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Evaluation of Biochar and Charcoal As Amendments and Their Effect on Sandy Soil Fertility and Wheat Productivity

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ABSTRACT

Two field experiments were conducted during two consecutive winter seasons. 2017/2018 and 2018/2019 to assess charcoal and biochar on soil fertility and wheat productivity in sandy soils at the Agriculture Station, Ismailia Governorate, Agricultural Research Center, Egypt. , Each trial was performed in a randomized, complete system fashion with three replicates. Charcoal used for application rates (0, 1 and 2 tons acre -1) was mixed with soil 20 days before planting. Biological fertilization, Rhizobium radiobacter (PGPR), was applied by coating wheat kernels (Triticum aestivum L.) Giza 171. The results indicated that the soil pH value ranged from 7.94 to 7.79 for soils treated with charcoal, while these values were. It was 7.94 to 7.81 for biochar treated soils. Also, ECe values tend to be lower with the application of charcoal, as the available micro and macronutrients have been increased due to the use of both biochar or charcoal. The values of all cultivated characteristics of wheat such as plant height (cm), spike length (cm), spike count, 1000 grain weight (g), and straw and grain yield weight (ton / acre) increased with the increase. The rate of charcoal compared to biochar. The increase in the concentration of macronutrients and micronutrients in the grain and straw of wheat plants may be due to the increased availability of nutrients in the soil as they are affected by charcoal compared to biochar. It can be concluded that charcoal at a rate of 2 tons/acre achieved monster results compared to biochar and increased wheat yield.

Keyworld: sandy soil – charcoal- biochar – soil fertility- wheat productivity.

INTRODUCTION

Sandy soils in Egypt are characterized by poor fertility and limited crop productivity. This low fertility is one of the constraints in this region limiting agricultural production mainly cereals which require improvement through industrial fertilizers to increase crop yields El-Etr and Hassan, (2017). Most of the available area for expanding agricultural activities is sandy soils characterized by poor physical, chemical and biological properties and located in Egyptian western desert Ali, (2018).

Biochar is a promising amendment, which is produced from the pyrolysis under limited oxygen conditions Alghamdi, (2018). The addition of biochar to the soil has the potential to improve soil quality and carbon sequestration, which is important for mitigation of excessive carbon dioxide in the atmosphere McHenry, (2009). Addition of fertilizer may also enhance microbial decomposition and reduce any phytotoxin effects of biochar as appeared to be evident with the high-pyrolysis-temperature biochar. This may also explain the decreased yield and N and P plant uptake in higher pyrolysis-temperature biochar treatments without a fertilizer added. It was previously reported that mineral N availability is essential in stimulating microbial decomposition of organic materials Sakala *et al*., (2000). Biochar is a carbon rich co product resulting from pyrolysis process. Biochar amendment applied to soil can improve productivity of wheat plant. Therefore, the utilization of biochar led to improving yield of wheat. Soil pH decreased 0.8 units and organic matter increased 0.67 % after 159 days of incubation for the biochar amendment Toufiq, (2017).

Charcoal is content of carbon, and the residual ash, removing water and other volatile constituents from vegetation substances Laird, (2008) and Kim *et al*., (2004) indicated that the Charcoal has also been shown to change soil biological conditions in terms of the quality and quantity of soil microorganisms. Biomass energy has become as placement for 14% of global energy consumption .there have been various studies on thermochamical conversion biomass such as combustion, pyrolysis and gasification, focusing on waste agriculture and forestry huang *et al*., (2018) Excessive use of chemical fertilizer has generated many problems like acidification of water, ozone layer depletion and greenhouse effect; this can be managed by the use of Biofertilizers Choudhury and Kennedy,(2005). Biofertilizers are playing an important role of plant nutrition through supplying them with available phosphorus by releasing organic and inorganic acids due to analysis of organic matter Wali *et al*., (2018).

Also, N2-fixing microorganisms render gaseous N2 available for plants, particularly legumes Fares and Khalil, (2003). Biofertilizer application results crop yield improvement due to increased uptake of N, P and K Bhishma and Subash, (2018). Wheat (Triticum aestivum L.) is highly cultivated in large areas in the

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world with an annual production of 650 million tons and its cultivated area and production come after maize and rice FAO, (2012). The cultivated area of wheat in Egypt reached 1.43 million hectare in 2015. The total production of wheat in Egypt was 8.4 million ton from a land area of 1.28 million hectare FAO, (2011). The objective of this study is to evaluate the effectiveness of both biochar and charcoal as a soil conditioner on some soil chemical properties and fertility as well as wheat crop productivity in sandy soil when applied single or in combination with biofertilizer and chemical fertilizers.

MATERIALS AND METHODS

Two field experiments were carried out in sandy soil of Agriculture Station in Ismalia governorate ARC, Egypt, during two successive winter seasons 2017/ 2018 and 2018/2019 to study the effect of two organic amendments (biochar and charcoal) in the presence or absence of biofertilizer on soil fertility and wheat productivity. The physical and chemical properties of the soil before and after planting were determined according to the methods described by Kulte (1986) and Page *et al*., (1982) and Cottenie *et al*., (1982). The obtained data were recorded in Table (1).

In both seasons, each experiment was carried out in a completely randomize design with three replicates.

Preparation of waste (olives cake) was done it is sunbathed in the sun and checked for moisture to arrive 12% then was divided into two parts. Treatment of thermal conversion to produce both charcoal and biochar was done.

