Response of Nutrients, Biofertilizers, and Biochar on Soil properties under cultivation of Pea Crop (*Pisum sativum* L.) var. Kashi Mukti in an Inceptisol of Prayagraj district, Uttar Pradesh, India

---

ABSTRACT

The experiment was conducted at the research farm of Soil Science and Agricultural Chemistry to investigate the response of nutrients, biofertilizers, and biochar on soil properties under cultivation of pea crop (*Pisum sativum* L.) var. Kashi Mukti. Pea (*Pisum sativum* L.) is an important rabi leguminous crop found in the Indian subcontinent. It is mostly grown as a winter crop in the fields of northern India and as a summer vegetable on the slopes. The experimental design used was a randomized block design (RBD) with three replications Pea was taken for study with recommended doses of fertilizers (N, P_2O_5 and K_2O @ 20, 60 and 40 kg ha^{-1}) was applied with Rhizobium and Biochar. The bulk density (Mg m^{-3}) and particle density (Mg m^{-3}) of the soil were found to be maximum in treatment T_1 (NPK @ 0% + Rhizobium @ 0% + Biochar @ 0%), on the other hand, treatment T_9 (NPK @ 100% + Rhizobium @ 100% + Biochar @ 100%) exhibited the highest values for pore space (%), water holding capacity (%), pH (1:2) w/v, electrical conductivity (dS m^{-1}), organic carbon (%), available nitrogen (kg ha^{-1}), available phosphorus (kg ha^{-1}) and available potassium (kg ha^{-1}). In conclusion, the experiment demonstrated that the application of NPK fertilizers, rhizobium, and biochar had a significant impact on the soil health under pea cultivation.

Key words: Kashi Mukti, Biochar, Rhizobium, NPK, Pea, Soil Properties, Yield

1. INTRODUCTION

"Soil is a medium for plant growth. Crop production is largely based 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" **(Singh et al., 2008).** Pea (*Pisum sativum* L.) is a vital rabi leguminous crop found in Indian subcontinent. It is one of the most vital

UNDER PEER REVIEW

sources of dietary protein for the lion's share of Indians. In India, it is cultivated mainly in Uttar Pradesh, Madhya Pradesh, Jharkhand, Punjab, West Bengal, Haryana, Andra Pradesh, Bihar, Uttarkhand and Himachal Pradesh, where it is grown for both vegetable and pulse purposes and is a highly remunerative crop [11,12]. In addition, its tall surrender potential (3.5 t ha^{-1}) through adjusted fertilization envisages plentiful scope to extend its yields assist. In India, it is basically developed as winter vegetable within the fields of north India and as summer vegetable within the slopes. The seeds may be planted as before long as the soil temperature comes to 10 °C (50 °F), with the plants developing best at temperatures of 13 to 18 °C (55 to 64 °F). They don't flourish within the summer warm of hotter mild and swamp tropical climates, but do develop well in cooler, high-altitude, tropical zones. Numerous cultivars reach maturity almost 60 days after planting It is by and large utilized as new vegetable and within the frame of canned, handled or dried out. "Pea is one of the important vegetables in the world and ranks among the top 10 vegetable crops. Pea is commonly used in human diet throughout the world and it is rich in protein (21-25 %), carbohydrates, vitamin A and C, Ca, phosphorous and has high levels of amino acids lysin and tryptophan" **(Bhat *et al.*, 2013). "**Pea considered as one of the oldest known vegetable and is one of the most important vegetable crops cultivated in most parts of the world and ranks among the top 10 vegetable crops. India is the second largest producer of Pea in the world after Russia" **(Singh, 2008).** "It is grown as a garden or field crop throughout the temperate region or as cool season crop in the tropic. Pea is also widely used as pulse in daily diet, it contains a high percentage of digestible proteins (7.2/100g of edible protein), good content of vitamins *i.e.* Vit B1 (.025 mg /100g),Vit C (9mg/100g), and minerals like Phosphorus (139/100mg), Magnesium (34mg/100g) and Iron (1.5mg/100g)". (Singh, 2008).

