http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS Pakistan Journal of Biological Sciences

ISSN 1028-8880
DOI: 10.3923/pjbs.2021.1236.1245

Research Article
Rice Straw Biochar Application and its Impact on Yield of Some Faba Bean Varieties in Sandy Soil

[1]Reda E. Essa, [2]Ahmed A. Afifi, [2]Soad M. El-Ashry and [1]Mohamed A. Ahmed

[1]Department of Field Crop Research, National Research Centre, Dokki, Giza, Egypt
[2]Department of Soils and Water Use, National Research Centre, Dokki, Giza, Egypt

Abstract

Background and Objective: Biological fertilization in the development of agriculture became one new strategy in the increased production of field crops to decrease the costs of production input and environmental pollution. This study focused on the influence of biochar fertilization on the productivity of faba bean varieties under sandy soils. **Materials and Methods:** Appreciation of the yield and its components, in addition to measurement of grain protein content as well as carbohydrates (%) of faba bean. **Results:** The data obtained indicated that the biochar amendment affects plant production at different rates, where the best yield obtained is 90 kg fed^{-1}. The grain yield increase is significant for the variety's types where, Mariout-2, followed by Nubaria-3 followed by Giza-716 for the addition of 90 kg fed^{-1} of biochar as referenced by the non-conditioning treatment. Likewise, the protein content was highest in the Mariout-2 variety, followed by Nubaria-3 variety and Giza-716 variety for the addition. This improvement may be regarded to the impact of biochar on the physic-chemical characteristics for the soils, in addition to the biological characteristics. Furthermore, the biochar itself add nutrient to the soil after decomposition. The best improvement happens by the long-term cropping for a long period could be reached up to years. **Conclusion:** The conclusion that plant growth was better at a high rate (90 kg fed^{-1}) but the economy of this rate may be questioned, under the condition of the study. However, the validation for different soils may vary with different rates, which needs more research. Also, it is recommended to use Mariout-2 cultivars for their high production under these conditions.

Key words: Biochar, growth, faba bean, sandy medium, leaching, biphasic mineralization

Citation: Essa, R.E., A.A. Afifi, S.M. El-Ashry and M.A. Ahmed, 2021. Rice straw biochar application and its impact on yield of some faba bean varieties in sandy soil. Pak. J. Biol. Sci., 24: 1236-1245.

Corresponding Author: Reda E. Essa, Department of Field Crop Research, National Research Centre, Dokki, Giza, Egypt

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In Egypt and many other areas of the globe, the faba bean (*Vicia faba* L.) is the primary vital legume crop, where it is utilized for human consumption as an excellent source of vegetarian protein[1]. Protein is abundant in its grains (28-36%). It may be eaten raw or canned. It is also utilized as a break crop in grain rotations and as a crop for soil development, to maintain the land healthy and productive by fixing nitrogen[2,3].

Biochar is a stable type of charcoal generated at a high temperature (350°C or more) using natural organic materials (woody waste, maize stalks, etc.). Biochar is more chemically and physiologically stable than the original carbon, making it more difficult to convert back to CO_2 and allowing it to store carbon for longer periods. Because of the obvious benefits to soil and increased crop yields, biochar has recently gained a lot of attention in agricultural fields[4]. The addition of biochar to mineral fertilizers resulted in a significant improvement in plant growth[5].

Biochar improves soil fertility, reduces fertilizer requirements while maintaining or increasing crop production, reduces nutrient leaching, enhances microbial activity in the soil, improves water holding capacity and efficient water use and boosts cation exchange capacity in clay and sandy soils[6,7]. Biochar is not biologically inert and when it is put into the soil, it undergoes biphasic mineralization, resulting in the slow breakdown of aromatic compounds[8]. Biochar was used to improve and improve the growth characteristics and quality of legumes. The addition of biochar to sandy soil boosted mung bean plant growth, biomass and yield[9,10].

Furthermore, biochar is very inert, with the majority of it staying in the soil for orders of magnitudes longer than any other organic amendment and biochar application to soils is usually associated with improved crop production[11]. According to Jalal *et al.*[12] using biochar to legumes could be a good method for increasing overall farm profitability and productivity in cereal-based systems by increasing yields. Sławomir *et al.*[13] studied the effects of biochar on physical and chemical properties as well as beneficial soil microbes like bacteria, fungus and invertebrates in both field and laboratory situations.

Discovered[1] that using different forms of biochar with varying levels of nitrogen fertilizer improved all of the investigated criteria. Furthermore, biochar with a level of 30 kg N/fed had the highest values of all the metrics studied. According to Semida *et al.*[14], biochar is a useful input for sustainable agriculture as it improves soil fertility, crop yield and reduces global warming. Furthermore, biochar has the potential to improve agricultural productivity under various biotic and abiotic conditions.

Researches on field crop production had shown promising results with biochar treatments. So, this study aimed was to investigate the effects of biochar as a soil conditioner on the yield and quality of some faba bean cultivars grown in sandy soil.

MATERIALS AND METHODS

Experimental site: This research was performed over the two consecutive season's winter of 2018/2019 and 2019/2020 in Wadi El-Natroun, El-Beheira, Egypt, to evaluate the impact of adding biochar production of various faba bean cultivars cultivated in sandy soils. In both seasons, the field trials were carried out using a drip irrigation system with 30 cm between drippers (2 L hrs^{-1}) and 60 cm between rows. The patch was 15 m^2 (1/280 fed) in size. Each plot had five ridges that were five meters long and 0.6 meters wide. The irrigation system was calibrated every 4-6 days. Before starting the experiment, soil samples (0-30 cm) were gathered and physicochemical analysis was performed.

