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Response of Different Level of Bulky Organic Manure and Biochar on Soil Parameters and Yield Attributes of Maize (*Zea mays* L.) var. Surabhi

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A trial was carried out on maize in the zaid season during 2023, with the soil being of sandy loam texture. The trial followed a randomized block design and involved three different levels of NPK. Each combination of treatments was repeated three times and randomly assigned within each

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replication. The findings indicate that using different combinations of NPK, FYM, and Biochar at T9 - [NPK @ 120:60:40 Kg ha^{-1} + FYM @ 125 t ha^{-1} + Biochar @ 5 t ha^{-1}] resulted in a slight decrease in pH, bulk density, and particle density. However, there was a significant increase in pore space, water holding capacity, EC, organic carbon, available nitrogen, phosphorus, potassium, and plant growth and yield characteristics. This combination yielded the best results for plant height (cm), number of leaves per plant (Kg ha^{-1}), number of cobs per plant (Kg ha^{-1}), seed yield (Kg ha^{-1}), and stalk yield (Kg ha^{-1}) in maize. Following closely was T8 - [NPK @ 60:30:20 Kg ha^{-1} + FYM @ 62.5 t ha^{-1} +Biochar @ 2.5 t ha^{-1}]. In the analysis of various treatment combinations, it was observed that the use of NPK, FYM, and Biochar in treatment T8 - [NPK @ 60:30:20 Kg ha^{-1} + FYM @ 62.5 t ha^{-1} + Biochar @ 2.5 t ha^{-1}] resulted in the highest net profit of Rs. ₹86,058.97 with a cost benefit ratio of 1:2.70. This was followed by T9 - [NPK @ 120:60:40 Kg ha^{-1} + FYM @ 125 t ha^{-1} + Biochar @ 5 t ha^{-1}], which provided a net profit of Rs. ₹84,640.83 ha^{-1} with a cost benefit ratio of 1:2.2.

Keywords: Soil properties; yield attributes; maize; FYM; biochar.

1. INTRODUCTION

Soil is the most wondrous gift of nature to human society. Development of soil from earth and evolution of sapiens go hand in hand. Truly, 4.5-billion-year-old earth is the mother of soil. If planet Earth is inhabited with humans (and other forms), it is because there is soil on it. “When you have land, you the world”. “Be it deep or shallow, red or black, sand or clay, the soil is the link betweenthe rock core of the earth and living things on its surface. It is the foot fold for the plants we grow, therein lies the main reason for our interest in soils” [1].

In recent years, the application of bio-char as soil amendments has generated a huge interest for the preservation of soil fertility by improving the physico-chemical and biological properties of soil, and for the reduction of the negative effects of greenhouse emission (climate change adaptation). Biochar derived from wood (BC), soil digested (SD), and biochar derived from soil digested (BSD), on soil parameters and their influence in maize growth performance [2].

Maize can thrive in a diverse range of soil types, spanning from loamy sand to clay loam. Nevertheless, soils that possess ample organic matter, a strong ability to retain water, and a neutral pH are deemed favourable for achieving greater yields. Its remarkable potential has earned it the titles "Queen of cereals" and "King of fodder." Maize is cultivated extensively across numerous states in India. The protein content in grain is approximately 8-10%, with oil content at 4-5%, and carbohydrate content at 70%. Additionally, it contains about 2.3% crude fiber, 10.4% aluminizes, and 1.4% ash. The protein "Zein" found in grain is rich in the essential amino acids tryptophan and lysine [3].

Farmyard manure has been utilized as a soil conditioner since ancient times, but its full benefits have not been fully realized due to the large quantities required to meet the nutritional needs of crops. [4]. Farmyard manure release nutrients slowly and steadily and activates soil microbial biomass [5,6,15,16]. Biochar is described as "a solid material obtained from thermochemical conversion of biomass in an oxygen-limited environment" by the International Biochar Initiative (IBI, 2013). Biochar is a product derived from pyrolysis of biomass that could be utilized as a soil amendment. The positive effects to crops by the addition of biochar combined with inorganic or organic fertilization have been reported [7].