"Potassium is often referred as the quality element for crop production due to its positive interaction with other nutrients (especially with nitrogen) and production practices. It promotes synthesis of photo-synthates and transport to fruits and grains, and enhances their conversion into starch, protein, vitamins, oil etc" (**Mengel and Kirkby, 1997**). "Phosphorus is known to play an important role in growth and development of the crop and have direct relation with root proliferations, straw strength, grain formation, crop maturation" (**Bhat *et al.*, 2013**). "Enhancing P availability to crop through phosphate-solubilizing bacteria (PSB) holds promise in the present scenario of escalating prices of phosphatic fertilizers and a general deficiency of Phosphorus in Indian soils. Potassium is associated with the movement of water, nutrients, and carbohydrates in plant tissue, it's involved with enzyme activation within the plant, which affects protein, starch and adenosine triphosphate (ATP) production.

UNDER PEER REVIEW

The production of ATP can regulate the rate of photosynthesis" **(Kumari *et al.*, 2012). "**Biofertilizers are substances that contain microorganisms which when applied to the soil increase the nutrient content and enhance the plant growth. Rhizobium present in the root nodules of the leguminous plants, add nitrogen to the soil which is supplied to the plants to enhance their growth. Biochar is a carbon rich product that is produced by pyrolysis (heating in incomplete or partial absence of oxygen) of biomass at relatively low temperature (< 700°C)" **(Demirbas 2002; and Mayhead, 2010)**. "The efficiency and effectiveness of the process of its creation and use can vary and the specific biomass sources used can affect the characterization and usability of the biochar" (**Demirbas, 2002**). "Some of the attributes that might be expected from biochar can go beyond just physical characteristics to issues of whether the feedstock used in its creation was from a renewable feedstock, whether its production reduced greenhouse gas emissions and whether the biochar can improve soil quality in a reliable way" **(International Biochar Initiative, 2009). "**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).**
"Application of biochar not only increases crop productivity and soil cation exchange capacity (CEC) but also is possible to increases oil macro- and microelement" **(Lehmann *et al.*, 2011)** "The use of biochar for soil improvement of crop yields in agricultural field is lately recognized. Effect of biochar on soil physical and chemical properties and have not investigated the impact on seed germination or root growth" **(Gebremedhin *et al.*, 2015).**

2. MATERIALS AND METHODS

"The exploratory led at the Soil Science Research Farm of SHUATS, Prayagraj, U.P., which is situated at 25º24'46.14" N scope, 81º50'49.95" E longitude and 98 m over the mean ocean level. The soil of the test region falls arranged by Inceptisol and in exploratory plots is alluvial soil in nature. The soils from each plot were separately collected at depth of 0-15 cm, air-dried, and passed through a 2-mm-size sieve for laboratory analysis. Soil samples were analyzed for bulk density, particle density, Percentage pore space, and water holding capacity **(Muthuvel *et al.*, 1992)**, pH **(Jackson,1958),** EC **(Wilcox, 1950)** , Percentage Organic Carbon **(Walkley and Black, 1947),** Available Nitrogen **(Subbiah and Asiija, 1956)** , Available Phosphorus **(Olsen *et al.*, 1954)** and Available Potassium **(Toth and Prince, 1949)** before sowing and after

UNDER PEER REVIEW

harvest of the crop. Findings of the Soil analysis before sowing of the crops at depth of 0-15 cm are bulk density (1.36 Mg m^{-3}), particle density (2.54Mg m^{-3}), pore space (42.59 %), water holding capacity (%4 0.12), pH (6.97) EC (0.32dS m^{-1}), organic carbon (0.36 %), available nitrogen (229.85kg ha^{-1}), available Phosphorus (22.01kg ha^{-1}) and available potassium (190.59kg ha^{-1}).

Agro climatically, Prayagraj addresses the subtropical belt of the South East of Uttar Pradesh is supplied with incredibly blistering summer and genuinely cool winter". "The Maximum temperature of the area comes to up to 46ºc-49ºc and only occasionally falls as low as 4ºc-5ºc. The general moistness ranges between 20-94%. The mid points precipitation of this area is around 1100mm annually with significant precipitation from November to February. Be that as it may, intermittent precipitation was additionally normal during winter. The cold weather months were cold while the late spring months were extremely sweltering and dry. The base temperature during the harvest season was to be 21.38℃ and the greatest is to be 37.82℃. The base moistness was to be 46.42% and the most extreme was to be 96.85%. The data recorded during the course of the investigation will be subjected to statistical analysis by 3 x 3 RBD, as per the method "Analysis of Variance (ANOVA) technique". Experiment was laid out in RBD and the treatment was replicated three times. The significant and non-significant effect was judged with the help of "F" (variance ratio) table.