Charcoal product

The first part of olives cake heating in the presence of oxygen combustion conversion to product charcoal was prepared in furnace or retort machine without close the door of machine to sure inside oxygen, according to the method described by Nowack and Bucheli,(2007) charcoal is produced in natural and anthropogenic combustion processes.

Table 1. Some physical and chemical properties of the soil used before wheat planting.

Sand (%)		Silt (%)	Clay (%)	Texture		O.M (%)		CaCO$_3$ (%)
85.20		5.90	8.90	Sandy		0.62		1.17
pH	EC	Soluble Cations (meq l^{-1})				Soluble Anions (meq l^{-1})		
(1:2.5) Soil Sasp	(dS/m) in soil past ext	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO^{-}_{3}	Cl^{-}	SO^{-2}_{4}
7.96	1.75	5.80	3.65	7.29	0.79	1.17	6.13	10.20
Available macronutrients (mg/kg)			Available micronutrients (mg/kg)					
N	P	K		Fe		Mn		Zn
33.60	3.25	108.00		1.25		0.80		0.50

Biochar product

The second part of heating the olive cake at a temperature of 350 degrees Celsius for a period of 3 hours in the absence of oxygen (pyrolysis conversion) to the biochar produced in homemade machines in Egypt illustrated in Figure (1) by an Egyptian retort machine made in Egypt from Research (design and manufacture of a pyrolysis reactor to produce biochar and biofuels from biomass) according to the methods described by Collard *et al*. Therefore, there is an urgent need for a properly treated PSH method. Ossification, pyrolysis and combustion are among the most recent thermal-chemical processes. Biochar and charcoal analyzes were performed according to standard methods as described by Brunner and Wasmer (1978).

Fig.1. Egyptian retort machine

The biochar and pyrolysis analysis results are presented in Table (2).

Table 2. The chemical characterizes of charcoal and biochar used.

Parameters		charcoal	Biochar
pH	(1:2.5)	7.72	7.70
EC(1:10)	(dSm^{-1})	3.25	4.59
Total C	(%)	70.20	75.21
Ash	(%)	0.18	0.24
N	(%)	1.64	1.60
P	(%)	0.52	0.47
K	(%)	5.78	6.39
Na^{+}	(%)	4.15	5.95
O_2	(%)	13.00	12.57
Fe	(mg/Kg)	78.60	85.34
Pb	(mg/Kg)	2.88	3.14
Mn	(mg/Kg)	18.0	38.2
Zn	(mg/Kg)	12.10	15.37

The area of each experimental unit (plot) was 10 m long and 5m wide (50m2). All farming processes were carried out before planting. Also, the soils were amendmented by biochar and charcoal at rates of (0, 1 and 2 ton fed-1) applied mixed with soil before 20 days from planting. Calcium super phosphate (15.5%P2O5) was applied at rate of 100 kg fed- 1during tillage soil. Bio-fertilization, Rhizobium radiobacter (PGPR) by coating grains with the gum media carrying the bacteria strain on the same day of sowing. The inoculated grains plots were soil applied with liquid bacteria strain three times after 21, 42 and 62 days of planting, described by Shaban and Omar, (2006). The grains of wheat Giza 171 were obtained from Crop Institute Agriculture Research Center, Giza Egypt. Sown grains of the wheat

(Triticum aestivum, L.) were (Giza 171) Varity, in 15th November 2017 and 2018.

Wheat crop was harvested on 15 may 2018 and 20 may 2019. The plant part samples were ground, 0.5 g of each sample was digested using $H_2SO^-_4$, $HClO_4$ mixture according to the methods described by Soltanpoure, (1985). The plant content of N, P, K, Fe, Mn and Zn was determined in plant digestion using the methods described by Cottenie *et al*., (1982) and Soltanpoure, (1985). The obtained data were statistically analyzed according to Snedecore and Cochran, (1979).

RESULTS AND DISCUSSION

Effect of charcoal and biochar at different rates combined with or without bioferilizer and N mineral fertilizer on some soil properties.

Soil pH:

Data presented in Table (3) show that the effects of different rates of charcoal and biochar application on soil pH with or without mineral nitrogen and biofertilizer, the data showed that no significant different between all treatments. It is also found that soil pH tends to increase slightly due to application charcoal compared with biochar. However, the values of soil pH varied between (7.94 to7.79) and (7.94 to 7.81) for soils treated with charcoal and biochar, respectively. Furthermore, the highest reductions of soil pH values were observed in the case of biochar. This is probably related to some chemical oxidation and microbial decomposition of charcoal and biochar in soil, resulting in acidic compounds being produced and therefore lowering soil pH. These results are in agreement by Abed El-Azeim and Haddad, (2017) found that the application of biochar on sandy soil was decreased of soil pH influence microbial activity and increase of organic acid product. Tasneem and Shah, (2017) suggested that the application of biochar led to decrease soil pH, depending mainly on the salt contents of the biochar used. Mostafa and Shaban, (2019) reported that the addition of biochar may induce an increase in soil pH, through the negative charge on the surface that buffers acidity in soils and the presence of mineral ashes in the biochar, which has a positive effect on soil microbial activity in soil.

Soil salinity (EC dSm^{-1}):

Data presented in Table (3) (a&b) indicted that the effect of charcoal and biochar application and nitrogen fertilizer with or without biofertilizer individually or combined on the ECe. The magnitude reduction of EC was observed with charcoal or biochar application. The application of 2 ton/fed.charcoal and biochar decreased Ec (1.16 and 1.31) as compared to the first dose (1 ton fed.) and the untreated soil (without amendment).