The analysis of soil particle size was carried out using a hydrometer method to assess the soil texture[15]. The data in Table 1 shows the physical and chemical features of the soil, as well as the chemical analysis of the irrigated water (Table 2).

Cultural practices: In the first and second seasons, faba bean was planted on October 15th. Faba bean (Giza-716, Nubaria-3 and Mariout-2) grains were injected with a specific streptococcus bacteria strain before seeding. Thirty kilogram fed^{-1} (fed = 4200 m^2) faba bean was sowed 30 cm apart on two sides of the ridge in the hills and one plant/hill was left for thinning (21days after sowing). In both seasons, maize was the previous crop. Grains of faba bean varieties (Giza-716 and Nubaria-3) were obtained from the bean Research Department, Field Crops Research Institute, Agricultural Research Centre, Egypt and Mariout-2 variety was obtained from bean Areej El-Zohour Company, Egypt.

At a rate of 60 and 50 kg K_2O fed^{-1}, phosphorus and potassium were supplemented. Before planting, phosphorus was applied as a single super phosphate (15.5% P_2O_5). Before seeding in a single dose, biochar was treated at three rates: 0.0, 30.0, 60.0 and 90.0 kg fed^{-1}. For all treatments, nitrogen fertilizer was applied at a rate of 60 kg N fed^{-1} as Ammonium Nitrate (33.5% N) 20 and 30 days after sowing as an active dosage. At 45 and 60 days following seeding, potassium sulfate (48% K_2O) was administered in two doses.

Table 1: Physical and chemical properties of the experimental soil

	Particle size distribution (%)										
Season	Sand	Silt	Clay	Texture	O.M (%)	F.C (%)	pH (1:5)	E.C (mm hos cm^{-1})	Nitrogen (ppm)	Phosphorus (ppm)	Potassium (ppm)
2018/2019	89.35	7.07	3.58	Sandy	0.13	8.80	8.15	2.77	3.60	3.12	8.50
2019/2020	90.56	5.32	4.12	Sandy	0.17	8.63	8.30	2.69	3.76	3.25	9.30

E.C: Electrical conductivity, O.M: Organic matter, F.C: Field capacity

Table 2: Chemical analysis of irrigation water

		Soluble cations (mg L^{-1})				Soluble anions (mg L^{-1})			
pH	E.C (dS m^{-1})	K^+	Na^+	Mg^{2+}	Ca^{2+}	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}
8.20	1.22	0.30	7.22	1.28	1.72	0.00	2.17	5.77	2.58

Table 3: Chemical analysis of used biochar

Chemicals	Percentage
C	29.30
N	0.70
S	0.09
P	0.002
K	0.03
Ca	0.07
Mg	0.02
Na	0.08
Fe (ppm)	73.00
Mn (ppm)	160.0
Zn (ppm)	11.60
Cu (ppm)	10.00
pH (1:5)	9.85

Weed management was done twice during the growing season, at 30 and 60 days following seeding and pest control, if necessary, was done according to the experiment station's norms. The other cultural practices were implemented according to Egypt's Ministry of Agriculture's recommendations.

Biochar preparation: According to Fang *et al.*[16] submerged ground rice straw in a 1:3 mass ratio for 2 hrs, dried at 110°C and in double deionized DDI water. A dry biomass mixture was heated to 500°C for 0.5 hrs at 10°C min^{-1}. The pyrolysis biochar was crushed into 0.3 mm fractions with a gentle crusher. Furthermore, the selected samples were washed, dried in an oven (80°C) and tested in a container many times, according to Zhang *et al.*[17]. Before being added to the biochar, it was subjected to laboratory examination, as shown in Table 3.

Experimental design and treatments: A split-plot design in a randomized full block arrangement with three replications was used in the experiment. The main plots received the faba bean varieties, while the biochar rates were placed in the subplots, with one treatment, urea fertilization, serving as the control.

Soil analysis: To evaluate soil chemical properties, soil samples were collected at one point throughout the growing season for each treatment. Standard methods employing soil extract solutions (1:5) were used to determine the chemical characteristics of the soil. A conductivity meter[18] was used to test the electrical conductivity[19].

Yield and its components: Plant height, number of pods/plants, the weight of pods/plant (g), grain weight/plant (g), 100-grain weight (g), grain yield (ton/fed) and straw yield (ton/fed) were measured 120 days after planting from samples selected at random from each plot to the three repetitions. After harvesting all plants in each plot, seed and straw yields (ton/fed) were calculated by multiplying seed and straw yields/plot*280.

Plant and grain, chemical analysis: Samples of 0.5 g of plant material were placed in a 100 mL beaker with 10 mL H_2SO_4 and digested for 30 mins on a hot plate with perchloric acid. The suspension was filtered into a 100 mL volumetric flask using ash-free filter paper.

The nitrogen, phosphorus and potassium levels in the filtrate were measured, using the method described by Cottenie *et al.*[20]. Phosphorus was determined spectrophotometrically using the method described by potassium levels in the filtrate were measured, using the method described by Cottenie *et al.*[20]. The K^+ concentrations were determined by an emission flame photometer and the concentration of Ca^{2+} and Mg^{2+} was measured by titration with a standard EDTA solution[21].