PEER REVIEW

Table 1. Treatment Combination for Pea

Treatment	Treatment Combination
T_1	Absolute control
T_2	[NPK @ 0% + Rhizobium @ 50% + Biochar @ 50%]
T_3	[NPK @ 0% + Rhizobium @ 100% + Biochar @ 100%]
T_4	[NPK @ 50% + Rhizobium @ 0% + Biochar @ 0%]
T_5	[NPK @ 50% + Rhizobium @ 50% + Biochar @ 50%]
T_6	[NPK @ 50% + Rhizobium @ 100% + Biochar @ 100%]
T_7	[NPK @ 100% + Rhizobium @ 0% + Biochar @ 0%]
T_8	[NPK @ 100% + Rhizobium @ 50% + Biochar @ 50%]
T_9	[NPK @ 100% + Rhizobium @ 100% + Biochar @ 100%]

3. RESULTS AND DISCUSSION

3.1. Physical and Chemical Properties

The results showed that the treatment T9 (NPK @ 100 % + Rhizobium @ 100 % + Biochar @ 100 %) was recorded maximum physio-chemical characters such as pore space (%), water holding capacity (%), pH, EC (dS m^{-1}), organic carbon (%), available nitrogen (kg ha^{-1}), available phosphorus (kg ha^{-1}) and available potassium (kg ha^{-1}). While bulk density (Mg m-3) and particle density was recorded maximum in T1 (NPK @ 0 % + Rhizobium @ 100 % + Biochar @ 100 %).

Table 2. Response of NPK, Rhizobium and Biochar on bulk density, particle density, percent pore space, and water holding capacity of soil.

Treatments	BD (Mg m^{-3})	PD (Mg m^{-3})	Pore space (%)	WHC (%)
T_1	1.36	2.54	42.59	40.12
T_2	1.32	2.50	44.97	41.55
T_3	1.28	2.46	45.98	42.72
T_4	1.35	2.53	43.89	40.87
T_5	1.31	2.48	45.60	41.88
T_6	1.26	2.45	46.81	43.59
T_7	1.33	2.52	44.46	41.39
T_8	1.29	2.47	45.57	42.34
T_9	1.24	2.44	47.57	43.90
F-Test	S	S	S	S
S. Em. (±)	0.004	0.005	0.256	0.235
CD at (5%)	0.011	0.014	0.775	0.711

Table 3. Response of NPK, Rhizobium and Biochar on pH, EC (dSm^{-1}), OC (%) available Nitrogen (kg ha^{-1}), Phosphorus (kg ha^{-1}), and Potassium (kg ha^{-1}) of soil.

Treatments	pH	EC (dS m^{-1})	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1	6.97	0.32	0.36	229.85	22.01	190.59
T_2	7.15	0.34	0.43	233.95	23.18	194.48
T_3	7.22	0.37	0.51	237.8	24.06	196.72
T_4	7.03	0.33	0.38	244.38	24.97	199.45

UNDER PEER REVIEW

T_5	7.19	0.35	0.45	249.45	25.43	202.86
T_6	7.24	0.37	0.52	251.81	25.98	205.79
T_7	7.05	0.33	0.41	257.95	26.51	208.74
T_8	7.20	0.36	0.47	261.57	27.14	211.52
T_9	7.26	0.38	0.54	266.18	27.68	213.59
F-Test	NS	NS	S	S	S	S
S. Em. (±)	0.014	0.003	0.006	0.536	0.164	0.586
CD at (5%)	0.044	0.010	0.017	1.622	0.495	1.772

