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Effect of different level of NPK and biochar on soil physico - chemical properties, yield and attributes of green gram (*Vigna radiata* L.) Var. – RMG 975 (Keshwanand Mung 1)

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Abstract
An experiment was conducted on "Effect of Different Level of N P K and Biochar on Soil Physico - Chemical Properties and Yield Attribute of Green Gram (*Vigna radiata* L.) Var. RMG 975 (Keshwanand mung 1)" during *Kharif* season 2019-2020 at the Research Farm Department of Soil Science and Agricultural Chemistry, Naini Agriculture Institute, SHUATS, Prayagraj. The design applied was 3 x 3 Randomized block design having three factors with three level of N P K @ 0, 50, and 100 % ha^{-1} three level of Biochar @ 0, 50, 100 % ha^{-1} respectively. The result obtained with treatment T_9 - [N P K @ 100 % + Biochar @ 100 %] that showed the physico - chemical properties of soil, gave the best results with respect to Biochar in combination resulted in a slight increase in soil pH 7.20 and electrical conductivity 0.17 ds m^{-1}. In post soil of N P K fertilizers observations were resulted in significant increase in organic carbon 0.71 %, particle density 2.48 Mg m^{-3}, bulk density 1.03 Mg m^{-3}, porespace 51.00 % and available N 302.25 kg ha^{-1}, P 32.99 kg ha^{-1}, K 195.45 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 green 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.

Keywords: organic fertilizers, biochar, N P K, green gram

Introduction
Pulses are an important commodity group of crops that provide high quality protein complementing cereal proteins for pre-dominantly substantial vegetarian population of the country. In India, pulses can be produced with a minimum use of resources and hence, it becomes less costly even than animal protein. In comparison to other vegetables, pulses are rich in protein and contribute about 14 % of the total protein of average human diet. Apart from this, pulses possess several other qualities such as improve soil fertility and physical structure, fit in mixed/inter-cropping system, crop rotations and dry farming and provide green pods for vegetable and nutritious fodder for cattle as well. Pulses improve soil health by enriching nitrogen status, long-term fertility and sustainability of the cropping systems. The cultivation of pulses builds-up a mechanism to fix atmospheric nitrogen in their root nodules and thus meet their nitrogen requirements to a great extent. It meets up to 80 % of its nitrogen requirement from symbiotic nitrogen fixation from air. Although, being the largest pulse crop cultivating country in the World, India's production of pulses is relatively low in comparison to total cereal crops productions. Green gram (*Vigna radiata* L.) is an important pulse crop in India and believed to be originated from India. It is short duration legume crop grown mostly as a fallow crop in rotation with rice. Similar to the leguminous pulses, green gram enriches soil nitrogen content. It is grown mostly in Asian region traditionally, while its cultivation has spread to Africa and America relatively in the recent times. India contributes more than 70 % of world's green gram (*Vigna radiata* L.) production. Indian farmers have covered 134.02 lakh ha under kharif pulses as on 27th September 2019 as against 136.40 lakh ha last year. Around 31.15 lakh ha was covered under green gram (*Vigna radiata* L.), while the same was 34.24 lakh ha last year. The states of Rajasthan (18.30 lakh ha), Maharashtra (3.28 lakh ha), Karnataka (2.69 lakh ha), Madhya Pradesh (1.82 lakh ha), Odisha (1.63 lakh ha) and

Telangana (0.70 lakh ha) are the major producers of green gram (*Vigna radiata* L.) in India. Green gram (*Vigna radiata* L.) production in kharif 2019-20 is at 1.42 million tonnes (Directorate of Economics and Statistics). Production of pulses in the county is far below the requirement to meet even the minimum level per capita consumption. The per capita availability of pulses in India has been continuously decreasing which is 32.52 g day^{-1} against the minimum requirement of 80 g day^{-1} per capita prescribed by Indian Council of Medical Research (ICMR). Therefore, it is necessary for agricultural scientists to evolve strategy to increasing production of pulses to meet the protein requirements of increasing population of the country (Anonymous, 2009) [4].

