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Effect of fertilizers and organic manures on soil properties under maize (*Zea mays* L.) crop

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Abstract
A field experiment entitled "Effect of Fertilizers and Organic Manures on Soil Properties under Maize (*Zea mays* L.) Crop" was conducted on clay loam soils at Instructional Farm, Rajasthan College of Agriculture, Udaipur during *Kharif* 2023. The experiment consisted of 16 treatment combinations comprises of four fertility levels (control, 50% RDF, 75% RDF and 100% RDF) in main plots and four levels of organics (control, biochar @ 4 t ha^{-1}, FYM @ 5 t ha^{-1} and biochar @ 4 t ha^{-1} + FYM @ 5t ha^{-1} in sub plots. These 16 combinations were evaluated under Split Plot Design (SPD) with three replications during the *Kharif* season of 2023 where the impact of different fertility levels and organic manures application on soil properties under maize (*Zea mays* L.) crop was carried out. Results revealed that application of 100% RDF with biochar (4 t ha^{-1}) + FYM (5 t ha^{-1}) had a significant effect on soil chemical (EC, OC, available NPK) and biological properties including soil microbial population (bacteria, fungi and actinomycetes) and enzymatic activities (dehydrogenase and alkaline phosphate activity).

Keywords: RDF, biochar, FYM, maize

Introduction
Maize (*Zea mays* L.) is a member of the Gramineae family and commonly known as the "Queen of cereals" due to its highest productivity among the cereals. It is believed that maize was originated from Mexico or Central America and introduced to West Africa during the 16th century. The rank of maize among the world's most crucial cereals in global agricultural economies and specifically in India standing as the third most significant cereal followed by rice and wheat. Fertilizers play a crucial role in augmenting the food production in India. Fertilizer is credited with nearly 50% of the rise in productivity alone. India relies heavily on the application of fertilizers in agriculture to ensure food security for its growing population. In recent times, biochar has gained significance as a valuable soil amendment, showed a beneficial effect on soil fertility. It shows potential to enhance crop yields when combined with mineral fertilizer applications. Farm Yard Manure (FYM) is one of the oldest manures used by the due to its widespread availability and the presence of essential nutrients in readily mineralizable forms (Yadav and Chhipa, 2007) [5]. The combined use of manures and fertilizers has been found to be significant in enhancing soil chemical properties, as well as the distribution and transformation of both macro and micronutrients across various cropping systems (Yadav 2008 and Singh *et al.* 2013) [6, 4].

Material and Methods
The experiment was conducted during *Kharif* season, 2023 at Instructional Farm, Rajasthan College of Agriculture, Udaipur. The experiment consisted of 16 treatment combinations comprises of four fertility levels (control, 50% RDF, 75% RDF and 100% RDF) in main plots and four levels of organics (control, biochar @ 4 t ha^{-1}, FYM @ 5 t ha^{-1} and biochar @ 4 t ha^{-1} + FYM @ 5t ha^{-1} in sub plots. These 16 combinations were evaluated under Split Plot Design (SPD) with three replications. DHM-121 maize variety was taken as test crop and crop geometry was 60 cm x 25 cm. The soil of experimental site was clay loam in texture, alkaline in reaction, low in available nitrogen, medium in phosphorus and high in available potassium.

The electrical conductivity of soil was measured with the help of solubridge from 1:2 suspension and organic carbon through Walkey and Black's rapid titration method. The available nitrogen was determined by alkaline permagnate method using kjeldahl assembly and available phosphorus was determined colorimetrically. The available potassium was measured with 1 N neutral ammonium acetate at pH 7.0 and determined by flame photometer. The microbial population was determined using Standard serial dilution and plate count method. Dehydrogenase activity and alkaline phosphate activity was determined by Colorimetric determination of TPF (triphenyl formazon) and Microplate Method, respectively.

Results and Discussion

Fertility level: The chemical and biological properties of soil were significantly influenced under different fertility levels (Table 1 and 2). The maximum electrical conductivity (0.22 dSm^{-1}) was observed under application of 100% RDF which was statistically at par with 50% RDF and 75% RDF. The application of 100% RDF resulted in significant increase in organic carbon (1.06%) which was superior over control and 50% RDF. The available nitrogen was significantly higher (271.12 kg ha^{-1}) with the application of 100% RDF which was statistically at par with 75% RDF and superior over 50% RDF and control. The available phosphorus also reported maximum under the application of 100% RDF which was significantly higher over control, 50% RDF and 75% RDF. The application of 100% RDF achieved significantly higher available potassium which was statistically at par with 50% RDF and 75% RDF. The results revealed that the bacterial, fungi and actinomycetes population in soil after harvest of maize was significantly influenced due to different levels of fertility. Yadav *et al.* (2021) [8] had also observed similar results in soil properties. The maximum population of bacteria ($63.23x10^5$ cfu g^{-1}), fungi ($27.77x10^4$ cfu g^{-1}) and actinomycetes ($27.50x10^6$ cfu g^{-1}) was found under the application of 100% RDF which was higher over rest of the fertility levels. However, dehydrogenase (13.20 µg TPF g^{-1} soil h^{-1}) and alkaline phosphate activity (148.63 µg PNP g^{-1} soil h^{-1}) was also reported maximum under the application of 100% RDF. Such findings are also reported by Chandar *et al.* (2012) [3], and Yadav *et al.* (2022) [7].

