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Effect of Some Soil Conditioners on Snap Bean Growth Yield and Sandy Soil Properties

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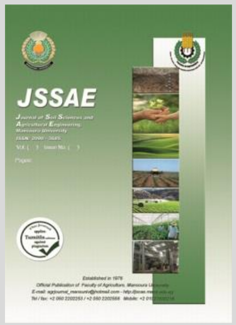

ABSTRACT

During 2018-2019 and 2019-2020 seasons, two-field experiments were conducted at El-Kasasin Horticultural Research Station, Ismailia Governorate, Egypt, to test the impact of potassium humate(KH) and biochar with substitution part of recommended mineral fertilization on growth parameters, physical, chemical characteristics of pods and green yield of snap bean as well as some physical and chemical soil properties after harvesting. The experiment was laid out in randomized complete block design (RCBD) with nine treatments included; solo application from 2 ton biochar+4 kg KH and 4 ton biochar+6 kg KH and each one was mixed with 25, 50 and 75% NPK from recommended dose comparing with 100% NPK. Overall, the results of this study indicated that soil addition of 75% NPK+ 4 ton biochar+6 kg KH recorded the best mean values of all tested parameters and improved growth, which reflected on yield and its components followed by 100% NPK.

Keywords: Biochar, humic acid, NPK and snap bean

INTRODUCTION

The vast majority of the accessible zone for expanding agricultural activities are characterized as sandy soils, which portrayed by poor fertility and limited crop productivity due its poor physical, chemical and biological properties (Ali, 2018). This low fertility is the major reason in this area mainly limiting agricultural production, which require chemical and natural fertilization to increase crop productivity, El-Etr and Hassan (2017). Application of organic amendments in sandy soils face the challenge of constant turnover, because of the decomposition rate is high and that the added organics are usually mineralized within only short cropping seasons (Baiamonte *et al.* 2019). Thus, the suitable option is using of more stable organic materials, in this respect; biochar could be a great choice to replace the effectively decomposable organic manures.

As the most suitable potential solution, applying biochar as soil amendment was progressively investigated during the last years because of the assumed beneficial impacts on soil properties, e.g. cation exchange capacity, soil pH, long term carbon, soil water holding capacity and sequestration, which reflect on crop yield and the potential of greenhouse gas mitigation (Cayuela *et al.* 2014). Biochar is an organic amendment, which considered C-rich material created by various thermochemical biomass conversion processes as pyrolysis and hydrothermal carbonization. Since biochar contain organic carbon in stable form, the addition of biochar to the soil has the potential to carbon sequestration and improves soil quality, which is remarkable for mitigation of excessive carbon dioxide in the atmosphere (Baiamonte *et al.* 2019). Biochar can contribute to improve water storage by modifying that portion of the soil pore size distribution, which is associated with aggregation and with water storage in pores. Many studies agree with the positive effect of biochar on soil physical properties such as soil water retention, porosity and plant available water, which is the amount of water between field capacity and wilting point (Głąb *et al.* 2016). Fouda *et al.* (2020) indicated that the soil pH was slight lower and increased available micro and macronutrients due to the use of biochar. Youseef *et al.* (2017) resulted that application of 3 m^3 biochar increased all plant growth characters (Plant height, number of leaves/plant, diameter of both neck and bulb (mm), and bulbing ratio=Neck diameter/Bulb diameter) and marketable and total yields of garlic plant under sandy soil condition. Mostafa and Shaban (2019) reported that application of biochar under sandy loam soil significantly improved soil physical and chemical properties and increased production of faba bean plant.