Concerning the effect of nitrogen fertilizer with or without biofertilizer invidually or combined, the nitrogen fertilizer combined with biofertilizer was significantly decreased the EC of soil (15.94%) was obtained with application ½ recommended dose of N + biofertilizer. The highest decreased of mean values of EC (1.10 and 1.18) were recorded by ½ recommended dose of N +biofertilizer+2ton/fed. charcoal and biochar, respecively

These results could be the charcoal applied at different rates combined with mineral in the presence of bio-fertilizer were decrease the soil salinity resulted in, the charcoal and biochar were produced the organic acids provided a substantial modification of soil physical properties, especially soil structure as well as soil aggregation and drainable pores. Consequently, these favorable conditions are positively affected soil permeability and encourage the downward movement of leaching water that enhances progressive removal for Na-salts. These results are in agreamant by Khaled and Jeff, (2019). Reported that the decrease of soil pH and EC was observed with the biochar 300ºC. Tasneem and Shah, (2017). Reported that the application of biochar at rate 20 ton/ha to soil decrease with increasing of periods for 0 day, 5 days and 50 days were 1.29, 1.27 and 1.25 dSm^{-1} respectively.

Table 3a. Soil pH, EC and available macronutrients content in soil after wheat harvest.

Treatments	Charcoal (ton/fed)			Mean	Biochar (ton/fed)			Mean
Rates (ton/fed)	0	1	2		0	1	2	
				pH				
Control	7.94	7.89	7.85	7.89	7.94	7.91	7.88	7.91
RDN fertilizers	7.92	7.86	7.83	7.87	7.93	7.88	7.85	7.89
Biofertilizer	7.90	7.84	7.80	7.85	7.92	7.86	7.83	7.87
1/2 RDN + bio	7.88	7.82	7.79	7.83	7.90	7.84	7.81	7.85
Mean	7.91	7.85	7.82	7.86	7.92	7.87	7.84	7.88
LSD. 0.5 %	Organic = 1.23 - Treatment= 0.501 - fertilizer = 0.435 (8.78 a) - (7.86 ab) - (7.25 b)							
				EC (dSm^{-1})				
Control	1.55	1.34	1.27	1.38	1.62	1.50	1.46	1.52
RDN fertilizers	1.43	1.28	1.15	1.28	1.59	1.45	1.36	1.46
Biofertilizer	1.36	1.23	1.12	1.23	1.52	1.32	1.24	1.36
1/2 RDN + bio	1.25	1.15	1.10	1.16	1.40	1.24	1.18	1.27
Mean	1.4	1.25	1.16		1.53	1.38	1.31	
LSD. 0.5 %	Organic = 1.26 - Treatment= 0.510 - fertilizer = 0.444 (2.254 a) - (1.338 ab) - (0.7304 b)							

Table 3b. Soil pH, EC and available macronutrients content in soil after wheat harvest.

Treatments Rates (ton/fed)	Charcoal (ton/fed) 0	1	2	Mean	Biochar (ton/fed) 0	1	2	Mean
				N (mg kg^{-1})				
Control	37.40	39.44	41.60	39.48	35.22	38.90	40.33	38.15
RDN fertilizers	39.77	41.79	42.88	41.48	37.19	40.27	41.00	39.48
Biofertilizer	40.88	42.85	44.75	42.82	39.40	41.65	43.20	41.41
1/2 RDN + bio	42.10	44.55	47.80	44.81	40.85	43.33	45.19	43.12
Mean	40.04	42.16	44.26		38.17	41.04	42.43	
LSD. 0.5 %	Organic = 0.457 - Treatment= 0.2306 - fertilizer = 0.2206 (42.264 a) - (41.347 b) - (40.448 C)							
				P (mg kg^{-1})				
Control	3.89	4.25	4.86	4.33	3.56	3.85	4.10	3.8
RDN fertilizers	4.35	5.10	5.40	4.95	3.85	3.98	4.26	4.03
Biofertilizer	4.75	5.40	5.75	5.30	4.09	4.23	4.60	4.30
1/2 RDN + bio	4.88	5.80	5.90	5.52	4.30	4.88	5.04	4.74
Mean	4.47	5.14	5.48	5.03	3.95	4.24	4.5	4.22
LSD. 0.5 %	Organic = 1.109 - Treatment= 0.447 - fertilizer = 0.403 (5.544 a) - (4.628 ab) - (3.966 b)							
				K (mg kg^{-1})				
Control	115.30	138.41	140.55	131.42	110.38	120.50	138.20	123.02
RDN fertilizers	123.77	154.98	163.90	147.55	115.80	136.87	150.33	134.33
Biofertilizer	130.44	175.99	185.60	164.01	120.88	145.60	174.22	146.90
1/2 RDN + bio	136.00	180.20	188.30	168.16	127.65	148.80	177.20	151.21
Mean	126.38	162.4	169.59		118.68	137.94	159.99	
LSD. 0.5 %	Organic = 7.684 - Treatment= 2.894 - fertilizer = 2.647 (151.71 a) - (146.23 b) - (142.17 C) - (139.46 d)							

Cont = control (Recommended doses of NPK fertilizers); 1/2 Rf = 1/2 recommended fertilizers

Data in Table (3) (a&b) showed that the values of the available macronutrients i.e. N, P and K (mg/kg soil) in studied soil were affected by application of charcoal and biochar individually or combined with fertilizers.

