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Effect of crop residue incorporation on physical and chemical properties of soil under rice-wheat, guar-wheat and cotton-wheat cropping systems

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Abstract

A field experiment was conducted during May 2018 to April 2020 at agricultural research farm of Guru Kashi University, Talwandi Sabo, Bathinda. The experiment was carried out by incorporating kharif crops *viz.*, rice, guar, cotton and rabi crop *viz.*, wheat residues in combination There were twelve treatments in randomized block design with three replications. Incorporation of crop residues (rice straw and wheat straw) resulted in increase in soil organic carbon, electrical conductivity (EC) and porosity (%) of soil although decrease in bulk density and soil pH was found due to crop residue application. In 2018-19, the highest organic carbon content was recorded for the treatment T_5 (0.54%) where crop residues (both cotton and wheat) were incorporated and the lowest was recorded for T_4, T_8 and T_{12} (0.42%) and in 2019-20, combine application of both cotton and wheat residues exerted significant positive effect on soil organic carbon content and the highest organic carbon content was recorded for the treatment T_5 (0.76%).

Keywords: Crop residue, organic carbon, rice, sustainable agriculture and wheat

Introduction

Rice-wheat cropping system of the Indo-Gangetic Plains has played a significant role in the food security of India. This system spread over a vast area spanning from Punjab in the North-west to East up to West Bengal. Conservation agriculture involving zero or minimum-tillage and innovations in crop residue management (CRM) to avoid straw burning should assist in achieving sustainable productivity and allow farmers to reduce nutrient and water inputs, and reduce risk due to climate change. Crop residues generally left over plant parts of crops after harvest and threshing are important natural resources. The crop residue recycling helps in converting the surplus farm waste into useful products to meet the nutrient requirements of crops apart from improving the ecological balance of crops production system, but burning of rice straw is common in north-western parts of India causing nutrient losses, and serious air quality problems affecting human health and safety. About 82% of rice residue produced is burnt in the field after harvesting rice by combine harvester, resulting in the substantial loss of plant nutrient there in. Straw carbon, nitrogen and sulphur are completely burnt and also lost to the atmosphere in the burning process of rice straw. In addition, the ash lying on the surface of soil after burning absorbs the applied weedicide and decrease the efficiency of herbicides. Residue incorporation legumes have been reported to have greater influence over crop yield and enrichment of soil physicochemical and biological properties by Mandal *et al.*, (2004) [4].
Incorporation of crop residues alters the soil environment, which in turn influences the microbial population and activity in the soil and subsequent nutrient transformations. It is through this chain of events that management of crop residues regulates the efficiency with which fertilizer, water, and other reserves are used in a cropping system. The removal of crop residues leads to low soil fertility and thereby decreased crop production. Organic materials such as crop residues offer sustainable and ecologically sound alternatives for meeting the nutrient requirements of crops. In addition to their role as the primary source of C inputs, crop residues, and the way they are managed, have a significant impact on soil physical properties (Boyle *et al.*, 1989).

Materials and Methods

The present investigation was carried out in an experimental area of research farm of Guru Kashi University, Talwandi Sabo (Bathinda) during *Kharif* and *Rabi* season in the year 2018-20. Talwandi Sabo is located at 290 57'N latitude and 750 7'E longitude and altitude of 213 meters above the sea levels. This tract is characterized by semi humid climate, where both winters and summers are extreme. The detail of the treatment combination and layout are given below –

The experiment was laid out in randomize block design with three replications. The crop residue of previous harvested crop was incorporated in the same plot before sowing of next crop in Rice Wheat, Cotton-Wheat and Guar-Wheat cropping system. Total number of plots was 36 and the plot size was 6 m x 4 m.

The experimental data analyzed using Analysis of Variance technique in Randomized Block Design. The critical differences at 5 per cent of probability were calculated for testing the significance of difference between any two means where„ F" test was significant (Snedecor and Cochran, 1967).

Table 1: Treatment details

Treatments	Kharif 2018/2019	Rabi 2018-19/2019-20
T_1	Wheat straw to rice	Rice straw to wheat
T_2	Wheat straw to rice	No Rice straw to wheat
T_3	No wheat straw to rice	Rice straw to wheat
T_4	No wheat straw to rice	No Rice straw to wheat
T_5	Wheat straw to cotton	Cotton straw to wheat
T_6	Wheat straw to cotton	No Cotton straw to wheat
T_7	No wheat straw to cotton	Cotton straw to wheat
T_8	No wheat straw to cotton	No Cotton straw to wheat
T_9	Wheat straw to guar	Guar straw to wheat
T_{10}	Wheat straw to guar	No Guar straw to wheat
T_{11}	No wheat straw to guar	Guar straw to wheat
T_{12}	No wheat straw to guar	No Guar straw to wheat