Total carbohydrates content were determined according to DuBois *et al.*[22]. According to Magomya *et al.*[23] total, N-content in grains was determined using the Micro-Kjeldahl method and protein percent was estimated by multiplying N-content by 6.25.

Statistical analyses: The obtained all data were statistically analyzed by analysis of variance (ANOVA), mean comparison

using Costat Edition 6.3 software and differences among means were determined by least significant differences (LSD) at 5 % level according to Snedecor and Cochran[24].

RESULTS AND DISCUSSION

Effect of biochar rates application on growth of faba bean varieties: The addition of biochar significantly increased plant height. Fascinatingly, the relative contribution of biochar to improved plant growth in the sandy soil substrate was significantly higher as long as increasing the amount of biochar, a significant correlation between plant height and biochar amount was detected (Table 4). While the correlation between the addition and the plant variety was very clear since it gives the higher in height in Mariout-2 cultivar followed by Giza-716 followed by Nubaria-3 special with the amount of addition (the higher was in 90 kg fed^{-1}) in the first season (2018/2019). While, in the second season (2019/2020), the plant height was greater than the first season, which is regarded to the decomposition of the biochar need more time which is soundly obvious at the long-term cropping.

Regarding the number of branches, it's significantly correlated with the amount of biochar added as well as with the type of cultivars as well. Where, the Mariout-2 with the higher the number of branches per plant with the addition of 90 kg fed^{-1} of biochar, followed by Giza-716 followed by Nubaria-3 (Table 4). Furthermore, in the second season (2019/2020) the number of branches increased more than in the first season in the same manner which may be due to the biochar give bush more in the long-term cropping due to its ability to resist the decomposition.

For the number of pods, Mariout-2 was highly correlated with the addition of biochar in the number of pods per plant for the first and second season, followed by Giza-716 and followed by Nubaria-3 (Table 4).

Effect of biochar rates application on yield components of faba bean varieties: The yield components (weight of pods/plant, weight of grain/plant and weight of 100 grain) show a highly significant correlation with the biochar addition 90 kg fed^{-1} ($p<0.05$). As well as the Mariout-2 cultivars show a high correlation with the addition of the biochar in both seasons (2018/2019 and 2019/2020), followed by Nubaria-3 and followed by Giza-716, as seen in Table 5. The highest of increasing pods weight/plant reached up to in Mariout-2 variety with the 90 kg fed^{-1} addition of biochar, followed by Nubaria-3 variety and Giza -716 variety in the addition of 90 kg fed^{-1}. While, for the addition of biochar (60 kg fed^{-1}) the increase of pods weight per plant as Mariout-2>Nubaria-3>Giza-716, respectively.

However, for the lowest addition of biochar (30 kg fed^{-1}), the increase of pods weight/plant was as follows: (Mariout-2), (Nubaria-3) and (Giza-716). Although the 30 kg fed^{-1} of biochar was the lowest in production, it gives a higher production than the non-conditioning treatment (control). For the increase of weight of grain as a function of biochar amendment with the plant variety, it was commented that the increase is clear for the variety Mariout-2 followed by Nubaria-3 followed by Giza-716 for the addition of 90 kg fed^{-1} of biochar as referenced by the non-conditioning treatment.

However, for the treatment 60 kg fed^{-1} of biochar, the rate increased in the same manner (Mariout-2>Nubaria-3>Giza-716), respectively. Nevertheless, the 30 kg fed^{-1}

Table 4: Effect of biochar rates application on growth to faba bean varieties

	Plant height (cm)					Number of branches/plants					Number of pods/plants				
Varieties	0.0	30	60	90	Mean	0.0	30	60	90	Mean	0.0	30	60	90	Mean
2018/2109															
Giza-716	72.67	78.00	87.67	97.67	84.00	3.80	4.44	5.44	6.11	4.95	13.00	15.33	17.77	20.00	16.53
Nubaria-3	74.00	95.00	102.33	111.67	95.75	3.76	4.78	6.12	7.12	5.45	14.00	18.35	19.08	20.87	18.08
Mariout-2	75.40	111.67	119.67	129.00	108.94	4.10	6.45	7.79	11.43	7.44	15.00	17.73	21.60	24.01	19.59
Mean	74.02	94.89	103.22	112.78	96.23	3.89	5.22	6.45	8.22	5.95	14.00	17.14	19.48	21.63	18.06
$LSD_{0.05}$	Var.				3.00					0.90					1.22
	Rates				3.15					1.06					2.38
	V*R				5.20					1.55					2.11
2019/2020															
Giza-716	79.67	90.33	97.00	103.33	92.58	5.00	6.00	7.00	8.00	6.50	17.00	20.33	22.67	25.00	21.25
Nubaria-3	81.33	102.33	110.67	120.67	103.75	5.33	7.33	8.67	9.67	7.75	18.00	24.33	25.00	26.67	23.50
Mariout-2	82.33	119.67	131.00	140.00	118.25	5.67	9.00	10.33	14.00	9.75	20.30	25.33	30.33	34.67	27.66
Mean	81.11	104.11	112.89	121.33	104.86	5.33	7.44	8.67	10.56	8.00	18.43	23.33	26.00	28.78	24.14
$LSD_{0.05}$	Var.				4.08					0.96					1.24
	Rate				3.42					1.18					2.39
	V*R				7.06					1.66					2.15