Generally, it is clear from the data presented in Table (3) (a&b) suggested that the application of charcoal and biochar at different rates alone or combined with Recommended dose, bio-fertilizer or 1/2 recommended doses+biofertilizer were significant increase of available N, P and K content in soil.

Data showed that addition of both charcoal or biochar enhanced the available of N,P and K , the mean values of available N, P And K were increased over control by (5.68% and 10.53%) , (7.31% and 11.16%) and (14.98% and 22.59%), respectively under 1 ton/fed. and 2 ton/fed. Charcoal, while the corresponding values were increased from (7.34% and 13.92%), (28.50% and 34.49%) and (10.22% and 34.8) in the case of the biochar treatment at rates of 1 ton/fed. and 2 ton/fed. Nitrogen fertilizer application as recommended dose, biofertilzer and ½ recommended dose + biofertilizer increased available N, P and K over control in an average (4.30%, 8.51 % and 13.28%), (10.59%, 18.22% and 26.35%), (10.78%, %22.19 and 25.51%), respectively. As for the interaction between soil amendment and nitrogen fertilizer it worthy to mention that the highest values of available N,P and K (47.80 mg/kg, 5.90 mg/kg and 188.30 mg/kg) were obtained with treatment charcoal combined with ½ recommended dose+ biofertlizer. These results are in agreement by Osman, (2016) found that the increase rate of biochar application led to increasing the availability of N, P and K nutrients in sandy soil. Korai *et al.*, (2018) shown that biochar application increased N and P content in soil.

Availability of micro-elements in the studied soils:

Data presented in Table (4) show that the micronutrients (Fe, Mn and Zn) available in soil were significant increased due to the application of charcoal and biochar at different rates individually or combined with mineral nitrogen fertilizers and bio-fertilizer.

Table 4. Available micronutrients contents in soil studied after wheat harvest.

Treatments Rates (ton/fed)	Charcoal (ton/fed) 0	1	2	Mean	Biochar (ton/fed) 0	1	2	Mean
				Fe (mg kg^{-1})				
Control	1.28	1.40	1.48	1.39	1.27	1.35	1.39	1.34
RDN fertilizers	1.34	1.46	1.52	1.44	1.29	1.38	1.44	1.37
Biofertilizer	1.37	1.50	1.56	1.48	1.32	1.42	1.49	1.41
1/2 RDN + bio	1.40	1.57	1.63	1.53	1.37	1.48	1.55	1.47
Mean	1.35	1.48	1.55		1.31	1.41	1.47	1.4
LSD. 0.5 %	Organic = 1.180 - Treatment= 0.4845 - fertilizer = 0.4188 (2.344 a) - (1.427 ab) - (0.7908 b)							
				Mn (mg kg^{-1})				
Control	0.89	0.93	1.04	0.95	0.85	0.88	0.97	0.90
RDN fertilizers	0.95	0.98	1.08	1.00	0.89	0.97	1.02	0.96
Biofertilizer	1.01	1.06	1.12	1.06	0.95	1.05	1.09	1.03
1/2 RDN + bio	1.05	1.10	1.15	1.10	1.01	1.09	1.13	1.08
Mean	0.98	1.02	1.1		0.93	1	1.05	0.99
LSD. 0.5 %	Organic = 1.014 - Treatment= 0.5037 - fertilizer = 0.4388 (1.89 a) - (1.011 ab) - (0.4142 b)							
				Zn (mg kg^{-1})				
Control	0.55	0.59	0.62	0.59	0.53	0.55	0.59	0.56
RDN fertilizers	0.57	0.63	0.67	0.62	0.55	0.59	0.62	0.59
Biofertilizer	0.61	0.68	0.72	0.67	0.59	0.64	0.68	0.64
1/2 RDN + bio	0.65	0.73	0.78	0.72	0.63	0.68	0.73	0.68
Mean	0.6	0.66	0.7		0.58	0.62	0.66	0.62
LSD. 0.5 %	Organic = 1.0159 - Treatment= 0.506 - fertilizer = 0.443 (1.5079 a) - (0.633 ab) - (0.039 b)							

Cont = control (Recommended doses of NPK fertilizers); 1/2 Rf = 1/2 recommended fertilizers

Data illustrated that applicatoon and of both charcoal or biochar improvement the available of Fe, Mn and Zn, The relative increases of mean values for available Fe, Mn and Zn in soil were (9.62% and 14.81%) and (4.08% and 12.24%) and (10.00% and 10.00%), respectively under 1 ton/fed. and 2 ton/fed. charcoal, while the corresponding values were increased from (7.63% and 0.7%) and (7.52% and 6.45%) and (6.89% and 13.79%) in the case of the biochar treatment at rates of 1 ton/fed. and 2 ton/fed., however application of nitrogen fertilizer, the relative increases of mean values for available Fe, Mn and Zn in soil were (4.80%, 6.25% and 14.00%), (5.37%, 12.36 and 17.20 %) and (10.00, 18.18, 27.27 and 37.27 %) , respectively for soil application of recommended mineral nitrogen fertilizer, as recommended dose, biofertilzer and ½ recommended dose + biofertilizer, respectively compared to control. The effect of interaction the maximum values of available Fe, Mn and Zn. (1.63, 115 and 78 mg kg^{-1}) were obtained due to the application of charcoal combined with ½ recommended dose+ biofertlizer. On the other hand, the minimum values were recorded by the control. It is worthy to mention that the contents of all the studied available microelements, in generally, lay within the sufficient limits of Fe and Mn or in the critical limits identical division for the others FAO, (1992) and Sohil *et al* ., (2010) found that the addation of biochar to soil led to increase of nutrient availability through improving nutrient retention, modified soil microbial dynamics and increased decomposition of organic material in soil and the biochar can improve the availability of these nutrients through soil liming and by reducing leaching losses. The relatively increases in soil available Fe, Mn and Zn as results of using charcoal and biochar may be due to a pronounced content of organic materials and reduce through leaching , however , available content of Fe, Mn and Zn has not reached to the toxic level.