Green gram is primarily a rainy season crop but with the development of early maturing varieties, it has also proved to be an ideal crop for spring and summer season. The grain (whole or split) are used as dal or to make flour. It is excellent source of high-quality protein, the grain contains protein 24.5 %, iron 8.5 mg, mineral 3.5 %, fat 0.5-4.33, fibbers 4.0 % and carbohydrates 59.9 %. The straw and husk are used as fodder for cattle. The germinated grains are also used as sprouts (Afzal *et al.*, 2004) [3].

By keeping in view all the factors related to soil fertility and productivity fertilizers are applied to soil to maintain soil status and crop productivity Green grams highly responsive to fertilizer application. The dose of fertilizer depends on the initial soil fertility status and moisture availability conditions. Application of N, P and K to pulses and oilseeds showed greater response than to cereals. Sulphur not only improved grain yield but also improved the quality of crops (Hedge and Babu, 2004) [12].

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, soil 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. 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) [5]. 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) [22]. 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) [24]. Biochar is a fine-grained, carbon-rich, porous product remaining after plant biomass has been subjected to thermo-chemical conversion process (pyrolysis) at low temperatures (~350–600°C) in an environment with little or no oxygen (Amonette and Joseph, 2009) [9]. Biochar is not a pure carbon, but rather mix of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulphur (S) and ash in different proportions (Masek *et al.*, 2009) [15]. The central quality of biochar and char that makes it attractive as a soil amendment is its highly porous structure, potentially responsible for improved water retention and increased soil surface area. Biochar hold great promise as a source of multiple nutrients and ability to improve soil characteristics. It also preserves the ecosystem by carbon sequestration. By charring (burning) the organic material, much of the carbon becomes "fixed" into a more stable form and when the resulting biochar is applied to soils, the carbon is effectively sequestered. It is estimated that use of this method to "tie up" carbon has the potential to reduce current global carbon emission by as much as 10 %, with the application of biochar optimum soil biological activities could be ensured to maintain soil fertility and improve crop yield (Steiner *et al.*, 2007) [26]. 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) [8]. Properties of Biochar and their composition: Soil pH = 9.90, Electrical Conductivity = 3.53 dS m^{-1}, Bulk Density = 0.19 Mg m^{-3}, Particle Density = 0.58 Mg m^{-3}, W.H.C. = 58.5 %, Zinc = 157 mg kg^{-1}, Manganese = 214 mg kg^{-1}, Copper = 54 mg kg^{-1}, Cobalt = 3.43 mg kg^{-1}, Nickle = 17.2 mg kg^{-1}, Lead = 45.5 mg kg^{-1}, Cadmium = 1.84 mg kg^{-1}, Phosphorus = 0.09 %, Potassium = 3.22 %, Sodium = 0.99 %, Iron = 0.28 %, Calcium = 0.38 %, Magnesium = 0.25 %, Aluminium = 1.83 % (Bird *et al.*, 2011) [6].

Materials and Methods

The field experiment was conducted during the *Kharif* season of the year 2019 in the research form of Soil Science and Agricultural Chemistry Department (SSAC), Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (UP), located at 25.57 °N latitude 81.57 °E longitude and 98 m above the mean sea level. Agro climatically, Allahabad district represents the subtropical belt of the South East of Uttar Pradesh, and is endowed with extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 °C - 48 °C and seldom falls as low as 4 °C - 5 °C. The relative humidity ranges between 20 - 94 %. The average rainfall of this area is around 1100 mm annually. It comes under subtropical climate receiving the mean annual rainfall of about 1100 mm, major rainfall from July to end of October. However, occasional precipitation was also not uncommon during experiment. The summer months were very hot and dry. The minimum temperature during the crop season was to be 5.9 °C and the maximum is to be 29.04 °C. The minimum humidity was to be 42.72 % and maximum was to be 93.28 %. The Soil of experimental area comes in the order Inceptisol and in experimental plot was alluvial soil. 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 was air dried and passed through a 2 mm sieve by way of preparing the samples and preserved in polythene bags for analysis of various physical and chemical properties.

