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Enhancing soil physical properties and yield of basmati rice through chemical fertilization and crop residue incorporation

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Abstract
A field experiment was conducted during *Kharif* season of July 2013 and 2014 at crop research farm SHUATS Allahabad to study the response of chemical fertilizer and crop residue on soil properties, yield parameters and yield of rice. Twelve treatments were arranged using (4x3) factorial R.B.D with three replications. The result were showed that the grain yield and pore space increased steadily with the increase in inorganic fertilizer level up to the 100% NPK ha^{-1} and wheat residue up to 5 tonnes. Further, interaction effect of increasing level of chemical fertilizer & wheat residue on yield and pore space was found significant in both the year of experiment. The date further showed that the given data maximum grain yield and pore space was found with the application of 100 % NPK along with 5 tonnes wheat residue followed by 50% NPK along with 2.5 tonnes wheat residue. However, reverse trend was noted in bulk density. Though, minimum grain yield and pore space was found under the treatments where no fertilization and wheat residue incorporation in rice had taken place.

Keywords: fertilizers, yield, rice, wheat residue

Introduction
Rice being the most important food crop grown in India! Rice based cropping system occupying nearly 80% of Agricultural land in south Asia. R-W is grown in an annual sequence and is the most important cropping system in Indo-Gangetic plains and covering nearly 11 M ha in India Jeet *et* al., (2014) [2]. Amongst rice, Basmati rice is known as queen of rice, and area under scented rice varieties are also increasing day by day with the opening world market as well as domestic consumption (Singh *et al.,* 2008) [3]. India's long-grain Basmati rice is traditionally grown in Punjab, Haryana and western Uttar Pradesh.

The suitability of crop production depends on the soil physical properties. A physically fertile soil provides a good crop stand. This is greatly influeced by several management practices. Soil physical properties *i.e.,* water holding capacity, bulk density, total porosity, air-filled porosity, hydraulic conductivity, and soil-depth together greatly influence the root development which in turn influence plant growth and performance. Tillage depth and intensity alter the soil physical and chemical properties that affect plant growth and crop yields. Soil loosening by means of deep-tillage systems improves water infiltration, internal drainage, and aeration in the soil; increases root depth, intensity and development and allows for deeper fertilizer placement (Strudley *et al.,* 2008) [1]. Rice residue retention has a significant positive influence on soil fertility, physical and biological properties of soil. Sowing wheat in residual soil moisture without pre-sowing irrigation will save about 20% in irrigation water. Natural sources like crop residue, enhances the physical condition and biological health of soil that enhances the accessibility of connected and local supplements Dick and Gregorich, (2004) [4]. It also maintains the soil physical & chemical condition thereby improving the overall ecological balance in the crop production system. Crop residue & tillage management may affect surface soil physical properties which is important for water holding capacity & infiltration. Management practices of minimum disturbance, the soil & produce, return, & leave more residue biomass on the soil surface (such as no-till) have the potential to decrease soil bulk density, increase porosity, & increase sorptivity in the soil over time. Also, systems that produces the return, & leave largest amounts of crop residue in the soil poses the highest potential for increased root activity, soil aggregation & channels that can increase water infiltration In India over 500 million tonne of agricultural residue are produced

every year (MNRE 2009; www.nicra.iari.res.in/Data/Final CRM.doc). With increment, generation of rice and wheat, CRs creation has additionally expanded considerably. There is an extensive inconsistency underway for CRs, and their utilization relies on upon the harvests developed, editing force and profitability in various regions of India. One tonne of wheat residue contains 4-5 kg N, 0.7- 0.9 kg P, and 9-11 kg K. Besides NPK, one tonne of rice and wheat residue contain about 9-11 kg S, 100 g Zn, 777g Fe and 745g Mn (Singh and Sidhu, 2014) [11].

It is well known that incorporation of residue into soils increases their water holding capacity and decrease bulk density. Soil texture is the main determinant of soil water holding capacity. However, the level of organic matter also determines water holding capacity of a soil. Mousavi *et al*., (2012) [5] and (Plaster, 2008) [6] Yield responses to residue retention were affected by both climate and soil conditions. Furthermore, agronomic practices, particularly N management, significantly influenced yield gains under crop residue retention. The increasing levels of NPK increased both grain and straw yields of rice, thus increased the economic return (Das *et al.,* 2003) [8].

