFA}{Total\ organic\ carbon} \times \mathbf{100}$$

$$\mathbf{HI} = \frac{CHA\ as\ carbon}{Total\ organic\ carbon} \times \mathbf{100}$$

Field experiment

A field experiment was carried out at Ismailia Agric. Res. Sta. ARC located at 30° 35´41.9" N Latitude and 32° 16´ 45.8" E longitude, during the summer season (2018) to evaluate the effects of different produced compost piles on some sandy soil physical and chemical properties, beside nutritional status and yield productivity of Sesame (*Sesame indicium* L. var., Shandaul 3) and Soybean (*Glycine max* L. var., craw ford) under sprinkler irrigation system. The soil under study was analyzed according to Page et *al.* (1982) as shown in Table (2).

Table 2. Some physical and chemical properties of the experimental site soil

Soil characteristics	Values	Soil characteristics	Values
Particle size distribution (%)		Soluble cations and anions (mmolc L^{-1})	
Coarse Sand	23.0	Ca^{++}	3.42
Fine Sand	64.6	Mg^{++}	3.10
Silt	9.3	Na^{+}	3.92
Clay	3.10	K^{+}	1.21
Texture class	Sandy	CO_3^{--}	-
Chemical properties		HCO_3^{-}	2.16
$CaCO_3$ %	1.46	Cl^{-}	4.44
Organic matter %	0.30	SO_4^{--}	5.05
pH (Suspension 1: 2.5)	8.00	Available nutrients (mg kg-1)	
EC dSm^{-1} (saturated past extract)	1.16	N	54.0
		P	7.0
		K	97.0

The experimental fertilization treatments comprised tow compost application rates as the following:

A - Control (without compost)	
compost	B1- (Bc + FYM+ tap water) at rate of 5.o Ton ha^{-1}
	B2- (Bc + FYM+ tap water) at rate of 10.0 Ton ha^{-1}
	C1- (RS + FYM+ tap water) at rate of 5.0 Ton ha^{-1}
	C2- (RS + FYM +tap water) at rate of 10.0 Ton ha^{-1}
	D1- (Bc + FYM+ OMWW) at rate of 5.0 Ton ha^{-1}
	D2- (Bc + FYM+ OMWW) at rate of 10.0 Ton ha^{-1}
	E1- (RS + FYM+ OMWW) at rate of 5.0 Ton ha^{-1}
	E2- (RS + FYM+ OMWW) at rate of 10.0 Ton ha^{-1}

The appropriate recommended mineral fertilizers dose was given to all treatments. For Sesame and soyabean crops, superphosphate (15.5 % P_2O_5) was added at a rate of 480 kg ha^{-1} along with compost treatments before sowing. Potassium sulfate (50 % K_2O) was added at a rate of 120 kg ha^{-1} in two equal doses at sowing and 30 days after sowing. Nitrogen was applied as ammonium sulfate (20.6%N) at 540 kg ha^{-1} for Sesame crop and 360 kg ha^{-1} for soybean crop in three equivalent doses at sowing, 30, and 45 days after planting. At maturity stage, sesame and soybean were harvested to determine biological yield and divided to seeds and straw. Plant samples were oven-dried at 70 °C for 48 hours, up to constant dry weight, grounded and digested using sulfuric acid and hydrogen peroxide mixture used for N, P and K determinations according to methods of micro Kjeldahl, Spectrophotometer and Flame Photometer by Cottenie et *al.* (1982), respectively. Soil chemical properties and nutrient status were evaluated according to Page et *al.* (1982).

Statistical design and analysis:

The tow field experiments for sesame and soya bean were designed in a randomized complete block design (RCBD). Three replicates were performed to estimate the significant differences among treatments, the data were statistically evaluated by using the computer MSTAT-C statistical analysis package. The L.S.D. at 0.05 was used to compare mean values according to Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

To monitor the performance of the composting process several parameters were measured including pile temperature, pH, carbon to nitrogen ratio (C/N ratio), cation exchange capacity (CEC), humification ratio (HR) and humification index (HI).

Composting process performance:

Temperature:

Figure (1) showed the changes in temperature of the four piles during composting process, reflecting the same typical phases of changes in their temperatures. As the temperature rose from the first week of composting (initial activation phase) to its higher peak after four weeks, that might be due to the exothermic activities of microorganisms in decomposing organic content in piles (thermophilic phase) the highest temperature reached 68 °C for pile C (FYM+RS+TW). After six weeks, the temperature gradually decreased until the end of composting process (maturation phase), explained by the end of bio-oxidative phase as temperatures in piles became stable and close to that of the surrounding environment (Paredes et *al.*, 2005).

