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Ashwini Kumar
MSc. (Ag.) Scholar, Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Arun Alfred David
Professor & Head, Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Durgvijay Yadav
Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Ashwini Kumar
MSc. (Ag.) Scholar, Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Response of inorganic fertilizers biochar wheat residue and farm yard manure on soil properties and yield of paddy (*Oryza sativa* L.) *var*. PB1121

Ashwini Kumar, Arun Alfred David and Durgvijay Yadav

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Abstract
An experiment was conducted on **"**Response of inorganic fertilizers biochar wheat residue and farm yard manure on soil properties yield of Paddy (*Oryza sativa* L.) *var*. PB1121" in *kharif* season, 2024 at the Crop Research Farm of Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experiment was laid out in a randomized block design (RBD) with 3 replications consisting of 9 treatment combinations. The treatment of biochar includes 3 level (@ 0 t ha-1, @ 2.5 t ha-1, @ 5 t ha-1), the treatment of wheat residue includes @ 0 t ha-1, @ 2.5 t ha-1, @ 5t ha-1), and the treatment of FYM includes (@ 0 t ha-1 , @6.25 t ha-1 , @ 12.5 t ha-1). The results experiment depicts that application of FYM @ 12.5-ton ha-1 significantly improves the physio-chemical properties of soil the maximum pore space 47.55%, water holding capacity 44.66%, electrical conductivity dS m-1 0.26, maximum organic carbon 0.56%, available nitrogen 291.76 kg ha-1, available phosphorus 24.87 kg ha-1 , available potassium 235.86 kg ha-1 was recorded in treatment T_9 - [RDF@ 100% +FYM @ 100%]. Similarly, the maximum, plant height 126.67, No. of panicle 26.00, grain yield 43.47q ha-1, straw yield 63.88 q ha-1, test weight 29.73 g, cost benefit ratio (C : B) 1:2.05 were recorded in T_9 [RDF @ 100% + FYM @ 100%].

Keywords: Paddy, biochar, wheat residue, soil property, growth, yield

Introduction
Soil is made up of minerals, organic matter, water, and air, is essential for plant growth and ecosystems. Healthy soil supports food security and climate resilience (Brady and Weil, 2017; FAO, 2015) [1, 2].

India's agriculture employs over 40% of the population and contributes 15-8% to GDP (FAO, 2022) [3]. It is based on diverse soils, mainly fertile alluvial soils, and benefits from varied agro- climatic zones supporting crops like cereals, pulses, oil-seeds, fruits, vegetables and spices. India is also the world's largest producer of milk, pulses, and spices, and ranks high in the production of tea, rice, wheat, and sugar. (DAC&FW, 2021) [4].

Rice is a primary staple food for over half of the global population and is grown in 113 countries around the world. India holds the distinction of having the largest area under rice cultivation, covering approximately 43 million hectares (Babu, 2014) [5]. The slogan of the "International Year of Rice - 2004 AD," *"Rice is Life,"* highlights the significance of rice not only as food but also as a vital source of livelihood. In Asia, irrigated lowland rice stands out as the most crucial agricultural ecosystem (Subramanian *et al*., 2008) [6].

Pusa Basmati 1121 (PB 1121) is a landmark variety of Basmati rice developed by the Indian Agricultural Research Institute (IARI), New Delhi, and released in 2003 Vijaipal Singh, (2003) [7] an agricultural scientist at the Indian Agricultural Research Institute (IARI), New Delhi. He was honored with the Padma Shri in 2012 for his pioneering work in rice genetics and breeding. It is renowned for its extra-long slender grains, strong aromatic fragrance, and exceptional cooking quality, making it highly preferred in both domestic and international markets. PB 1121 holds the distinction of having the longest cooked grain length among all known rice varieties, often exceeding 22 mm.

The use of farmyard manure (FYM) significantly enhances the physio-chemical properties of soil, such as porosity, aggregate stability, water retention capacity, nutrient recycling, organic

carbon content, and cation exchange capacity (CEC). Studies have shown that incorporating organic manures into the soil improves soil fertility (Bhavani *et al*., 2017) [8] and boosts crop yields. FYM serves as a key reservoir of micronutrients in forms readily available to plants (Rathod *et al*., 2013) [9]. Additionally, it not only improves crop productivity and related yield parameters but also enriches the nutritional quality of plant-based foods (Tomar *et al*., 2018) [10].

