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Effect of Using Biochar with Some Other Fertilizers on Growth and Productivity of Cucumbers under Sandy Soil Conditions

Souad Abdel Latif Mohamed Al-Mursi Al-Najjar
Agriculture Research Department under Modified Weather Conditions, Horticultural Research Institute, Agricultural Research Center, Al Dokki, Cairo, Egypt

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Abstract

There was a need to look for new materials that might be put into sandy soil to enhancement fertility and maintain minerals that are readily lost in it. The study's purpose was to see how biochar alone or incorporated with different fertilizers affects cucumber growth and yield under greenhouse in sandy soil. Rocket cultivar (*Cucumis sativas*) was used for this study by applying (RCBD) design with three replicates. Farmyard manure at 40 m^3/fed., chicken manure at 20 m^3/fed., compost at 20 m^3/fed., and mineral fertilizers at 300 kg/N: 600 kg/P: 200 kg/K fed^{-1} were added either to the soil separately or combined with the biochar (4.2 ton/fed.), which was used as a control sample when used alone. The data were examined at 0.05 %. It is illustrated how different fertilizers affect plant height, the number of branches, leaf, fresh and dry weight, leaf area, chlorophylls, carotenoids, yield, fruit features, and the concentration of NPK in leaf. When the effect of individual fertilizers was examined, biochar beat compost and mineral fertilizers in terms of crop growth and yields, while chicken manure and farmyard manure outperformed the biochar treatment. Using chicken manure achieved the best yield of the previous fertilizers studied. Finally, it was discovered that combining biochar with organic and chemical fertilizers (farmyard or chicken manure or compost or mineral fertilizers) increased cucumber crop productivity and quality, particularly when biochar and chicken manure were mixed.

Keywords: Cucumber, Sandy soil, Biochar, Farmyard manure, Chicken manure, Compost, Mineral fertilizers
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1. Introduction

Egypt's second most significant crop is cucumber (*Cucumis sativas*). Cucumber requires much nutrients, and a lack of minerals in the soil lowered yields, generated unmarketable qualities, and reduced farmers' profits (Grubben and Denton, 2004). Cucumbers include a high moisture level of 96 to 97%, vitamins, minerals, and organic acids (Peyvast, 2009).

Chemical fertilizers (Astarai and Kochaki, 1996) poison all humans, the environment, and soil microorganisms. Because such fertilizers had a negative environmental impact, there was a need to find a way to fulfil the plant's nutritional demands while decreasing pollution, increasing crop yield, and improving the soil.

Organic fertilizers, such as farm manure, are an excellent alternative to fertilizers made from chemicals since they release nutrients slowly and gradually over time and regularly increase soil fertility by promoting microbial population in the soil (Belay and other, 2001). Organic fertilizers include a high amount of micro and macronutrients, and certain organic matter, which improves soil structure and boosts crop growth, fertility, the population and activity of microorganisms at soil, soil nutrient retention, breathability, and water holding capacity (Deksissa et al., 2008). Organic matter, which is also present in humus colloids, binds mineral elements such as calcium, magnesium, and potassium, enhancing the bonding components (Zink and Allen, 1998). However, the value of organic compounds has declined due to the enormous amount necessary to fulfill the nutritional needs of the crop, in addition to the high transportation costs (Makinde et al., 2007), and its fast depletion in weak and poor soils, such as sandy soils. Thus, we will need to use different kinds of fertilizer that are more stable in the soil for long durations, therefore increasing soil characteristics and retaining nutrients, in order to lower the long-term expense of fertilizing crops. For the last 10 years, the global importance of utilizing biochar to reduce emissions by carbon storage in soil has expanded (Liu et al., 2015). Biochar is a reasonably stable organic carbon that is produced when biomass (the feedstock) is burnt at temperatures ranging from 300 to 1000°C with little or never oxygen concentrations (Verheijen et al., 2010). Amazonian Indians have utilized it to promote soil productivity for thousands of years. However, a lack of proper understanding of biochar's influence on crop output limits its application in modern farming. As a result, crop and soil responses should be evaluated, particularly the effects of biochar inputs on poor soils. Despite the fact that multiple published studies show that applying biochar increases agricultural output in acidic and sandy soils by increasing soil pH (from 5.2 to 6.7), net nitrogen rates, and soil organism respiration (Lehmann and Joseph, 2009; Woolf and others, 2010). Furthermore, because of its nutritional content and release qualities, biochar can greatly enhance crop yield, as well as indirectly through better nutrient retention and pH of soil (Rondon and others, 2007), improved soil interchange (Liang and others, 2006), increased soil water retention (Laird et al. 2010), as well as changes in soil physical characteristics (Pietikainen and others, 2000). Biochar improves soil productivity in two directions: it adds nutrients to the soil while also retain nutrients from all sources, including the soil itself. When applied to soil, it has the potential to enhance organic matter, water preservation and soil microbial activity, while fertilizers needs are reduced (Hawkins et al., 2007). There is limited evidence on the usefulness of biochar or its combined impact with different fertilizers on the growth and production of vegetable crops. The goal of this study was to see how biochar, alone or in combination with other fertilizers, affected cucumber (Rocket) growth and yield in a greenhouse with sandy soils.