V*R: Varieties*rates

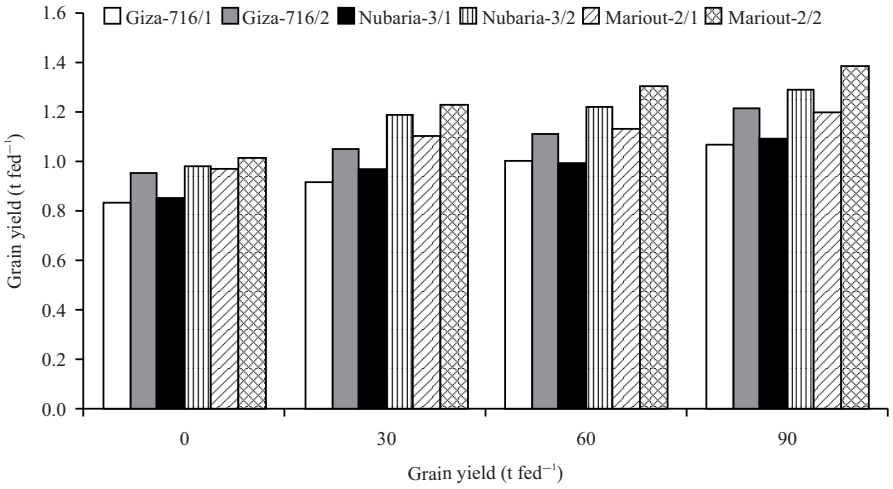

Fig. 1: Grain yield as a function in biochar addition and plant variety in the two seasons (2018/2019 and 2019/2020)

Table 5: Effect of biochar rates application on yield components to faba bean varieties

	Weight of pods/plant (g)					Weight of grain/plant (g)					Weight of 100 grain (g)				
Varieties	0.0	30	60	90	Mean	0.0	30	60	90	Mean	0.0	30	60	90	Mean
2018/2109															
Giza-716	36.00	42.67	46.00	48.67	43.34	31.00	38.67	42.00	45.00	39.17	83.00	95.33	103.33	110.33	98.00
Nubaria-3	37.00	45.67	52.33	57.00	48.00	32.00	41.67	48.33	53.33	43.83	84.00	114.67	119.33	124.67	110.67
Mariout-2	40.00	52.00	60.33	65.33	54.42	33.00	48.67	52.33	60.00	48.50	86.00	124.00	130.00	136.00	119.00
Mean	37.67	46.78	52.89	57.00	48.58	32.00	43.00	47.55	52.78	43.83	84.33	111.33	117.55	123.67	109.22
$LSD_{0.05}$	Var.				1.60					1.60				1.27	
	Rates				1.15					1.33				1.24	
	V*R				2.78					2.80				2.20	
2019/2020															
Giza-716	42.00	51.67	55.00	57.67	51.59	37.00	45.67	49.00	52.00	45.92	91.00	102.33	109.00	117.33	104.92
Nubaria-3	44.00	55.67	62.33	67.00	57.25	38.33	51.67	56.33	61.33	51.92	92.00	123.67	128.33	133.67	119.42
Mariout-2	45.33	60.67	66.33	75.00	61.83	39.00	54.33	60.33	69.00	55.67	94.33	133.00	137.00	143.67	127.00
Mean	43.78	56.00	61.22	66.56	56.89	38.11	50.56	55.22	60.78	51.17	92.44	119.67	124.78	131.56	117.11
$LSD_{0.05}$	Var.				1.59					1.66					1.35
	Rate				1.30					1.38					0.82
	V*R				2.76					2.87					2.34

V*R: Varieties*rates

addition was the lowest rate of increase which was as Mariout-2, Nubaria-3 and Giza-716, respectively. For the weight of 100 grain the increase was noticed by the Mariout-2 cultivars was the highest and the lowest cultivars were Giza-716 for 90 kg fed^{-1} addition i, also 60 and 30 kg fed^{-1} addition in both seasons.

Effect of biochar rates application on yield of faba bean varieties: As demonstrated in Table 6 the grain and straw yield was significantly correlated with the biochar addition, where the best addition was with the 90 kg fed^{-1} for both seasons. Also, the highly correlated was with the cultivars Mariout-2 followed by Nubaria-3 and followed by Giza-716 in the growing seasons (Table 6, Fig. 1 and 2).

Regarding the increase of grain yield as a function of biochar addition with the plant variety, it was remarked that the increase is obvious for the variety Mariout-2, followed by Nubaria-3 followed by Giza-716 for the addition of 90 kg fed^{-1} of biochar as referenced by the non-conditioning treatment.

