Int.J.Curr.Microbiol.App.Sci (2020) *9*(8): 2007-2015

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 9 Number 8 (2020)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2020.908.229

Effect of Different Level of N P K and Biochar on Soil Physico-chemical Properties and Yield Attribute of Black Gram (*Vigna mungo* L.*)* var KPU 07-08

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Keywords

Blackgram, Soil, Urea, SSP, Biochar *etc.*

Article Info

Accepted:
20 July 2020
Available Online:
10 August 2020

A B S T R A C T

An experiment was conducted on "Effect of different level of N P K and Biochar on Soil Physico-chemical properties and Yield Attribute of Black gram (*Vigna mungo* L.) Var. KPU 07-08" during Rabi season 2019-20 at the Research farm Department of Soil Science and Agricultural Chemistry, Naini Agriculture Institute, SHUATS, Prayagraj. The design applied was 3x3 randomized block design having three factors with three levels of NPK @ 0, 50, and 100 % ha^{-1}, three levels of Biochar @ 0, 50 and 100% ha^{-1} respectively. The result obtained with treatment T_8- [N P K @ 100 % + Biochar @ 100%] that showed the highest yield regarding, gave the best results with respect to plant height 60.10 cm, number of leaves $plant^{-1}$ 34.00, No. of pod $plant^{-1}$ 38.77, it gave highest yield 13.05 q ha^{-1}Biochar in combination resulted in a slight increase in soil pH 7.25, Electrical conductivity 0.28 dSm^{-1}. In post-harvest soil of NPK fertilizers observations were resulted in significant increase in Organic carbon 0.79 %, Particle density 2.64Mg m^{-3}, Bulk density 1.10 Mg m^{-3}, Pore space 58.33 % and available N 340.23 $kgha^{-1}$, P 35.85 kg ha^{-1}, K 206.64 kg ha^{-1}, significant increase in case of Nitrogen (kg ha^{-1}), Phosphorus (kg ha^{-1}), Potassium (kg ha^{-1}) was found to be significant among other treatments in Black gram cultivation and soil quality improvement. It was also revealed that the application of N P K with Biochar was excellent source for fertilization than fertilizers.

Introduction

Urdbean (*Vigna mungo* L. Hepper) is among the major pulses grown throughout the country during both in summer and rainy season. Pulses are the main source of protein particularly for vegetarians and contribute about 14% of the total protein of average Indian diet. It is a self-pollinated leguminous crop containing 24% protein, 60% carbohydrate, 1.4 % fat, 3.2% minerals, 0.9% fibre, 154 mg calcium, 385 mg phosphorus, 9.1 mg iron and small amount of vitamin B-complex. Being a short duration crop, it fits well in various multiple and intercropping systems. After removing pods, its plant may be used as good quality green or dry fodder or green manure. Being a legume, it also

enriches soil by fixing atmospheric nitrogen. India currently represents the largest producer of black gram accounting for more than 70% of the global production. India is followed by Myanmar and Pakistan. In India during *kharif* 2019-20, area covered under black gram is 37.52 lakh ha as against 38.18 lakh ha in last year. The states of Madhya Pradesh (16.50 lakh ha), Uttar Pradesh (7.01 lakh ha), Rajasthan (4.56 lakh ha), Maharashtra (2.87 lakh ha), Karnataka (0.687 lakh ha) and Andhra Pradesh (0.11 lakh ha) are the major producers of black gram in India during Kharif. (Directorate of Economics and Statistics (DES), *4th Advance Estimates (2019-20). It can be grown on all type of soils ranging from sandy loam to heavy clay except alkaline and saline soils. However, it does well on heavier soils such as black cotton soils which retain higher moisture for longer time (Markam *et al.*, 2017).

Soil is a medium for plant growth. Crop production is based largely on soils. Some of the soil properties affecting plant growth include: soil texture (coarse fine), aggregate size, porosity, aeration (permeability), and water holding capacity, pH, bulk density, particle density. The rate of water movement into the soil (infiltration) is influenced by its texture, physical condition (soil structure and tilth), and the amount of vegetative cover on the soil surface.