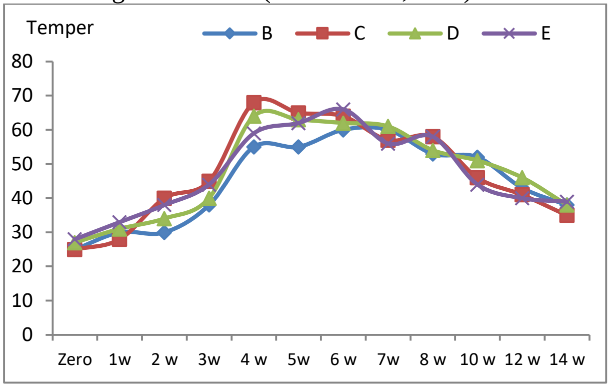


Fig. 1. Changes in temperature of the four piles during the 14 weeks (w) of composting process.

pH values:

Data presented in Figure (2) showed changes in pH values of the four piles tending to alkalinity at early stage of composting process, explained by formation of ammonia from urea and amid groups from amino acids during organic matter decomposition. The formation of organic acids, dissolved CO_2 and other byproducts from the decomposition of easily biodegradable substances could explain the reason for decreasing pH values up till the end of the composting process. The pH values decreased and stabilized at almost neutral values (6.96 and 6.67) in C and E piles of rice straw (RS), respectively, while reached 7.38 and 7.16 in B and D piles of biochar (Bc), respectively. Majbar et *al.* (2018) stated that pH stabilized values due to the formation of humic substances acting as buffers. Worthy to mention that higher pH values in the piles (B and D) might be due to their biochar contents, while wetting the piles with olive mill wastewater (OMWW) led to decrease in the pH values due to their contents of organic acids.

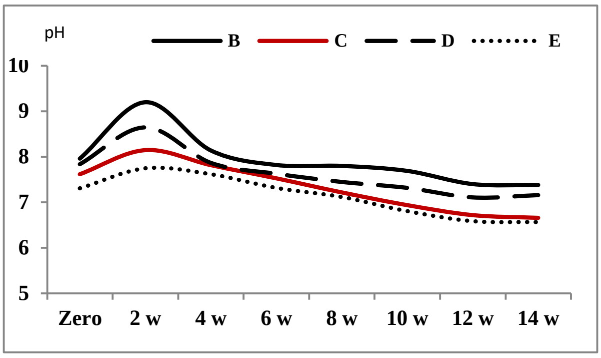


Fig. 2. Changes in pH values of the four piles during the 14 weeks (w) of composting process.

Electric Conductivity (EC):

The results presented in Figure (3) showed gradual increase in EC values during the composting process due to the mineralization of composted compounds, leading to relative increase in the ions concentration especially RS piles. Obviously, the high electric conductivity of (OMWW) itself caused an increase in EC values of D and E piles as compared to B and C piles.

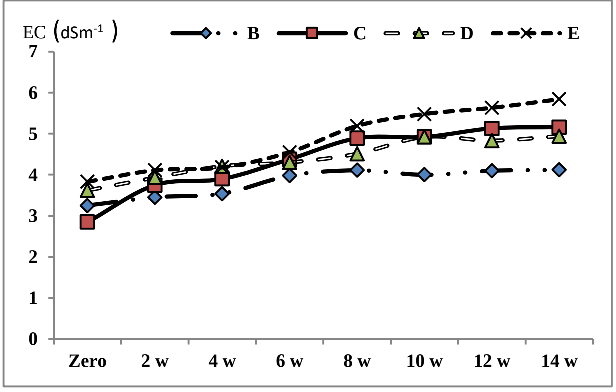


Fig. 3. Changes in EC values of the four piles during the 14 weeks (w) of composting process

C/N ratio:

Figure (4) showed a notable decrease in organic matter, organic carbon and increase in total-N among all composted piles during different time intervals of composting process. The C/N ratio decreased from 40.10 to 20.85; and from 35.97 to 14.92; while decreased from 38.16. to 17.24 and 33.15 to 14.12 for B, C, D and E piles, respectively, that were correlated to gaseous loss of carbon as CO_2 during the organic matter degradation by microorganisms. Worthy to mention that piles containing biochar (Bc) (B and D) had higher C/N ratios than those containing rice straw (RS) (C and E), as biochar were characterized by aromatic and recalcitrant structures that were difficult to degrade by microorganisms and lose carbon as CO_2 than rice straw, as deduced before by Siedt et *al.* (2021).

Cation exchange capacity (CEC):

Cation exchange capacity was a good indicator for maturity and compost quality. Data illustrated in Figure (5) showed significant increase in CEC among all piles (B, C, D and E), where CEC values were greater in piles C and E than B and D, correlated to their rice straw contents that were easier to decompose and release more carboxyl and hydroxyl phenolic groups essentially participating in humic material formation and consequently offering higher CEC (Roca-perez et *al.*, 2009).