Table 1: Treatment combinations for Green gram

S. No.	Symbol	Description
1.	T_1-L_0B_0	[@ 0 % N P K + @ 0 % Biochar]
2.	T_2-L_0B_1	[@ 0 % N P K + @ 50 % Biochar]
3.	T_3–L_0B_2	[@ 0 % N P K + @ 100 % Biochar]
4.	T_4–L_1B_0	[@ 50 % N P K + @ 0 % Biochar]
5.	T_5-L_1B_1	[@ 50 % N P K + @ 50 % Biochar]
6.	T_6–L_1B_2	[@ 50 % N P K + @ 100 % Biochar]
7.	T_7–L_2B_0	[@ 100 % N P K + @ 0 % Biochar]
8.	T_8–L_2B_1	[@ 100 % N P K + @ 50 % Biochar]
9.	T_9-L_2B_2	[@ 100 % N P K+ @ 100 % Biochar]

Table 2: Physical analysis of pre sowing soil samples

Particulars	Results	Method employed
Sand (%)	58	Bouyoucos Hydrometer (1927) [7]
Silt (%)	27	
Clay (%)	15	
Textural class	Sandy loam	
Soil Colour		Munsell Colour Chart (1971) [18]
Dry Soil	Light yellowish Colour	
Wet Soil	Olive brown Colour	
Bulk density (Mg m^{-3})	1.37	Graduated Measuring Cylinder (Muthuvel *et. al.*,1992) [19]
Particle density (Mg m^{-3})	2.42	
Pore Space (%)	47.53	

Table 3: Chemical analysis of pre soil samples

Parameters	Method employed	Results
Soil pH (1:2)	Glass electrode, pH meter (Jackson, 1958) [14]	7.5
Soil EC (dS m^{-1})	EC meter (Conductivity Bridge) (Wilcox, 1950) [32]	0.29
Organic Carbon (%)	Wet Oxidation Method (Walkley and Black's, 1947) [31]	0.39
Available Nitrogen (Kg ha^{-1})	Kjeldhal Method (Subbaih and Asija, 1956) [27]	228.4
Available Phosphorus (Kg ha^{-1})	Colorimetric method (Olsen *et al.*, 1954) [21]	20.13
Available Potassium (Kg ha^{-1})	Flame photometric method (Toth and Price, 1949) [30]	148.3

