Effects of Integrated Nutrient Management on Soil Properties, Growth and Yield of Black Gram (*Vigna mungo L.*) var. Sekhar-2

ABSTRACT

A field experiment was conducted atresearch farmof Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj, (U.P.) on sandy loam soil to Assess the**"Effects of Integrated Nutrient Management on Soil Properties, Growth and Yield of Black gram (*Vigna mungo L.*) var. Sekhar-2"** during *Zaid season* of 2022. The experiment consists ofnine treatment combinations, comprised in randomized block design with three replications. To achieve higher growth and yield it was found application of T_9 (RDF + 100% Rhizobium + 100% Biochar) has shown effective growth under Prayagraj climatic conditions. It was observed that for physical and chemical properties of soil in treatment T_9 (RDF + 100% Rhizobium + 100% Biochar) were improved significantly due to the application of Nitrogen, Phosphorus, Potassium, Rhizobium and Biochar inputs. Bulk density (Mg m^{-3}), Particle density (Mg m^{-3}), Pore space (%), Water holding capacity (%), pH, Electrical conductivity (dS m^{-1}), Organic carbon (%), Available Nitrogen (kg ha^{-1}),Available Phosphorus (kg ha^{-1}),Available Potassium (kg ha^{-1}). The soil organic carbon content, Water holding capacity and available NPK significantly increased in most of the treatments after harvest of Black gram, it was observed that treatmentT_9 (RDF + 100% Rhizobium + 100% Biochar) was best in terms of growth, yield and economic parameters with maximum plant height, the number of branches $plant^{-1}$, seeds pod^{-1}, pod yield and maximum cost benefit ratio.

Key Words: Black gram, Biochar, MOP, SSP, Rhizobium and Urea

1. Introduction

“The word soil represents one of the most active and complex natural systems on the earth’s surface. It is essential for the existence of many forms of life and provides plant or plant’s growth and also supplies the organism with most of their nutritional requirements. Soil is a dynamic, natural body that occurs on the earth’s surface which supports the growth of plants”. (**Zaware 2014**)

“Black gram (*Vignamungo* L), also known as urad dal or black lentil, is a warm-season legume crop that is widely cultivated for its nutritious seeds. It is primarily grown in India, Pakistan, Nepal, and other Asian countries. Black gram is a versatile crop used for various culinary purposes, including making dal, soups, curries, and sweets. It is well adapted to tropical and subtropical climates. It thrives in warm weather with temperatures ranging between 25°C to 35°C (77°F to 95°F)” (Anonymous, 2012) . “The crop requires a frost-free growing season. It can tolerate a wide range of rainfall, but a well-distributed rainfall of 600 to 800 mm (24 to 32 inches) is ideal. Black gram can be grown in a variety of soils, but it prefers well-drained loamy soils with a pH range of 6 to 7.A soil test should be conducted to determine the nutrient status of the soil. Based on the results, apply fertilizers accordingly. Generally, black gram requires nitrogen (N), phosphorus (P), and potassium (K) fertilizers. Apply well-decomposed organic manure before sowing to improve soil fertility”**(Anonymous, 2012).**

“Blackgram (*Vignamungo* L) is one of the most important pulse crop grown in India. Black gram contributes 13% in total pulses area and 10% in total pulses production of India. Black gram seeds are highly nutritious containing higher amount of protein 24% ,60% carbohydrate, 1.3% 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” (Selvakumar et al.,2012). “Urdbean contributes about 13 % of total area and 10 % production of pulses in our country. It is grown on 3.06 million hectares area with a production of 1.70 mt and productivity of 555 kg ha in the country(DAC, 2014). This crop is extensively grown in the states of Maharashtra (23.36%), Andhra Pradesh (18.50%), Uttar Pradesh (12.29%). Madhya Pradesh (11.86%), Tamil Nadu (8.64%) and Rajasthan (4.29%). It can be grown on all type of soils ranging from sandy loam to heavy and are reported to be rich in potassium, phosphorus and calcium with good amount of sodium. It is also reported to be rich in vitamin A, B1, B3 besides nutritionally rich protein, important minerals and vitamin” (**Selvakumar*et al*.,2012)**

“Biochar is the lightweight black residue made of carbon and ashes, remaining after the pyrolysis of biomass. It is defined by the International Biochar Initiative as the solid material obtained from the thermochemical conversion of biomass in an oxygen-limited environment. Biochar is a stable solid that is rich in pyrogenic carbon and can endure in soil for thousands of years. Carbon sequestration in the form of biochar. It may be a means to mitigate climate change due to its potential of sequestering carbon with minimal effort. Biochar increase the soil fertility of acidic soils and increase agricultural productivity” (**Datt**

***et al*. 2003**). 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. Urdbean is highly responsive to fertilizer application. The dose of fertilizer depends on the initial soil fertility status and moisture availability conditions.