Effect of charcoal and biochar combined with mineral and biofertilizer on some growth characters of wheat plans, straw and grain yields;

Directly effects of the used different rates of biochar and biochar and bio-fertilizer or mineral fertilizers individually or combined on some wheat characters as well as straw and grain yields are shown in Table (5) (a&b).

The obtained data show that the values of all growth characters of wheat i.e., plant length (cm), spike length (cm), No. of spike, weight of 1000 grains (g), weight of straw yield (ton/fed) and weight of grains yield (ton/fed) increased with increasing rate of charcoal and biochar. The above mentioned parameters were increased in case charcoal, which were (9.88%, 54.89%, 52.11%, 13.69%, 25.75% and 22.60%), respectively over control. While, the mean relative increase were (3.47%, 9.94% &11.4), (10.32%, 10.37% & 27.41%), (17.88%, 33.50% & 44.50%) (7.40% 14.48% & 21.88%) (14.48%, 34.11% & 51.00%) and (18.71%, 34.50% & 59.64%) for nitrogen fertilizer, as recommended dose, biofertilzer and ½ recommended dose + biofertilizer, respectively compared to control.

Interaction effect of soil amendments (charcoal and biochar) with nitrogen fertilizers found to be significant in table (5) (a&b). The highest values of plant length (99.43 cm), spike length (17.82 cm), No. of spike 5.63, weight of 1000 grains (69.92g), weight of straw yield (3.88 ton/fed) and weight of grains yield (3.24 ton/fed) were obtained in the treatment charcoal at 2ton/fed. Combined with ½ recommended dose+ biofertlizer.

Table 5a. Wheat plant productivity under sandy soil.

Treatments	Charcoal (ton/fed)			Mean	Biochar (ton/fed)			Mean
Rates (ton/fed)	0	1	2		0	1	2	
				Plant length (cm)				
Control	73.14	77.34	79.18	76.55	69.35	72.10	74.63	72.03
RDN fertilizers	74.85	79.63	81.63	78.70	71.52	75.36	78.24	75.04
Biofertilizer	75.95	83.17	85.77	81.63	73.45	79.61	83.19	78.75
1/2 RDN + bio	77.53	86.41	89.43	84.46	74.63	82.17	86.37	81.06
Mean	75.37	81.64	84.00		72.24	77.31	80.61	
LSD. 0.5 %		Organic = 0.9666 - (79.443 a)		Treatment= 0.3349 - (78.527 ab)		fertilizer = 0.4579 - (77.156 b)		
				Spike length (cm)				
Control	9.21	12.34	13.85	11.80	9.01	11.52	12.10	10.87
RDN fertilizers	9.85	13.55	15.41	12.94	9.70	12.63	13.85	12.06
Biofertilizer	10.52	14.63	15.82	13.66	9.95	13.66	14.53	12.71
1/2 RDN + bio	11.35	15.95	17.82	15.04	10.25	14.89	16.37	13.84
Mean	10.23	14.12	15.73		9.73	13.18	14.21	
LSD. 0.5 %		Organic = 0.2080 - (13.781 a)		Treatment= 0.1737 - (12.865 b)		fertilizer = 0.3116 - (11.830 C)		
				No. of spike /plant				
Control	3.14	4.25	4.69	4.03	3.04	3.85	4.13	3.67
RDN fertilizers	3.25	4.85	5.14	4.41	3.20	4.08	4.60	3.96
Biofertilizer	4.60	5.14	5.58	5.11	3.98	4.25	4.95	4.39
1/2 RDN + bio	5.10	5.27	5.63	5.33	4.25	5.14	5.39	4.93
Mean	4.02	4.88	5.26		3.62	4.33	4.77	
LSD. 0.5 %		Organic = 1.0473 - (5.396 a)		Treatment= 0.4209 - (4.479 ab)		fertilizer = 0.3878 - (3.795 b)		

These results are in agreement by Biederman and Harpole, (2013) who showed that biochar increased growth and crop yield as well as soil microbial biomass, rhizobia nodulation, and plant nutrients. Christoph *et al*., (2007) suggested that the used the Charcoal to soil was significantly improved plant growth and grain yield production combined with NPK fertilizers in comparison with the NPK-fertilizer without charcoal. Bader *et al*., (2015) show that addition of charcoal to soil led to an increase of growth characters of wheat plant i.e. grain yield (tons/fed), straw yield (tons/fed), biological yield (tons/fed), number of grains/spike, weight of grains/spike and 1000 grains weight (g). José *et al*., (2013) found that the application of biochar combined with mineral fertilization to soil increased wheat grain production ranged from 149 to 281 % compared to the control.

Table 5b. Wheat plant productivity under sandy soil.