Organic matter tends to increase the ability of all soils to retain water, and also increases infiltration rates of fine textured soils. Bulk density reflects the soil's ability to function for structural support, water and solute movement, and soil aeration. Soil pH directly affects the solubility of many of the nutrients in the soil needed for proper plant growth and development. As such, it is also a useful tool in making management decisions concerning the type of plants suitable for location, the possible need to modify soil pH (either up or down), and a rough indicator of the plant availability of nutrients in the soil.

Urdbean is capable of fixing atmospheric nitrogen, it responds to small quantity of nitrogenous fertilizers applied as starter dose. Application of 15-20 Kg N ha^{-1} has been found optimum to get better response. Application of higher dose of nitrogen may reduce nodule number and nodule growth and thus adversely affect the nitrogen fixation capacity. Nitrogen is an important nutrient for all crops. It increases yield nutrition also increases the protein content. Deficient plants may have stunted growth and develop yellow-green colour. It accelerates photosynthetic behaviour of green plants as well as growth and development of living tissues specially tiller count in cereals (Azadi *et al.,* 2013). Phosphorus is the second most important nutrient that must be added to the soil to maintain plant growth and sustain crop yield. It stimulates early root development and growth and there by helps to establish seedlings quickly. Large quantities of Phosphorus are found in seed and fruit and it is considered essential for seed formation. It enhances the activity of rhizobia and increased the formation of root nodules. Thus, it helps in fixing more of atmosphere nitrogen in root nodules (Patil *et al.,* 2011). Potassium is one of the seventeen elements which are essential for growth and development of plants. Potassium is required for improving the yield and quality of different crops because of its effect on photosynthesis, water use efficiency and plant tolerance to diseases, drought and cold as well for making the balance between protein and carbohydrates (Singh *et al.,* 2008). Biochar is charcoal used as a soil amendment for both carbon sequestration and soil health benefits. Biochar is stable solid, rice in carbon and can endure in soil for thousands of years. Like most charcoal, it is made from biomass via pyrolysis it has the potential to help mitigate

global warming and climate change. It results from processes related to pyrogenic carbon capture and storage (PyCCS). Biochar may increase soil fertility of acidic soils, increase agricultural productivity, and provide protection against some foliar and soil-borne diseases. The properties of biochar can be characterized in several respects, including the proximate and elemental composition, pH value, porosity etc, which correlate with different biochar properties. The atomic ratios of biochar, including H/C and O/C, correlate with the biochar properties that are relevant to the organic content such as polarity and automaticity the carbonization process, both the H/C and O/C ratio (Lehmann *et al.,* 2006). Biochar may help improve soil quality includes: Enhancing soil structure, increasing water retention and aggregation, decreasing acidity, reducing nitrous oxide emissions, improving porosity, regulating nitrogen leaching, improving EC and improving microbial properties(Cantrell *et al.,* 2012). Properties of Biochar and their composition: pH=9.90, EC=3.53 dSm^{-1}, B.D. = 0.19 Mgm^{-3}, P.D. = 0.58 Mgm^{-3}, W.H.C. = 58.5 %, Zn = 157 $mgkg^{-1}$, Mn = 214 $mgkg^{-1}$, Cu = 54 $mgkg^{-1}$, Co = 3.43 $mgkg^{-1}$, Ni = 17.2 $mgkg^{-1}$, Pb = 45.5 $mgkg^{-1}$, Cd = 1.84 $mgkg^{-1}$, P = 0.09%, K = 3.22%, Na = 0.99%, Fe = 0.28%, Ca = 0.38%, Mg = 0.25%, Al = 1.83% (Bird *et al.,* 2011).

In India, about 435.98 million tons of agro-residues are produced every year, out of which 313.62 million tons are surplus. These residues are either partially utilized orun-utilized due to various constraints. Efficient use of biomass by converting it as a useful source of soil amendment/nutrients is one way to manage soil health and fertility. One of the approaches for efficient utilization of biomass involves carbonization of biomass to highly stable carbon compound known as biochar and its use as a soil amendment. Use of biochar in agricultural systems is one viable option that can enhance natural rates of carbon sequestration in the soil, reduce farm waste and improve the soil quality IARI (2012).