Its known that fertilization is important method to all plants by improving soil fertility and quality then increasing crop production. The application of nitrogen, phosphorus and potassium play pivotal roles in plant growth and development. N is major for synthesis of chlorophyll, enzymes and proteins. Mansouri *et al.* (2020) stated that using nitrogen fertilization application significantly increased dry matter in both flowering and fruiting stages, for snap bean. Pod number per plant and seed yield was increased by the application of N fertilizer. P is main for root growth and ATP, ADP formation, phosphor lipids - and phosphor- proteins, Raihan *et al.* (2021) found that phosphorus application had a significant effect on pod number per plant, number of individual pod length, pod width and pod weight of country bean plant. K plays a vital role in water relations, photosynthesis, enzyme activation and assimilate transport can have direct consequences on crop productivity. It maintains turgor pressure of cell which is essential for cell expansion. Abdel-Mawgoud *et al.* (2005) with increasing NPK application found an increase in vegetative growth parameters, total yield and pod quality as pod length, thickness and fiber content. The use of mineral fertilizers

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without rationalization may cause environmental pollution. In recent years, to mitigate the environmental impacts of excessive rates of chemical fertilization in agroeco-systems, the combined use of inorganic fertilizers with organic manures has attracted increasing interest in Egypt (Islam *et al.* 2016).

In the agricultural sector, efforts have been made to improve soil defects due to addition of NPK, which reflect in plant performance. Humic substances (for example humic acid or potassium humate) are the major fraction of humic substances used in appropriate quantities as a soil conditioner/fertilizer to improve root and whole plant growth (Rady *et al.* 2016). Humic acid can enhance availability of nutrients improving physical, chemical and biological soil properties (Nardi *et al.* 2002; Selim and Mosa, 2016) .The direct and indirect beneficial impacts of humic acid on plant growth and development by its effect on cell membranes which lead to the increased transport of nutrients, plant activity hormone, improved protein synthesis, enhanced photosynthesis, modified enzyme activities, solubility of macro-elements and micro-elements reduction of active levels of toxic minerals and increased microbial populations (Hamideh *et al.* 2013)

The snap bean *(Phaseolus vulgaris* L.) especially its green pods and dry seeds is the most important and vital leguminous crops in the Egypt. Besides providing high quality protein for human consumption through its green pods or dry seeds and rich with mineral elements (N, P, K, Zn and Fe), fibers, carbohydrates, TSS and proteins (Baddour and Atia 2021).

An effective fertilizing strategy for horticultural crops as *P. vulgaris* is the use of organic fertilizers (for example, potassium humate, biochar, etc.) in integration with NPK fertilizers for sustainable agriculture. Hence, the aim of this study is to investigate the effect of biochar and humic substance in substitution with NPK on soil properties and its reflection on growth and productivity of snap bean plants.

MATERIALS AND METHODS

The study was conducted during 2018-2019 and 2019-2020 seasons at El-Kasasin Horticultural Research Station, Ismailia Governorate, Egypt, to test the impact of potassium humate and biochar with substitution apart of recommended mineral fertilization on growth parameters, physical, chemical of pod and green yield of snap bean as well as some physical and chemical soil properties after harvesting.

The experiment was laid out in randomized complete block design (RCBD) with nine treatments included:

1.100% NPK
2.75% NPK+ 2 ton biochar+4 kg humic.
3.75% NPK+ 4 ton biochar+6 kg humic
4.50% NPK+ 2 ton biochar+4 kg humic
5.50% NPK+ 4 ton biochar+6 kg humic
6.25% NPK+ 2 ton biochar+4 kg humic
7.25% NPK+ 4 ton biochar+6 kg humic
8.2 ton biochar+4 kg humic
9.4 ton biochar+6 kg humic

Some chemical and physical analyses of the experimental site as routine work are presented in Table (1). Soil analysis parameters were determined according to the methods of Haluschak (2006) and Reeuwijk (2002).

The wastes of olive trees were dried under sun then weighted and insert into homemade Egyptian retort machine at a temperature of 350 degrees in absence of oxygen (pyrolysis conversion) and left for 3 hours to cold then the biochar was produced. Biochar was mixed with soil before 20 days from sowing at soil preparation at rate of 2 and 4 ton.fed^{-1} and then the soil was irrigated up to saturation percentages. Chemical analyses of the used biochar are presented in Table (2). As for humic acid applied with soil preparation in form of potassium humate at rate of 4 and 6 kg.fed^{-1} with soil.