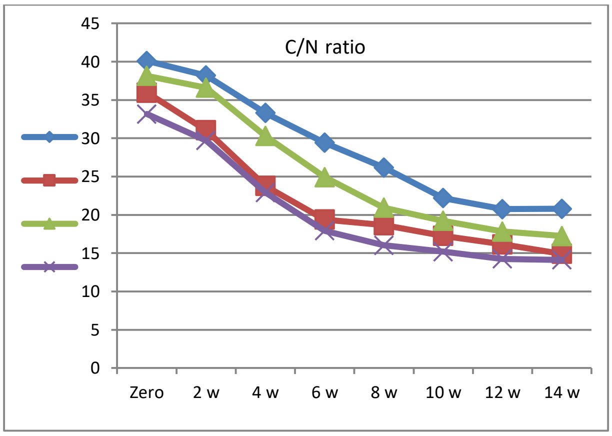


Fig. 4. Changes in C/N ratio values of the four piles during the 14 weeks (w) of composting process.

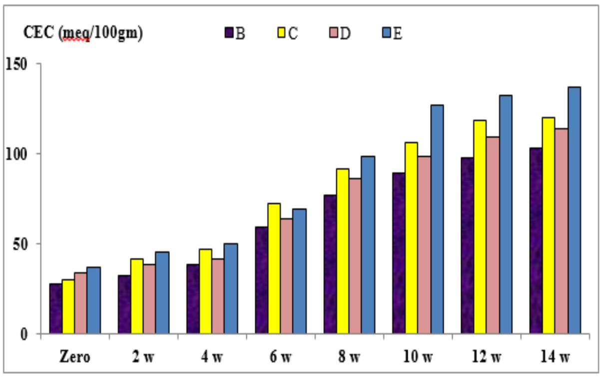


Fig. 5. Changes in CEC values of the four piles during the 14 weeks (w) of composting process.

Humification parameters:

Humification process and carbon reduction could be used as indicator to compost maturity. The maturity and stability indicators included fulvic acid (FA %), humic acid (HA%), HA/FA, Humic ratio (HR) and humification index (HI) that strongly correlated to each other. Consequently, data in Table (3) showed progressive fall in carbon concentration parallel to composting time, since microorganisms utilize those organic compounds as source for nutrition.

Generally, data showed fluctuating increase/decrease in FA%, while showed progressive increase in HA% among all piles under investigation. The humic acid concentration increased during the process, whereas fulvic acid (FA) increased initially and later on decreased throughout the process. Formation of humic substances depends on the OM in which humification and polymerization have taken place (Mushtaq et al.2019).

Moreover, maturation parameters humic to fulvic ratio (HA/FA), HR and HI in piles containing rice straw (C and E) preceded those piles containing biochar (B and D) due to the simple and easily degradable structure of rice straw with lower aromatic contents than biochar, as discussed before. Similarly, Siedt et *al.* (2021) reported that straw had high content of humus reproductive carbon. On the other hand, piles treated with olive mill waste caused higher degradation % in organic matter and increase of cation exchange capacity, agreed with the findings of Paredes et *al.* (2001).

Table 3. Changes in the humification parameters during the composting process in different piles B, C, D and E

Period/ week	**B (FYM+Bc+TW)**						**C (FYM+RS+TW)**					
	Organic C %	**Humic (HA)%**	**Fulvic (FA)%**	**HA/ FA**	**HR**	**HI**	**Organic C %**	**Humic (HA)%**	**Fulvic (FA)%**	**HA/ FA**	**HR**	**HI**
Initial	47.54	3.21	3.52	0.91	14.1	6.75	44.80	3.34	3.6	0.93	15.49	7.14
2	44.38	4.28	4.11	1.04	18.9	9.64	39.21	4.46	4.21	1.06	22.1	11.37
4	42.63	4.52	4.50	1.00	21.11	10.60	36.14	5.82	4.63	1.26	28.91	16.10
6	39.14	5.11	4.74	1.08	25.13	13.06	32.18	6.38	4.90	1.30	35.05	19.83
8	36.14	5.34	4.88	1.09	28.27	14.78	31.90	6.91	4.80	1.44	36.70	21.66
10	34.19	5.64	4.52	1.18	29.13	16.49	30.40	7.59	4.72	1.61	40.49	24.97
12	33.18	5.9	4.32	1.37	30.8	17.78	28.90	8.35	4.38	1.91	44.04	28.89
14	30.86	6.33	4.00	1.58	33.47	20.51	27.70	8.85	4.11	2.15	46.78	31.94