2. MATERIALS AND METHODS

The experiment was conducted at research farm of Soil Science and Agricultural Chemistry, [NAI,] SHUATS, Prayagraj. It is situated at 25◦24’23” N latitude, 81◦50’38” E longitude and at an altitude of 98 meter above the sea level. During the summer season the maximum temperature of the location reaches up to 46˚C-48˚C and seldom falls as low as 4˚C - 5◦C during winter season. The relative humidity ranged between 20 to 90 percent. The average rainfall in this area is around 1100mm annually.

The design applied for statistical analysis was carried out with 3_3 randomized block

designs having three levels of NPK @ 0, 50 and 100 % ha^{-1}, three levels of FYM @ 0, 50 and 100 % ha^{-1} and three levels of Biochar @ 0, 50 and 100 % ha^{-1} respectively. The details of the treatment combinations are given Table 1 and observation were recorded bulk density, particle density, water holding capacity %,

Table 1. Treatment combination of maize var. surabhi

Treatment	Description
T_1	Absolute Control
T_2	[NPK @ 0% + FYM @ 50% + Biochar @ 50%]
T_3	[NPK @ 0% + FYM @ 100% + Biochar @ 100%]
T_4	[NPK @ 50% + FYM @ 0% + Biochar @ 0%]
T_5	[NPK @ 50% + FYM @ 50% + Biochar @ 50%]
T_6	[NPK @ 50% + FYM @ 100% + Biochar @ 100%]
T_7	[NPK @ 100% + FYM @ 0% + Biochar @ 0%]
T_8	[NPK @ 100% + FYM @ 50% + Biochar @ 50%]
T_9	[NPK @ 100% + FYM @ 100% + Biochar @ 100%]

Note: NPK 100 % (120:60:40 Kg ha^{-1}), FYM 100 % (125 t ha^{-1}) and Biochar 100% (5 t ha^{-1}) ICAR (2020) Sources of Fertilizers, Farm Yard Manure (FYM) and Biochar

Table 2. Composition of FYM, and Biochar

Source	FYM	Biochar
Nitrogen	0.5-1.5 %	7.49 g Kg^{-1}
Phosphorus	0.2-0.4 %	1.38 mg Kg^{-1}
Potassium	0.5-1.0 %	4.62 g kg^{-1}
Carbon	16.39 %	281.33g Kg^{-1}

Zhang et al. [8], Nitrogen – Urea, Phosphorus – DAP, Potassium - MoP

Table 3. Morphological analysis of soil

Particulars	Results	Method employed
Soil color		
1. Dry soil	Pale brown color	Munsell Color Chart (1971)
2. Wet soil	Olive brown color	

Table 4. Mechanical analysis of soil

S. No.	Soil separates	(%)	Methods
1.	Sand	61.20	(Bouyoucos, 1927)
2.	Silt	23.20	
3.	Clay	15.60	
4.	Texture of soil	Sandy loam	

Table 5. Physical Parameters of sandy loam soil

Particulars	Methods employed	Reference Range
Bulk density (Mg m^{-3})	(Muthuvel *et al.,* 1992)	1.45-1.8
Particle density (Mg m^{-3})	(Muthuvel *et al.,* 1992)	2.65-2.8
Pore space (%)	(Muthuvel *et al.,* 1992)	Less than 50%
Water holding capacity (%)	(Muthuvel *et al.,* 1992)	Less than 50 %