Table 1. Soil physical and chemical analysis of the experimental site for two seasons (average values)

Physical parameters			Chemical parameters	
Distribution particle size (%)	Sand	76.79	EC, dS.m^{-1}	0.99
	Silt	15.58	pH (1:2.5)	8.09
	Clay	7.63	O.M. %	0.67
Soil texture	Sandy		CEC (cmol(+) kg^{-1} soil)	8.55
S.P %	20.25		N mg.kg^{-1}	38.24
Bulk density (g.cm^{-3})	1.63		P mg.kg^{-1}	7.46
			K mg.kg^{-1}	206.62

Table 2. Physical and chemical analyses of the used biochar for the two studied seasons (average values)

	Biochar
Bulk density (g cm^{-3})	1.18
EC (dS m^{-1})	2.86
pH	10.5
CEC (cmol kg^{-1})	28.5
OC%	58.27
Total N%	1.21
C/N ratio	48.16
Total P%	0.37
Total K%	0.52

Recommended dose of mineral fertilizers was added in form of calcium super phosphate (15% P2O5) for P at rate of 100 kg.fed^{-1} during soil preparation. N in form of ammonium sulphate (20.6%N) at rate of 200 kg.fed^{-1} and potassium sulphate (48% K2O) for K at rate of 100 kg.fed^{-1}. The N and K fertilizers, were split into two equal parts, which added during the growth seasons, the first addition after 20 days and the second one 20 days interval.

The area of each experimental plot was 10.5 m^2, every plot consisted of 5 dripper lines (3 m in length X 0.7 m in width). Seeds of snap been (cv. Paulista) were soaked in *Rhizobium* bacteria then sown in 15th September for both seasons. Seeds were sown in hills 20 cm apart on one side of dripper lines and two seeds per hill. The plant thinning after 15 days from seeding when seed germination was completed and one plant per hill was left. The drip lines were placed before planting on the soil surface at the soil bed center and the normal agriculture practices of snap bean under drip irrigation system were done.

After 55 days from planting, a random sample of 5 plants were taken from each plot to measure plant height (cm), number of branches/plant, number of leaves/plant, and chlorophyll content mg.g^{-1} fresh weight was measured by spectrophotometric method of Gavrilenko and Zigalova (2003). Then samples were oven dried at 70 °C till constant weight and the dried parts were thoroughly ground and stored for chemical analysis of N, P, K %, which determined according to the methods mentioned by Mertens, (2005).

At harvesting stage after 70 days from planting, green pods were collected and measured the following parameters; pods length and weight, number of pod/plant and total green pod yields (per plot and $Mg.fed^{-1}$). About 20 pods were oven dried to determined N, P and K% as well as Protein content (%) (calculated by multiplying N percentage by 6.25 according A.O.A.C, 2000).

Data of average two seasons were subjected to statistical analysis by method conducted by Gomez and Gomez, (1984), the comparison between treatments were compared at the least significant difference (5%) and Duncan's multiple range test using CoSTATE Computer Software.

RESULTS AND DISCUSSION

Vegetative growth parameters:

Data presented in Table 3 showed the tested rates of biochar and potassium humate, which replaced with part of recommended NPK on vegetative growth parameters and chlorophyll content of snap bean plants and comparing with the full doses and solo addition of biochar + potassium humate. It is evident from the Table that all treatments were significantly affected in plant height (cm), number of branches/plant and number of leaves/plant, and chlorophyll content $mg.g^{-1}$ FW. From listed data found that soil addition of biochar and potassium humate with NPK increased mentioned parameters over biochar and potassium humate in solo form. The highest mean values were recorded with 75% NPK+ 4 ton biochar+6 kg humic followed by 100% NPK and the lowest values with 2 ton biochar+4 kg humic.

