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Conservation of organic carbon in relation to crop productivity, yield stability and soil fertility under rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system

V. KATYAL, K.S. GANGWAR AND B. GANGWAR

Project Directorate for Cropping Systems Research, Modipuram, Meerut, Uttar Pradesh 250 110

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ABSTRACT

A field experiment was conducted for 6 years at Kanpur, Uttar Pradesh, and 7 years at R.S. Pura, Jammu and Kashmir, to study the effect of different management practices on soil organic carbon conservation on crop productivity and soil fertility in rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system. Higher system productivity of 9.30 tonnes/ha was recorded when 20 kg N/ha was applied in addition to recommended dose of N at Kanpur, while application of recommended dose of N along with 5 tonnes FYM/ha in rainy season (*kharif*) gave greater system productivity of 8.49 tonnes/ha at R.S. Pura. The different management practices of soil organic carbon conservation not only increased the organic carbon in the soil but also improved the soil fertility under rice–wheat system at both the locations.

Key words : System productivity, Rice–wheat system, Organic carbon, Yield stability, Soil health.

During the last three and half decades, rice–wheat cropping system in India has assumed immense significance in view of its excellent growth in terms of area, production and productivity. However, continuous cropping of rice–wheat sequence in most of the irrigated fertile lands resulted in decline of soil organic carbon in particular and soil health in general. The organic matter plays an important role in maintaining overall soil health by supplying nutrients and providing good physical conditions to the plants. Therefore present study was undertaken under All-India Co-ordinated Research Project (AICRP) on Cropping Systems to find out the ways and means to conserve organic carbon in the soil, so as to sustain crop and soil productivity in rice–wheat cropping system.

MATERIALS AND METHODS

A field experiment was started during 1990–91 and continued up to 1995–96 at

Kanpur, Uttar Pradesh, while up to 1996-97 at R.S. Pura, Jammu and Kashmir, centres of All-India Co-ordinated Research Project on Cropping Systems, to study the effect of crop residue (stubbles)-management methods to conserve organic carbon in the soil for improving soil condition and crop productivity. The experiment was conducted in randomized block design with 4 replications. The treatments were: T_1, recommended dose of N (100%) (no N at the time of incorporation of crop residue and only recommended N to crop; T_2, recommended dose of N, out of which 10 kg N/ha was applied at first ploughing; T_3, recommended dose of N, out of which 20 kg N/ha at the first ploughing; T_4, recommended dose of N and an additional 10 kg N/ha at first ploughing, T_5, recommended dose of N and an additional 20 kg N/ha at first ploughing; T_6, recommended dose of N+10 kg N/ha (no N at the time of incorporation of crop residues and increased dose of the recommended N by 10 kg/ha; T_7, recommended dose of N + 20 kg N/ha (no N at the time of incorporation of crop residues and increased dose of the recommended N by 20 kg/ha); T_8, recommended dose of N + cellulose decomposing enzyme; T_9, recommended dose of N + FYM (5 tonnes/ha) on oven dry-weight basis in rainy season; T_{10}, recommended dose of N + FYM (5 tonnes/ha) on oven-dry weight basis in winter.

The recommended dose of N during rainy season and winter season was 120 kg N/ha at Kanpur in all the experimental years. However, at R.S. Pura, in rainy-season it was 100 kg N/ha in all the experimental years, while in winter 100 kg N/ha during 1990 and 1994–96 and 120 kg N/ha during 1991–93.

Pooled analysis of the yield data was carried out and stability indices of the system in treatments were computed as per the procedure of Singh *et al.* (1990). Data on soil characters were collected for interpretation of the results. Kanpur centre is located at 25° 26'N and 80° 34'E, with annual rainfall (mm) of 891 and altitude of 126 m. Texture of the soil was Udic Ustochtepts and soil type was alluvium. Initial organic carbon (%) was 0.34, while available N, P and K (kg/ha) were 189, 20.2 and 188 respectively. The R.S. Pura centre is located at 32° 5'N and 74° 8'E, with annual rainfall, 1,225 mm and altitude of 308 m. The texture of the soil at R.S. Pura was Eutrochrepts (very deep) and soil type was lowland clay. Available organic carbon (%) in the soil was 0.43, while available nutrients in the soil were 265.4 kg N, 10.4 kg P and 91.5 K kg/ha.