While, the treatment 60 kg fed^{-1} of biochar the rate increased by the same manner (Mariout-2> Nubaria-3>Giza-716), respectively. However, the 30 kg fed^{-1} addition were the lowest rate of increase which was as follows Mariout-2, Nubaria-3 and Giza-716, respectively. For the yield of straw, the increase in the yield was as follows Mariout-2>Nubaria-3>Giza-716 for the 90 kg fed^{-1} addition. The last one was at the addition of

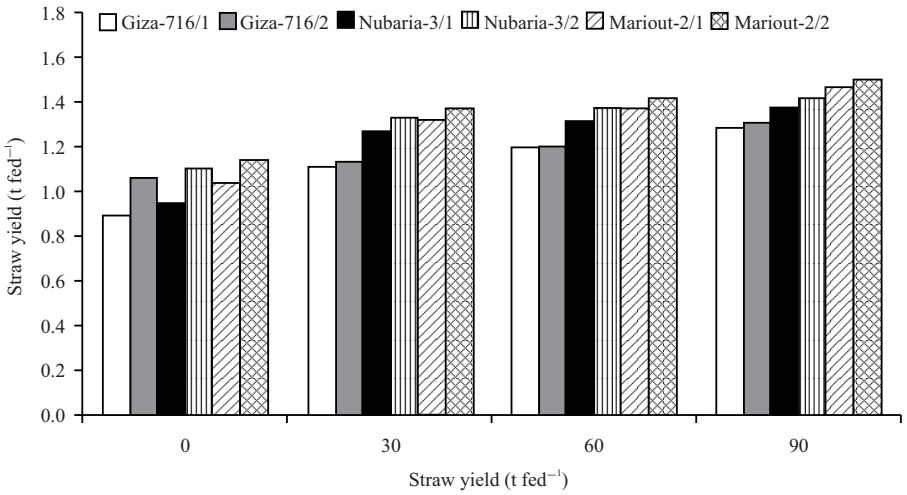

Fig. 2: Straw yield as a function in biochar addition and plant variety in the two seasons (2018/2019 and 2019/2020)

Table 6: Effect of biochar rates application on yield to faba bean varieties

	Grain yield (t fed^{-1})					Straw yield (t fed^{-1})				
Varieties	0.0	30	60	90	Mean	0.0	30	60	90	Mean
2018/2019										
Giza-716	0.83	0.91	0.99	1.04	0.94	0.90	1.12	1.21	1.30	1.13
Nubaria-3	0.85	0.96	1.00	1.09	0.98	0.96	1.29	1.33	1.40	1.25
Mariout-2	0.91	1.09	1.13	1.21	1.09	1.05	1.34	1.39	1.48	1.32
Mean	0.86	0.99	1.04	1.11	1.00	0.97	1.25	1.31	1.39	1.23
$LSD_{0.05}$	Var.				0.01					0.02
	Rates				0.01					0.03
	V*R				0.02					0.03
2019/2020										
Giza-716	0.95	1.05	1.12	1.21	1.08	1.07	1.15	1.22	1.33	1.19
Nubaria-3	0.98	1.18	1.22	1.29	1.17	1.12	1.34	1.4	1.45	1.33
Mariout-2	1.01	1.23	1.30	1.38	1.23	1.15	1.39	1.43	1.54	1.38
Mean	0.98	1.15	1.21	1.29	1.16	1.11	1.29	1.35	1.44	1.30
$LSD_{0.05}$	Var.				0.01					0.02
	Rate				0.01					0.03
	V*R				0.02					0.03

V*R: Varieties*rates

30 kg fed^{-1} of biochar were, it was as follows the same sequence Mariout-2, Nubaria-3 and Giza-716 varieties.

Effect of biochar rates application on quality of faba bean varieties: Data in Table 7 showed a positive statistical result on the seed nitrogen (%) for the whole verities in both seasons, with the addition of biochar. The highly was with the addition 90 kg fed^{-1}. In addition, the grain potassium and grain protein (%) were highly correlated with the biochar addition (90 kg fed^{-1}) in the growing seasons. The cultivars variety effect of the Mariout-2 was highly correlated followed by Giza-716 and followed by Nubaria-3 in both season's (Table 7, Fig. 3.)

Regarding the increase of nitrogen as a function of biochar addition and plant varieties, the more biochar added the best result we get on the one hand and plant varieties affect the increase of the N in the grains on the other hand. The Mariout-2 cultivars were the best, followed by Nubaria-3, while the Giza-716 cultivars were the least for 90 kg fed^{-1} addition. While, the lowest rate was for 30 kg fed^{-1} addition of biochar Mariout-2, Nubaria-3 and Giza-716 sequentially.

For the potassium, the increase was as follows: Mariout-2, Nubaria-3 and Giza-716 cultivars, respectively in the case of 90 kg fed^{-1} addition of biochar. While was for Mariout-2, Nubaria-3 and Giza-716 cultivars, sequentially.

For the protein ratio in the grains, it is seen the increase of protein as a function of soil amendments addition, where it increased as follows: (Mariout-2 variety), (Nubaria-3 variety) and (Giza-716 variety) for the 90 kg fed^{-1}. While the minimum increase was in 30 kg fed^{-1} this was as follows: (Mariout-2 variety), (Nubaria-3 variety) and (Giza-716 variety).