2.Materials and Methods

The field experiment was conducted atResearch Farm of Soil Science and Agricultural Chemistry at Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj which is situated six km away from Prayagraj city on the right bank of Yamuna river. The experimental site is located at 25^0 28'46.14” N Latitude, 81^0 54'49.95” E Longitude and 98m above the mean sea level altitudes.The fieldwork was done in the Prayagraj district, which is part of the subtropical belt and has semi-arid climatic conditions with both winter and summer temperature extremes.

The maximum temperatures of the location reaches up to 46^0- 48^0 C and seldom falls as 4^0-5^0 C. The relative humidity ranges between 20% to 94%. The average rainfall in Prayagraj is around 900-1100 mm annually. The minimum temperature during the crop season was to be 43.73% and maximum was to be 93.28%. The present research investigation was setup in randomized block design (RBD) with nine treatment combination, which are replicated three times and randomly allocated in each replication, dividing the research site into twenty - seven plots. In this study, inorganic fertilizers like nitrogen, phosphorus, and potassium were used as RDF, Biochar and biofertilizer like Rhizobium was applied in three different dose. Sowing of the Black gram crop was carried out on the 29 April, 2022, respectively, by hand. The seed variety Shekhar-2 was sown at a rate of 20 kg ha^{-1} and at a row-to-row spacing of 60 cm and plant-to-plant spacing of 45 cm. The recommended doses of NPK were applied @20:40:40 $kgha^{-1}$ The graded level of NPK were applied through Urea, Diammonium phosphate and Murate of potash.

The Soils from each plot were separately collected, air-dried, ground and passed through a 2mm-size sieve for laboratory analysis. Soil samples were analyzed for bulk density, particle density, percentage of pore space and water holding capacity, pH, EC, Percentage of organic carbon, Available Nitrogen, Available Phosphorus and Available Potassium before sowing and after harvest of the crop.

Table.1 Fertilizer Dose

S.No	**Fertilizer Dose**	**Source (%)**	**Amount to be Fertilizer to be used**
1	Nitrogen	Urea (N- 46%)	20 $kgha^{-1}$
2	Phosphorus	SSP (P_2O_5 – 68-18%) (S- 12-14%)	40$kgha^{-1}$
3	Potassium	MOP (K-60%)	40$kgha^{-1}$

4	Organic manure	Biochar (10t/ha)	10 t ha^{-1}
5	Bio Fertilizer	Rhizobium	200gm/100g seed

(Source- Handbook of Agriculture,2010)

Table.2 Treatment combination

TREATMENT	**TREATMENT COMBINATION**
$\mathbf{T_1}$	RDF + 0% Rhizobium + 0% Biochar
$\mathbf{T_2}$	RDF + 0% Rhizobium + 50% Biochar
$\mathbf{T_3}$	RDF + 0% Rhizobium + 100% Biochar
$\mathbf{T_4}$	RDF + 50% Rhizobium + 0% Biochar
$\mathbf{T_5}$	RDF + 50% Rhizobium + 50% Biochar
$\mathbf{T_6}$	RDF + 50% Rhizobium + 100% Biochar
$\mathbf{T_7}$	RDF + 100% Rhizobium + 0% Biochar
$\mathbf{T_8}$	RDF + 100% Rhizobium + 50% Biochar
$\mathbf{T_9}$	RDF + 100% Rhizobium + 100% Biochar