Period/ week	D (FYM+ Bc+OMWW)						E (FYM+ RS+OMWW)					
	Organic C %	Humic (HA)%	Fulvic (FA)%	HA/ FA	HR	HI	Organic C %	Humic (HA)%	Fulvic (FA)%	HA/FA	HR	HI
Initial	46.8	3.20	3.42	0.94	14.14	6.84	43.4	3.40	3.70	0.92	16.35	7.83
2	44.3	3.72	3.61	1.03	16.5	8.40	42.2	4.29	4.31	1.00	20.38	10.17
4	41.1	4.50	3.59	1.25	19.68	10.94	36.9	5.60	5.24	1.07	29.3	15.18
6	38.15	4.69	4.1	1.14	23.04	12.29	31.0	6.21	5.71	1.09	38.45	20.03
8	33.5	5.22	4.38	1.19	28.65	15.58	29.18	6.82	5.19	1.31	41.15	23.37
10	32.3	5.92	4.11	1.44	31.05	18.33	28.4	7.82	4.83	1.62	44.54	27.54
12	31.9	6.84	3.9	1.75	33.66	21.44	27.39	8.49	4.46	1.90	47.39	31.00
14	30.00	7.18	3.71	1.94	36.3	23.93	27.11	9.36	4.16	2.25	49.87	34.53

Phenol degradation and seed germination index in mature composts:

Data presented in Table (4) showed a reduction in free phenol by 91%, 90%, 87% and 85%, while the seed germination increased from 60 to 90%, 65 to 92%, 40 to 86% and from 44 to 88 % for mature composts B, C, D and E, respectively.

Table 4. Phenol degradation and seed germination for composted piles

Composted Piles	**Phenol degradation**			**Seed germination index**	
	Initial value (initial time)	**Final value (14 weeks)**	**Reduction %**	**Initial value (initial time)**	**Final value (14 weeks)**
B	0.183	0.017	91	60	90
C	0.176	0.018	90	65	92
D	0.482	0.065	87	40	86
E	0.500	0.076	85	44	88

Moreover, data presented showed decrease in seed germination index in piles D and E compared to C and B, as former piles had been treated with olive mill waste water characterized by phytotoxic contents including phenols and organic acids, as explained before by Parades et *al.* (2005). On the other hand, the increment in seed germination index in each composted pile after maturation was due to reduction in phenols done by fungus *Pleurotus eryngii* under investigation. This result agreed with Sanjust et *al.* (1991), who discovered that *Pleurotus eryngii* removed about 90% from total phenol in olive mill waste water.

Nutritional status in composted piles:

Data presented in Table (5) showed that total and available (mineral) nitrogen content (NH_4, NO_3) in B and D (with biochar) were lower than in B and D (with rice straw) which might be due to nitrogen loss through ammonia volatilization correlated to high pH values recorded for piles containing biochar as previously shown in Figure (2). In addition to, the wider C/N ratios as presented in Figure (4) at the final stage of maturation proved the increase in nitrogen among all piles during the composting process which was previously clarified by Abdel-Gawad and El-Howeity (2019) as due to the reduction in the weight of composted materials. On the other hand, it was found that the mineralization and nitrification rate was faster in rice straw compost piles due to low C/N ratio and suitable pH for microbial activity.

Total and available phosphorus (P) and potassium (K) were higher in composted piles D and E than in B and C, due to their higher content in olive mill waste water (OMWW) used. Moreover, the presence of phenolic acids in used OMWW allowed their acidity to increase the availability of P from rock phosphate and K from feldspar amended in the compost piles.

Table 5. Macro and Micro nutrients in composted piles

Composted Piles	**Total NPK,%**			**Available NPK, mg kg^{-1}**				
	N	**P**	**K**	**NH_4-N**	**NO_3-N**	**N**	**P**	**K**
B	1.48	0.31	0.82	114	204	318	92	776
C	1.87	0.39	1.07	128	340	468	102	950
D	1.74	0.41	1.22	125	288	413	126	1125
E	1.92	0.46	1.58	136	374	510	134	1155

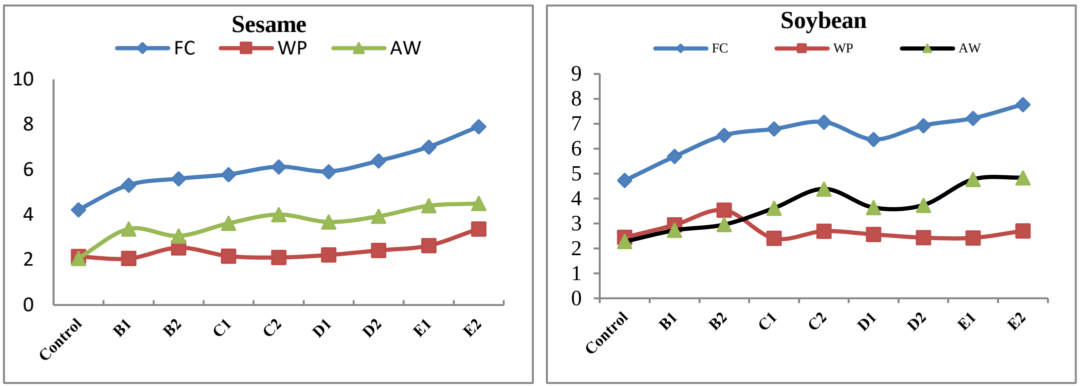
Field experiments

Data presented soil moisture content and soil chemical characteristics after harvesting of both sesame and soybeans crops experiments as affected by different treatments of compost types and rates showed positive effects.