Result and Discussion

As depicted in tables no. 4 & 5 which is representing data of physical and chemical properties of soil sample after harvesting of green gram respectively having maximum Bulk density (Mg m^{-3}) of soil was recorded 1.28 Mg m^{-3} in treatment T_1 (control) and minimum Bulk density (Mg m^{-3}) of soil was recorded 1.03 Mg m^{-3} in treatment T_9 (N_{20} P_{40} K_{40} + and 100 % Biochar). Similar results were also reported by (Sudarso and Pontianak 2010) [28], (Githinji *et al.*, 2013) [11] and (Mukherjee *et al.*, 2014) [17]. Particle density (Mg m^{-3}) of soil was recorded 2.48 Mg m^{-3} in treatment T_9 (N_{20} P_{40} K_{40} + and 100 % Biochar) and minimum Particle density (Mg m^{-3}) of soil was recorded 2.32 Mg m^{-3} in treatment T_1 (control). Similar results were also reported by (Sudarso and Pontianak 2010) [28], (Githinji *et al.*, 2013) [11] and (Mukherjee *et al.*, 2014) [17]. Soil pore space was recorded 51.00 % in treatment T_9 (N_{20} P_{40} K_{40} + and 100 % Biochar) and minimum soil pore space was recorded 44.90 % in treatment T_1 (Control). Similar results were also reported by (Sudarso and Pontianak 2010) [28], (Githinji *et al.*, 2013) [11] and (Mukherjee *et al.*, 2014) [17]. Soil pH was recorded 7.70 in treatment T_1 (control) and minimum soil pH was recorded 7.20 in treatment T_9 (N_{20} P_{40} K_{40} + and 100 % Biochar). Similar results were also reported by (Chan *et al.*, 2008) [9], (Shenbagavalli and Mahimairaja 2012) [23] and (Abujabhah *et al.*, 2016) [2]. EC (dS m^{-1}) of soil was recorded 0.17 dS m^{-1} in treatment T_9 (N_{20} P_{40} K_{40} + and 100 % Biochar) and minimum EC (dS m^{-1}) of soil was recorded 0.11 dS m^{-1} in treatment T_1 (control). Similar results were also reported by (Chan *et al.*, 2008) [9], (Shenbagavalli and Mahimairaja 2012) [23] and (Abujabhah *et al.*, 2016) [2]. The maximum % Organic carbon in soil was recorded 0.71 % in treatment T_9 (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 0.55 % in treatment T_1 (control). Similar findings were recorded by (Steinbeiss *et al.*, 2009) [25], (Masulili *et al.*, 2010) [16] and (Wu *et al.*, 2014) [33]. The highest available Nitrogen in soil was recorded 302.25 (Kg ha^{-1}) in treatment T_9 (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 248.49 (Kg ha^{-1}) in treatment T_1 (control). Similar findings were also recorded by (Sukartono *et al.*, 2011) [29], (Nigussie *et al.*, 2012) [20], (Abewa *et al.*, 2014) [1] and (Xu *et al.*, 2014) [33, 34]. The highest available Phosphorus in soil was recorded 32.99 (Kg ha^{-1}) in treatment T_9 (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 23.57 (Kg ha^{-1}) in treatment T_1 (control). Similar findings were also recorded by (Sukartono *et al.*, 2011) [29], (Nigussie *et al.*, 2012) [20], (Abewa *et al.*, 2014) [1] and (Xu *et al.*, 2014) [33, 34]. The highest available Potassium in soil was recorded 195.45

(Kg ha^{-1}) in treatment T_9 (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 115.65 (Kg ha^{-1}) in treatment T_1 (control). Similar findings were also recorded by (Sukartono *et al.*, 2011) [29], (Nigussie *et al.*, 2012) [20], (Abewa *et al.*, 2014) [1] and (Xu *et al.*, 2014) [33, 34].

Table 4: Effect of N P K and Biochar on physical properties of soil sample after harvesting of Green gram

Treatment	Bulk Density (Mg m^{-3})	Particle Density (Mg m^{-3})	Pore space (%)
T_1	1.28	2.32	44.90
T_2	1.27	2.37	45.58
T_3	1.25	2.40	46.38
T_4	1.22	2.41	46.69
T_5	1.20	2.41	47.40
T_6	1.17	2.44	48.09
T_7	1.07	2.44	49.27
T_8	1.05	2.47	50.38
T_9	1.03	2.48	51.00
F-test	S	S	S
S. Em$\pm$	0.017	0.02	0.03
C.D	0.035	0.05	2.69

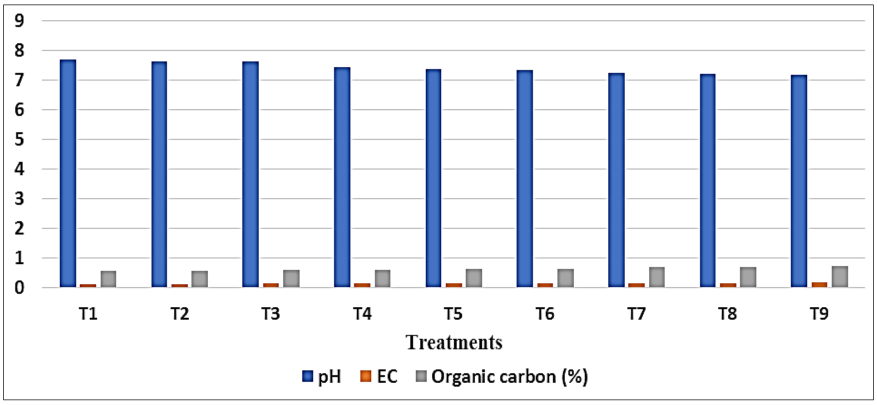

Fig 1: Effect of N P K and Biochar on physical properties of soil sample after harvesting of Green gram