Results and Discussion

Physical properties of soil

Bulk density and porosity

There were not much change in soil bulk density and porosity as presented in the Table 2, however, it has been observed that bulk density seem to decrease in case of the treatments consisting of crop residue (rice or wheat guar or cotton or combination) incorporation treatments T9 (1.25 Mg cm-3), T1, T2, T5, T6, and T10 (1.26 Mg cm^{-3}), as compared to the initial values and increase in bulk density has also been observed in case of treatment where only chemical fertilizers were applied treatments T4, T8 and T12 (1.28 Mg cm^{-3}).

Whereas, porosity increases in those treatments which were getting crop residue (rice or wheat guar or cotton or combination) incorporation. Initially porosity 51.58% in a soil sample, after crop residue incorporation of rice, wheat, guar and cotton it slightly increases up to 52.86%. The addition of crop residue decreased the bulk density and increased the levels of organic carbon, field capacity; permanent wilting point and available soil moisture were reported by Boparai *et al.*, (1992) [1], Walia *et al.*, (1995) [6] and Dhaliwal and Walia (2008) [2].

Chemical properties of Soil

Soil pH

The treatment effects were found non-significant for soil pH all throughout the experimental period as presented in the Table 3. However, a decreasing trend of pH for the treatments comprising of crop residues (rice or wheat or cotton or guar) incorporation (T1, T2, T3, T5, T6, T7, T9, T10 and T11) was observed as compared to without crop residue incorporation treatments (T4, T8 and T12). The findings were in accordance with Kharub *et al*., (2003) who reported that pH of soil decreased due to the continuous inclusion of incorporation of green-manure as soil amendments under a rice-wheat cropping system.

Electrical conductivity (dSm^{-1})

Influences of treatments on electrical conductivity of the soil have found to be not significant in both the years as depicted in the Table 3. Similar trend was observed for EC as that of soil pH.

Soil organic carbon

There was no significant influence of treatments on organic carbon content of the soil in the first year (2018-19) but significant influences have been observed in the second year (2019-20) as given in Table 3. In 2018-19, the highest organic carbon content was recorded for the treatment T 5 (0.54%) where crop residues (both cotton and wheat) were incorporated and the lowest was recorded for T 4 T 8 and T 12 (0.42%) and in 2019-20, combine application of both cotton and wheat residues exerted significant positive effect on soil organic carbon content and the highest organic carbon content was recorded for the treatment T5 (0.76%). The findings were in accordance with Shamna and Sharma (2005) [5] who reported that retention or incorporation of rice, wheat or both crop residues increased soil organic carbon

Table 2: Effect of crop residues incorporation on soil bulk density and porosity

Treatments	Bulk density (Mg cm^{-3})	Porosity (%)
Initial	1.28	51.58
Final Value		
T_1	1.26	52.74
T_2	1.26	52.38
T_3	1.27	52.34
T_4	1.28	51.78
T_5	1.26	52.86
T_6	1.26	52.48
T_7	1.27	52.72
T_8	1.28	51.72
T_9	1.25	52.82
T_{10}	1.26	52.78
T_{11}	1.27	52.62
T_{12}	1.28	51.64

Table 3: Effect of crop residues incorporation on pH, EC and SOC.

Treatments	pH		EC (dSm^{-1})		SOC (%)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1	7.92	7.45	0.256	0.265	0.47	0.74
T_2	7.69	7.42	0.258	0.268	0.44	0.68
T_3	7.76	7.35	0.254	0.255	0.43	0.66
T_4	7.35	7.32	0.245	0.262	0.42	0.48
T_5	8.12	7.72	0.248	0.256	0.54	0.76
T_6	7.78	7.69	0.252	0.264	0.51	0.64
T_7	7.98	7.58	0.264	0.272	0.47	0.72
T_8	7.59	7.55	0.268	0.276	0.43	0.52
T_9	7.78	7.46	0.278	0.284	0.52	0.68
T_{10}	7.68	7.44	0.282	0.292	0.48	0.64
T_{11}	7.72	7.41	0.269	0.276	0.46	0.66
T_{12}	7.48	7.46	0.285	0.292	0.42	0.58
LSD (p=0.05)	NS	NS	NS	NS	NS	0.04

In conclusion, incorporation of crop residues (rice straw and wheat straw) resulted in increase in soil organic carbon, electrical conductivity (EC) and porosity (%) of soil although decrease in bulk density and soil pH was found due to crop residue application.

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