Supply of nutrient plays a significant role in vegetative growth of plants due to it's helping in cell elongation of stem because of development of cell elongation in meristematic region and rapid cell division of plant. Additionally, the major part of nitrogen in nuclic acids, proteins and co-enzymes. As for, phosphorus also has a beneficial part in growth of the root system epidermal osmotic adjustment, enhance nodulation of plant and fundamental role in the number of enzymatic reaction as well as increase photosynthesis of plant. While potassium activates some enzymes and K^+ ions play a major part in control stomatal guard cells of leaves, cell division and elongation and metabolism of carbohydrates and protein compounds as well increase photosynthesis. This endorses by (Raihan *et al.* 2021).

Biochar addition to mineral fertilizer induced plant growth stimulation and improves the response of crop may be due to direct effects via biochar-supplied nutrients (Silber *et al.* 2010), and to various other indirect impacts, including: improvements in soil reaction (pH), increased retention of nutrient, increased soil CEC, neutralization of phytotoxic compounds in the soil, impacts on S, P transformations and turnover, and alteration of soil microbial populations and functions, which caused a shift in populations microbial towards beneficial plant growth promoting fungi or rhizobacteria due to either physical and chemical attributes of the biochar (Elad *et al.* 2011).

The enhancing effect on morphological characters of snap bean by soil addition of potassium humate could be attriebuted to its ability in form stable complexes with metal ions that can be accounted for their high content of oxygen-containing functional groups viz., alcoholic –OH groups, aliphatic phenolic and carboxylic (Stevenson *et al*., 1993). Also, Nardi *et al.* (1999) found that humic acid in potassium humate had an auxin and gibberellins exhibiting higher amount of phenolic. Therefore, the benefits of potassium humate for vegetative growth parameters may be related to its positive effects on increased fertilizer-use efficiency and/or decrease soil compaction (Nardi *et al.* 2002). In addition, potassium humate has been claimed to promote plant growth by increasing chlorophyll and carotenoids contents. additionally, potassium humate converted to readily available humic substances improved the chemical properties of soil and its fertility by increasing soil microorganisms that enhance uptake of nutrient and decrease soil pH (Hemida *et al.* 2017 and Taha and Osman 2018), thus leading to increase the nutrients absorption as N, P and K.

Many other reports support our obtained results such as Mostafa and Shaban (2019); Osman *et al*. (2020) and Raihan *et al.* (2021).

Table 3. Effect of NPK fertilization, biochar and potassium humate on vegetative growth parameters and chlorophyll content of snap bean plant (average of two seasons).

Treatments	Plant height (cm)	Number of branches/plant	Number of leaves/plant	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll (mg/g)
100% NPK	40.66ab	6.67ab	16.33ab	0.828b	0.583b	1.411b
75% NPK+ 2 ton biochar+4 kg KH	40.21bc	6.00bc	15.67abc	0.822bc	0.576b	1.398c
75% NPK+ 4 ton biochar+6 kg KH	41.30a	7.33a	17.67a	0.838a	0.591a	1.429a
50% NPK+ 2 ton biochar+4 kg KH	38.86de	5.33cd	14.33a-d	0.808d	0.560d	1.368e
50% NPK+ 4 ton biochar+6 kg KH	39.40cd	5.67bc	15.00a-d	0.817c	0.569c	1.385d
25% NPK+ 2 ton biochar+4 kg KH	37.50fg	4.33def	12.67bcd	0.793e	0.515e	1.308g
25% NPK+ 4 ton biochar+6 kg KH	38.25ef	5.00cde	13.67bcd	0.802d	0.553de	1.355f
2 ton biochar+4 kg KH	36.26h	3.67f	11.33d	0.782f	0.534f	1.316h
4 ton biochar+6 kg KH	36.88gh	4.00ef	12.00cd	0.785f	0.538f	1.323h
LSD at 5%	0.96	1.28	3.85	0.007	0.007	0.011