Materials and Methods

The experiment was conducted at research farm of department of Soil Science and Agricultural Chemistry which is situated six km away from Prayagraj city on the right bank of Yamuna river, the experimental site is located in the sub–tropical region with $25^0 24' 23''$N latitude, $81^0 50' 38''$Elongitude and at an altitude of 98 m above mean sea level. The area of Prayagraj district comes under subtropical belt in the South east of Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 ^{0}C-48 ^{0}C and seldom falls as low as 4^0C– 5^0C. The relative humidity ranges between 20 to 94 percent. The average rainfall in this area is around 1013.4 mm annually. The soil of experimental area falls in order of *Inceptisol*. The soil samples were randomly collected from five different sites in the experiment plot prior to tillage operation from a depth of 0-15 cm. The size of the soil sample was reduced by conning and quartering the composites soil sample and was air dried passed through a 2 mm sieve for preparing the sample for physical and chemical analysis. The KPU 07–08 (Pratap Urd-1) is a high yielding cultivar of blackgram. It was released from Agriculture Research Station, Kota for rainfed conditions and notified in the year 2013. The characteristic of KPU 07-08(Pratap urd-1)is appropriate 10-11 q ha^{-1} yield and it is to moisture stress, moderately resistant to yellow mosaic virus, leaf crinkle, anthracnose, bacterial leaf blight.

Results and Discussion

As depicted in tables no. 4 & 5 which is representing data of physical and chemical properties of soil sample after harvesting of

black gram respectively having maximum Bulk density (Mg m^{-3}) of soil was recorded 1.26 Mg m^{-3} in treatment T_0 (control) and minimum Bulk density (Mg m^{-3}) of soil was recorded 1.10 Mg m^{-3} in treatment T_8 (N_{20} P_{40} K_{40} + and 100 % Biochar). Similar results were also reported by (Amruta *et al.*, 2016). Particle density (Mg m^{-3}) of soil was recorded 2.64 Mg m^{-3} in treatment T_8 (N_{20} P_{40} K_{40} + and 100 % Biochar) and minimum Particle density (Mg m^{-3}) of soil was recorded 2.35 Mg m^{-3} in treatment T_0 (control). Similar results were also reported by (Sarvanan *et al.*, 2013). Soil pore space was recorded 58.33 % in treatment T_8 (N_{20} P_{40} K_{40} + and 100 % Biochar) and minimum soil pore space was recorded 46.38 % in treatment T_0 (Control). Similar results were also reported by (Tiwari and Kumar 2009). Soil pH was recorded 7.25 in treatment T_0 (control) and minimum soil pH was recorded 6.75 in treatment T_8 (N_{20} P_{40} K_{40} + and 100 % Biochar). Similar results were also reported by (Takase *et al.*, 2011). EC (dS m^{-1}) of soil was recorded 0.28 dS m^{-1} in treatment T_8 (N_{20} P_{40} K_{40} + and 100 % Biochar) and minimum EC (dS m^{-1}) of soil was recorded 0.16 dS m^{-1} in treatment T_0 (control). Similar results were also reported by (Akbari *et al.*, 2010**).** The maximum % Organic carbon in soil was recorded 0.79 % in treatment T_8 (N_{20} P_{40} K_{40} + and Biochar 100 %) which was significantly higher than any other treatment combination and the minimum % Organic carbon in soil was recorded 0.58 % in treatment T_0 (control).Similar findings were recorded by (Jat *et al.*, 2012). The highest available Nitrogen in soil was recorded 340.23 (Kg ha^{-1}) in treatment T_8 (N_{20} P_{40} K_{40} + and Biochar 100 %) which was significantly higher than any other treatment combination and the minimum available Nitrogen in soil was recorded 292.50 (Kg ha^{-1}) in treatment T_0 (control). Similar findings were also recorded by (Biswash *et al.*, 2014), (Amrita *et al.*, 2017). The highest available Phosphorus in soil was recorded 35.85 (Kg ha^{-1}) in treatment T_8 (N_{20} P_{40} K_{40} + and Biochar 100 %) which was significantly higher than any other treatment combination and the minimum available Phosphorus in soil was recorded 25.50 (Kg ha^{-1}) in treatment T_0 (control).Similar findings were also recorded by(Datt *et al.*,2013), (Tomar *et al.*, 2013). The highest available Potassium in soil was recorded 206.64 (Kg ha^{-1}) in treatment T_8 (N_{20} P_{40} K_{40} + and Biochar 100 %) which was significantly higher than any other treatment combination and the minimum available Potassium in soil was recorded 134.95 (Kg ha^{-1}) in treatment T_0 (control). Similar findings were also recorded by (Owla *et al.*, 2007) (Fig. 1 and 2; Table 1–5).