Treatments Rates (ton/fed)	Charcoal (ton/fed) 0	1	2	Mean	Biochar (ton/fed) 0	1	2	Mean
			Weight of straw yield (ton/fed)					
Control	1.85	2.35	2.84	2.35	1.72	1.95	2.14	1.94
RDN fertilizers	2.14	2.85	2.98	2.66	1.98	2.18	2.55	2.24
Biofertilizer	2.44	3.14	3.29	2.96	2.33	2.88	3.14	2.78
1/2 RDN + bio	2.75	3.56	3.88	3.40	2.48	3.28	3.45	3.07
Mean	2.3	2.98	3.25		2.13	2.57	2.82	
LSD. 0.5 %	Organic = 1.0344 - Treatment= 0.4339 - fertilizer = 0.3812 (3.589 a) - (2.673 ab) - (1.9845 b)							
			Weight of grains yield (ton/fed)					
Control	1.25	1.99	2.18	1.81	1.19	1.69	1.98	1.62
RDN fertilizers	1.98	2.28	2.35	2.20	1.56	1.88	2.13	1.86
Biofertilizer	2.18	2.49	2.63	2.43	1.89	2.14	2.47	2.17
1/2 RDN + bio	2.57	2.95	3.24	2.92	2.10	2.58	2.95	2.54
Mean	2	2.43	2.6		1.69	2.07	2.38	
LSD. 0.5 %	Organic = 1.084 - Treatment= 0.4401 - fertilizer = 0.3902 (3.110 a) - (2.194 ab) - (1.523 b)							
			Weight of 1000 grains (g)					
Control	45.85	55.32	59.14	53.44	44.75	49.63	53.75	49.38
RDN fertilizers	48.96	58.24	63.47	56.89	47.89	54.10	58.63	53.54
Biofertilizer	52.17	62.85	67.85	60.96	50.47	57.63	62.14	56.75
1/2 RDN + bio	55.10	67.52	69.20	63.94	53.14	64.14	66.85	61.38
Mean	50.52	60.98	64.92		49.06	56.38	60.34	
LSD. 0.5 %	Organic = 1.3155 - Treatment= 0.4799 - fertilizer = 0.7677 (57.949 a) - (57.033 ab) - (55.538 b)							

Cont = control (Recommended doses of NPK fertilizers); 1/2 Rf = 1/2 recommended fertilizers

Micro and micronutrients concentration in straw and grains wheat.

Results obtained in Table (6&7) (a&b). show that the application of charcol or biochar individually or combined with nitrogen fertilizer were non-significant effect on N, P and K as well as Fe, Mn and Zn concentration in straw and grains of wheat plants, it could be observed that the highest values of the (N, P and K) and (Fe, Mn and Zn) concentration in both straw and grains were associated with that plants received treatment charcoal at 2ton/fed. combined with ½ recommended dose+ biofertlizer. On the other hand, the lowest values from the above mentioned nutrients were recorded with control. Badr *et al*., (2015) who suggested that the application of charcoal increased N, P and K (%) concentration in straw when charcoal was added to soil for improvement of crop. Evangelou *et al*., (2014) found that the biochar application increased significantly K, P, Fe, Mn and Cu content in plant shoots compared to control. Khaled and Jeff, (2019) found that the application of biochar with or without mineral fertilizers increased N, P and K uptake in plants. Finally, it can concluded that the concentrations of N, P, K, Fe, Mn, and Zn in straw of wheat, reflect ad on their available contents in soil and biochar or charcoal under different rates combined with all treatments.

Generally the obtained increases in macronutrients concentration in grains and straw of wheat may be due to the increase of the nutrients availability in the soil. These beneficial effects are attributed to the improvements in status of soil water regime of studied sandy soil, consequently increasing nutrients availability for plants. It is well known that, during the decomposition of organic matter, macro and micronutrients are incorporated into the soil matrix, allowing the soil to act as a reservoir of these nutrients.

Table 6a. Macro-Micronutrients concentration in straw of wheat

Treatments Rates (ton/fed)	Charcoal (ton/fed) 0	1	2	Mean	Biochar (ton/fed) 0	1	2	Mean
			N (%)					
Control	0.98	1.03	1.08	1.03	0.93	0.99	1.04	0.98
RDN fertilizers	1.02	1.09	1.13	1.08	0.98	1.03	1.09	1.03
Biofertilizer	1.08	1.15	1.22	1.15	1.03	1.08	1.13	1.08
1/2 RDN + bio	1.13	1.20	1.25	1.19	1.07	1.14	1.22	1.14
Mean	0.96	1.12	1.17		1.0	1.06	1.12	
LSD. 0.5 %	Organic = 1.016. - Treatment= 0.501 - fertilizer = 0.439 (1.966 a) - (1.087 ab) - (0.491 b)							
			P (%)					
Control	0.17	0.19	0.22	0.19	0.16	0.18	0.21	0.18
RDN fertilizers	0.19	0.23	0.25	0.22	0.18	0.21	0.24	0.21
Biofertilizer	0.22	0.24	0.27	0.24	0.20	0.23	0.26	0.23
1/2 RDN + bio	0.26	0.28	0.32	0.29	0.22	0.26	0.29	0.25
Mean	0.21	0.24	0.27		0.19	0.22	0.25	
LSD. 0.5 %	Organic = 1.029 - Treatment= 0.506 - fertilizer = 0.443 (1.107 a) - (0.2283 ab) - (- 0.3633 b)							
			K (%)					
Control	2.31	2.36	2.39	2.35	2.27	2.31	2.36	2.31
RDN fertilizers	2.35	2.38	2.43	2.39	2.33	2.36	2.40	2.36
Biofertilizer	2.38	2.45	2.49	2.44	2.37	2.41	2.46	2.41
1/2 RDN + bio	2.41	2.48	2.55	2.48	2.39	2.45	2.50	2.45
Mean	2.36	2.42	2.47		2.34	2.38	2.43	
LSD. 0.5 %	Organic = 1.195 - Treatment= 0.4889 - fertilizer = 0.424 (3.316 a) - (2.399 ab) - (1.768 b)							