3. Result and Discussion

3.1 Soil Physical Properties

The effect of Rhizobium and Biochar on thebulk density of soil after crop harvest was also found significant. The maximum bulk density was recorded 1.275 Mg m^{-3} at (0-15 cm) and 1.279 Mg m^{-3} at (15-30 cm) in T_9 (RDF +100% Rhizobium +100% Biochar) treatment and minimum bulk density of soil was recorded 1.241 Mg m^{-3} at (0-15 cm) and 1.245 Mg m^{-3} at (15-30 cm) in treatment T_1 (RDF + 0% Rhizobium +0% Biochar) respectively.The effect of Rhizobium and Biochar onparticle density of soilafter crop harvest was also found significant. Themaximum particle density was recorded 2.466 Mg m^{-3} at (0-15 cm) and 2.475 Mg m^{-3} at (15-30 cm) in treatment T_1 (RDF +0% Rhizobium +0% Biochar) and minimum bulk density of soil was recorded 2.452 Mg m^{-3} at (0-15 cm) and 2.460 Mg m^{-3} at (15-30 cm) in treatment T_9 (RDF + 100% Rhizobium + 100% Biochar)] respectively.The effect of Rhizobium and Biochar onPore Space of soil after crop harvest was also found Nonsignificant. The maximum pore space wasrecorded 47.12% at (0-15 cm) and 46.75% at (15-30 cm) in treatment T_9 (RDF +100% Rhizobium +100% Biochar) and minimum Pore space of soil was recorded 44.97% at (0-15 cm) and 44.53% at (15-30 cm) in treatment T_1 [control (RDF + 0% Rhizobium +0% Biochar)] respectively.The effect of Rhizobium and Biochar on water holding capacity of soil after crop harvest was also found significant. The maximum Water holding capacity of soil was recorded 40.20 % at (0-15 cm) and 39.08 % at (15-30 cm) in treatment T_9 (RDF +100% Rhizobium + 100% Biochar) and minimum water holding capacity of soil was recorded 33.56 % at (0-15 cm) and 30.45 % at (15-30 cm) in treatment T_1 [control (RDF + 0% Rhizobium +0% Biochar)] respectively.

3.2 Soil Chemical Properties

The effect/ response of Rhizobium and Biochar on pH of soil after crop harvest was found nonsignificant. The maximum pH of soil was recorded 7.385 at (0-15 cm) and 7.468 at (15-30 cm) in treatment T_3 (RDF + 0% Rhizobium + 100% Biochar) and minimum pH of soil was recorded 6.879 at (0-15 cm) and 6.996 at (15-30 cm) in treatment T_9 (RDF + 100% Rhizobium + 100% Biochar) respectively.The effect/ response of Rhizobium and Biochar on EC of soil after crop harvest was found nonsignificant. The maximum EC of soil was recorded 0.282 dS m^{-1} at (0-15 cm) and 0.298 dS m^{-1} at (15-30 cm) in treatment T_3 (RDF + 0% Rhizobium + 100% Biochar) and minimum EC of soil was recorded 0.234 dS m^{-1} at (0-15 cm) and 0.252 dS m^{-1} at (15-30 cm) in treatment T_9 (RDF + 100% Rhizobium + 100% Biochar)] respectively.The effect/ response of Rhizobium and Biochar on Organic carbon of soil after crop harvest was found significant. The maximum Organic carbon was recorded 0.439 % at (0-15 cm) and 0.409% at (15-30 cm) in treatment T_9 (RDF + 100% Rhizobium + 100% Biochar)and minimum Organic carbon of soil was recorded 0.361 % at (0-15 cm) and 0.332 % at (15-30 cm) in treatment T_1 (RDF + 0% Rhizobium + 0% Biochar) respectively.The effect/ response of Rhizobium and Biochar on Available Nitrogen of soil after crop harvest was found significant.The maximum Available Nitrogen of soil was recorded 285.08 kg ha^{-1} at (0-15 cm) and 278.37 $kgha^{-1}$ at (15-30 cm) in treatment T_9 (RDF + 100% Rhizobium + 100% Biochar) and minimum Available Nitrogen of soil was recorded 258.67 kg ha^{-1} at (0-15 cm) and 251.21 kg ha^{-1} at (15-30 cm) in treatment T_1(RDF + 0% Rhizobium + 0% Biochar) respectively.The effect/ response of Rhizobium and Biochar on Available Phosphorus of soil after crop harvest was found significant.The maximum Available Phosphorus of soil was recorded 21.54 kg ha^{-1} at (0-15 cm) and 20.85 kg ha^{-1} at (15-30 cm) in treatment T_9 (RDF + 100% Rhizobium + 100% Biochar) and minimum Organic carbon of soil was recorded 18.29 kg ha^{-1} at (0-15 cm) and 16.93 kg ha^{-1} at (15-30 cm) in treatment T_1 (RDF + 0% Rhizobium + 0% Biochar) respectively.The effect/ response of Rhizobium and Biochar on Available Potassium of soil after crop harvest was found significant.The maximum Available Potassium of soil was recorded 201.35 kg ha^{-1} at (0-15 cm) and 194.62 kg ha^{-1} at (15-30 cm) in treatment T_9 (RDF + 100% Rhizobium + 100% Biochar) and minimum Organic carbon of soil was recorded 177.34 kg ha^{-1} at (0-15 cm) and 171.65 kg ha^{-1} at (15-30 cm) in treatment T_1 [control (RDF + 0% Rhizobium + 0% Biochar)] respectively.

