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Effect of Different Level of N P K and Biochar on Soil Physico-chemical Properties, Yield and Attributes of Finger Millet (*Eleusine Coracana*) Var. – KM 65

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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, yield and attribute of Finger Millet (*Eleusine coracana*) Var. – KM 65" during Kharif 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 N P K @ 0, 50, and 100% ha^{-1}, three levels of Biochar @ 0, 50 and 100% ha^{-1} respectively. The result obtained with treatment T_9 - [N P K 100% + Biochar 100%] that showed the highest yield regarding, gave the best results with respect to plant height 110.18 cm, number of finger ear $head^{-1}$ 7.42g, 1000 grain weight 3.48g, it gave highest yield 27.29 q ha^{-1} Biochar in combination resulted in a slight decrease in pH 6.78 and EC increase 0.26 dS m^{-1}. In post soil of N P K fertilizers observations were resulted in significant increase in OC 0.82%, Particle density 2.63 Mg m^{-3}, Bulk density 1.08 Mg m^{-3},Porespace 58.93% and available N 328.75 kg ha^{-1}, P 36.10 kg ha^{-1}, K 186.10 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 finger millet cultivation and soil quality improvement. It was also revealed that the application of NPK with Biochar were excellent source for fertilization than fertilizers.

Introduction

Finger millet (*Eleusine coraana*) ranks 3rd in importance among all millets in the country in both area (1.38 million hectare) and production (2.03 matric tonnes) after the sorghum and pearl millet. Ragi is an important crop in dry land area due to its high resilience and ability to withstand aberrant weather conditions. In India and Africa, finger millet is one of the staple foods. In southern Karnataka, ragi is the main dietary component particularly grown in districts of Bangalore, Mysore, Mandya, Tumkur, Hassan and Chitradurga. The major finger millet growing states are Karnataka, Andhra Pradesh, Tamil Nadu, Orissa, Maharashtra, Jharkhand and Uttaranchal. Further ragi is

also a good food for diabetic patients. The finger millet grains are rich in calcium, iron and carbohydrates. Finger millet is the staple food grain for majority of the population in India since it is economical and very nutritious. Dietary fiber protects against hyperglycemia, phytates against oxidation stress by chelating iron and some phenolics and tannins act as antioxidants. In south India, grains are used in many food preparations like cakes, porridge and sweetmeat. Germinating grains are malted and fed to infants also. It is also good for pregnant women. The finger millet flour is consumed by mixing with milk, boiled water or yoghurt. It is non acid forming food and easy to digest. It is considered to be one of the least allergic and most digestible foods (Pragya and Rita Singh, 2012). Finger millet is a small cereal grain with outstanding properties viz., strength of calcium (8.3 percent), iron (0.017 percent), dietary fibre and polyphenols (0.3 to 3 percent). Finger millet is rich in calcium content, about 10 times that of paddy or wheat (Stanly and Shanmugam, 2013). Besides this, it is a good source of essential amino acids of tryptophan, cystine and methionine and thus considered as a favourite wholesome food for hard toiling class and diabetic patients.

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.

In recent years, biochar has emerged as an important amendment with fertilizer and hold a key role to improve the yield of crops. The biochar has been found to have a great impact on soil fertility and increase in crop yield without causing any detorious hazards to the soil. Biochar is a fine-grained, highly porous charcoal substance that is differentiated from other charcoals in its use as a soil amendment.

The particular heat treatment of organic biomass used to produce biochar contributes to its large surface area and its characteristic ability to persist in soils with very little biological decay (Lehmann *et al.,* 2006). While raw organic materials provide nutrients to plants and soil microorganisms, biochar acts as a catalyst that enhances plant uptake of nutrients and water. Compared to other soil amendments, the high surface area and porosity of biochar enable it to adsorb or retain nutrients and also provide food for beneficial microorganisms (Glaser *et al.,* 2002, Lehmann *et al.,* 2006, and Warnock *et al.,* 2007).

Properties of Biochar and their composition: pH = 9.90, EC = 3.53 dS m^{-1}, B.D. = 0.19 Mg m^{-3}, P.D. = 0.58 Mg m^{-3}, W.H.C. = 58.5%, Zn = 157 mg kg^{-1}, Mn = 214 mg kg^{-1}, Cu = 54 mg kg^{-1}, Co = 3.43 mg kg^{-1}, Ni = 17.2 mg kg^{-1}, Pb = 45.5 mg kg^{-1}, Cd = 1.84 mg kg^{-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).

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. Phosphorus is the second most important nutrient that must be added to the soil to maintain plant growth and sustain crop yield (Patil *et al.,* 2011). Phosphorus plays a vital role in photosynthesis, respiration, energy storage, cell elongation and improves the quality of crops. Deficient plants may have thin, erect and spindly stems and leaves turn into bluish-green colour. Phosphorus is an essential constituent of majority of enzymes, which are of great importance in the transformation of energy, in carbohydrate metabolism, in fat metabolism and also in respiration of plants. 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 and Yadav, 2008). Potassium enhances the ability of plants to resist diseases, insect-pest attack, cold, drought and other adversities.