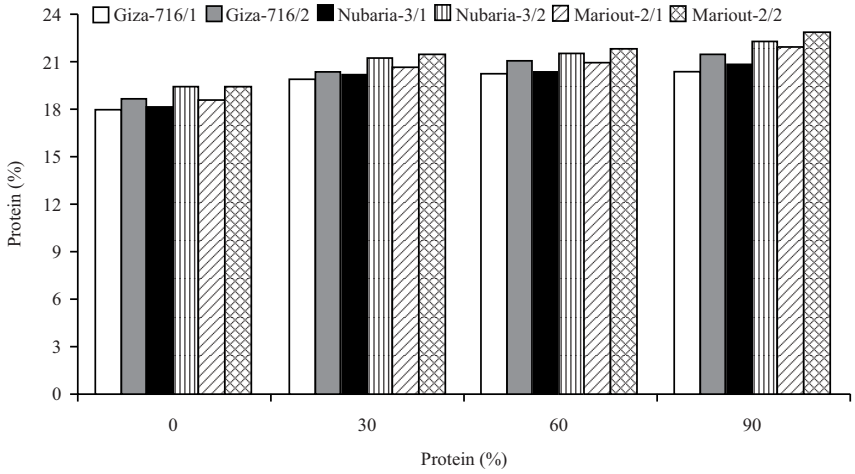

Fig. 3: Protein content as a function in biochar addition and plant variety in the two seasons (2018/2019 and 2019/2020)

Table 7: Effect of biochar rates application on quality to faba bean varieties

	Nitrogen (%)					Potassium (%)					Protein (%)				
Varieties	0.0	30	60	90	Mean	0.0	30	60	90	Mean	0.0	30	60	90	Mean
2018/2109															
Giza-716	2.84	3.14	3.18	3.21	3.09	2.28	2.45	2.51	2.57	2.45	17.75	19.63	19.88	20.06	19.33
Nubaria-3	2.87	3.19	3.22	3.31	3.15	2.3	2.48	2.61	2.78	2.54	17.94	19.94	20.13	20.69	19.68
Mariout-2	2.91	3.27	3.32	3.45	3.24	2.35	2.75	2.88	2.96	2.74	18.19	20.44	20.75	21.56	20.24
Mean	2.87	3.20	3.24	3.32	3.16	2.31	2.56	2.67	2.77	2.58	17.96	20.00	20.25	20.77	19.75
$LSD_{0.05}$	Var.				0.02					0.02					0.12
	Rates				0.03					0.01					0.16
	V*R				0.03					0.04					0.20
2019/2020															
Giza-716	2.93	3.21	3.30	3.38	3.21	2.31	2.53	2.58	2.64	2.52	18.31	20.06	20.63	21.13	20.03
Nubaria-3	3.05	3.36	3.40	3.53	3.34	2.35	2.73	2.8	2.87	2.69	19.06	21.00	21.25	22.06	20.84
Mariout-2	3.08	3.40	3.45	3.60	3.38	2.33	2.93	2.97	3.05	2.82	19.25	21.25	21.56	22.50	21.14
Mean	3.02	3.32	3.38	3.50	3.31	2.33	2.73	2.78	2.85	2.67	18.87	20.77	21.15	21.90	20.67
$LSD_{0.05}$	Var.				0.02					0.02					0.15
	Rates				0.01					0.01					0.07
	V*R				0.04					0.03					0.26

V*R: Varieties*rates

Economic feasibility: Under biochar production and agronomic circumstances, the economic analysis given here shows a high chance of profitability for biochar and faba bean co-production in the research region. In the best-case scenario, Faba bean (Mariout cultivar) cultivation may yield as much as 11452.50 L.E fed^{-1}, which is mostly due to the high yield potential demonstrated in two years of regional bean growing trials, where the control condition produced close to 8133.50 L.E fed^{-1}. While, Nubaria-3 and Giza-716 were 10592.50 and 9950.00 L.E fed^{-1}, respectively (Table 8). Based on data derived from Liu *et al.*[25] used to estimate the improvements in potato yields, biochar and bean co-production may also be lucrative in some conditions. The possibility of successful potato cultivation with biochar backs up the idea that potato-biochar field trials are needed to show better yields or at the very least a site-specific range of yield values.

In general, biochar field investigations reveal site-specific susceptibility, raising questions regarding the applicability of results thru out the research. All projects are distinct due to local ecological, infrastructural and commercial circumstances. Any biochar production business endeavour would be regarded as very hazardous, given the small market for biochar demand.

This study, on the other hand, uses agronomic field data from the study area to provide a realistic, albeit large, range for the economic feasibility of biochar and agronomic output. According to the research, faba bean would be beneficial in

Table 8: Economic feasibility of biochar amendment on yield of faba bean varieties (Average of two years)

Varieties	Fertilizers (biochar)	Price (LE)	Grain yield (ton fed^{-1})	Price (LE)	Straw yield (ton fed^{-1})	Price (LE)	Total yield income
Control	Non biochar	0.00	0.92	7360.00	1.04	773.50	8133.50
Giza-716	90 kg fed^{-1}	630.00	1.12	8960.00	1.32	990.00	9950.00
Nubaria-3	90 kg fed^{-1}	630.00	1.19	9520.00	1.43	1072.50	10592.50
Mariout-2	90 kg fed^{-1}	630.00	1.29	10320.00	1.51	1132.50	11452.50

Grain yield of faba bean: 8 LE kg^{-1}, Straw yield of faba bean: 0.75 LE kg^{-1} and Biochar: 7 LE kg^{-1}

more than 90% of the scenarios considered, making it a very feasible enterprise in comparison to many other agronomic endeavours. Biochar is a commercially viable biofuel that may be utilized in agriculture, industry and the energy sector. As a result, biochar production can improve soil properties while also providing new revenue prospects.

As illustrated in Table 8, the total yield income (straw and grain) for the varieties are varies.