Table 6. Soil chemical parameters

Parameters	Method employed	Reference Range		
		Low	Medium	High
Soil pH (1:2)	(Jackson 1958)	< 6.5	6.5-7.5	>7.5
Soil EC (ds m^{-1})	(Wilcox 1950)	< 0.8	0.8-2.0	> 2.0
Organic Carbon (%)	(Walkley and Black 1947)	< 0.50	0.50-0.75	>0.75
Available Nitrogen (Kg ha^{-1})	(Subbiah and Asija, 1956)	< 280	280-560	> 560
Available Phosphorus (Kg ha^{-1})	(Olsen *et al.* 1954)	< 10	10-25	>25
Available Potassium (Kg ha^{-1})	(Toth and Prince 1949)	< 118	118-280	>280

Table 7. Crop Calendar of Pre sowing of Maize

S. NO.	Date	Operation	Remark
1.	01/04/2023	Tillage operation	Open ploughing by mould board plough Followed by harrowing and ploughing.
2.	03/04/2023	Layout and demarcation of plot	Manually
3.	05/04/2023	Collection of soil sample for analysis	Randomly from a depth of 0-15cm
4.	07/04/2023	Organic manure application	Biochar
5.	13/04/2023	Inorganic fertilizer application	Urea, SSP and MOP
6.	13/04/2023	Seed sowing	Manually

Table 8. Crop calendar of post sowing of maize

S. NO.	Date	Operation	Remark
1.	25/04/2023	Gap filling and resowing	12 days after sowing
2.	20/04/2023	First Irrigation	By irrigation channel
3.	10/05/2023	First weeding	By Khurpi at 27 days aftersowing
4.	30/04/2023	Second Irrigation	By irrigation channel
5.	11/06/2023	Second weeding	By Khurpi 58 days after sowing
6.	11/06/2023	Thinning	58 days after sowing
7.	20/06/2023	Third Weeding	By Khurpi 67 days after sowing
8.	23/06/2023	Third Irrigation	By irrigation channel
9.	15/07/2023	First Picking of fruits	92 days after sowing
10.	20/07/2023	Second Picking of fruits	97 days after sowing
11.	27/07/2023	Final Picking of fruits	104 days after sowing
12.	02/08/2023	Display of Crop	109 days after sowing
13.	10/08/2023	Collection of soil sample	Randomly from a depth of 0-15cm

pH, organic matter, nitrogen, phosphorus, potassium, plant height, number of leaves plant-1, number of cob plant-1, seed yield and stalk yield.

Throughout the experiment, mean values of the data were noted as observations. The treatment allocation determined the application of a basal dose of fertilizer in corresponding plots, with furrows being opened to a depth of approximately 5 cm before sowing seeds in the soil. The seeds were sown in shallow furrows at the same time on well-prepared beds, with a row-to-row distance of 30 cm and a plant-to-plant distance of 45 cm.

3. RESULTS AND DISCUSSION

The chapter discusses the impact of various levels of bulky organic manure and biochar on soil parameters and yield attributes of maize (*Zea mays* L.) var. surabhi, focusing on specific objectives.

(1) To study the effect of inorganic fertilizers bulky organic manures and biochar on soil parameters.

(2) To compare the interaction of inorganic fertilizers bulky organic manures and biochar in the yield attributing of maize.

In Table 9, it was observed that the soil's bulk density (Mg m-3) showed significance across NPK, FYM, and biochar levels, with a recorded value of 1.247 Mg m^{-3} in treatment T_1 (Absolute control) and a minimum value of 1.171 Mg m^{-3} in treatment T_9 (NPK @ 100% + FYM @ 100% + biochar @100%). The soil's particle density (Mg m^{-3}) also displayed significance across NPK, FYM, and biochar levels, with a maximum value of 2.14 Mg m^{-3} in treatment T_9 (NPK @ 100% + FYM @ 100% + Biochar @ 100%) and a minimum value of 2.30 Mg m^{-3} in treatment T1 (Absolute control). Treatment T_9 showed the highest soil water holding capacity at 48.59 %, achieved with NPK at 100%, FYM at 100%, and Biochar at 100%. In contrast, treatment T1, the absolute control, exhibited the lowest soil water holding capacity at 44.27 %. Additionally, treatment T_2, with NPK at 100%, FYM at 100%, and Biochar at 100%, demonstrated the greatest soil pore space at 46.765%, while treatment T_9, the absolute control, had the least soil pore space at 45.155%. These results were similarly documented by Kumar et al. [17,18].