2. Materials and methods

The research was carried out in a greenhouse on the Agricultural Research Station's farm in Ismailia, Egypt. During the 2019 and 2020 seasons, a rocket cucumber cultivar (*Cucumis sativas*) was cultivated.

2.1. Experimental details

Farmyard manure at level (40 m^3/fed.), chicken manure (20 m^3/fed.), compost (20 m^3/fed.), and mineral fertilizers (300 kg/N as ammonium sulphate (20.5 N %): 600 kg/P as super calcium phosphate (15.5%): 200 kg/ K as potassium sulfate (48%) fed^{-1}) were applied to the soil with or without biochar (4.2 ton/fed.). The soil in the experimental region was chemically examined before planting, and the findings are presented in Table 1, while Table 2 presents the results of the organic fertilizers analysis used in the experiment.

Table 1. Physical and chemical properties of agricultural soil.

Properties	Soil	Properties	Soil
Particle size distribution (%)		Soluble anions (mmolc L^{-1})**	
Sand	97.49	CO_3^{--}	0.00
Silt	1.81	HCO_3^{-}	4.75
Clay	0.70	CI^{-}	3.10
Texture	Sand	SO_4^{--}	3.15
pH*	8.03	Bulk density (mg $m^{-3)}$	1.80
$CaCO_3$ (g kg^{-1})	16.2	Saturation %	16.8
Organic matter (g kg^{-1})	1.8	CEC (emolc kg^{-1} soil)	1.05
EC (dSm^{-1})"at 25 °C	1.11	Total N (g kg^{-1})	0.03
Soluble cations (mmolc L^{-1})**		Available N (mg kg^{-1})	10.81
Ca^{++}	4.90	Total P (g kg^{-1})	0.02
Mg^{++}	2.10	$NaHCO_3$ Available P(mg kg^{-1})	3.15
Na^{+}	2.90	water Soluble P (mg kg^{-1})	0.90
K^{+}	1.10		

*In soil water suspension 1: 2.5
** In soil saturation extract

The nine treatments employed in the study are listed in Table 3. Organic fertilizers and biochar were added during preparing soil for planting, while mineral fertilizers were added in three batches. Firstly, one-third nitrogen and half phosphorous were added, whereas the second batch was added a month later and contained the second third of nitrogen, half phosphorous, and the first half of potassium. The third batch landed a month after the last one, and it included the final third of nitrogen and the final half of potassium. During the first and second seasons, the seedlings were planted on January 1st and 5th, respectively. The spacing between plants was 50 cm and 100 cm for the distance between the lines. The experiment included three replicates and was designed as (RCBD). Each plot has 20 plants. During the growing season, plants were drip-irrigated to retain soil moisture at 60%.

Table 2. Chemical analysis of biochar, farmyard manure, chicken manure, and compost.