Soil moisture content:

Soil moisture content, including field capacity (FC), wilting point (WP), and available water (AW), can indicate the improvement of soil water retention characteristics. Figure (6) showed that rice straw compost types (C and E) and biochar composts types (B and D) applied at two rates to soil (5 and 10 ton ha^{-1}) increased soil FC, WP, and AW compared to control during sesame and soybean growth stages, at the same time, soil moisture content parameters increased by increase compost application rate to 10 ton ha^{-1} than lower application rate (5 ton ha^{-1}).

Concerning the effect of rice straw (RS) composts results showed that (Fig. 6) RS compost types (C and E) increased FC, WP, and AW more than control in both sesame and soybean cultivated soils, with higher rates being better results. Noor et *al.* (2020) found that the physical and chemical characteristics of the soil were enhanced when compost was used as an amendment. This improvement was noted in the wilting point, field capacity, porosity, and bulk density measurements. In addition, the productivity of sesame yields was improved by increasing the rate of compost application. The high organic matter (OM) content of compost stabilized organic matter content in the soil according to the compost type and application rate, improving soil physical properties including water holding capacity, total pore space, aggregate stability, erosion resistance, and apparent soil density (Shiralipour et *al.*, 1992). Moreover, the results showed that using compost type E [RS+OMWW] was better than compost (C) [RS+ TW] and control (A). These findings supported by (Cabrera et *al.* 1996), who found that olive mill wastewater compost improved soil physical, chemical, and biological qualities.



LSD 0.05 %: FC 0.31 WP 0.165 AW 0.213

LSD 0.05 %: FC 0.367 WP 0.171 AW 0.184

Fig. 6. Soil moisture contents [field capacity (FC), wilting point (WP) and available water (AW)] as affected by different compost amendments types and rates during sesame and soybean cultivation.

Regarding to the applied of biochar composts types (B and D) considerable raise in (FC), (WP), and (AW) values were noted. The results indicated that application of [Bc+OMWW] compost (D) being better than [Bc+TW] compost (B) and control (A) during both growing of sesame and soya bean crops. Biochar application may improve soil physical qualities due to its high porosity, adsorptive nature, microorganisms habitat and organic carbon high content (Aslam et *al.*, 2014). According to Dumroese (2018), biochar enhanced soil moisture and nutrient availability. The hydrophilic functional groups on the biochar graphene sheet and holes may potentially explain the increase in accessible water, as stated by Uzoma et *al.* (2011). The obtained results in both growth crops indicated that type [RS+OMWW] compost (E) achieved the highest moisture content parameters (FC, WP, and AW) compared to control (A).

Soil chemical characteristics

Soil reaction (pH) :

Table (6) demonstrated slight decrease in soil pH values when either rice straw compost or biochar compost were applied. As rice straw compost or biochar compost rates increased, pH values declined steadily. pH could decrease owing to compost breakdown creating organic acids. These findings were consistent with (Chitravadivu et *al.*, 2009).

The results in table (6) showed that rice straw compost treated with olive mill wastewater (RS+OMWW) type (E) and tab water type (C) (RS+TW) decreased soil pH as compared to control (A) and the other treatments, followed by biochar compost treated with olive mill wastewater type (D) (Bc+OMWW). In case of Biochar compost, the acidic functional groups generated during organic manure oxidation and biochar can lower soil pH (Zhang et *al.*, 2014). In addition to, organic wastes degradation increased active humified components such humic acid (HA) and fulvic acid (FA), lowering soil pH (Plaza et *al.*, 2005). Worthy to mention that both crops followed the same pattern.

Electrical conductivity (EC):

Table (6) showed that rice straw compost or biochar compost increased the soil electric conductivity (EC) more than the control treatment in both crops. EC values increased progressively as rice straw compost or biochar compost rate (5 and 10 ton ha^{-1}) increased. [RS+OMWW] compost (E) achieved the highest soil EC values compared to control and other compost type treatments. The olive mill effluent included high potassium, nitrogen, phosphorus, calcium, magnesium and iron concentrations which could raise EC values as explained by Paredes et *al.* (1999).