According to the data in Table 9, the impact of soil pH was deemed significant across different levels of NPK, FYM, and biochar. The highest soil pH of 7.25 was observed in treatment T_1 - the absolute control, while the lowest soil pH of 6.89 was recorded in treatment T_9 - NPK @ 100% + FYM @ 100% + Biochar @ 100%. Similar results were documented [18,19]. The soil's EC (dS m^{-1}) response was not statistically significant across different NPK, FYM, and biochar levels. The highest soil EC (dS m^{-1}) value of 0.223 was observed in T_9 treatment - [NPK @ 100% + FYM @ 100% + Biochar @ 100%], while the lowest value of 0.203 was observed in T_1 treatment [Absolute control]. Similar results were documented by prior studies [18,19]. The level of NPK, FYM, and biochar had a significant impact on the increase in organic carbon (%) in soil. Treatment T_9 - [NPK @ 100% + FYM @ 100% + Biochar @ 100%] showed the highest organic carbon (%) at 0.488%, which was significantly greater than any other treatment combination. In contrast, treatment T_1- [Absolute control] had the lowest organic carbon (%) at 0.404%. Similar results were documented by Singh et al. [18,19]. The soil's nitrogen availability (kg ha^{-1}) increased notably as the levels of NPK, FYM, and biochar increased. In treatment T_9, the soil had the highest nitrogen content at 246.44 (Kg ha^{-1}), which was significantly more than any other treatment combination. Conversely, treatment T_1, the absolute control, had the lowest nitrogen content in the soil at 175.52 (Kg ha^{-1}). Similar findings were noted by Singh et al. [18,19]. The available phosphorus (Kg ha^{-1}) in soil increased significantly with the increase in levels of NPK FYM and biochar. The maximum available phosphorus in soil was recorded 39.80 (Kg ha^{-1}) in treatment T_9-[NPK @ 100% + FYM @ 100% + biochar @ 100%] which was significantly higher than any other treatment combination and the minimum available phosphorus in soil was recorded 24.09 (Kg ha^{-1}) in treatment T_1 – [Absolute control], similar findings were reported by Singh et al. [18,19]. The available potassium in soil increased significantly with the increase in levels of NPK FYM and biochar. Maximum available potassium in soil was recorded 232.05 (Kg ha^{-1}) in treatment T_9 - [NPK @ 100% + FYM @ 100% + Biochar @ 100%], which was significantly higher than any other treatment combination and the minimum available potassium in soil was recorded 202.99 (Kg ha^{-1}) in treatment T_1 – [Absolute control], similar findings were reported by Singh et al. [18,19].

In Table 10, observed differences in plant height was exhibited maximum in T_9-[NPK @ 100% + FYM @ 100% + Biochar @ 100%], 194.45 cm at crop harvesting (90 DAS) and found to be lowest in T_1-[Absolute control] 158.25 cm at crop harvesting (90 DAS), similar findings were reported by Kumar et al. [20] Faisal et al. [21]. The number of leaves $plant^{-1}$ was exhibited maximum in T_9 – [NPK @ 100% + FYM @ 100% + Biochar @ 100%], 15.2, 39.4 and 44.2 at 30, 60 and 90 DAS respectively and found to be lowest in T1 – [Absolute control] 8.2, 31.2 and 36.4 at 30, 60 and 90 DAS respectively, similar findings were reported by Kumar et al. [20] and Faisal et al. [21]. The mean value of number of cob plant-1 was exhibited maximum in T_9 – [NPK @ 100% + FYM @ 100% + Biochar @ 100%], 2.06 and found to be lowest in T_1– [absolute control] 1.18, similar findings were reported by Kumar et al. [20] and Faisal et al. [21].. The Seed yield (kg ha^{-1}) was exhibited maximum in T_9 – [NPK @ 100% + FYM @ 100%+ Biochar @ 100%], 5331.11 and found to be lowest in T_1 – [Absolute control], 1580.00, similar findings were reported by Kumar et al. [20] and Faisal et al. [12]. The Stalk yield was exhibited maximum in T_9 - [NPK @ 100% + FYM @ 100% + Biochar @