	Biochar	Farmyard manure	Chicken manure	Compost
pH	7.75	7.63	7.35	7.97
Organic matter content (g/kg)	472	253	393	293
Nitrogen (g/kg)	0.35	12.5	14.0	10.40
Available P (mg/kg)	43.83	130	189.0	64.36
Exchangeable K (cmol/kg)	0.92	2.58	2.93	2.12

Table 3. The codes of treatments employed in the study.

Treatments	Code
Biochar 4200 kg/fed. (control)	Bio
Farmyard manure (40m^3/fed.)	Farm
Biochar + Farmyard manure (40 m^3 / fed.)	BioFarm
Chicken manure (20 m^3/fed.)	Chick
Biochar + Chicken manure (20 m^3/fed.)	BioChick
Compost (20 m^3/fed.)	Comp
Biochar + Compost (20 m^3/fed.)	BioComp
Minerals fertilizer (300kg/N: 600kg/P: 200kg/K fed^{-1})	Min
Biochar + minerals fertilizer (300kg/N: 600kg/P: 200kg/K fed^{-1})	BioMin

2.2. Data recorded

2.2.1. Plant growth

During the flowering stage, three plants from each plot was obtained to determine the following parameters:

2.2.1.1. Morphological character

Plant height, leaf numbers, branch numbers, leaf area, stem fresh and dry weight, leaf fresh and dry weight, and total fresh and dry weight of stem and leaves were all estimated. The dry weight disc procedure established by Rhoads and Bloodworth was used to compute the leaf area (1964).

2.2.1.2. Dry weight

The stems and leaves were dried at 70 degrees Celsius until they reached a constant weight. The dry weight of the stem and leaves were measured.

2.2.1.3. Photosynthetic pigments

The chlorophyll pigments were extracted from the fourth leaf and analysed according to the methods described by Lichtenthaler and Buschmann (2001) to determine chlorophyll a, b, a+b, and carotenoids.

2.2.2. Mineral contents:

NPK content were measured in leaves at the start of blooming after wet digestion. The Wolf method was used to digest the plant material (1982). In digestion tubes, 0.2 g of dried and powdered plant material was taken for this purpose. After filling each digestion tube with 4 mL of pure H_2SO_4, they were kept at 25 °C overnight. The digestion tubes were then twisted while 2 mL of 35 percent analytical-grade H_2O_2 was started pouring the sidewalls. Tubes were put in the digesting block and heated to 350°C until fumes emerged, then maintained warm for another 20 minutes. Digestion tubes were withdrawn, and two ml H_2O_2 with continued for digestion until 20 minutes due to removing fumes formed. The plant material turned colorless and cooled after repeating the previous procedure. The extract volume was raised to 50 mL using distilled water. Following filtering, the aliquot was used to measure N, P, and P content as reported by (Chapman and Prat, 1961 and Ryan et al. 2001).

2.2.3. Yield and its components

Throughout the harvesting period, all fruits collected from each treatment were measured for length, fruit diameter, plant yield, plot yield, and total yield/fed.

2.3. Statistical analysis

SAS version 9 was used to analyze the obtained data, and means were compared using the Duncan multiple range test with a significance level of 0.05.

3. Results and discussion

3.1. The impact of various fertilizers on cucumber plant height, number of branches and leaves, and leaf area

Except for the Comp and Min treatments, cucumber plant heights were significantly greater in all treatments than in Bio across the growth seasons, as shown in Table 4. When the treatments with and without biochar are compared, it is clear that using biochar in combination with other treatments improved plant height. The highest plant achieved by BioChick and Chick treatments, with no noticeable differences between them throughout the two growing seasons.

There have been no notable changes in the number of cucumber branches across treatments during the first season. During the second season of cultivation, Chick and BioChick had far more branches.

Since different fertilizers are compared in terms of leaf count, it is clear that Farm and Chick are superior to Bio, although Bio outperformed both Comp and Min throughout the two seasons of culture. During the two growth seasons, all treatments containing biochar outnumbered those that did not include biochar in terms of leaf count. After two growing seasons, the treatment of BioChick outperformed all other treatments, as the number of leaves ranged from 56.6 to 67.7. Min was the worst during the two growing seasons, followed by Comp with 37 leaves per plant.