Table 6b. Macro-Micronutrients concentration in straw of wheat

Treatments	Charcoal (ton/fed)			Mean	Biochar (ton/fed)			Mean
Rates (ton/fed)	0	1	2		0	1	2	
				Fe (mg /kg)				
Control	110.25	112.63	117.52	113.46	108.34	110.52	114.85	111.24
RDN fertilizers	113.52	118.63	124.00	118.72	110.62	115.63	120.74	115.66
Biofertilizer	118.52	126.84	135.10	126.82	117.85	120.69	130.45	122.99
1/2 RDN + bio	123.10	132.40	138.75	131.42	120.63	127.95	133.86	127.48
Mean	116.3	122.6	128.8		122.6	114.4	118.7	124.9
LSD. 0.5 %	Organic = 1.444 - Treatment= 1.326 - fertilizer = 1.292 (122.27 a) - (120.97 ab) - (119.30 b)							
				Mn (mg/kg)				
Control	71.23	75.62	82.41	76.42	68.52	72.50	76.88	72.63
RDN fertilizers	73.14	78.62	85.74	79.16	70.48	75.39	79.92	75.26
Biofertilizer	75.46	82.17	88.32	81.98	72.10	78.62	83.41	78.04
1/2 RDN + bio	77.82	87.34	91.74	85.63	75.22	84.10	87.20	82.17
Mean	74.4	80.9	87.1		71.6	77.7	81.9	
LSD. 0.5 %	Organic = 1.037 - Treatment= 0.3734 - fertilizer = 0.587 (79.83 a) - (78.91 b) - (77.518 C)							
				Zn (mg/kg)				
Control	8.95	9.37	10.20	9.50	8.42	8.96	9.88	9.08
RDN fertilizers	9.24	10.22	11.00	10.15	9.14	10.00	10.75	9.96
Biofertilizer	10.44	11.55	12.95	11.65	10.23	10.96	11.50	10.89
1/2 RDN + bio	10.85	13.59	17.35	13.93	10.76	12.40	14.33	12.50
Mean	9.87	11.18	12.87		9.63	10.58	11.62	
LSD. 0.5 %	Organic = 0.712 - Treatment= 0.2733 - fertilizer = 0.2806 (11.876 a) - (10.96 ab) - (10.155 b)							

Macro-micronutrients concentration in grains of wheat.

Data presented in Table (7) (a&b). show the recommended dose of mineral fertilizers (NPK), 1/2 recommended dose, bio-fertilizer and 1/2 recommended dose + bio-fertilizer individually or combined with charcoal and biochar at different rates on macro and micronutrients concentrations in grains of wheat, the obtained data indicated that the concentration of nutrients were increased with increasing rate of charcoal and biochar application. While, the nutrients concentration were more increasing by addition of charcoal with mineral and biofertilizer when compared with the biochar.

Table 7a. Macro-micronutrients concentration in grains of wheat

Treatments	Charcoal (ton/fed)			Mean	Biochar (ton/fed)			Mean
Rates (ton/fed)	0	1	2		0	1	2	
				N (%)				
Control	1.75	1.86	1.98	1.86	1.66	1.78	1.85	1.76
RDN fertilizers	1.88	2.04	2.09	2.00	1.89	1.97	2.01	1.96
Biofertilizer	1.97	2.08	2.14	2.06	1.94	2.05	2.10	2.03
1/2 RDN + bio	2.03	2.18	2.27	2.16	1.95	2.10	2.17	2.07
Mean	1.09	2.04	2.12		1.86	1.98	2.03	
LSD. 0.5 %	Organic = 1.174 - Treatment= 0.4818 - fertilizer = 0.417 (2.905 a) - (1.989 ab) - (1.350 b)							
				P (%)				
Control	0.28	0.31	0.35	0.31	0.25	0.29	0.32	0.29
RDN fertilizers	0.31	0.36	0.41	0.36	0.29	0.33	0.37	0.33
Biofertilizer	0.33	0.42	0.48	0.41	0.30	0.38	0.43	0.37
1/2 RDN + bio	0.38	0.45	0.53	0.45	0.35	0.42	0.48	0.47
Mean	0.33	0.39	0.44		0.3	0.36	0.4	
LSD. 0.5 %	Organic = 1.015 - Treatment= 0.503 - fertilizer = 0.439 (1.2466 a) - (0.367 ab) - (- 0.229 b)							
				K (%)				
Control	2.10	2.16	2.23	2.16	2.07	2.14	2.17	2.13
RDN fertilizers	2.17	2.22	2.28	2.22	2.10	2.21	2.24	2.18
Biofertilizer	2.20	2.28	2.35	2.27	2.18	2.25	2.30	2.24
1/2 RDN + bio	2.28	2.35	2.39	2.34	2.22	2.29	2.34	2.28
Mean	2.19	2.25	2.31		2.14	2.22	2.26	
LSD. 0.5 %	Organic = 1.190 - Treatment= 0.488 - fertilizer = 0.422 (3.1466 a) - (2.23 ab) - (1.597 b)							