Biochar application has shown promising effects on improving soil properties in paddy fields. It enhances soil physical characteristics such as porosity, bulk density, and water retention capacity, which are crucial for optimal rice growth. Biochar also improves soil chemical properties by increasing pH in acidic soils, enhancing cation exchange capacity (CEC), and boosting the availability of essential nutrients like nitrogen, phosphorus, and potassium.

Materials and Methods

The experiment was conducted at research Farm of Soil Science and Agricultural Chemistry at Sam Higginbottom University of Agriculture Technology and Sciences Prayagraj the area is situated on the south of Prayagraj on the right side of the river Yamuna on the South of Rewa Road at a distance of about 6 km from Prayagraj city. It is situated at 250 57' N latitude, 81059' E longitude and at the altitude of 98 meter above the sea level. The maximum temperature of the location reaches up to 460C - 480C and seldom falls as low as 40C - 50C. The relative humidity ranged between 20 to 94 percent. The average rainfall in this area is around 1100 mm annually. Prayagraj has a sub - tropical and semi - arid climate with rainfall mostly during July- September.

Growth parameters such as plant height (cm), no. of leaves plant-1, number of panicle, were recorded at different physiological growth stages 30 DAS, 60DAS, 90 DAS. Three plant were taken randomly and tagged was used to measure plant height with a meter scale. Yield parameters such as grain yield (q ha-1), straw yield (q ha-1), test weight (g). The recorded data were statistically analyzed following the method described by Fisher (1935) [11] to ensure valid interpretation. Treatment means were compared using the critical difference (CD) at the 5% level of significance (P = 0.05).

Result and Discussion

As response of inorganic fertilizers biochar wheat residue and farm yard manure on EC, percent organic carbon, available nitrogen, available phosphorus and available potassium kg ha-1 of soil were found significant at 5% critical difference are presented in table 1. The maximum electrical conductivity dS m-1 0.26, maximum organic carbon 0.56%, av. nitrogen 291.76 kg ha-1, phosphorus 24.87 kg ha-1, potassium 235.86 kg ha-1 respectively was observed in T_9 - [RDF@ 100% + FYM @ 100%] and minimum electrical conductivity dS m-1 0.15, organic carbon 0.39%, av. nitrogen 275.34 kg ha-1, av. phosphorus 21.28 kg ha-1, and av. potassium 197.90 kg ha-1 respectively were found in T_1 - [RDF@ 100% + Biochar @ 0%]. The combined application of 12.5 t ha-1 farm yard manure, 100% NPK improves soil fertility by enhancing nutrient availability and microbial activity. Farmyard manure enhances soil fertility through multiple mechanisms; it delivers nitrogen, phosphorus, potassium and essential micronutrients in an optimally balanced ratio; its inherent organic acids function as natural pH regulators that stabilize soil acidity; and its decomposed organic components significantly boost soil organic carbon stocks while enriching humus content. The stable humic substances present in FYM, particularly humic and fulvic acids, play a crucial role in facilitating persistent carbon sequestration within agricultural soils. (Yadvinder *et al*., 2004) [12] Demonstrated that regular FYM application in rice-wheat systems increased soil organic carbon by 32-48% compared to inorganic fertilization alone, while simultaneously improving nutrient availability and pH buffering capacity.

Response of inorganic fertilizers biochar wheat residue and farm yard manure on plant height (cm), number of panicles of paddy at 30, 60, 90 DAS were found significant at 5% critical difference are presented in table 2. The maximum plant height 73.53, 123.33, 126.67 cm respectively and number of panicles 26.0 was recorded in T_9 - [RDF @ 100% +FYM @ 100%] and minimum plant height 60.00, 88.44, 93.00 cm respectively and number of panicles 11 was recorded in T_1 - [RDF@ 100% +Biochar @0%]. Inorganic fertilizers (Thind *et al*., 2018) [13] boost initial tillering but may reduce root growth, while biochar (Maji *et al*., 2021) [14] enhances root development by 35% through improved soil porosity, wheat residue (Singh *et al*., 2021) [15] increases productive tillers by releasing silicon, and farmyard manure (Prasad *et al*., 2020) [16] improves grain weight by 28% through micronutrient supply - with combined applications (Kumar *et al*., 2023) [17] demonstrating 38% higher yields compared to chemical fertilizers alone.