Table 5: Effect of N P K and Biochar on Chemical properties of soil sample after harvesting of Green gram

Treatments	pH	EC (dS m^{-1})	Organic carbon (%)	Available Nitrogen (Kg ha^{-1})	Available Phosphorus (Kg ha^{-1})	Available Potassium (Kg ha^{-1})
T_1	7.70	0.11	0.55	248.49	23.57	115.65
T_2	7.63	0.12	0.57	253.29	26.72	124.02
T_3	7.63	0.13	0.59	262.09	27.50	132.22
T_4	7.45	0.13	0.61	266.73	27.79	145.45
T_5	7.38	0.14	0.62	273.11	28.05	157.49
T_6	7.33	0.14	0.64	278.89	28.85	167.75
T_7	7.26	0.16	0.68	288.42	30.13	174.78
T_8	7.21	0.16	0.69	297.22	31.27	183.73
T_9	7.20	0.17	0.71	302.25	32.99	195.45
F-test	S	S	S	S	S	S
S. Em. $\pm$	0.04	0.01	0.01	1.09	0.68	0.90
C.D. (P= 0.05)	0.09	0.02	0.02	2.32	1.42	1.90

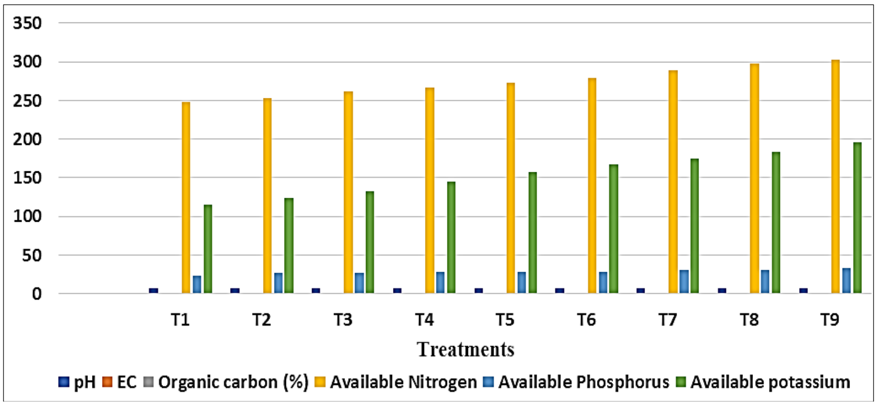

Fig 2: Effect of N P K and Biochar on chemical properties of soil sample after harvesting of Green gram

Summary

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 physical and chemical properties have increase by the application of N P K and Biochar. The best treatment was T_9 - L_2B_2 [@ 100 % N P K + @ 100 % Biochar]. In post soil the important parameter on chemical properties on green gram crop different treatment of N P K and Biochar, percentage pore space, soil pH, organic carbon (%), Nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}), potassium (kg ha^{-1}) respectively were found significant and EC was found significant. pH, organic carbon (%), available nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}), and potassium (kg ha^{-1}) was recorded as 7.20, 0.71, 302.25, 32.99, and 195.45 respectively.

Conclusion

It was concluded from trail that treatment T_9 - L_2B_2 [@ 100 % N P K + @ 100 % Biochar] gave the most significant findings in terms of soil properties and yield attributes of Green gram var. RMG-975 (Keshwanand Mung 1), N P K and Biochar. Biochar increases soil organic matter content in soil, it's can improve soil health and enhance the yield of Green gram.

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