KH: potassium humate

Yield and its components:

Soil addition of NPK fertilization, biochar and potassium humate at different rates on yield and its components were presented in Table 4. The yield and its component parameters expressed as pod length, number of pods, average weight of pods and yield ($kg.plot^{-1}$ and $Mg.fed^{-1}$) were increased significantly in response to all treatments. The highest mean values of traits were connected with soil addition of 75% NPK+ 4 ton biochar+6 kg humic followed by 100% NPK from recommended dose comparing with other treatments and the lowest values with addition of 2 ton biochar+4 kg humic.

Enhancement in snap bean yield due to mineral fertilization (NPK) could be attributed to its availability and solubility the easily absorptions by plant. Additionally, soil addition of NPK make nutrient available in rooting zone consequently caused increase the ability of plant roots to uptake more elements in plant tissues. As for the positive effects of biochar as soil addition to its impacts on improvements of: P and S transformations and turnover, soil cation exchange capacity and soil physical properties including pH (Yamato *et al.* 2006 and Deluca *et al*. 2009), water and nutrient retention (Novak *et al*. 2009), elements supply of plants and alteration of soil microbial populations and functions (Kolton *et al.* 2011). These results support those of (Mostafa and Shaban, 2019). The improvement occurred in yield and its segments due to the soil addition of potassium humate may be attributed to its effect on growth parameters, which reflected positively on yield and components. In the same line, Taha and Osman (2018) reported that soil application of potassium humate significantly increased the number of green pods plant^{-1}, green pods yield plant^{-1} and green pods yield. Also, Osman *et al.* (2020) obtained an increase in number of green pods, average weight of green pods and total yield of green pods were significantly increased by soil addition of potassium humate.

Table 4. Effect of NPK fertilization, biochar and potassium humate on yield and its components of snap bean plant (average of two seasons).

Treatments	Pod length, cm	No. of pods/ plant	Average weight of pod, g.plant^{-1}	Yield, kg.plot^{-1}	Yield, Mg.fed^{-1}
100% NPK	12.27b	27.33a	5.94b	12.18ab	4.63ab
75% NPK+ 2 ton biochar+4 kg KH	12.11c	26.00ab	5.64c	10.99abc	4.17abc
75% NPK+ 4 ton biochar+6 kg KH	12.66a	28.00a	6.17a	12.94a	4.92a
50% NPK+ 2 ton biochar+4 kg KH	11.23e	23.00a-d	5.16e	8.91cde	3.39cde
50% NPK+ 4 ton biochar+6 kg KH	11.71d	24.33abc	5.44d	9.94bcd	3.78bcd
25% NPK+ 2 ton biochar+4 kg KH	10.39g	20.33cd	4.76g	7.25ef	2.76ef
25% NPK+ 4 ton biochar+6 kg KH	10.77f	21.67bcd	4.95f	8.05def	3.06def
2 ton biochar+4 kg KH	9.11i	18.33d	4.22i	5.81f	2.21f
4 ton biochar+6 kg KH	9.52h	19.00cd	4.45h	6.32f	2.40f
LSD $_{at\ 5\%}$	0.13	5.50	0.16	2.25	0.85

KH: potassium humate

Chemical composition of leaves and pods:

The nutrition values of leaves (N, P, K) and pods (N, P, K and protein%) as affected by biochar and potassium humate, which replaced with part of recommended NPK under investigation realized in Table 5. The statistical analysis of the obtained data showed that the differences within the different treatments addition were true to reach the significant level in the average of two experimental seasons. With increasing rate of both biochar and potassium humate increased all nutrients with replaced part of recommended NPK. From the data obtained in Table 5 found that, the highest mean values of N, P and K in leaves and pods as well as protein in pods were realized with treatment of 75% NPK+ 4 ton biochar+6 kg humic followed by application of 100% NPK and the lowest values with application of solo 2 ton biochar+4 kg humic.