The response of faba bean to the rate of biochar addition up to 90 kg fed^{-1} indicated that the faba been was affected by the addition, where the number of branches, plant height, number of pods, the weight of pods, grain and 100 grain, grain yield, straw yields and N, K and protein (%) of the seeds were significantly correlated by the addition. Also, the cultivars type was influenced by the addition where the highly correlated one was Mariout-2 followed by Giza-716 and followed by Nubaria-3. These improvements may be regarded to the enhancing of soil physical properties (bulk density, surface and water capability, permeability as mentioned by[26,27]. As well as, soil chemical properties (nutrient retention and availability, CEC and pH). Through the addition of biochar, the development of a plant occurred, which confirmed with the results obtained by many authors (e.g.,[28-31]).

Furthermore, biochar improves soil biological characteristics by increasing diversity and creating a conducive environment for soil microbial communities[32,33] indicated that biochar's resistance to chemical and biological processes promotes its long-term agronomic and environmental advantages with residence period could be reached up to hundreds to thousands of years.

The positive influence of biochar produced from wastes was reported by many authors such as Abujabhah *et al.*[34] as mentioned by Lehmann and Joseph[35] the biochar application enhances the germination rate of the plant (maize) in types of soils, i.e., plant height and green biomass. In the current study, biochar amendment, affect faba bean growth with an increased rate of biochar. The higher growth of biochar-treated plants compared to control plants might be due to the biochar porosity, which allowed more water to be retained in the soils. Another hypothesis is that extra nutrients, particularly phosphorus, might be accessible to biochar-treated plants due to the chars' ash content, despite the frequent irrigation flush.

CONCLUSION

In this investigative research, plant growth was better at a high rate (90 kg fed^{-1}) but the economy of this rate may be interrogated. We found this rate suitable for sandy medium, however, the endorsement for different soils may vary with different rates. We also tried to discover the end level of biochar for optimal plant growth, so that we could set up further trials in different soil types. From this research, we illustrated a conclusion that further research on biochar rates versus other aspects in soil should be limited considering 90 kg fed^{-1} as an end level of biochar use. Also, it is recommended to use Mariout-2 cultivars for their high production and this condition.

SIGNIFICANCE STATEMENT

This study discovers the possible effect of biochar application on some faba bean varieties that can be beneficial for quantity and quality of yield. This study will help the researcher to uncover the critical areas of application biochar rates of sandy soil that many researchers were not able to explore. Thus, a new theory on biochar use may be arrived at.

ACKNOWLEDGMENT

The author(s) are thankful to the Director of a private farm in Wadi El-Natroun, El-Behaira Governorate, Egypt for providing all the necessary to complete the research work.

REFERENCES

1. Mostafa, F. and k. Shaban, 2019. Effect of different types of biochar on soil chemical properties, microbial community, pathogenic fungi and faba bean productivity. Sci. J. Agric. Sci., 1: 72-86.
2. Mona, A.M., M.A. Sabah and A.M. Rehab, 2011. Influence of potassium sulfate on faba bean yield and quality. Aust. J. Basic Appl. Sci., 5: 87-95.