Table. 3Effect of different levels of N P K, Biochar and Rhizobium inoculationon bulk density, particle density, pore space and water holding capacity of soil after crop harvest.

Treatments	Bulk density ($Mg\ m^{-3}$)		Particle density ($Mg\ m^{-3}$)		Pore space (%)		W.H.C (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	1.241	1.245	2.466	2.475	44.97	44.53	33.56	30.45
T_2	1.242	1.247	2.462	2.473	46.61	45.48	34.97	31.85
T_3	1.245	1.250	2.465	2.474	46.18	45.36	36.09	33.08
T_4	1.249	1.252	2.461	2.468	46.64	46.21	37.41	34.67
T_5	1.253	1.256	2.462	2.470	46.33	46.08	38.23	35.83
T_6	1.257	1.261	2.457	2.466	46.81	46.30	39.78	36.78
T_7	1.262	1.267	2.455	2.463	46.98	46.61	40.05	37.84
T_8	1.268	1.273	2.453	2.461	47.03	46.72	40.12	38.91
T_9	1.275	1.279	2.452	2.460	47.12	46.75	40.20	39.08
F- test	NS	NS	NS	NS	NS	NS	S	S

S. Em(±)	0.0191	0.0193	0.0316	0.0359	0.8890	0.6537	0.52	0.47
C.D.@5%	0.0577	0.0582	0.0951	0.1082	2.6763	1.9680	1.02	0.91

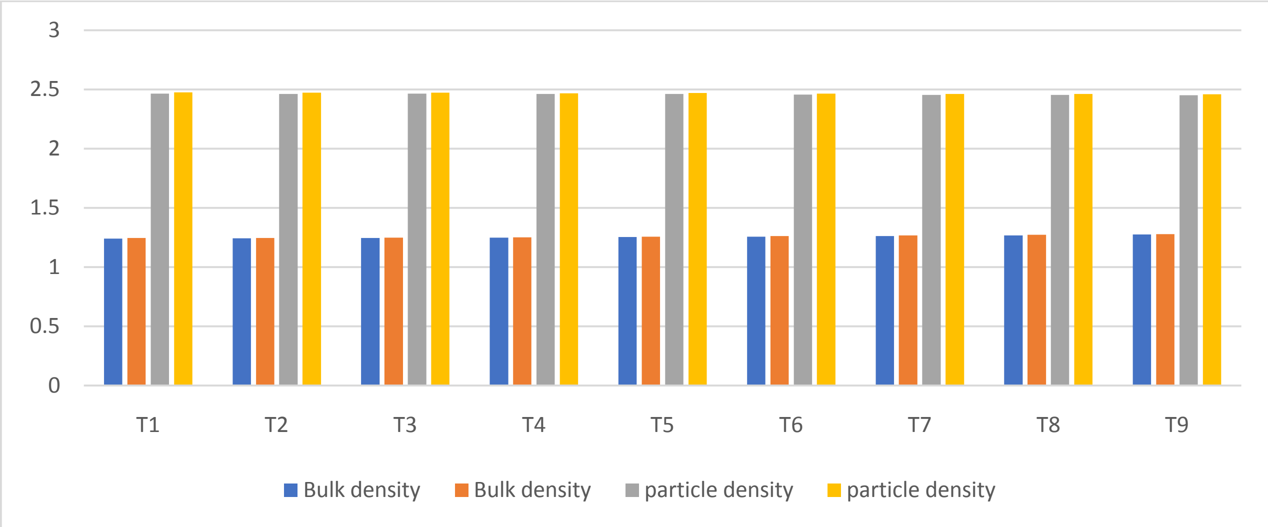

Fig .1 Effect of different levels of N P K, Biochar and Rhizobium inoculation on bulk density and particle density of soil after crop harvest.