Under mineral fertilization, most of soil nitrogen will be turn out in form of nitrate and will be available to plants in great quantity of nitrogen due to its assimilation capacity. P as nutrient plays a part for improving the growth of root system, then enhancing the capacity of root to absorb more nutrients. Wile, the role of K in nutrients uptake and nutritional balance, may be due to increase the biosynthesis of photosynthesis, also as a result of K_2SO_4 in the soil may be attributed to the role of S, which played a part in minimizing the values of soil pH and, subsequently facilitate the absorption of nutrients by the roots of snap beans. Biochar is produced from organic materials, in its mineral fraction inherently contains different nutrients. Therefore, soil appliction of biochar adds free exchangeable bases such as Mg, Ca and K to occupy the soil-exchange sites, which resulting an increase in soil pH, and readily supplying plant nutrients for growth (Glaser, 2007). Although the soil mixed with biochar increasing C:N ratios, it is important to note that the total elemental contents of N, which is organically bound, does not reveal the definite plant available N (Chan and Xu, 2009). Biochar also contains a high content of soluble P salts formed during the charring of organic material. This result is similar to the result reported by (Mostafa and Shaban, 2019). Potassium humate can promote the nutrients absorption by preventing their precipitation in the nutrient solution (Osman and Rady, 2012). Also, potassium humate can create more accessibility for the nutrients by reducing soil pH value, thus increasing the mineral availability of nutrients to be absorbed easily by plant roots (Taha and Osman 2018 and Osman *et al.* 2020) they reported that soil application with potassium humate had a positive effect on N, P and K leaf contents as compared with control.

Table 5. Effect of NPK fertilization, biochar and potassium humate on chemical content in leaves and pods of snap bean plant (average of two seasons).

Treatments	Leaves			Pods			
	N%	P%	K%	N%	P%	K%	Protein %
100% NPK	4.07b	0.464b	2.73b	3.41ab	0.407b	2.43b	21.33ab
75% NPK+ 2 ton biochar+4 kg KH	4.00c	0.456c	2.64c	3.35bc	0.400c	2.33c	20.96bc
75% NPK+ 4 ton biochar+6 kg KH	4.16a	0.474a	2.82a	3.46a	0.415a	2.48a	21.65a
50% NPK+ 2 ton biochar+4 kg KH	3.85e	0.444d	2.49e	3.24d	0.383e	2.14e	20.27d
50% NPK+ 4 ton biochar+6 kg KH	3.94d	0.449d	2.58d	3.31c	0.393d	2.24d	20.69c
25% NPK+ 2 ton biochar+4 kg KH	3.70g	0.427f	2.35g	3.09ef	0.367g	2.01g	19.33ef
25% NPK+ 4 ton biochar+6 kg KH	3.77f	0.435e	2.44f	3.15e	0.373f	2.06f	19.69e
2 ton biochar+4 kg KH	3.56i	0.417g	2.24h	2.98g	0.353h	1.86i	18.63g
4 ton biochar+6 kg KH	3.63h	0.422fg	2.30g	3.04f	0.358h	1.93h	19.02f
LSD $_{at\ 5\%}$	0.05	0.006	0.05	0.06	0.006	0.05	0.38

KH: potassium humate

Chemical and physical properties of soil after harvesting:

Data illustrated in Table 5, show the effect of biochar and humic acid at different rates which replaced with a part of recommended NPK on some chemical and physical properties of sandy soil under investigation comparing with the full doses and solo addition of biochar + potassium humate. Addition of all treatments significantly affected in some chemical properties such as available N, P, K, EC, CEC and SOC, while had no significant effect on pH. The pH of all treatments investigated was near neutral value so, their addition to the alkaline sandy soil studied slightly decreased soil pH from 8.09 to 8.17.