Materials and Methods

The experiment was conducted at Research Farm of Soil Science and Agricultural Chemistry at Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj. The area situated on the south of Prayagraj on the right side of the river Yamuna on the South of Rewa Road at a distance of about 6 Km from Prayagraj city. It is situated at 25°58' North latitude and 81°52' East longitude and at the altitude of 98 meter above the sea level. The area of Prayagraj district comes under subtropical belt in the South east of Uttar Pradesh, which experience extremely hot summer and 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 ranged between 20 to 94 percent. The average rainfall in this area is around 1100 mm annually. The Soils of experimental area falls in order of Inceptisol and soil was alluvial. The soil samples were randomly collected from five different sites in the experimental plot prior to tillage operation from a depth of 0-15cm. The size of the soil sample were reduced by conning and quartering the composites soil samples were air dried and passed through a 2 mm sieve by way of preparing the sample for physical and chemical analysis. Finger Millet var. KM 65 Selection from exotic germplasm CSAUA&T, Kanpur 1994 Uttar Pradesh. This variety has early maturity and resistant from blast.

Results and Discussion

As depicted in tables 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 1.08 Mg m^{-3} in treatment T_9 (N_{20} P_{40} K_{40} + 100% Biochar). Similar results were also reported by (Chintala *et al.,* 2014). Particle density (Mg m^{-3}) of soil was recorded 2.63 Mg m^{-3} in treatment T_9 (N_{20} P_{40} K_{40} + 100% Biochar) and minimum Particle density (Mg m^{-3}) of soil was recorded 2.36 Mg m^{-3} in treatment T_1 (control). Similar results were also reported by (chan *et al*.,) and (Chintala *et al.,* 2014). Soil pore space was recorded 58.93 % in treatment T_9 (N_{20} P_{40} K_{40} + 100% Biochar) and minimum soil pore space was recorded 45.76 % in treatment T_1 (Control). Similar results were also reported by (chan *et al.*,) and (Chintala *et al.,* 2014). Soil pH was recorded 7.18 in treatment T_1 (control) and minimum

soil pH was recorded 6.78 in treatment T_9 (N_{20} P_{40} K_{40} + 100% Biochar). Similar results were also reported by (chan *et al.*,) and (Chintala *et al.*, 2014). EC (dS m^{-1}) of soil was recorded 0.26 dS m^{-1} in treatment T_9 (N_{20} P_{40} K_{40} + 100% Biochar) and minimum EC (dS m^{-1}) of soil was recorded 0.12 dS m^{-1} in treatment T_1 (control). Similar results were also reported by (chan *et al.*,) and (Chintala *et al.*, 2014)**.** The maximum % Organic carbon in soil was recorded 0.82 % in treatment T_9 (N_{20} P_{40} K_{40} + 100% Biochar) which was significantly higher than any other treatment combination and the minimum % Organic carbon in soil was recorded 0.65 % in treatment T_1 (control). Similar findings were recorded by (chan *et al.*,) and (Chintala *et al.*, 2014). The highest available Nitrogen in soil was recorded 328.75 (Kg ha^{-1}) in treatment T_9 (N_{20} P_{40} K_{40} + 100% Biochar) which was significantly higher than any other treatment combination and the minimum available Nitrogen in soil was recorded 287.50 (Kg ha^{-1}) in treatment T_1 (control). Similar findings were also recorded by (Pallavi *et al.*, 2016) and (Gajbhaiya *et al.*, 2017). The highest available Phosphorus in soil was recorded 36.10 (Kg ha^{-1}) in treatment T_9 (N_{20} P_{40} K_{40} + 100% Biochar) which was significantly higher than any other treatment combination and the minimum available Phosphorus in soil was recorded 24.12 (Kg ha^{-1}) in treatment T_1 (control). Similar findings were also recorded by (Pallavi *et al.*, 2016) and (Gajbhaiya *et al.*, 2017) (Fig. 1 and 2; Table 1–5).