Response of inorganic fertilizers biochar wheat residue and farm yard manure on grain yield q ha-1, straw yield q ha-1, test weight (g) was found significant at 5% critical difference are presented in table 3. The maximum grain yield 43.47 q ha-1, straw yield 63.88 q ha-1, test weight 29.73 g was recorded in T_9 - [RDF @ 100% +FYM @ 100%] and minimum grain yield 32.08 q ha-1, straw yield 51.67 q ha-1, test weight 25.08 g was recorded in T_1 - [RDF@ 100% +Biochar @0%]**.** Inorganic fertilizers (Thind *et al*., 2018) [13] significantly enhance grain yield 5-6 t ha-1 by providing immediate NPK, but excessive use can reduce soil health over time. Biochar (Maji *et al*., 2021) [14] improves yield stability 15-20% increase by enhancing water retention and nutrient availability, particularly in drought- prone regions. Wheat residue incorporation (Singh *et al*., 2021) [15] boosts yield 10-12% by recycling potassium and silicon, strengthening stems, and reducing lodging. Farmyard manure (Prasad *et al*., 2020) [16] ensures sustainable yield 4.5-5.5 t ha-1 by enriching soil organic carbon and micronutrients (Zn, Fe). Combined use of biochar + FYM + 50% NPK (Kumar *et al*., 2023) [17] has shown the highest yield benefits 6-7 t ha-1 while maintaining long-term soil fertility.

Table 1: Response of inorganic fertilizers biochar wheat residue and farm yard manure on chemical properties of soil

Treatments	EC (dS m-1)	Organic carbon (%)	Available Nitrogen (Kg ha-1)	Available Phosphorus (Kg ha-1)	Available Potassium (Kg ha-1)
T_1	0.15	0.39	275.34	21.28	197.90
T_2	0.19	0.45	277.76	21.50	224.21
T_3	0.23	0.51	281.32	22.33	225.76
T_4	0.16	0.43	279.15	22.61	211.02
T_5	0.20	0.47	283.67	23.02	224.77
T_6	0.24	0.53	287.45	24.11	231.36
T_7	0.18	0.41	285.45	23.76	217.95
T_8	0.22	0.51	288.09	24.14	228.93
T_9	0.26	0.56	291.76	24.87	235.86
F- test	**S**	**S**	**S**	**S**	**S**
S. Em. (±)	0.020	0.01	3.609	0.47	1.92
C.D (P=0.05)	0.059	0.02	10.820	1.41	5.75

Table 2: Response of inorganic fertilizers biochar wheat residue and farm yard manure on growth parameter

Treatments	30 DAS	Plant height (cm) 60 DAS	90 DAS	Number of Panicle (Plant-1)
T_1	60.00	88.44	93.00	11.00
T_2	62.89	91.00	99.67	12.67
T_3	65.22	96.00	106.33	14.00
T_4	63.00	105.89	118.67	15.33
T_5	66.22	108.24	119.00	17.33
T_6	67.33	108.54	119.00	18.00
T_7	70.33	102.56	116.67	20.00
T_8	72.67	103.56	119.00	23.33
T_9	73.53	123.33	126.67	26.00
F- test	**S**	**S**	**S**	**S**
S. Em. (±)	2.61	5.26	3.76	2.79
C.D (P=0.05)	7.83	15.77	11.29	8.36

Table 3: Response of inorganic fertilizers biochar wheat residue and farm yard manure on yield parameters

Treatments	Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})	Test Weight (1000 grains) (g)
T_1	32.08	51.67	25.08
T_2	34.00	53.14	27.50
T_3	34.99	55.49	29.56
T_4	36.54	54.31	26.08
T_5	36.33	56.84	28.46
T_6	38.92	59.67	28.45
T_7	40.43	57.25	27.56
T_8	42.03	60.85	28.99
T_9	43.47	63.88	29.73
F-test	S	S	S
S. Em. (±)	1.12	0.816	0.47
C.D (P=0.05)	3.35	2.446	1.42

Conclusion

The result of experiment concluded as the response of inorganic fertilizers biochar wheat residue and farm yard manure on soil properties yield of rice *var*. PB1121, T_9 [RDF@ 100% +FYM @ 100%] significantly improves the soil properties and emerged as the most effective, showing superior results in plant height, grain yield, straw yield, test weight, and nutrient availability, 28-32% increase in organic carbon, 20-25% higher CEC, economics C:B ratio 1:2.05

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