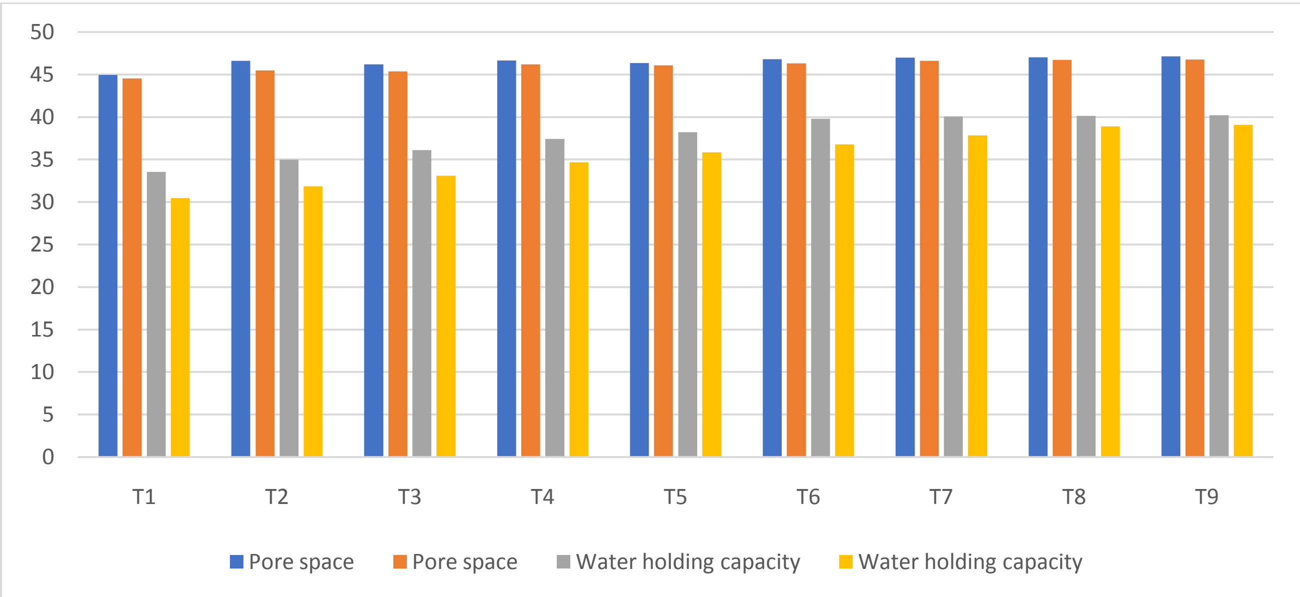

Fig .2 Effect of different levels of N P K, Biochar and Rhizobium inoculation on pore space and water holding capacity of soil after crop harvest.

Table . 4Effect of different levels of N P K, Biochar and Rhizobium inoculationon pH, Electrical conductivity and Organic carbon of soil after crop harvest.

Treatment	pH	Electrical Conductivity	Organic Carbon
		(dS m^{-1})	(%)

	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30cm
T_1	7.375	7.457	0.271	0.285	0.361	0.332
T_2	7.379	7.464	0.276	0.291	0.372	0.345
T_3	7.385	7.468	0.282	0.298	0.385	0.353
T_4	7.151	7.234	0.274	0.285	0.365	0.343
T_5	7.142	7.227	0.268	0.276	0.382	0.362
T_6	7.136	7.192	0.254	0.272	0.407	0.371
T_7	6.971	7.021	0.241	0.256	0.425	0.379
T_8	6.956	7.005	0.238	0.253	0.437	0.404
T_9	6.897	6.996	0.234	0.252	0.439	0.409
F- test	NS	NS	NS	NS	S	S
S. Em(±)	0.1087	0.1081	0.0074	0.0063	0.0063	0.0052
C.D.@5%	0.3272	0.3254	0.0223	0.0191	0.0191	0.0158