3. Egamberdieva, D., S. Wirth, U. Behrendt, E.F. Abd_Allah and G. Berg, 2016. Biochar treatment resulted in a combined effect on soybean growth promotion and a shift in plant growth promoting Rhizobacteria. Front. Microbiol., Vol. 7. 10.3389/fmicb.2016.00209.
4. Kahil, A.A., Y.M. Issa, Y.M. Al-Sodany and E.F. Ali, 2018. Effects of biochar amended saline soil on growth and some metabolic activities of two Soybean cultivars in Saudi Arabia. Annu. Res. Rev. Biol., 25: 1-14.
5. Borchard, N., J. Siemens, B. Ladd, A. Möller and W. Amelung, 2014. Application of biochars to sandy and silty soil failed to increase maize yield under common agricultural practice. Soil Tillage Res., 144: 184-194.
6. Nair, A., R.A. Kruse, J.L. Tillman and V. Lawson, 2014. Biochar application in potato production. Iowa State University Research and Demonstration Farms Progress Reports.
7. Zheng, H., X. Wang, L. Chen, Z. Wang and Y. Xia *et al*., 2018. Enhanced growth of halophyte plants in biochar-amended coastal soil: Roles of nutrient availability and rhizosphere microbial modulation. Plant Cell Environ., 41: 517-532.
8. de Freitas Furtado, G., L.H.G. Chaves, J.R.M. de Sousa, N.H.C. Arriel, D.A. Xavier and G.S. de Lima, 2016. Soil chemical properties, growth and production of sunflower under fertilization with biochar and NPK. Aust. J. Crop Sci., 10: 418-424.
9. Alotaibi, K.D. and J.J. Schoenau, 2019. Addition of biochar to a sandy desert soil: Effect on crop growth, water retention and selected properties. Agronomy, 9: 2-14.
10. Wang, G.J., Z.W. Xu and Y. Li, 2016. Effects of biochar and compost on mung bean growth and soil properties in a semi-arid area of Northeast China. Int. J. Agric. Biol., 18: 1056-1060.
11. Leta, A., 2018. Effect of biochar application on beneficial soil organism review. Inter. J. Res. Stud. Sci. Eng. Technol., 5: 9-18.
12. Jalal, F., M. Arif, M.T. Jan and D. Muhammad, 2016. Integra biochar and legumes in summer gap for enhancing productivity of wheat under cereal based cropping system. Pak. J. Bot., 48: 2281-2288.
13. Głuszek, S., L. Sas-Paszt, B. Sumorok and R. Kozera, 2017. Biochar-rhizosphere interactions-a review. Pol. J. Microbiol., 66: 151-161.
14. Semida, W.M., H.R. Beheiry, M. Sétamou, C.R. Simpson, T.A.A. El-Mageed, M.M. Rady and S.D. Nelson, 2019. Biochar implications for sustainable agriculture and environment: A review. South Afr. J. Bot., 127: 333-347.
15. Klute, A., 1986. Methods of Soil Analysis Part 1. Physical and Mineralogical Methods. 2nd Edn., American Society of Agronomy and Soil Science Society of America, Madison, WI.
16. Fang, Y., B. Singh, B.P. Singh and E. Krull, 2014. Biochar carbon stability in four contrasting soils. Eur. J. Soil Sci., 65: 60-71.
17. Zhang, A., Y. Liu, G. Pan, Q. Hussain, L. Li, J. Zheng and X. Zhang, 2012. Effect of biochar amendment on maize yield and greenhouse gas emissions from a soil organic carbon poor calcareous loamy soil from Central China Plain. Plant Soil, 351: 263-275.
18. Black, C.A., 1982. Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties. 2nd Edn., American Society of Agronomy, Madison, WI., USA.
19. Nelson, D.W. and L.E. Sommers, 1983. Total Carbon, Organic Carbon and Organic Matter. In: Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties Page, A.L., R.H. Miller and D.R. Keeney (Eds.)., 2nd Edn., ASA and SSSA, Madison, WI., USA, pp: 539-579.
20. Cottenie, A., M. Verloo, L. Kiekens, G. Velghe and R. Camerlynck, 1982. Chemical Analysis of Plants and Soils. Laboratory of Analytical and Agrochemistry, State University-Ghent, Belgium.
21. AOAC, 1990. Official Methods of the Association of Official Analytical Chemists. 15th Edn., AOAC, Washington DC, USA, ISBN: 0-935584-42-0. pp: 777.
22. DuBois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers and F. Smith, 1956. Colorimetric method for determination of sugars and related substances. Anal. Chem., 28: 350-356.
23. Magomya, A.M., D. Kubmarawa, J.A. Ndahi and G.G. Yebpella, 2014. Determination of plant proteins via the Kjeldahl method and amino acid analysis: A comparative study. Int. J. Sci. Technol. Res., 3: 68-72.
24. Snedecor, G.W. and W.G. Cochran, 1990. Statistical Methods. 8th Edn., Iowa State Univ. Press, USA, Pages: 609.
25. Liu, X., A. Zhang, C. Ji, S. Joseph and R. Bian*et al*., 2013. Biochar's effect on crop productivity and the dependence on experimental conditions-A meta-analysis of literature data. Plant Soil, 373: 583-594.
26. Asai, H., B.K. Samson, H.M. Stephan, K. Songyikhangsuthor and K. Homma *et al*., 2009. Biochar amendment techniques for upland rice production in Northern Laos: 1. Soil physical properties, leaf SPAD and grain yield. Field Crop Res., 111: 81-84.
27. Sun, L., L. Li, Z. Chen, J. Wang and Z. Xiong, 2014. Combined effects of nitrogen deposition and biochar application on emissions of N_2O, CO_2 and NH_3 from agricultural and forest soils. Soil Sci. Plant Nutr., 60: 254-265.
28. Abel, S., A. Peters, S. Trinks, H. Schonsky, M. Facklam and G. Wessolek, 2013. Impact of biochar and hydrochar addition on water retention and water repellency of sandy soil. Geoderma, 202-203: 183-191.
29. Major, J., M. Rondon, D. Molina, S.J. Riha and J. Lehmann, 2010. Maize yield and nutrition during 4 years after biochar application to a *Colombian savanna* oxisol. Plant Soil, 333: 117-128.

30. Solaiman, Z.M., P. Blackwell, L.K. Abbott and P. Storer, 2010. Direct and residual effect of biochar application on mycorrhizal root colonisation, growth and nutrition of wheat. Soil Res., 48: 546-554.
31. Vaccari, F.P., S. Baronti, E. Lugato, L. Genesio, S. Castaldi, F. Fornasier and F. Miglietta, 2011. Biochar as a strategy to sequester carbon and increase yield in durum wheat. Eur. J. Agron., 34: 231-238.
32. Cornelissen, G., V. Martinsen, V. Shitumbanuma, V. Alling and G.D. Breedveld *et al*., 2013. Biochar effect on maize yield and soil characteristics in five conservation farming sites in Zambia. Agronomy, 3: 256-274.
33. Tong, H., M. Hu, F.B. Li, C.S. Liu and M.J. Chen, 2014. Biochar enhances the microbial and chemical transformation of pentachlorophenol in paddy soil. Soil Biol. Biochem., 70: 142-150.
34. Abujabhah, I.S., S.A. Bound, R. Doyle and J.P. Bowman, 2016. Effects of biochar and compost amendments on soil physico-chemical properties and the total community within a temperate agricultural soil. Appl. Soil Ecol., 98: 243-253.
35. Lehmann, J. and S. Joseph, 2015. Biochar for Environmental Management. 2nd Edn., Taylor & Francis Group, Pages: 976.