Materials and Methods

Experimental details

The trial with three replications and twelve treatments was laid out in Factorial (4x3) R.B.D to assess the performance of different organic and chemical fertilizer on soil physical properties, productivity and yield during *Kharif* season at crop research farm SHUATS Naini, Allahabad (UP) INDIA. The Crop Research Farm is situated at 25^0 57' N latitude, 87^0 19' E longitude and 98 m altitude from the sea level. This area is situated on the right side of the river *Yamuna* and by the opposite side of Allahabad City.The area received about 800.45 mm rainfall during the *Kharif* season of both the Years. The soil of the experimental plot was sandy loam in texture (59.16.0% sand, 25.23% silt and 15.61% clay), slightly acidic (pH 7.81) low in soil organic carbon (0.38%), available nitrogen (191.43 kg ha^{-1}) low in available phosphorus (17.16 kg ha^{-1}) and medium in potassium (143.62kg ha^{-1}).

Table: Factor levels

I_0	Control	0:0:0 NPK
I_1	25% NPK	30:15:15 NPK
I_2	50% NPK	60:30:30 NPK
I_3	100% NPK	120:60:60 NPK
W_1	50% Wheat residue	2.5 tonne/ha.
W_2	100%Wheat residue	5.0 tonne/ha.

The experiment comprised twelve treatments with 3 replications having 4 different Chemical fertilizer levels and 3 different residue incorporation levels. Required quantity of fertilizer as per treatment was applied uniformly in the plots through broadcast method of application. A uniform dose of 120 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} were applied in the form of Urea (46 % N), Diammonium Phosphate (16% P_2O_5) and Mureate of Potash (60% K_2O). All plots received ½ dose of N, full dose of P and K and 1/4th N fertilizer at two equal splits - at tillering and panicle initiation as per treatments. The crop irrigated as and when required. The weeds were removed manually at 30 and 60 days after transplanting (DAT). The residue incorporation was at 5 tonnes wheat straw.

Observations recorded

The soil samples collected from 5 location of experimental area was taken by soil auger up to 0-15cm and samples were mixed together for obtaining a composite soil sample for measuring bulk density and pore space. Moreover, grain yield was recorded as per the standard procedure.

Statistical analysis

The data were statistically analyzed applying the techniques of analysis of variance and the significance of different sources of variations was tested under Factorial RBD design at probability level 0.05%.

Results and Discussion

Bulk density (g cm^{-3})

The interaction effect of increasing level of chemical fertilizer & wheat residue on soil bulk density was found slightly decline in both the year of experiment. Combine application of I_0 and W_0 had noted minimum bulk density, whereas maximum were noted with I_3 along with W_2 during both the year of experimentation. As similar finding given by Singh *et al*., (2005) [12] and Mousavi *et al*., (2012) [5] reported that the incorporation/ retaintion of crop residues in soil improve soil structure, reduce bulk density. It is well known that incorporation of crop residue causes soil particles to stick together and form aggregates; hence, bulk density is reduced as described by

Table 1: Effect of different levels of chemical fertilizer and wheat residue on soil Bulk density (%).

	Ist Year (2013)				**IInd Year (2014)**			
Treatment	**W_0**	**W_1**	**W_2**	**Mean**	**W_0**	**W_1**	**W_0**	**Mean**
I_0	1.49	1.47	1.36	1.44	1.45	1.39	1.40	1.41
I_1	1.44	1.39	1.34	1.39	1.47	1.36	1.32	1.38
I_2	1.44	1.37	1.32	1.38	1.4	1.34	1.32	1.35
I_3	1.49	1.31	1.26	1.35	1.47	1.31	1.25	1.34
Mean	1.47	1.38	1.32		1.45	1.34	1.31	
	F test	S. Ed	C.D		F test	S. Ed	C.D	
Chemical(I)	S	0.004	0.009		S	0.006	0.013	
Residue(W)	S	0.004	0.007		S	0.007	0.015	
Interaction(I x W)	S	0.007	0.015		S	0.013	0.027	