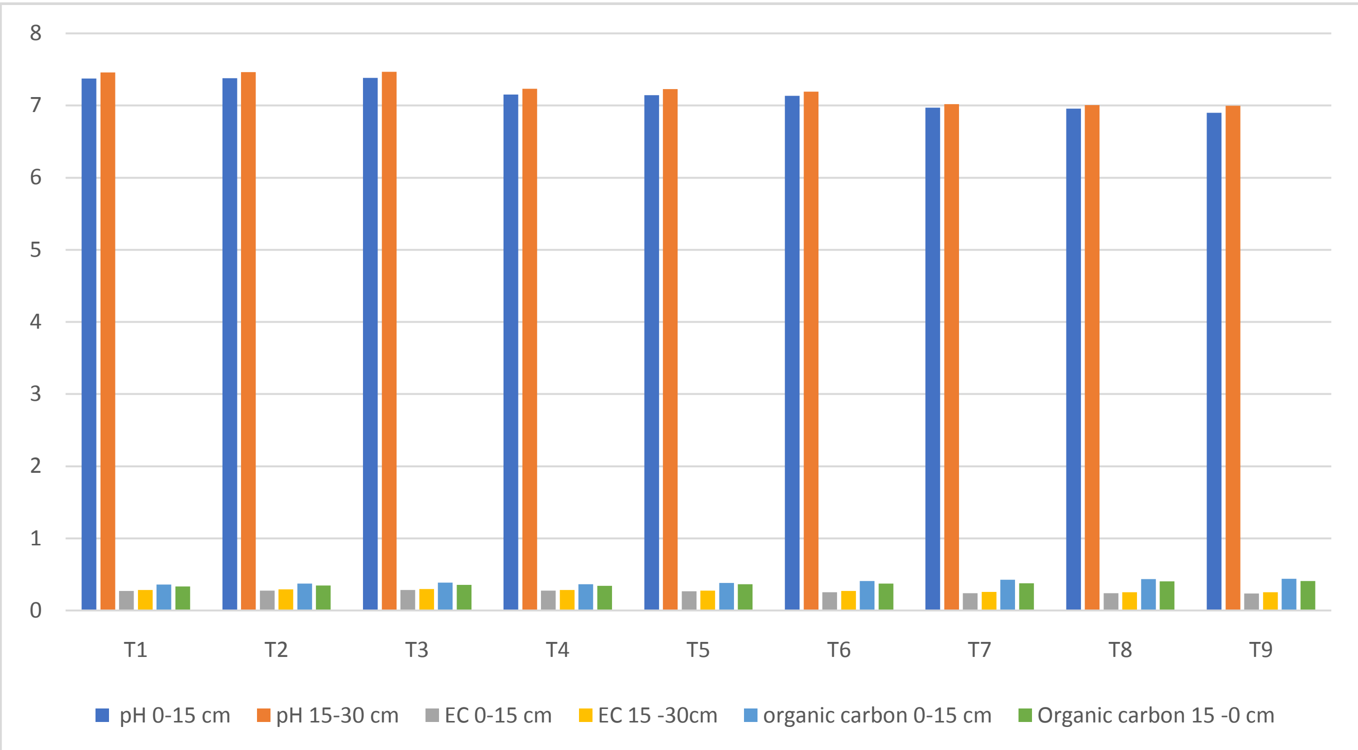

Fig . 3Effect of different levels of N P K, Biochar and Rhizobium inoculation on the pH, Electrical conductivity and Organic carbon of soil after crop harvest.

Table . 5Effect of different levels of N P K, Biochar and Rhizobium inoculation on the Available Nitrogen, Phosphorus and Potassium of soil after crop harvest.