Concerning the leaf area for the various treatments, it is observed that both Chick and Farm exceeded the Bio (25.8 cm^2), although no significant variation between the Bio and Comp treatments found throughout the first season. During the second season, BioChick had the maximum leaf area (40.1cm^2), whereas Min had the least leaf area. The findings followed the same pattern as the first season, with BioChick recording the greatest leaf area and Min recording the lowest.

Table 4. The impact of various fertilizers on cucumber plant height, number of branches, leaves, and leaf area throughout the 2019 and 2020 seasons.

Characters / Treatments	Plant height cm (PH)		Branch num. (BN)		Leave num. (LN)		leaf area cm^2 (LA)	
	S1	S2	S1	S2	S1	S2	S1	S2
Bio	107.6^{f}	113.6^{d}	3.6^{ab}	4.0^{cd}	41.0^{e}	41.6^{e}	25.8^{e}	26.2^{e}
Farm	116.6^{d}	123.3^{b}	3.3^{ab}	4.3^{bc}	44.3^{d}	45.3^{d}	26.4^{d}	27.2^{de}
BioFarm	126.0^{b}	125.3^{b}	3.6^{ab}	4.3^{bc}	49.0^{c}	57.0^{b}	28.5^{c}	30.2^{c}
Chick	134.6^{a}	131.6^{a}	4.0^{a}	4.6^{ab}	53.6^{b}	59.0^{b}	39.3^{b}	33.3^{b}
BioChick	137.3^{a}	134.0^{a}	4.0^{a}	5.0^{a}	56.6^{a}	67.6^{a}	30.1^{a}	35.8^{a}
Comp	105.3^{f}	107.0^{e}	4.0^{a}	3.6^{de}	37.6^{f}	37.3^{f}	25.4^{ef}	26.1^{e}
BioComp	121.0^{c}	123.6^{b}	3.6^{ab}	4.3^{bc}	48.0^{c}	52.0^{c}	28.2^{c}	27.6^{d}
Min	101.3^{g}	113.6^{d}	3.6^{ab}	3.3^{e}	35.0^{g}	34.3^{f}	24.8^{f}	24.3^{f}
BioMin	112.3^{de}	118.6^{c}	3.0^{b}	4.0^{cd}	42.3^{de}	43.3^{de}	26.0^{de}	26.3^{de}

Means having similar alphabet within a column are not significantly different at 0.05.

Graber et al. (2010) found a similar pattern of results, they found that combining between biochar and different fertilizers significantly increases growth parameters, i.e. PH, BN, LN, and LA per tomato plant. This is because the combination of biochar and organic fertilizers improved the soil's nutritional condition, which helped in the growth of the plants that led to increase the PH, BN, LN, and LA (Manolikaki and Diamadopoulos, 2019).

3.2. The impact of various fertilizers on the fresh, dry, and total weights of cucumber stems and leaves

Table 5 displays the fresh, dry and total weights of cucumber stems and leaves. When contrasting the individual treatments to the fresh stem, they revealed that Chick and Farm exceeded (Bio) which exceeded Comp and Min over two seasons of cultivation.

Table 5. The impact of various fertilizers on the fresh and dried weights of cucumber stems and leaves throughout the 2019 and 2020 growing seasons.