Organic matter (OM) %

Table (6) showed that rice straw compost or biochar compost enhanced organic matter content more than control. Noor et *al.* (2020) stated that composted materials improved soil structure and organic matter. The maximum organic matter content (OM) was found in soil amended with [Bc + tap water] compost (B) in both crops. This might be because biochar contained high percent of stable organic carbon. In sandy soil, organic fertilizer is needed to increase organic matter and soil physical and chemical health. Biochar has a priming effect and accelerates soil organic matter (Cross and Sohi, 2011).

Table 6. Effect of different composts application on some soil chemical characteristics and nutrients availability for both sesame and soybean crops after harvest.

Sesame crop						
Compost type and rate	**pH (1:2.5)**	**EC (dSm^{-1})**	**OM, %**	**Soil NPK availability (mg kg^{-1})**		
				N	**P**	**K**
Control (A)	8.12	1.06	0.35	24.22	8.73	89.9
B1	7.99	1.13	0.64	35.49	8.95	113.2
B2	7.95	1.19	0.73	45.44	10.04	115.0
C1	7.87	1.20	0.48	44.53	10.82	119.0
C2	7.86	1.34	0.60	60.06	16.55	130.5
D1	7.88	1.18	0.55	49.03	15.01	122.2
D2	7.80	1.23	0.66	65.03	18.73	150.2
E1	7.80	1.34	0.51	73.83	18.38	138.0
E2	7.65	1.68	0.62	78.93	21.09	174.5
LSD 0.05	0.157	0.13	0.104	18.25	0.97	10.37
Soybean crop						
Compost type and rate	pH (1:2.5)	EC (dSm^{-1})	OM, %	Soil NPK availability (mg kg^{-1})		
				N	P	K
Control (A)	7.88	0.97	0.32	50.95	8.77	79.20
B1	7.87	1.13	0.67	54.82	8.69	84.00
B2	7.46	1.26	0.80	56.12	9.73	108.70
C1	7.41	1.05	0.51	57.36	10.71	89.00
C2	7.26	1.42	0.61	69.12	15.68	111.30
D1	7.56	1.02	0.59	63.82	11.61	108.30
D2	7.46	1.45	0.71	75.61	15.79	109.00
E1	7.37	1.30	0.45	82.58	13.81	134.30
E2	7.11	1.33	0.62	91.73	15.48	142.30
LSD $_{0.05}$	0.252	0.16	0.091	11.68	3.67	18.76

Macronutrient availability:

Statistical analysis showed that rice straw compost or biochar compost application at two rates increased soil macronutrients (N, P, and K) availability after sesame and soybean harvesting compared to the control treatments due to the biological nitrogen fixation by non-symbiotic microorganisms (*Bacillus polymyxa*) and phosphate dissolver Bactria (*Bacillus megatherium*)in compost piles, This results matched that of Abdel-Gawad and El-Howeity (2019). Both tested crops followed this tendency (Table 6). Rice straw compost was superior in increasing N and K availability at both tested crops due to its low C/N ratio and the high content of humic substance.

High rice straw or biochar compost application rates were better than low rates. [RS+OMWW] compost type (E) increased N, P, and K availability more than the other compost treatments. Olive mill wastewater has a high potassium concentration and high levels of nitrogen, phosphorus, calcium, magnesium, and iron, which improved soil fertility and nutrient availability (Paredes et *al.*, 1999).

Nutritional status and yield productivity of both sesame and soybeans crops as affected by different compost treatments.

Nutritional status:

With respect to content of macronutrients (N, P and K) in straw and grains, data illustrated in Table (7) indicated general positive effects on total content of macronutrients (N, P and K) absorbed by plants in presence of different compost treatments (types and rates) as compared to control. Worthy to mention that using rice straw (RS) compost as soil amendment was found to be easily biodegradable (Siedt et *al.*, 2021) and that biochar compost was found to reduce nutrient losses by leaching (Wang et *al.*, 2019). Obtained results showed that contents of N, P and K in straw and grains for both tested crops increased by increasing the application rate of rice straw and biochar composts.

Concerning the effect of rice straw composts (C and E) results indicated that increased contents of N, P and K in straw and grains for both tested crops as compared to control (A). The high application rate with [RS+OMWW] compost type (E) was superior in increasing the contents of macronutrients (N, P and K) as compared to [RS+-TW)] compost type (C) (Table 7). It was proved before by Cabrera et *al.* (1996) that OMWW caused positive effects on physical, chemical and biological properties of the tested soil and enhanced expected nutrient uptake.