Table.1 Treatment combinations

S. No.	Symbol	Description
1.	T_0-L_0B_0	[@ 0% N P K + @ 0 %Biochar]
2.	T_1-L_0B_1	[@ 0% N P K + @ 50% Biochar]
3.	T_2 –L_0B_2	[@ 0% N P K + @ 100% Biochar]
4.	T_3 –L_1B_0	[@ 50% N P K + @ 0% Biochar]
5.	T_4 -L_1B_1	[@ 50% N P K + @ 50% Biochar]
6.	T_5 –L_1B_2	[@ 50% N P K + @ 100% Biochar]
7.	T_6 –L_2B_0	[@ 100% N P K + @ 0 % Biochar]
8.	T_7 –L_2B_1	[@ 100% N P K + @ 50 % Biochar]
9.	T_8-L_2B_2	[@ 100% N P K+ @ 100% Biochar]

Table.2 Physical analysis of pre sowing soil samples

Particulars	Results	Method employed
Sand (%)	62.71	Bouyoucos Hydrometer (1927)
Silt (%)	23.10	
Clay (%)	14.19	
Textural class	Sandy loam	
Soil Colour		Munsell Colour Chart (1971)
Dry Soil	Pale brown Colour	
Wet Soil	Olive brown Colour	
Bulk density (Mg m^{-3})	1.23	Graduated Measuring Cylinder (Muthuvel *et al.*,1992)
Particle density (Mg m^{-3})	2.37	
Pore Space (%)	47.53	Graduated Measuring Cylinder (Muthuvel *et al.*,1992)

Table.3 Chemical analysis of pre sowing soil samples

Parameters	Method employed	Results
Soil pH (1:2)	Glass electrode, pH meter (Jackson, 1958)	7.58
Soil EC (dSm^{-1})	EC meter (Conductivity Bridge)(Wilcox, 1950)	0.177
Organic Carbon (%)	Wet Oxidation Method (Walkley and Black's, 1947)	0.45
Available Nitrogen (Kg ha^{-1})	Kjeldhal Method (Subbaih and Asija, 1956)	238.21
Available Phosphorus (Kg ha^{-1})	Colorimetric method (Olsen *et al*., 1954)	20.73
Available Potassium (Kg ha^{-1})	Flame photometric method (Toth and Price, 1949)	127.65

Table.4 Physical properties of soil sample after harvesting of Black gram

Treatment	Bulk Density (Mg m^{-3})	Particle Density (Mg m^{-3})	Pore space (%)
T_0	1.26	2.35	46.38
T_1	1.23	2.38	48.31
T_2	1.22	2.42	49.58
T_3	1.19	2.48	52.01
T_4	1.16	2.52	53.96
T_5	1.15	2.54	54.72
T_6	1.13	2.56	55.85
T_7	1.11	2.58	56.97
T_8	1.10	2.64	58.33
F-test	NS	NS	S
S. Em±	0.05	0.33	1.38
C.D	0.11	0.69	2.94

Table.5 Chemical properties of soil sample after harvesting of Black gram

Treatments	pH	EC (dSm^{-1})	Organic carbon (%)	Available Nitrogen (Kg ha^{-1})	Available Phosphorus (Kg ha^{-1})	Available potassium (Kg ha^{-1})
T_0	7.25	0.16	0.58	292.50	25.50	134.95
T_1	7.25	0.17	0.60	303.83	27.15	145.18
T_2	7.05	0.19	0.68	304.88	27.85	155.43
T_3	7.04	0.20	0.65	312.22	28.95	156.27
T_4	7.00	0.22	0.66	314.31	30.05	169.45
T_5	6.95	0.22	0.70	320.60	30.75	172.45
T_6	6.95	0.23	0.69	322.65	30.95	191.65
T_7	6.85	0.25	0.77	328.93	34.54	199.28
T_8	6.75	0.28	0.79	340.23	35.85	206.64
F-test	S	NS	S	S	S	S
S. Em. ±	0.06	0.28	0.01	3.24	0.56	7.78
C.D. (P= 0.05)	0.12	0.06	0.03	6.87	1.18	16.49