Table 7b. Macro-micronutrients concentration in grains of wheat

Treatments	Charcoal (ton/fed)			Mean	Biochar (ton/fed)			Mean
Rates (ton/fed)	0	1	2		0	1	2	
				Fe (mg /kg)				
Control	88.23	92.41	97.32	92.65	85.63	89.63	93.52	89.59
RDN fertilizers	89.65	97.23	98.59	95.16	87.65	93.20	96.41	92.42
Biofertilizer	93.41	100.58	103.58	99.19	90.52	97.53	98.30	95.45
1/2 RDN + bio	97.32	105.37	112.47	105.05	94.10	100.14	107.85	100.70
Mean	92.2	98.9	103		89.5	95.1	99.0	
LSD. 0.5 %			Organic = 1.302 - (97.19 a)	- Treatment= 0.481 - (96.276 ab)		- fertilizer = 0.468 (94.786 b)		
				Mn (mg/kg)				
Control	56.31	62.14	65.30	61.25	52.14	56.32	59.63	56.03
RDN fertilizers	58.61	65.34	71.14	123.71	55.13	59.00	63.52	59.22
Biofertilizer	61.38	68.95	72.14	67.49	58.79	65.20	69.85	64.61
1/2 RDN + bio	63.52	72.14	75.10	70.25	60.22	68.59	73.42	67.41
Mean	60.0	67.1	70.92		56.6	62.3	66.6	
LSD. 0.5 %			Organic = 1.167 - (64.828 a)	- Treatment= 0.443 - (63.911 a)		- fertilizer = 0.511 (62.469 b)		
				Zn (mg/kg)				
Control	22.85	24.13	26.35	24.44	20.98	23.10	24.00	22.69
RDN fertilizers	24.85	27.32	29.89	27.35	22.63	25.88	27.33	25.28
Biofertilizer	27.31	31.56	33.84	30.90	25.88	29.83	31.75	29.15
1/2 RDN + bio	29.85	34.18	37.85	33.96	27.95	32.55	35.40	31.96
Mean	26.2	29.3	32.0		24.4	27.8	29.6	
LSD. 0.5 %			Organic = 0.266 - (29.135 a)	- Treatment= 0.150 - (28.219 b)		- fertilizer = 0.239 (27.119 C)		

CONCLUSIONS

The application of charcoal and biochar at rate of 2 ton/fed combined with biofertilizer + 1/2 recommended doses of mineral nitrogen fertilizer increased soil fertility and wheat productivity (straw and grain yields) It can be concluded that charcoal application to sandy soil at rate 2 ton/fed achieved the beast results than biochar and caused increase of wheat yield.

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تقيم تاثير كل من الفحم النباتى والفحم الحيوى على خصوبه الارض الرملية وانتاجية القمح

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أجريت تجربتان حقليتين خلال موسمي شتاء متعاقبتين (2018/2017 و 2019/2018) لتقييم تاثير الفحم النباتي الشاركول والفحم الحيوي البيوشار فى وجود التسميد الحيوى وتاثير المواد على بعض خصوبة التربة وإنتاجية القمح في التربة الرملية بمحطة مركز البحوث الزراعة بمحافظة الإسماعيلية ، مصر. أجريت التجارب عشوائياً بثلاث مكررات. وتم استخدام الفحم النباتي والفحم الحيوى بمعدلات (0 ، 1 و 2 طن فدان -1) خلط مع التربة قبل الزراعة ب 20 يوم. التسميد الحيوي ، (Rhizobium radiobacter (PGPR عن طريق تغليف حبوب القمح (.Triticum aestivum L) جيزة 171. * وكانت النتائج التي تم الحصول عليها تشير إلى أن قيم الأس الهيدروجيني للتربة تراوحت دائمًا حوالي 7.94 إلى 7.79 للتربة المعالجة بالفحم ، في حين أن 7.94 إلى 7.81 للتربة المعالجة بالفحم الحيوي. * كما اشارت قيم ECe إلى الانخفاض عند استخدام الفحم مع 2/1 جرعة موصى بها من الأسمدة المعدنية + والسماد الحيوى كذلك ومعامله الفحم الحيوي المستخدم مع 2/1 جرعة موصى بها من الأسمدة المعدنية + السماد الحيوي. * في حين أن المغذيات الدقيقة التى تم قياسها تزداد بسبب استخدام كل من الفحم النباتي أو الفحم الحيوى مع نصف الجرعه الموصى بها من الأسمدة المعدنية + الأسمدة الحيوية. * ايضا زادت قيم جميع الصفات المرفولجيه والمحصوليه لنباتات القمح مثل طول النبات (سم) ، طول السنبلة (سم) ، عدد السنابل ، وزن 1000 حبة (جم) ، وزن كل من محصول القش والحبوب (طن / فدان) مع الزيادة. معدل الفحم النباتى مقارنة بالفحم الحيوي. * كذلك انخفض تركيز المغذيات الكبرى والمغذيات الصغرى في الحبوب والقش لنباتات القمح رغم زيادة توافر العناصر الغذائية في التربة حيث كان التاثير الاكبر مع الفحم النباتي مقارنة بالفحم الحيوي. يمكن الاستنتاج أن تطبيق الفحم النباتي على التربة الرملية بمعدل 2 طن / فدان كان له بعض الاثر السلبى مقارنة بالفحم الحيوي على الحاله الغذائيه انتاجيه محصول القمح.