Table 9. Effect of different level of NPK FYM and biochar on physico-chemical properties of maize

Treatment	Bd (Mg m^{-3})	Pd (Mg m^{-3})	Water holding capacity (%)	Pore space (%)	pH (1:2.5)	EC (dS m^{-1})	OC (%)	N (Kg ha-1)	P_2O_5 (Kg ha^{-1})	K_2O (Kg ha-1)
T_1	1.247	2.30	53.27	45.797	7.25	0.203	0.404	175.52	24.09	202.99
T_2	1.207	2.27	54.57	46.765	7.21	0.207	0.423	187.97	24.69	219.71
T_3	1.196	2.25	55.61	46.745	7.08	0.213	0.428	196.97	28.76	223.14
T_4	1.205	2.22	55.00	45.737	7.13	0.211	0.425	191.97	27.08	222.69
T_5	1.193	2.21	55.96	45.930	7.07	0.215	0.433	200.30	30.43	224.27
T_6	1.185	2.20	58.10	46.203	7.02	0.217	0.442	240.24	34.12	226.95
T_7	1.191	2.19	56.32	45.671	7.06	0.215	0.435	202.97	32.02	226.06
T_8	1.181	2.18	58.18	45.891	6.95	0.218	0.448	242.64	36.64	229.58
T_9	1.171	2.14	59.09	45.155	6.89	0.223	0.488	246.44	39.80	232.05
F- test	S	S	S	S	S	NS	S	S	S	S
S. Em. (±)	0.010	0.03	0.62	0.956	0.05	0.010	.012	1.11	0.76	1.38
CD@0.05	0.031	0.08	1.83	2.866	0.16	0.02	0.036	3.32	2.36	4.15

Table 10. Effect of different level of NPK FYM and biochar on growth and yield parameters of maize

Treatment	Plant height (cm)	Number of Leaves plant	Cob $Plant^{-1}$	Seed Yield (Kg ha^{-1})	Stalk Yield (Kg ha^{-1})
T_1	158.25	39.4	1.18	1580.00	1983.33
T_2	173.39	40.0	1.42	2116.50	3352.64
T_3	180.96	40.0	1.60	2735.86	4019.69
T_4	174.98	40.8	1.49	2292.96	3744.75
T_5	183.44	41.8	1.70	2809.33	4293.66
T_6	189.26	42.4	1.96	4601.19	6816.67
T_7	184.91	43.0	1.83	2850.28	5561.79
T_8	189.66	44.2	2.03	4943.43	6867.37
T_9	194.45	45.2	2.06	5331.11	6983.13
F- test	S	S	S	S	S
S. Em. (±)	0.60	0.75387	0.03	42.28	54.76
C.D. @ 0.05%	1.80	2.26938	0.10	126.75	164.16