Application of 100% NPK was the treatment recorded the highest values of available N, P and K. While, with increasing rates of biochar and potassium humate found an increase in Ec, CEC and SOC, the highest mean values of such tratis recorded with addition of 75% NPK+ 4 ton biochar+6 kg potassium humate all comparing with values before planting.

At all application rates of treatments, similar pronounced and significant improvements in some soil physical properties such as decreasing bulk density and increasing water holding capacity, field capacity, permanent wilting point, available water and finally porosity were observed. With increasing rates of biochar and potassium himate with NPK found an increase in physical parameters except bulk density was decresed. The highest values recorded with application of 75% NPK+ 4 ton biochar+6 kg potassium humate, while bulk density recorded with 2 ton biochar+4 kg potassium humate.

Increased availabilities of N, P, and K may also result from changes in soil nutrient turnover rates due to altered ecosystem properties. Soil nutrient turnover rate consist of decomposition, mineralization, weathering, chemical complexation, adsorption or nutrient uptake by crops and soil organisms. The results are in good agreement with those reported by (Kamble and Kathmale, 2015) found that, addition of 125 % recommended dose of NPK to onion appears to be improving soil fertility and recorded a significantly highest available N and P.

Addition of biochar did not affect in pH values as indicated by El-Naggar *et al* (2019) said that biochar is alkaline, and therefore its impact on increasing acidic soil pH was demonstrated in several studies whereas its effects on alkaline soil pH is expected to be minimal. Increase in other chemical or physical parameters are in agreement by Khaled and Jeff (2019) illustrated that the EC increase in the sandy loam soil amendment with biochar C (3.98 $ds.m^{-1}$) produced from town refuse may led to high salinity compared with other biochar types. Mahmood *et al*. (2016) stated that biochar (rice husk) addition led to decreased in soil bulk density and increase in soil porosity, followed by an increase in available water. Mostafa and Shaban (2019) resulted a decrease in pH with increasing application rates of biochar, while EC was increased.

The unique composition of humic substancesis interlinked inside the aggregation of soil particles and ameliorating biogeochemical responces in the rhizosphere. Sandy soils are the most vulnerable to the potential deteriorations of environmental conditions (e.g. erosion) due to their helpless texture (Mosa *et al*. 2020). Soil addition of humic acid not only mended aggregate stability but also decreased the disaggregating impacts of wetting and drying cycling and structural stability of soils. application of humic acid reduced the pH and increased the CEC of soil. According to Nan *et al*. (2016) demonstrated that addition of humic acid reduced soil pH, exchangeable sodium percentage, sodium adsorption ratio. Meantime, soil electrical conductivity and saturated hydraulic conductivity (Ks) showed slight increments. Zhou *et al.* (2019) found that addition of bentonite-humic acid mixture for 7 years under the field conditions improved soil physical properties (soil aggregate distribution, soil porosity and water holding capacity).

Table 6. Effect of NPK fertilization, biochar and potassium humate on some chemical and physical properties of soil after harvesting (average of two seasons).