Characters / Treatments	Stem fresh weight gm (SFW)		Leave fresh weights gm(LFW)		Total fresh weights gm (TFW)		Stem dry weight gm (SDW)		Leave dry weight gm (LDW)		Total dry weight gm (TDW)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Bio	639^{e}	656^{g}	676^{e}	694^{f}	1167^{de}	1423^{de}	57.51^{e}	59.37^{e}	1155.49^{e}	159.62^{e}	213^{d}	255.45^{d}
Farm	676^{d}	695^{e}	715^{d}	745^{d}	1391^{abc}	1519^{bcd}	60.84^{d}	65.04^{cd}	164.49^{d}	166.92^{d}	225.33^{c}	270.46^{c}
BioFarm	726^{bc}	747^{c}	768^{bc}	786^{bc}	1494^{ab}	1617^{abc}	65.34^{bc}	68.52^{bc}	176.66^{bc}	179.82^{b}	242^{b}	289.62^{b}
Chick	740^{b}	771^{b}	782^{b}	802^{b}	1522^{ab}	1659^{ab}	66.6^{b}	71.81^{ab}	180.06^{b}	183.71^{b}	246.66^{ab}	297.93^{b}
BioChick	766^{a}	802^{a}	810^{a}	835^{a}	1576^{a}	1727^{a}	68.94^{a}	74.43^{a}	186.39^{a}	192.23^{a}	255.33^{a}	310.94^{a}
Comp	590^{f}	614^{h}	624^{f}	649^{g}	1214^{cde}	1333^{ef}	53.1^{f}	54.78^{f}	143.56^{f}	146.48^{f}	196.66^{e}	234.76^{e}
BioComp	712^{c}	730^{d}	753^{c}	768^{c}	1465^{ab}	1580^{abcd}	64.08^{c}	71.56^{ab}	173.25^{c}	175.68^{c}	237.33^{b}	288.17^{b}
Min	538^{g}	573^{i}	569^{g}	596^{g}	1107^{e}	1233^{f}	48.42^{g}	51.77^{f}	130.91^{g}	135.29^{g}	179.33^{f}	218.15^{f}
BioMin	657^{de}	673^{f}	695^{de}	725^{d}	1352^{bcd}	1474^{cde}	59.13^{de}	61.95^{de}	159.87^{de}	163.76^{d}	219^{cd}	263.24^{cd}

Means having similar alphabet within a column are not significantly different at 0.05.

Using biochar incorporated with different treatments resulted in an increase SFW as opposed to not using it.

Over the two planting seasons, BioChick was the greatest SFW ever, followed by Chick. By assessing the effects of various treatments in terms of LFW, the same trend of outcomes was observed across the two growing seasons.

Concerning the TFW, the same direction of SFW and findings was achieved for the various treatments, BioChick recorded the maximum TFW of a plant over the two growing seasons which no significant different between it and (Farm, BioFarm, Chick, BioComp).

BioChick, and other fertilizers, except (Min, and Comp) had the maximum SDW after drying relative to the control over two seasons of cultivation.

BioChick recorded the highest LDW during growing seasons, with a value varying from (186.39-192.23 g).

The TDW data reveals that both Min and Comp have lower dry weight content as compared to Bio, while the fertilization with Chick, followed by Farm, outperformed Bio over the two seasons of cultivation. The results also demonstrated that the biochar complained with other treatments outperformed the non-biochar-treated treatments. Finally, BioChick outperformed all other treatments in terms of TDW, with a value ranging between (246.66-297.93 g) over the two seasons. The positive effects of the combination of biochar and the different fertilizers may be due to increasing organic carbon, available N, available P, and available K by combined biochar with other treatments as reported by Chadha et al. (2020), and stimulated changes in microbial populations toward beneficial to plant growth which stimulated plant growth Graber et al. (2010). Schulz and Glaser (2012) obtained the same increase in TFW and TDW after applied biochar with different fertilizers.

3.3. The impact of various fertilizers on chlorophyll a, b, a+b, and carotenoids of cucumber leaves

Table 6 clearly shows the influence of various treatments on the content of various chlorophylls in cucumber leaves through the growing seasons. In terms of chlorophyll a, no treatments differed substantially from biochar during the first season of growth, however the treatment of Chick or BioChick had a much greater chlorophyll a content than Bio. BioChick recorded the maximum value of chlorophyll a and this is may be due to reduce ammonia losses by 64% and overall nitrogen deficiency is 52 % according to Steiner et al. (2011)**.** During the second season the same two treatments, as well as the treatment of BioFarm, significantly outperformed Bio, with chlorophyll a levels ranging from 45.7 to 50.5 mg/kg for the three treatments, while the chlorophyll value for a type in Bio treatment was 42.5 mg/kg. In general, the chlorophyll a value in the second season was higher in all treatments than the value of chlorophyll a in the first season.