Organic level: The organic manures also have a significant effect on electrical conductivity of soil (Table 1 and 2). The EC of soil was reduced with increased level of organics and found minimum (0.17 dSm^{-1}) under combined application of biochar + FYM. Organic carbon in soil was also reported maximum under the application of biochar + FYM, which was superior over rest of the treatments. The application of biochar + FYM recorded higher soil available nitrogen (261.99 kg ha^{-1}) and potassium (457.78 kg ha^{-1}) which was found superior over control but found statistically at par with the application of biochar alone and FYM alone. Phosphorus content was recorded maximum (22.37 kg ha^{-1}) under the influence of biochar + FYM which was superior over rest of the organic levels. These findings are in line with the findings of Yadav *et al.* (2005) [2].

Results revealed that the maximum population of bacteria ($62.39x10^5$ cfu g^{-1}), fungi ($26.24x10^4$ cfu g^{-1}) and actinomycetes ($25.93x10^6$ cfu g^{-1}) was found under the combined application of biochar + FYM which was maximum over rest of the organic levels. However, alkaline phosphate (147.74 µg PNP g^{-1} soil h^{-1}) activity and dehydrogenase activity (13.14 µg TPF g^{-1} soil h^{-1}) was also reported maximum under the combined application of biochar + FYM. The findings of this investigation confirm the results of Yun *et al.* (2017) [9].

Table 1: Effect of fertilizers and organic manures (biochar and fym) on chemical properties of soil

Treatment	EC (dSm^{-1})	O.C. (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Fertility levels					
F_0	0.17	0.89	244.49	14.51	423.84
F_1	0.20	0.97	247.41	16.44	457.13
F_2	0.20	1.01	264.40	17.96	457.84
F_3	0.22	1.06	271.12	19.52	459.32
SEm±	0.01	0.01	3.65	0.33	6.83
C.D.(P = 0.05)	0.02	0.04	12.64	1.14	23.65
Organic level					
O_0	0.22	0.88	248.47	12.93	429.69
O_1	0.20	1.00	257.37	16.43	454.35
O_2	0.19	0.99	259.59	16.71	456.31
O_3	0.17	1.06	261.99	22.37	457.78
SEm±	0.00	0.01	1.81	0.24	3.60
C.D.(P =0.05)	0.01	0.02	5.27	0.71	10.50

Table 2: Effect of fertilizers and organic manures (biochar and fym) on biological properties of soil

Treatment	Soil Microbial Population (cfu g^{-1})			Alkaline Phosphate activity (µg PNP g^{-1} soil h^{-1})	Dehydrogenase activity (µg TPF g^{-1} soil h^{-1})
	Bacteria (10^5)	Fungi (10^4)	Actinomycetes (10^6)		
Fertility levels					
F_0	57.02	22.37	21.77	136.91	11.31
F_1	57.51	23.07	22.90	139.12	12.23
F_2	60.53	25.69	25.59	142.63	12.89
F_3	63.23	27.77	27.50	148.63	13.20
SEm±	0.60	0.22	0.27	1.23	0.19
C.D.(P = 0.05)	2.07	0.78	0.93	4.27	0.64
Organic level					
O_0	56.93	23.22	22.97	135.33	11.80
O_1	59.22	24.54	24.36	141.80	12.25
O_2	59.73	24.89	24.51	142.41	12.45
O_3	62.39	26.24	25.93	147.74	13.14
SEm±	0.45	0.21	0.19	0.81	0.16
C.D.(P = 0.05)	1.31	0.62	0.56	2.35	0.48

Conclusion

The present investigation showed that among the fertility levels 100% RDF and among different organic levels, combined application of biochar + FYM significantly influenced the chemical properties (available NPK, E.C. and O.C.) and biological properties of soil *i.e*., microbial population (bacteria, fungi and actinomycetes) and enzymatic activities (dehydrogenase and alkaline phosphate activity).

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