Fig.1 Physical properties of soil sample after harvesting of Black gram

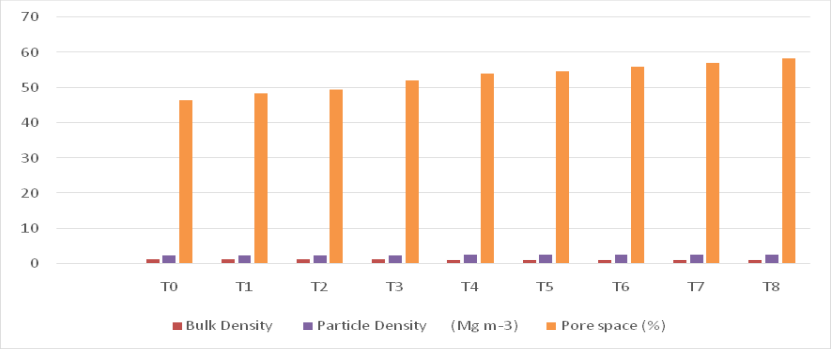
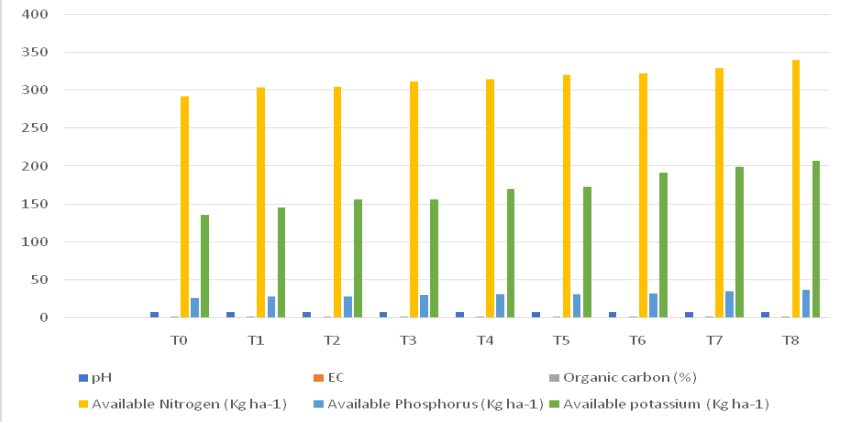


Fig.2 Chemical properties of soil sample after harvesting of Black gram



The salient findings of the present investigation are summarized as follows.

The soil texture observed was sandy loamy. The soil colour in dry condition was light yellowish brown and wet condition was olive brown. The soil pH was 7.25 and Bulk density 1.10 Mg m^{-3}, has resulted due to the application of NPK and Biochar while Particle density 2.64 Mg m^{-3}, Pore space 58.33 %, Electrical conductivity0.28 dSm^{-1},Organic carbon 0.79 %, respectively Nitrogen 340.23 kg ha^{-1}, Phosphorus 35.85 kg ha^{-1} and Potassium 206.64 kg ha^{-1},has increase by the application of NPK and Biochar. The best treatment was T_8 -L_2B_2 [@ 100% NPK+ @ 100% Biochar]. In post soil the important parameter on chemical properties on black gram crop different treatment of NPK and Biochar, percentage pore space, pH, organic carbon (%),nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}), potassium (kg ha^{-1}) respectively were found significant and EC was found non-significant. pH, organic carbon (%), available nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}), and potassium (kg ha^{-1}) was recorded as 7.25, 0.79, 340.23, 35.85, and 206.64 respectively.

It was concluded from trail that treatment T_8 - L_2B_2 [@ 100% NPK+ @ 100% Biochar] gave the most significant findings in terms of soil properties and yield attributes of Black gram var. KPU 07-08, N P K and Biochar. Biochar increases soil organic matter content in soil, it's improve soil health and enhance the yield of Black gram.

Acknowledgement

I am grateful for ever-inspiring guidance, constant encouragement, keen interest, comments and constructive suggestions throughout the course of my studies and investigation, from, head of the department and staff, department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh.

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How to cite this article:

Vivek Sehra, Tarence Thomas and Arun Alfred David. 2020. Effect of Different Level of N P K and Biochar on Soil Physico-chemical Properties and Yield Attribute of Black Gram (*Vigna mungo* L.) var KPU 07-08. *Int.J.Curr.Microbiol.App.Sci.* 9(08): 2007-2015.
doi: https://doi.org/10.20546/ijcmas.2020.908.229