Treatment	Available Nitrogen ($Kg\ ha^{-1}$)		Available Phosphorus ($Kg\ ha^{-1}$)		Available Potassium ($Kg\ ha^{-1}$)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30cm
T_1	258.67	251.21	18.29	16.93	177.34	171.65
T_2	259.58	251.98	18.17	17.27	178.67	173.54
T_3	260.83	253.41	19.89	17.49	180.46	174.89
T_4	264.65	258.07	20.11	19.54	184.64	179.46
T_5	268.42	261.67	20.42	19.85	186.78	181.58
T_6	270.24	262.91	20.91	19.98	187.43	183.57
T_7	272.93	264.76	21.02	20.14	189.85	185.20
T_8	281.53	273.35	21.34	20.38	196.96	192.32
T_9	285.08	278.37	21.54	20.85	201.35	194.62
F- test	S	S	S	S	S	S
S. Em(±)	4.6149	5.0077	0.2914	0.2960	3.5154	3.3078
C.D.@5%	13.8922	15.0749	0.8772	0.8910	10.5826	9.9577

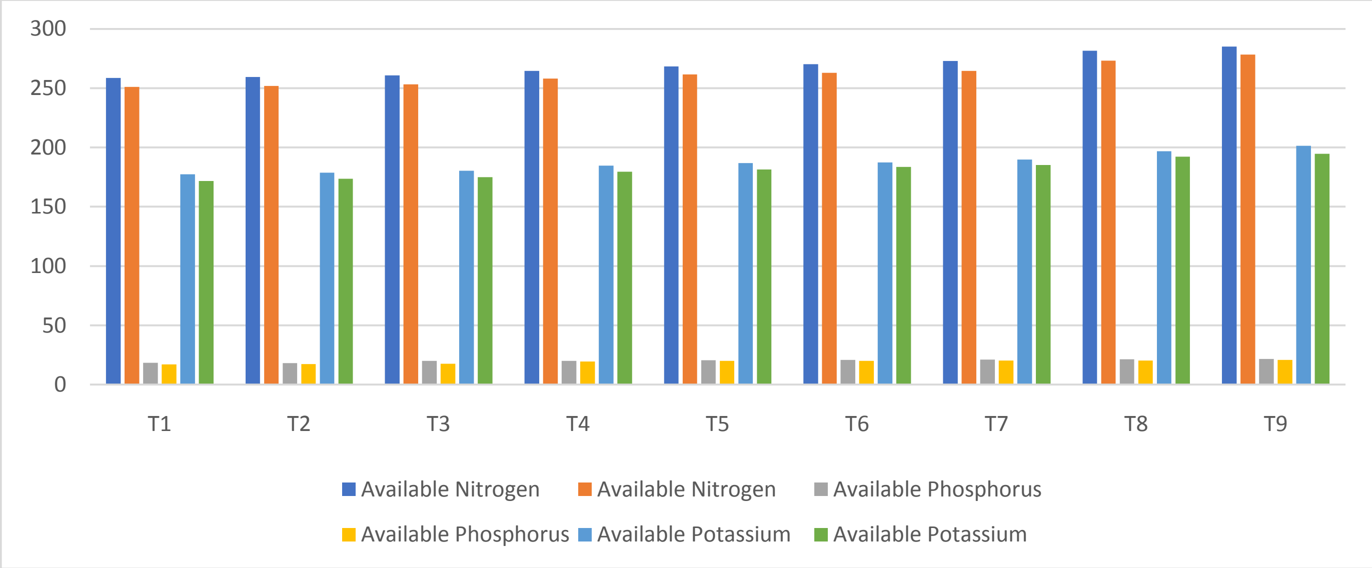

Fig . 3Effect of different levels of N P K, Biochar and Rhizobium inoculation on the Available Nitrogen, Phosphorus and Potassium of soil after crop harvest.

4. Conclusions

In conclusion, the use of INM practices such as application of organic manures, use of chemical fertilizers and use of biofertilizers can improve the soil health parameters in black gram and increase crop productivity. The treatment combination T_9 was concluded from trial that the various level of NPK, biochar and rhizobium is best for significant increase of soil physical and chemical properties. These practices can also help in the sustainable management of soil fertility and conservation of soil resources.

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 andAgricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh.

References

Achakzai, A. K. K., Shah, H. H. and Wahi, M. A. (2012). Effect of Nitrogen Fertilizerson the Growth of Mung bean [*Vigna Radiata* (L) Wilczek] Grown In Quetta. *Pak J Bot*, 440) 981-987.