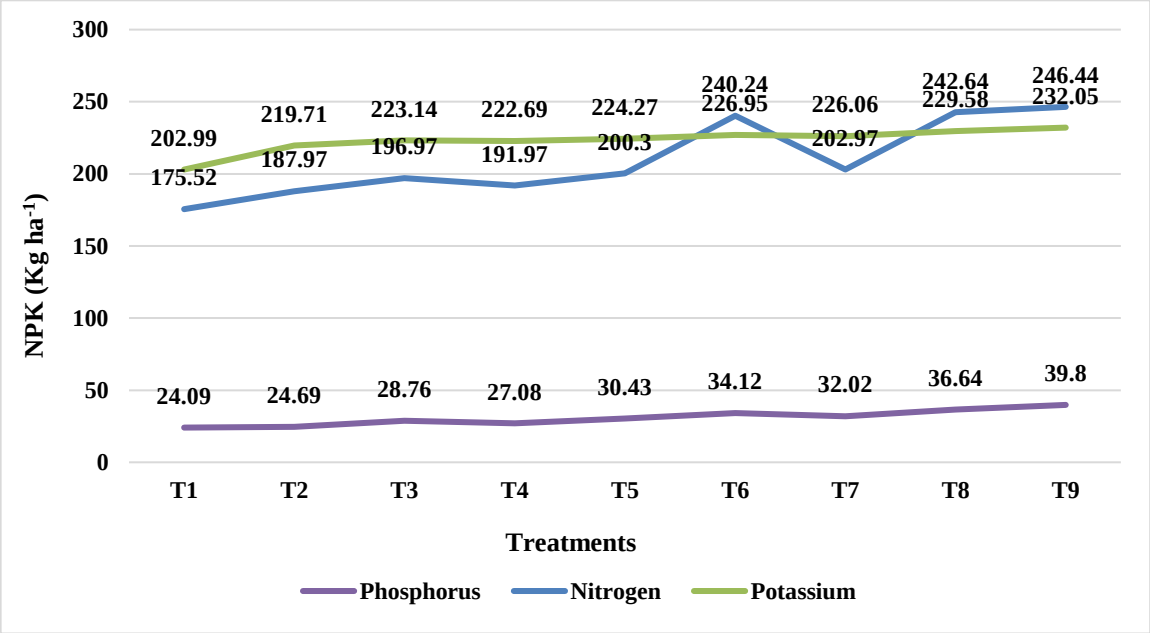

Fig. 1. Effect of different level of NPK FYM and biochar on soil

100%], 6983.13 Kg ha^{-1} and found to be lowest in T_1 – [Absolute control] 1983.33 Kg ha^{-1}, similar findings were reported by Kumar et al. [20] Faisal et al. [21].

4. CONCLUSION

It revealed from the trial that application of different level of N P K, FYM and Biochar used for Maize, the treatment combination T_8- [@ 100 % NPK + @ 50% FYM + @ 50 % Biochar] was found to be the best treatment for soil health parameters. Thus, treatment T_8 could be recommended for sustainable soil health and maize. Since the results is based on one season experiment, further trail is needed to substantiate the result.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Simonson R. Historical Highlights of soil survey and soil classification with emphasis on the United States; 1989.
2. Alessandro Calamai, David Chiaramonti, David Casini, Alberto Masoni, Enrico Palchetti short term effects of organic amendment on soil properties and maize (*Zea mays* L.) Growth 2020;10(5):158.
3. Singh N, Sandhu KS, Malhi NS. Some properties of corn grains and their flours I: Physicochemical, functional and chapatti-making properties of flours. Food Chemistry. 2017;101(3):938-946.
4. Makinde EA, Ayoola OT, Akande MO Effects of organo-mineral fertilizer application on the growth and yield of egusi melon. Australian J. Basic Appl. Sci. 2007;1:15-19.

