RESPONSE OF DIFFERENT LEVEL OF BULKY ORGANIC MANURE AND BIOCHAR ON SOIL PARAMETERS AND YIELD ATTRIBUTES OF MAIZE (*Zea mays* L..) var. SURABHI

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 replication. The findings indicate that using different combinations of NPK, FYM, and Biochar at T_9 - [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 T_8 - [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 T_8 - [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 T_9 - [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, *etc.*

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" **(Simonson 1989).**

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 **(Alessandro 2010).**

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 **(Singh *et al*., 2017).**

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. **(Makinde *et al.*, 2007).** Farmyard manure release nutrients slowly and steadily and activates soil microbial biomass **(Ayuso *et al.*, 1996; Belay *et al.*, 2001)**. 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 **(Adekiya *et al.* 2018)**

Material and Methods

The experiment was conducted at research farm of Soil Science and Agricultural Chemistry, [NAI,] SHUATS, Prayagraj. It is situated at $25^0$24'23" N latitude, $81^0$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 46^0C-48^0C and seldom falls as low as 4^0C - 5^0C 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 below table 1 and observation were recorded bulk density, particle density, water holding capacity %, p^H, 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.

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.* (2021)

Nitrogen - Urea

Phosphorus - DAP

Potassium - MoP

Table 3. Morphological analysis of soil

Particulars	Results	Method employed
Soil colour		
1. Dry soil	Pale brown colour	

		Munsell (1971)
2. Wet soil	Olive brown colour	

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

TNAU (2016)

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 manureapplication	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 after harvest	Randomly from a depth of 0-15cm

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 T_1 (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 T_1, 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.* 2020** and **Singh *et al.* 2023).**

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 **(Singh *et al.* 2023 and Murtaza *et al.* 2021).** 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 **(Singh *et al.* 2023 and Murtaza *et al.* 2021).** 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.* 2023 and Murtaza *et al.* 2021).** 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.* 2023 and Murtaza *et al.* 2021)**. 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.* 2023 and Murtaza *et al.* 2021).** 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.* 2023 and Murtaza *et al.* 2021).**

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	44.27	45.797	7.25	0.203	0.404	175.52	24.09	202.99
T_2	1.207	2.27	45.57	46.765	7.21	0.207	0.423	187.97	24.69	219.71
T_3	1.196	2.25	46.61	46.745	7.08	0.213	0.428	196.97	28.76	223.14
T_4	1.205	2.22	46.00	45.737	7.13	0.211	0.425	191.97	27.08	222.69
T_5	1.193	2.21	46.96	45.930	7.07	0.215	0.433	200.30	30.43	224.27
T_6	1.185	2.20	47.60	46.203	7.02	0.217	0.442	240.24	34.12	226.95
T_7	1.191	2.19	45.82	45.671	7.06	0.215	0.435	202.97	32.02	226.06
T_8	1.181	2.18	47.68	45.891	6.95	0.218	0.448	242.64	36.64	229.58
T_9	1.171	2.14	48.59	45.155	6.89	0.223	0.488	246.44	39.80	232.05
F- test	**NS**	**NS**	**S**	**S**	**NS**	**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	1.85	2.866	0.16	0.02	0.036	3.32	2.36	4.15

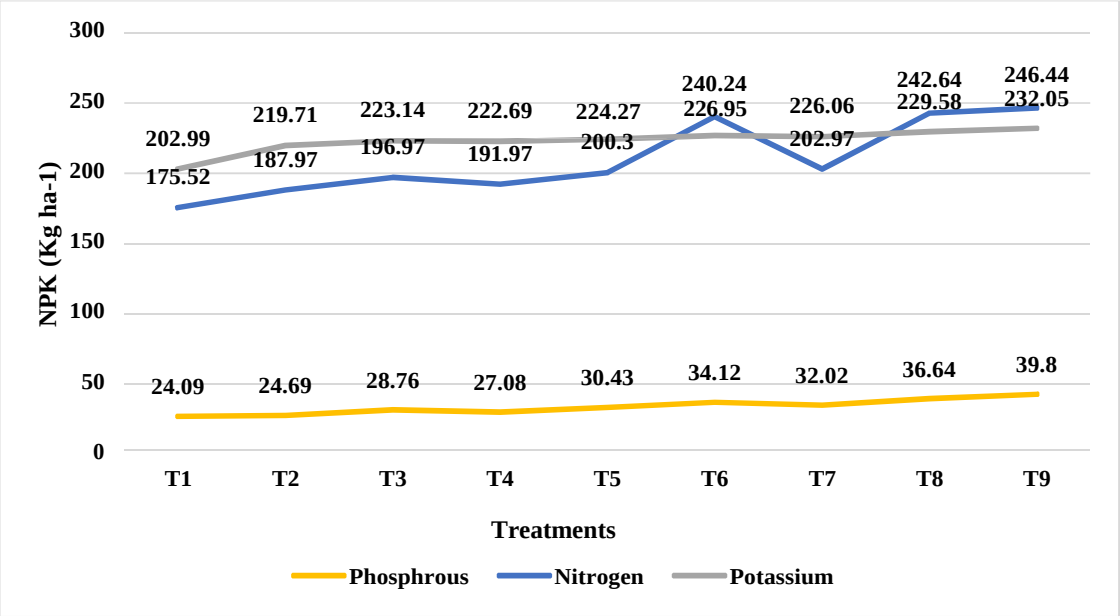

Fig 1. Effect of different level of NPK FYM and Biochar on Soil

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.* 2020 and Faisal *et al.* (2017).** 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 T_1 – [Absolute control] 8.2, 31.2 and 36.4 at 30, 60 and 90 DAS respectively, similar findings were reported by (**Kumar *et al.* 2020 and Faisal *et al.* (2017).** 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.* 2020 and Faisal *et al.* (2017)..** 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.* 2020 and Faisal *et al.* (2017).** The Stalk yield was exhibited maximum in T_9 - [NPK @ 100% + FYM @ 100% + Biochar @ 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.* 2020 and Faisal *et al.* (2017).**

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

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.

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