Table.1 Treatment Combination for Finger millet

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

Table.2 Physical analysis of soil (pre-sowing sample)

Particulars	Results	Method employed
Sand (%)	62.71	Bouyoucos Hydrometer (1952)
Clay (%)	23.10	
Silt (%)	14.19	
Texural class	**Sandy loam**	
Soil colour		Munsell Colour Chart (1971)
Dry Soil	Pale brown Colour	Graduated Measuring Cylinder (Muthuvel *et al.*, 1992)
Wet Soil	Olive brown Colour	
Bulk density (Mg m^{-3})	1.23	
Particle density (Mg m^{-3})	2.37	
Pore Space (%)	47.53	

Table.3 Chemical analysis of soil (pre-soil samples)

Parameters	Method employed	Results
Soil pH (1:2)	Glass electrode, pH meter	7.58
Soil EC (dS m^{-1})	EC meter (Conductivity Bridge)	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 finger millet

Treatment	Bulk Density (Mg m^{-3})	Particle Density (Mg m^{-3})	Pore space (%)
T_1	1.28	2.36	45.76
T_2	1.26	2.38	47.06
T_3	1.22	2.41	49.38
T_4	1.18	2.45	51.83
T_5	1.17	2.50	53.20
T_6	1.15	2.53	54.54
T_7	1.12	2.56	56.25
T_8	1.10	2.59	57.52
T_9	1.08	2.63	58.93
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 finger millet

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	7.18	0.12	0.65	287.50	24.12	130.25
T_2	7.15	0.15	0.68	292.75	25.15	135.10
T_3	7.05	0.18	0.68	301.80	27.85	140.38
T_4	7.04	0.20	0.70	302.55	28.10	152.05
T_5	7.01	0.22	0.65	310.12	29.05	154.10
T_6	6.96	0.22	0.75	318.85	30.15	162.28
T_7	6.95	0.24	0.69	320.65	31.30	168.36
T_8	6.88	0.25	0.72	324.92	34.28	178.52
T_9	6.78	0.26	0.82	328.75	36.10	186.10
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 finger millet

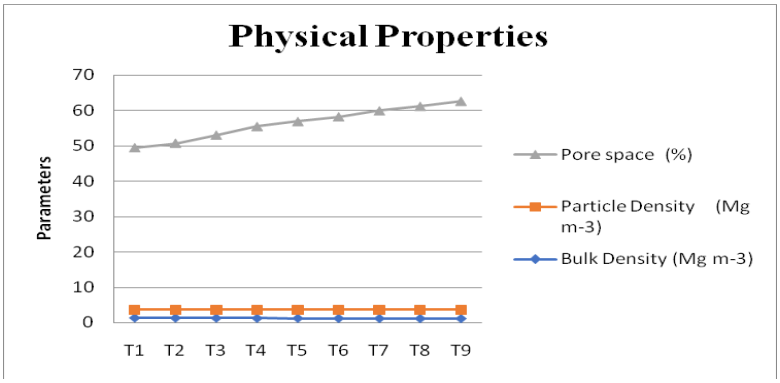
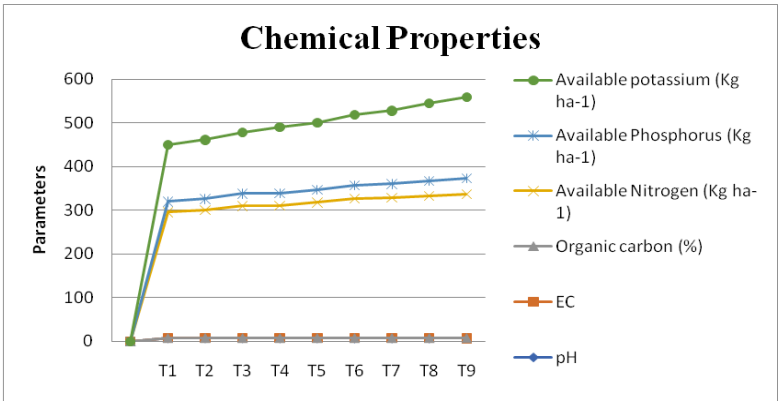


Fig.2 Chemical properties of soil sample after harvesting of finger millet



The highest available Potassium in soil was recorded 186.10 (Kg ha^{-1}) in treatment T_9 (N_{20} P_{40} K_{40} + 100% Biochar) which was significantly higher than any other treatment combination and the minimum available Potassium in soil was recorded 130.25 (Kg ha^{-1}) in treatment T_1 (control). Similar findings were also recorded by (Pallavi *et al.*, 2016) and (Gajbhaiya *et al.*, 2017)**.**

Summary and conclusion are as follows:

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 7.18 and Bulk density 1.08 Mg m^{-3}, has resulted due to the application of N P K and Biochar while Particle density 2.63 Mg m^{-3}, Pore space 58.93%, Electrical conductivity 0.26 dS m^{-1}, Organic carbon 0.82%, respectively Nitrogen 328.75 kg ha^{-1}, Phosphorus 36.10 kg ha^{-1} and Potassium 186.10 kg ha^{-1}, has 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 black gram crop different treatment of N P K 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 7.18, 0.82, 328.75, 36.10, and 186.10 respectively.

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 Finger Millet var. KM-65, N P K and Biochar. Biochar increases soil organic matter content in soil, it's can improve soil health and enhance the yield of Finger Millet.

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