Regarding application of biochar composts (B and D), the presented results indicated significant increase in N, P and K contents of straw and grains for both tested crops as compared to control in which [Bc+OMWW] compost type (D) being superior as compared to [Bc+ TW] compost type (B) (Table 7). Uzoma et *al.* (2011) clarified the presence of hydrophilic functional group on the surface of the graphene sheet of the biochar, that together with biochar porosity maintained adsorption of nutrients preventing it from leaching while allowing it to be absorbed by plants. Similarly, Aslam et *al.* (2014) stated before that biochar had a high porosity, adsorptive nature, provision for habitat by microorganisms and increased total soil organic carbon contents, while olive mill waste water was found to be rich in potassium and other essential soil fertility elements such as nitrogen, phosphorus, calcium, magnesium, and iron which shared in the significant increase of nutrient uptake. Moreover, biochar compost was found to have positive influences on N and P nutrient uptake by increasing the sorption capacity, improve soil nutrient availability and uptake (Farid et *al.*, 2022).

As presented in Table 7 applying [RS+OMWW] compost type (E) was the superior in increasing the content of N, P and K in straw and grains for both crops and showed a positive soil carbon balance and improved soil quality and plant uptake, in agreement with the study done by Chan et *al.* (2007) On the contrary, [Bc + tap water] compost (B) was inferior that might be due to its higher C/N ratio that did not provide sufficient N needed by plants which was caused imbalance in the uptake of nutrients.

Table 7. Effect of different composts application on macronutrients (N, P and K) contents in straw and grains of both sesame and soybean crops.

Sesame crop						
Compost type and rate	**Straw**			**Grains**		
	% N	**% P**	**% K**	**% N**	**% P**	**% K**
Control	0.73	0.39	0.71	2.63	0.82	0.45
B1	0.55	0.40	0.67	2.35	0.71	0.37
B2	0.92	0.41	0.93	3.12	1.03	0.58
C1	1.04	0.39	0.69	3.08	0.82	0.54
C2	1.13	0.51	1.22	3.49	0.92	0.62
D1	0.77	0.39	0.57	2.76	0.88	0.46
D2	1.13	0.49	1.34	3.08	0.89	0.54
E1	1.07	0.44	1.26	3.35	0.92	0.60
E2	1.31	0.60	1.30	4.21	0.98	0.61
LSD 0.05%	0.45	0.13	0.56	0.99	0.132	0.12

Soybean crop						
Compost type and rate	Straw			Seeds		
	% N	% P	% K	% N	% P	% K
Control	0.74	0.17	0.36	5.32	0.45	1.24
B1	0.74	0.21	1.60	5.60	0.63	1.35
B2	0.85	0.23	1.64	5.78	0.64	1.85
C1	0.83	0.19	1.54	6.11	0.66	2.07
C2	1.14	0.32	2.03	6.29	0.68	2.18
D1	0.76	0.15	1.18	5.72	0.68	2.07
D2	0.88	0.24	2.30	6.13	0.70	2.42
E1	0.96	0.38	2.52	6.39	0.70	2.49
E2	1.26	0.44	3.34	6.60	0.88	2.72
LSD 0.05%	0.06	0.045	0.39	0.144	0.06	0.16

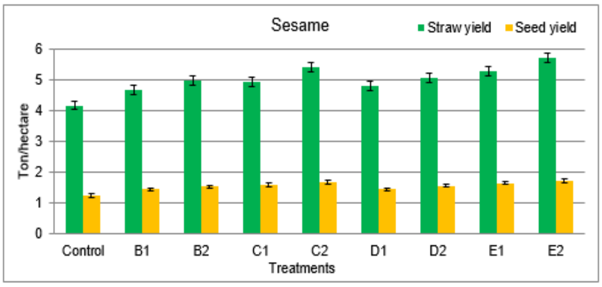
Yield productivity

Data presented in Figure (7) showed the biomass yields of sesame and soybeans amended with either rice straw or biochar composts treated with tap water or Olive mill wastewater, revealing their positive effect on yield component productivity (straw and grains) for both tested crops as compared to control. Also, yield components increased by increasing the application rate of composts.

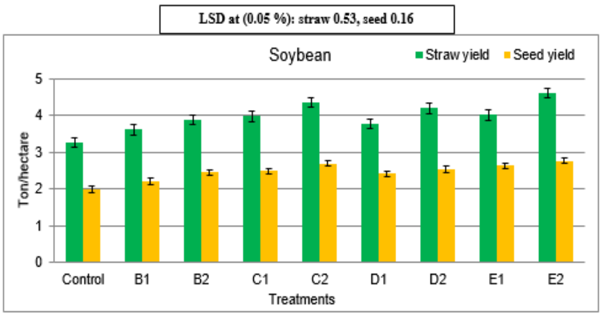
With respect to rice straw compost, data presented showed that [RS + OMWW] compost was superior in increasing the total yield components for both crop types, specifically when it was applied at high rate (E2) as it increased total yield components for straw and seeds by 37% and 39% in sesame, while 41.5% and 36.6% in soybeans, respectively, as compared to control. Cabrera et *al.* (1996) stated that applying OMWW caused positive effects on physical, chemical and biological properties of the soil and consequently increased yield productivity, beside that OMWW was found to possess high concentration of nutrients which were important factors in soil fertility that enhanced crop productivity as expected.