The results of the chlorophyll b analysis in cucumber leaves show that treatments BioFarm, Chick, and BioChick increased significantly in the value of chlorophyll b content over biochar during growing seasons. BioChick being the best treatment ever during the two seasons with value of 29.3 and 31.4 mg/kg, respectively.
The chlorophyll a+b study findings illustrated that Bio outperformed Comp over growing seasons, although there were no significant differences between it and BioComp or BioFarm.

Table 6. The impact of various fertilizers on chlorophyll a, b, a+b, and carotenoids of cucumber leaves during 2019 and 2020 seasons.

Characters / Treatments	Chl a (mg/kg)		Chl b (mg/kg)		Chl a+b (mg/kg)		Chl C (mg/kg)	
	S1	S2	S1	S2	S1	S2	S1	S2
Bio	33.89^{cd}	42.5^{d}	24.7d	28.1^{cd}	58.6^{d}	70.7^{d}	3.5^{b}	2.0^{b}
Farm	34.2^{cd}	42.8^{d}	24.8^{d}	28.3^{cd}	59.1^{d}	71.2^{d}	3.5^{b}	2.1^{ab}
BioFarm	34.6^{bc}	45.7^{bc}	26.6^{bc}	28.7^{bc}	61.2^{c}	74.5^{c}	4.0^{a}	2.3^{a}
Chick	35.1^{b}	47.6^{b}	27.6^{b}	29.1^{b}	62.5^{b}	76.8^{b}	4.0^{a}	2.4^{a}
BioChick	37.9^{a}	50.5^{a}	29.3^{a}	31.4^{a}	67.2^{a}	81.9^{a}	4.1^{a}	2.4^{a}
Comp	33.8^{cd}	39.7^{e}	23.1^{e}	28.0^{cd}	56.9^{e}	67.8^{e}	3.0^{c}	1.6^{c}
BioComp	34.2^{cd}	44.4^{cd}	25.8^{cd}	28.4^{cd}	60.0^{cd}	72.8^{cd}	4.0^{a}	2.3^{ab}
Min	33.5^{d}	39.2^{e}	22.7^{e}	27.8^{d}	56.3^{e}	67.0^{e}	2.9^{c}	1.4^{c}
BioMin	34.1^{cd}	42.7^{d}	24.8^{d}	28.3^{cd}	59.0^{d}	71.1^{d}	3.4^{b}	2.0^{b}

Means having similar alphabet within a column are not significantly different at 0.05.

Only throughout the two seasons did the other treatments BioFarm, Chick, and BioChick have considerably greater chlorophyll a+b content than Bio. Throughout the growing seasons, treatment BioChick had the greatest levels of chlorophyll a + b, with values of 67.2 and 81.9 mg/kg, respectively. The results also show that the overall chlorophyll concentration increased in the second planting season for all treatments when compared to the first planting season treatments.

There were no statistically significant changes in carotenoids' value between Comp and Min during the two growing seasons, but they were significantly decrease in carotenoids content compared with Bio. During the two growing seasons, there have been no notable changes in the content of chlorophyll C between the treatments BioFarm, Chick, and BioChick, which were regarded to be the best treatments considerably in terms of carotenoid content related to the rest of the treatments.

3.4. The impact of various fertilizers on NPK existent in leaves of cucumber

There weren't statistically significant changes in N content between the Bio and the individual treatments (Farm, Chick, Comp, and Min) during the two seasons. There were no significant differences between the treatments in the first and second season as a result of using biochar with other fertilizers except for BioChick in the second season, which gave significantly the highest nitrogen content (3.95 mg/kg) compared to the rest of the treatments (BioFarm, BioComp, and BioMin). In general, the highest nitrogen content during the two growing seasons was recorded by BioChick (3.35 and 3.95 mg/kg). The higher nitrogen concentration in the leaves after combining Bio and Chick might be ascribed to decreased nitrogen and ammonia loss, both of which are beneficial to the leaves after being absorbed from the soil (Steiner et al. 2011). In 2015, (Doan et al. and Li et al.) observed an increment in organic carbon after biochar employment with a higher nitrogen content after incorporation of biochar with different organic fertilizers.