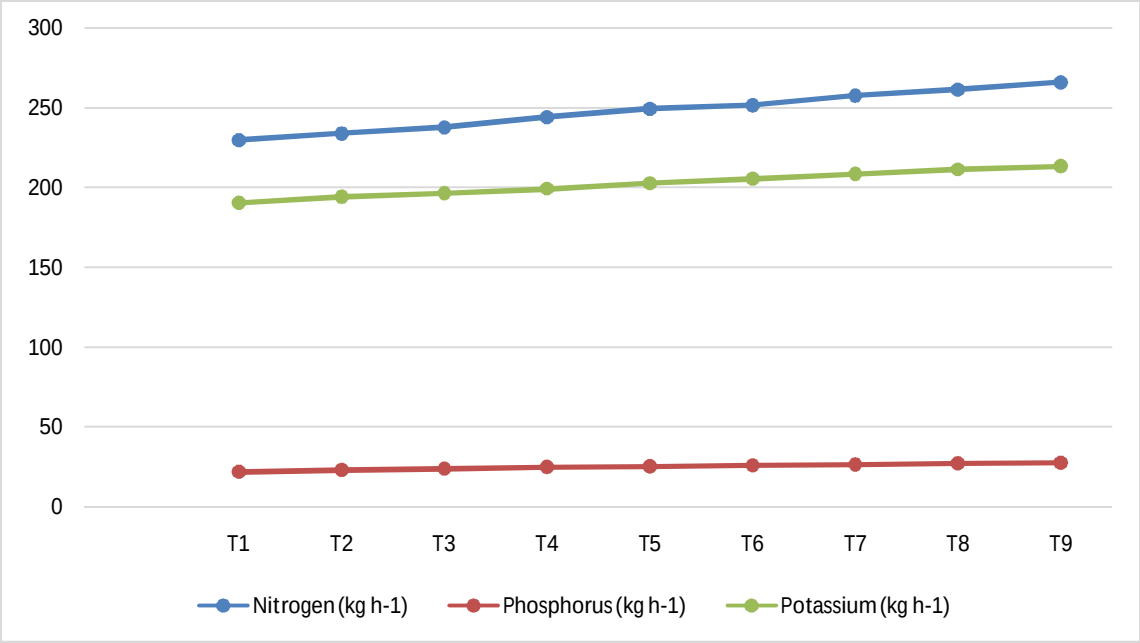

Fig. 1. Influence of NPK, Rhizobium and Biochar on available Nitrogen, Phosphorus and Potassium of soil

CONCLUSION

The results of experiment concluded as the application of NPK, Rhizobium and Biochar was found to improve soil health references to pea. Treatment T_9 [NPK @ 100% + Rhizobium @ 100% + Biochar @ 100%] was found optimal for improving soil properties like Pore space, Water holding capacity, organic carbon, pH, Electrical conductivity and Available Nitrogen, Phosphorus, Potassium of soil.

REFERENCES

1. **Bhat, T.A., Gupta, M., Ganai, M.A., Ahanger, R.A. and Bhat, H.A. (2013)** Yield, Soil Health and Nutrient Utilization of Field Pea (*Pisum sativum* L.) as Affected by Phosphorus and Biofertilizers under Subtropical Conditions of Jammu. *International Journal of Modern Plant and Animal Science,* 1(1): 1-8

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

3. **Demirbas, A. (2002)** An overview of biomass pyrolysis. Energy Source, 25, 471-482.

4. **Gebremedhin, G.H., Bereket, H., Daniel, B. and Tesfaye, B. (2015)** Effect of biochar on Yield and Yield components of Wheat and Post-harvest Soil Properties in Tigray, Ethiopia. *Journal of Fertilizers and Pesticides*, 6(2)

5. **International Biochar Initiative, (2009)** Recent research on biochar's potential in soils. International biochar initiative *(IBI)*.

6. **Walkley, A. J. and Black, J. A. (1934)** An examination of method for determination of organic carbon and nitrogen in soil. *J. Agric. Sci.* (England), **25**: 589-609

7. **Kumari *et al*., (2012)** Effect of integrated nutrient management on growth, seed yield and economics of field pea (*Pisum sativum* L.) and soil fertility changes. *Journal of Food Legumes* 25(2): 121-124

8. **Olsen, S. R., Cole, C.V., Watanable, F.S. and Dean, D. C. (1954)** Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *Circ. U.S Dept. Agric.*

9. **Lehmann, J., Gaunt, J. and Rondon, M., (2006)** Biochar sequestration in terrestrial ecosystems: A review. Mitig. Adapt. Strat. Gl. Chn, 11: 403–427.

10. **Singh R.S. and Yadav M.K. (2008)** Effect of phosphorus and biofertilizers on growth, yield and nutrient uptake of long duration pigeon pea under rainfed condition. Journal of Food Legumes, 21(1):46-48.

11. Chethan KV, David AA, Thomas T, Swaroop N, Rao S, Hassan A. Effect of different levels of NPK and Zn on physico-chemical properties of soil growth parameters and yield by pea (Pisum sativum L.) Cv. Rachana. Journal of Pharmacognosy and Phytochemistry. 2018;7(3):2212-5.

12. Bijarniya A, Thomas T, Swaroop N. Influence of Different Levels of NPK and Biochar on Physico-chemical Properties of Soil in Field Pea. International Journal of

UNDER PEER REVIEW

Environment and Climate Change. 2023 Jun 8;13(8):988-95.

UNDER PEER REVIEW