On the other hand, [Bc+TW] compost type (B) was the inferior due to the low response to its high C/N ratio of biochar used, providing insufficient N to leading to less yield under investigation, as previously clarified by Chan et *al.* (2007). Applying [Bc + OMWW] at high rate (D2) was more pronounced for increasing total yield components (straw and grains) for both tested crops as compared to [Bc + TW] compost.

Worthy to mention that high rate applications with either [Bc+OMWW] (D2) or [RS+ TW] (C2) composts gave nearly the same yields for both straw and seeds of sesame and soybeans with no significant differences.



LSD at (0.05 %): straw 0.53, seed 0.16



LSD at (0.05 %): straw 0. 25, seed 0.22

Fig. 7. Straw and seed yields of sesame and soybeans as affected by applied different compost piles

CONCLUSION

From the obtained results, it could be concluded that application of rice straw compost (C and E) and biochar compost (B and D) at two rates to the soil increased each of soil moisture content (FC, WP and AW), availability of macronutrients in soil and yield productivity (straw and seeds). Moreover, rice straw compost treated with olive mill wastewater (D2) recorded the highest values of soil moisture content (FC, WP and AW), yield components of sesame and soybeans as well as N, P and K contents for both crops. While biochar compost treated with tap water was the inferior.

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تأثيرإضافة كومات كمبوست قش الأرز أوالبيوتشار المعاملة بمخلف ماء عصر الزيتون على بعض خواص التربة الرملية والحالة الغذائية وانعكسها على الإنتاجية

مني حفني محمد قناوي، مني عبد العظيم عثمان و وفاءمحمد احمد صديق

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الملخص

تم تجهيز اربعه كومات من الكمبوست باستخدام السماد البلدي مع البيوتشار (B ,D) والسماد البلدى مع قش الارز (C,E) , ثم اضافة اليوريا وصخر الفوسفات و الفلسبار لجميع الكومات وتوصيل نسبة الرطوبة الي 60 % بماء الصنبور في الكومة (C, B) بينما بأضافه مخلفات ماء عصر الزيتون في الكومه (E, D). تم تلقيح جميع الكومات بفطر *Trichoderma harizianum* و *pleurotus eryngii,* وبكتريا *Bacillus megatherium* *Bacillus polymixa* واثناء عملية الكمر للكومات كانت كومات كمبوست قش الارز اسرع في النضج من كومات البيوتشار . ومن الملاحظات التى سجلت على خصائص الناتج النهائى لتحلل الكمبوست ، وجد ان كمبوست (E) كان الافضل من حيث المحتوى من النيتروجين والفوسفور والبوتاسيوم وجميع الصفات المتعلقة ب (humification parameters) مثل humic acid percent (HA%), humification ratio (HR) و humification index (HI) بالمقارنه بالكومات الاخرى. تم اضافه كومات الكمبوست الناضجه كسماد عضوى لمحصولى السمسم وفول الصويا المنزرعه في الارض الرملية بمعدلين. أدى إضافة كومات الكمبوست الناضج سواء المحتوية على قش الارز (E, C) او البيوتشار (D, B) الى التربة الرملية الى زياده المحتوي الرطوبى للتربة (A.W, W.P, F.C) بالمقارنه بالكنترول في كلا المحصولين. كذلك حدث انخفاض فى قيم ال pH التربة وارتفاع فى قيم التوصيل الكهربى نتيجة لاضافه كومات الكمبوست المحتويه علي قش الارز او البيوتشار وكان لذلك تاثير اكثر وضوحا عند معدل 10 طن للفدان .كذلك حدث زياده في المحتوي من الماده العضوية فى حاله اضافه المعدل الثاني من الكمبوست بالمقارنة بالكنترول. كما وجد ان اضافه البيوتشار كمكون اساسى للكمبوست والمعامل بماء الصنبور ادى الى زياده تركيز الماده العضوية بالمقارنه بباقي المعاملات ووجد ان لاضافه كومات كمبوست قش الارز تأثير معنوى مرتفع مقارنة بباقى المعاملا علي تيسر العناصر في التربة (نيتروجين وفوسفور وبوتاسيوم) وكذلك وجد ان هناك تاثير ايجابى معنوى للمحتوى من العناصر (نيتروجين وفوسفور وبوتاسيوم) وكذلك انتاجية المحصول (قش وحبوب) لكلا المحصولين السمسم وفول الصويا.