Treatments	Chemical properties							Physical properties					
	Available N, ppm	Available P, ppm	Available K, ppm	pH (1:2.5)	EC ($dS.m^{-1}$)	CEC cmol (+) kg soil	SOC %	Bulk Density, g/cm^3	WHC %	FC%	PWP%	Available water %	Porosity %
100% NPK	58.12a	9.71a	254.09a	8.09b	1.10g	9.92i	1.05g	1.68a	32.39i	10.17i	3.96i	6.21i	40.28i
75% NPK+ 2 ton biochar+ 4 kg KH	55.12bc	8.64c	248.66c	8.11ab	1.26de	12.57e	1.22bcd	1.53de	41.27e	15.35e	6.27e	9.08e	44.01e
75% NPK+ 4 ton biochar+ 6 kg KH	56.67ab	9.16b	251.36b	8.16a	1.55a	15.80a	1.36a	1.37h	50.09a	20.33a	8.20a	12.13a	47.15a
50% NPK+ 2 ton biochar+ 4 kg KH	52.04de	7.45e	244.09e	8.13ab	1.22e	11.73f	1.19cde	1.56cd	39.01f	13.95f	5.47f	8.48f	43.28f
50% NPK+ 4 ton biochar+ 6 kg KH	53.50cd	8.06d	246.28d	8.15ab	1.43b	15.13b	1.28ab	1.42gh	47.94b	19.18b	7.77b	11.41b	46.33b
25% NPK+ 2 ton biochar+ 4 kg KH	48.89fg	6.59g	238.26g	8.14ab	1.21ef	11.23g	1.15def	1.61bc	36.85g	12.60g	4.98g	7.62g	42.49g
25% NPK+ 4 ton biochar+ 6 kg KH	50.38ef	7.05f	241.11f	8.16a	1.35c	13.58c	1.25bc	1.46fg	45.64c	17.96c	7.30c	10.66c	45.53c
2 ton biochar+4 kg KH	45.24h	5.77i	232.05i	8.15ab	1.16f	10.18h	1.13efg	1.65ab	34.55h	11.29h	4.52h	6.77h	41.68h
4 ton biochar+6 kg KH	47.19g	6.16h	235.12h	8.17a	1.31cd	13.26d	1.09fg	1.49ef	43.49d	16.78d	6.88d	9.90d	44.76d
LSD $_{at\ 5\%}$	1.75	0.15	1.97	n.s	0.05	0.15	0.08	0.05	0.17	0.10	0.07	0.12	0.17

KH: potassium humate SOC: soil organic carbon

CONCLUSION

This investigation has the importance of different application rate of biochar and potassium humate replaced with apart of NPK recommended dose comparing with the solo addition of biochar + potassium humate or NPK in full dose in snap bean under sandy soil condition. During the experiment, we observed that biochar and potassium humate with apart of NPK had the greatest effect on improving the soil properties and vegetative plant growth. All treatments application significantly increased the morphological attributes of the plant. Finally, based on the biochar and potassium humate there were the greatest interaction when soil amended with 4 ton biochar+6 kg potassium humate with the combination of NPK fertilizer at rate of 75% from the recommended dose.

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تأثير بعض محسنات التربة على نمو وإنتاجية الفاصوليا وبعض خصائص التربة الرملية

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خلال موسمي النمو 2018-2019 و2019-2020، أجريت تجربتان حقليتان في محطه بحوث البساتين بالقصاصين، محافظه الإسماعيلية لدراسة تأثير إضافة هيومات البوتاسيوم والبيوشار مع التغيير في نسب الموصي به من التسميد المعدني على صفات النمو، الصفات الفيزيائية والكيميائية للقرون، محصول القرون الخضراء للفاصوليا بالإضافة الى بعض خصائص التربة الفيزيائية والكيميائية بعد الزراعة. صممت تجربه في قطاعات كامله العشوائية تحتوي على 9 معاملات كررت ثلاث مرات تشتمل على إضافات فرديه من 2 طن بيوشار+ 4 كجم هيومات بوتاسيوم، 4 طن بيوشار + 6 كجم هيومات بوتاسيوم وكل منهما مع 25، 50، 75% من الموصي به تسميد معدني مقارنه بالإضافة الكاملة 100% تسميد معدني. بشكل عام، أشارت نتائج هذه الدراسة بأن الإضافة الأرضية من 75% تسميد معدني + 4 طن بيوشار + 6 كجم هيومات بوتاسيوم سجلت أفضل النتائج لجميع الصفات تحت الدراسة وأعطت أفضل نتائج لصفات النمو والتي انعكست على صفات المحصول يليها إضافة الكمية الكاملة 100% من التسميد المعدني.