Pore space (%)

Interaction effect of increasing level of chemical fertilizer & wheat residue on soil pore space percentage was found significant in both the year of experiment. Showed that the given data maximum soil pore space percentage was found with the application of 100 % NPK along with 5 tonnes wheat residue followed by 50% NPK along with 2.5 tonnes wheat residue. However, least pore space was found under the treatments where no fertilization and wheat residue incorporation were used. Similar finding was reported by Singh *et al*. (2005) [12] Reported that the incorporation/ retention of crop residues in soil improve soil structure, reduce bulk density, and increase the porosity of soil.

Table 2: Effect of chemical fertilizer and wheat residue on soil Pore space (%).

	Ist Year (2013)				IInd Year (2014)			
Treatment	**W_0**	**W_1**	**W_2**	**Mean**	**W_0**	**W_1**	**W_2**	**Mean**
I_0	44.45	45.36	48.76	46.19	46.54	47.74	46.96	47.19
I_1	46.04	46.95	49.45	47.48	45.81	48.28	47.98	47.36
I_2	45.65	48.54	49.64	47.94	47.87	49.36	49.50	48.91
I_3	43.76	50.58	52.04	48.79	44.78	50.54	53.19	49.50
Mean	44.97	47.86	49.97		46.25	49.56	49.93	
	F test	S. Ed	C.D		F test	S. Ed	C.D	
Chemical(I)	S	0.30	0.63		S	0.43	0.89	
Residue(W)	S	0.35	0.72		S	0.50	1.03	
Interaction(I*W)	S	0.60	1.25		S	0.85	1.78	

Grain yield (q ha^{-1})

The inorganic fertilizer levels exerted significant effect on grain yield of rice. The grain yield increased steadily with the increase in inorganic fertilizer level up to the 100% NPK ha^{-1} and wheat residue up to 5 tonnes. Interaction effect of increasing level of chemical fertilizer & wheat residue on yield was found significant in both the year of experiment. The date further showed that the given data maximum grain yield was found with the application of 100 % NPK along with 5 tonnes wheat residue followed by 50% NPK along with 2.5 tonnes wheat residue. However, minimum grain yield was found under the treatments where no fertilization and wheat residue incorporation in rice had taken place. As similar findings have also been reported by Arshadullah *et al.*, (2012) [7] that crop residue incorporation alone and with an starter dose significantly affected grain yield. The increases in yield components and are associated with better nutrition, plant growth, increased nutrient uptake and yield attributing characters as explained by Pramanik and Bera (2013) [10].

Table 3: Effect of different levels of Chemical fertilizer and wheat residue on Grain yield (q ha^{-1}) of Rice

	Ist Year (2013)				IInd Year (2014)			
Treatment	**W_0**	**W_1**	**W_2**	**Mean**	**W_0**	**W_1**	**W_2**	**Mean**
I_0	21.93	22.50	22.73	22.39	21.60	23.59	26.20	23.80
I_1	25.57	32.97	33.70	30.74	25.98	31.86	35.20	31.01
I_2	26.10	35.20	39.07	33.46	28.55	35.30	38.87	34.24
I_3	35.00	40.12	43.50	39.54	37.03	42.93	45.39	41.78
Mean	27.15	32.70	34.75		28.29	33.42	36.41	
	F test	S. Ed	C.D		F test	S. Ed	C.D	
Fertilizer's (I)	S	0.43	0.90		S	0.62	1.28	
Residue (W)	S	0.38	0.78		S	0.71	1.48	
Interaction (I*W)	S	0.75	1.56		NS			

Conclusion

In Indian sub-continent, rice crop occupies a major share of total arable land. The recycling of its residues has the great potential to return a considerable amount of plant nutrients to the soil in the rice based crop production systems but burning of residue is very harmful for environment as well as all living beings. From the above discussions reported that in combination 5 tone ha-1 Wheat residue and 120:60:60 NPK given through chemical fertilizers gave maximum grain yield and good result in terms of properties of soil.

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