There have been significant variations in the phosphorus content of the leaves for the treatments didn't incorporate with biochar, with Chick having the greatest phosphorous content. BioChick having the highest phosphorous content in treatments combined with Bio, with values ranging between (0.491 and 0.590 mg/kg). Furthermore, BioChick had the greatest phosphorous content among several treatments used during planting seasons. The same direction of results was observed in potassium leaves content through the two planting seasons. The higher range of N, P, and K in BioChick might be due to increased nutrients availability owing to better physical, chemical, and bio attributes of soil under this using. Furthermore, higher yield with these treatments ultimately resulted in higher uptake of nutrients. The observed data are compatible with (Coumaravel et al. 2015; Jatav and Singh, 2019; Arunkumar et al. 2019). By comparing the results of treatments of different fertilizers that are not combined with biochar and incorporated with biochar, a relative increase in N, P, and K concentrate was observed in incorporated treatments with biochar. This is consistent with (Chadha et al. 2020), who state that using biochar with other fertilizers boosts nutritional abundance (significant increases N, P, Ca, K, Mg, and organic C).

Table 7. The impact of various fertilizers on NPK leaves cucumber during the 2019 and 2020 seasons.

Characters / Treatments	N (mg/kg)		P (mg/kg)		K (mg/kg)	
	S1	S2	S1	S2	S1	S2
Bio	2.87^{cd}	3.45^{b}	0.409^{d}	0.501^{b}	3.45^{bcd}	3.70^{bc}
Farm	2.96^{bcd}	3.47^{b}	0.433^{c}	0.507^{b}	3.55^{bcd}	3.72^{bc}
BioFarm	3.17^{abc}	3.60^{b}	0.465^{b}	0.575^{a}	3.81^{abc}	3.98^{ab}
Chick	3.26^{ab}	3.69^{ab}	0.474^{ab}	0.578^{a}	3.91^{ab}	4.14^{ab}
BioChick	3.35^{a}	3.95^{a}	0.491^{a}	0.590^{a}	4.02^{a}	4.39^{a}
Comp	2.82^{cd}	3.34^{b}	0.378^{e}	0.429^{c}	3.39^{cd}	3.45^{c}
BioComp	3.13^{abc}	3.53^{b}	0.456^{b}	0.571^{a}	3.76^{abcd}	3.86^{bc}
Min	2.76^{d}	3.31^{b}	0.344^{f}	0.416^{c}	3.31^{d}	3.40^{c}
BioMin	2.89^{bcd}	3.47^{b}	0.421^{cd}	0.493^{b}	3.47^{bcd}	3.71^{bc}

Means having similar alphabet within a column are not significantly different at 0.05.

3.5. The impact of various fertilizers on fruit length, diameter, plant yield, plot yield, and total yield of cucumber

Table 8 shows the data for fruit length, diameter, plant yield, plot yield, and total yield per fad. for various fertilizers across two planting seasons.

There weren't major differences discovered in the lengths of fruits between different fertilizers during the first season, except for the Comp and BioComp treatments, which exhibited shorter fruits lengths (13.3 cm and 12.5 cm, respectively). During the second season, no significant variations observed for fruit length between Bio and used other fertilizers.

There have been no statistical significance variations in fruit diameter between Bio and the rest treatments throughout the first planting season, but no treatment outperformed the Bio at the second season except for the BioMin (4 cm) treatment, which had the highest significant difference when compared to the Bio.

Plant yield did not change significantly between treatments Farm, Comp, and BioMin when compared with Bio during the first season, except that treatments BioComp, BioFarm, Chick, and BioChick outperformed Bio with values (0.545, 0.554, 0.637, and 0.751, respectively. Because the merge of biochar and organic amendments enhanced the nutritional status of the soil, which aided plant growth and increased plant yield (Manolikaki and Diamadopoulos, 2019). During the second season, BioChick and Chick had the most plant yield values, as they had in the first season, with values (0.730 and 0.623 kg), whereas Min had the lowest plant yield value (0.431kg). The findings show that treatments combined with biochar outperform treatments that do not combine with biochar.