5. Ayuso MA, Pascal. JA, Garcia C, Hernandez T Evaluation of urban wastes for urban agricultural use. Soil Sci. Plant Nutr. 1996;42:105111.
6. Belay A, Classens AS, Wehner FC, De Beer JM Influence of residual manure on selected nutrient elements and microbial composition of soil under long term crop rotation. S. Afr. J. Plant Soil. 2001;18: 1-6.
7. Adekiya, AO, Agbede TM, Aboyeji CM, O. Dunsin O, Simeon VT. Biochar and poultry manure effects on soil properties and radish (*Raphanus sativus* L.) yield. Biological Agriculture and Horticulture. Vol 2018;242:457-463
8. Meng Zhang, Yanling Liu, Quanguan Wei, Jiulan Gou Biochar enhances the retention capacity of nitrogen fertilizer and affects the diversity of nitrifying functional microbial communities in karst soil of southwest china; 2021.
9. Munsell AH. Munsell's description of his colour system, from a lecture to the American Psychological Association. American journal of psychology. 1921;23 (2):236 -244.
10. Bouyoucos GJ. The hydrometer as a new method for the mechanical analysis of soil. Soil Sci. 1927;23343-353.
11. Jackson ML. Soil Chemical Analysis, Prentice Hall of India Private Limited, New Delhi; 1973.
12. Wilcox LV. Electrical conductivity. Am. water works Assoc. J. 1950;42:775-776.
13. Walkley A, Black, IA. Critical examination of rapid method for determining organic carbon in soils, effect of variance in digestion conditions and of inorganic soil constituents; 1947.
14. Subbiah BV, Asija CL. A rapid procedure for the estimation of available nitrogen in soil, Current Sci. 1956;25:259-260
15. Olsen SR, Cole CV, Watnahe FS, Dean LA. Estimation of available phosphorous in soil by extraction with sodium bicarbonate U.S. Dept. Agr. Cric. 1954;939.
16. Toth SJ, Prince AL. Estimation of cation exchange capacity and exchangeable Ca, K and Na content of soil by flame photometer technique. Soil Sci. 1949;67: 439-445.
17. Kumar J., Kalita H. and Alone RA. Effect of organic and inorganicmanure and lime application on soil physico-chemical properties and yield of maize in acidic soil of mid hill of Arunachal. International Journal of Chemical Studies. 2020;8(2): 2187-2190.
18. Singh S, Swami S, Gogoi J, Dwivedi DK., Turkar GP. Effects of biochar- mediated treatments on the enhancements of soil acidity, crop performance and soil properties. Agricultural Mechanization in Asia. 2023;54.
19. Ghulam Murtaza, Zeeshan Ahmed, Muhammad Usman, Waseem Tariq Biochar induced modifications in soil properties and its impacts on crop growth and production. Journal of Plant Nutrition. 2021;44(11):1677-1691.
20. Kumar J, Kalita H, Alone RA. Effect of organic and inorganicmanure and lime application on soil physico-chemical properties and yield of maize in acidic soil of mid hill of Arunachal. International Journal of Chemical Studies. 2020;8(2): 2187-2190.
21. Faizal Mahmood, Imran Khan, Umair, Ashraf Tanveer Shahzad, Shabir Hussain, Muhammad Shahid. Effects of organic and inorganic manure on maize and their residual impact on soil physico-chemical properties. Journal of Soil Sciences and Plant Nutrition. 2017; 17(1):22-32.
22. Anonyomous; 2013. International Biochar Institute (IBI) Anonyomous; 1992. Indian Society of Soil Science (ISSS) Anonyomous; 2016. Tamil Nadu Agricultural University (TNAU).
23. Ecotoxicology and Environmental Safety, 226:112819.
24. Priya P, Singh S, & Mohan M. Influence of Organic Nutrients on Growth and Yield of Summer Greengram (*Vigna radiata*). Journal of Experimental Agriculture International. 2024;46(6):333–339.
    Available:https://doi.org/10.9734/jeai/2024/v46i62485
25. Singh M, Singh A, Singh V, Azam K, Kumar R, Nand V. Effect of Planting Geometry and Inorganic Fertilizers with Nano Urea on Growth Indices of Rice Crop (*Oryza sativa* L.). J. Adv. Biol. Biotechnol. [Internet]. 2024 ;27(6):474-82.
    Accessed On:2024 May 22
    Available:https://journaljabb.com/index.php/JABB/article/view/907

26. Agbede TM, Adekiya AO. Influence of biochar on soil physicochemical properties, erosion potential, and maize (*Zea mays* L.) grain yield under sandy soil condition. Communications in soil science and plant analysis. 2020;51(20):2559-68.

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