Akbari, K.N., Sutaria, G.S; Vora, V.D.; Hirpara, D.S. and Padmani, D.R. 2018. Effect of periodical application of phosphorus with and without FYM on yield of groundout on vertic ustochrepts under rainfed agriculture. *Legume Research*. 33.64-66.

Amrita Markam, Narendra Swaroop, Tarence Thomas and Soman Singh Dhraw. (2017) Effects of Different Levels of NPK and Molybdenum on Soil Physico-Chemical Properties of Black Gram (*Vigna mungo* L.) Var. Shekhar-2. Int J Carr Microbiol App Sei.6(8): 1082 -1088.

Amruta N., Devaraju, P. J., Mangalagowri, S. P., Kiran, Ranjitha, H. P. and Teli. K. (2016). Effect of integrated nutrient management and spacing on seed quality parameters of black gram cv. Lbg-625 (rashmi) *Journal of Applied and Natural Science*, 8(1): 340-345. Anonymous (2006) Economic survey, Ministry of Finance, Government of India.

Anonymous (2009) Annual report for 2008. IRRI, Los Banos, Philippines

Anonymous (2011) Ministry of Agricultural Government of India.

Anonymous (2011-12) Department of Agricultural Govt. of Sikkim.

Anonymous (2011-12) Indian MART Inter Mesh Ltd.

Anonymous (2014) USDANational Nutrient Database for Standard Reference Release 26. Report Date : January 23, 2014.

Bird, M.L. Wurster, C. M., Silva, P., Bass, A. M. and De Nye, R. (2011) Algalbiochar production and properties Bioresource Technology, 102, 1886- 1891.

Bouyoucos, G. J. (1927) The hydrometer ana new method for the mechanical analysis of soils. *Soil Sci.*, 23: 393-395.

Jackson, ML (1958) The pH was determined in 1:2 soil water suspensions using digital pH meter.

Markam, A., Narendra Swaroop, Tarence Thomas and Soman Singh Dhruw (2017) Effects of Different Levels of N PK and Molybdenum on Soil Physico- Chemical Properties of Black Gram (*Vigna mungo L)* Var. Shekhar-2. *Int. J. Curr. Microbial. App. Sci.* 6(8): 1082- 1088.

Munsell, A.H., ed. 12. (1971)A *Color Notation* Baltimore, MDMunsellColor. Company. PP-65

Muthuvel P., C. Udaysoorian, R. Natesan, P. P. Ramaswami, (1992) Introduction to Soil analysis, Tamil Nadu Agricultural, Coimbatore- 641002

Olsen, S.R., Watanale, F. S., (1954)Amethod to determine a phosphorus adsorption measured by colorimetric method *soil sci.soc.Am.J.21,144-149*

Owla. R.L.. Chavan, B.N. and Singh, U. 2007 Effect of plant densities and phosphorus levels on growth and yield of green gram (Vigna radiata) Annals of Agricultural Research 28(1): 95-97

Singh, R.P., Bisen. J.S., Yadav, P.K., Singh, S.N. Singh, R. K. and Singh, J. (2008) Integrated use of sulphur andmolybdenum on growth, yield andquality of black gram. Legume Research 31:214-217

Subbiah. B.V. and Asija (1956) Arapidprocedure for estimation of availablenitrogen in soil*curr. Sci. 25:259.*

Tomar, T. S., Kumar, S. and Tomar. S. (2013) Effects of plant density, nitrogen and phosphorus on black gram (*Vignamungo* L hepper). Annals Agril. Res.(New Series) 34(4): 374-379 .

Toth, S.J. A. L. Prince (1949) Estimation of cation exchange capacity and exchangeable calcium, potassium and sodium contents of soils by flame photometer techniques. *Soil sci*. 67. 439-445.

Walkley, A. and Black, I. A. (1947) Critical examination of rapid method for determining organic carbon in soils, effect of variance in digestion conditions and of inorganic soil constituents. Soil sci. pp. 632-251.

Wilcox (1950) Electrical conductivity. Am water work Assoc.J 42; pp. 77.

Zaware. Enviroment Impact Assesment on soil pollution issue about human health. International Research Journal of Enviroment Sciences 2014:3(11): 78-81