The yield of the experimental plots across the two seasons of cultivation followed the same pattern of plant yield, the treatments incorporated with biochar outperforming the treatments that did not combine with biochar. During the two seasons of planting, BioChick produced the highest outcomes, while Min gave the lowest yield of the experimental plot by its value (8.34 and 8.63 Kg, respectively).

In terms of total yield for fad. the results show convergence between the yield achieved from Bio and the yield obtained from compost alone, whereas the yield gained via Min dropped when compared to using biochar alone. Fertilization by Chick and Farm surpassed the use of Bio, with Chick achieving the highest overall yield values (12855 and 12466 kg/fed) throughout the binary seasons.

Table 8. The impact of various fertilizers on fruit length, fruit diameter, plant yield, plot yield, and total yield per fadden of cucumber during 2019 and 2020 seasons.

Characters / Treatments	Fruit length (cm)		Fruit diameter (cm)		Plant yield (Kg)		Plot yield (Kg)		Total yield (Kg/fed)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Bio	14.1^ab	14.6^abc	3.3^abc	3.6^bc	0.479^d	0.503^ef	9.58^d	10.06^ef	9663^de	10066^d
Farm	14.8^a	15.5^a	3.5^ab	3.8^ab	0.492^d	0.518^de	9.85^d	10.37^de	9932^d	10373^d
BioFarm	15^a	14.4^bc	3.6^a	3.1^d	0.554^c	0.580^bc	11.09^c	11.6^bc	11182^c	11600^c
Chick	14.5^a	13.8^c	3.3^abc	3.8^ab	0.637^b	0.623^b	12.75^b	12.46^b	12855^a	12466^b
BioChick	14.5^a	15.1^ab	3.3^abc	3.5^c	0.751^a	0.730^a	15.03^a	14.6^a	15153^a	14600^a
Comp	13.3^bc	14^bc	3^c	3.5^c	0.443^de	0.460^fg	8.86^de	9.2^fg	8937^ef	9200^ef
BioComp	12.5^c	14.8^abc	3.1^bc	3^d	0.545^c	0.564^cd	10.90^c	11.28^cd	10993^c	11280^c
Min	14.8^a	14b^c	3.3^abc	3^d	0.417^e	0.431^g	8.34^e	8.63^g	8413^f	8633^f
BioMin	14.3^a	15.1^ab	3.3^abc	4^a	0.482^d	0.492^ef	9.64^d	8.85^ef	9717^de	9853^de

Means having similar alphabet within a column are not significantly different at 0.05.

Based on the treatment comparison, we find that using biochar mixing with other fertilizers considerably enhances the total return value when compared to using each treatment separately without biochar. This may be due to the adequate quantity of nutrients required by the plant thru the growing seasons, improvement of the soil, physical, chemical, bio attributes of the soil by incorporating Bio along with Chick, Farm, Comp and Min which leads to improved root reproduction and promote crop growth. These results took the same line of (Lal et al. 2018; Mansour et al. 2019; Hirapara et al. 2020). The co-application of Bio and organic fertilizers could have maintained a high regime of soil fertility and moisture by means of better utilization of nutrients and available soil moisture by the crop leading to the production of more photosynthates leads to higher plant growth and development (Bhattacharya et al. 2015; Gokila, 2017; Garamu, 2019). During the two growing seasons, BioChick had the greatest yield of the treatments, with values of (15153 and 14600 Kg/fed.).

4. Conclusion

According to the data observations, it is possible to conclude that combining biochar with other fertilizers had a positive effect on all growth and production characteristics of cucumber plants, particularly when organic fertilizers were combined with Bio, as opposed to BioMin. The best results came from combining biochar and organic fertilizers from chicken manure, farm manure, and compost respectively. When comparing fertilizing with biochar alone and different fertilizers alone, it is clear that the yield and growth characteristics of the cucumber crop of biochar were superior to both the employment of compost or mineral fertilizer alone, but the response of the crop and plant growth was better with chicken manure fertilization and then farm manure fertilization. Conclusion incorporating biochar with these organic sources increases crop output and quality while lowering fertilization costs in the short and extended-term.

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