RESULTS AND DISCUSSION

System productivity

Among different management practices of soil organic carbon conservation, higher productivity of rice–wheat cropping system up to 9.30 tonnes/ha was recorded in the treatment where application of 20 kg N/ha was made in addition to recommended dose of N at Kanpur, while application of recommended dose of N along with 5 tonnes FYM/ha in rainy season resulted in greater system's productivity at R.S. Pura (Table 1). The variations in total productivity of the system at both the locations under different treatments were

mainly due to differences in soil and climatic environments.

System stability

At Kanpur, stability indices were more under T_1, T_2, T_3, and T_5, being 0.67 which clearly indicated that productivity of the system was stable over years under these treatments (Table 1). Treatments T_6, T_7, and T_9 were statistically at par for rice yield, while T_6 and T_7 for wheat. However, stability index of T_7 was 0.59 which was slightly less than 0.67. This implies that though productivity of the system was

Table 1. Productivity and stability of the rice–wheat system

Treatment	Kanpur				R S. Pura			
	Rice (kg/ha)	Wheat (kg/ha)	Total	Stability index	Rice (kg/ha)	Wheat (kg/ha)	Total	Stability index
T_1	4,409	3,744	8,153	0.67	4,300	3.525	7,825	0 70
T_2	4,265	3,551	7,814	0.67	4,096	3,563	7,659	0 70
T_3	4,184	3,528	7,711	0 67	3,926	3,480	7.407	0 72
T_4	4,565	3,996	8,561	0.65	4,599	3,852	8.451	0.76
T_5	4,655	4,070	8,732	0 62	4,483	3,970	8,453	0.73
T_6	4,718	4,271	8,989	0.58	4,491	3,704	8.195	0.65
T_7	4,857	4,450	9,307	0 59	4,623	3.817	8,440	0.65
T_8	4,504	3,859	8,363	0.67	4,363	3,646	8,009	0 71
T_9	4,783	4,025	8,808	0.63	4,765	3,727	8,492	0 74
T_{10}	4,504	4,301	8,805	0.64	4,408	3.977	8,385	0 73

Details of treatments are given in Materials and Methods

Table 2. Effect of soil organic carbon convervation practices on fertility status after 6 cycles of rice–wheat sequence

Treatment	Kanpur			R.S Pura		
	Organic carbon (%)	Available P (kg/ha)	Available K carbon (%)	Organic C (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
T_1	0.29	21.4	188.2	0.38	11.5	91 5
T_2	0.33	22.6	190.4	0.43	13.2	95.5
T_3	0.31	24.8	194.5	0 48	14 5	93.2
T_4	0.36	25.8	199.5	0 48	15.2	98.7
T_5	0.34	26.5	198.4	0 46	13.2	95.7
T_6	0.38	24 2	196.2	0.44	15.7	93 2
T_7	0.40	28.4	201.2	0.45	14.2	91.6
T_8	0.36	24.6	194 6	0.52	16.1	95 1
T_9	0.38	26 8	195.4	0 55	17.3	108.2
T_{10}	0.39	25.9	194 6	0 52	17 0	110 3
Initial	0.24	20.2	188 0	0 43	10.4	91 5

Details of treatments are given in Materials and Methods

higher in T_7, but it was not stable over years in comparison to other treatments (T_1, T_2, T_3 and T_8). At R.S. Pura, stability index of 0.76 was observed in T_4, followed by 0.74 in T_9, showing that productivity in system was more stable under these treatments.

Soil fertility

After 6–7 years of continuous rice–wheat cropping, there was build-up in soil organic carbon content as compared to initial level in all the management practices of soil organic carbon conservation at Kanpur and R.S. Pura except in treatment T_1 at R.S. Pura (Table 2). The build-up of soil organic carbon was more in the treatments, wherein application of 5 tonnes FYM/ha and additional 20 kg N/ha was made with recommended dose of N. This was probably due to addition of organic matter through farmyard manure on one hand and higher production of root biomass leading to more organic residues in the soil on the other (Lal and Mathur, 1989).

Available soil P and K also improved at both the locations after 6 and 7 cycles of rice–wheat cropping in all the treatments. However, the magnitude of improvement varied under the different treatments. Application of FYM in addition to recommended dose of N tended to increase available soil P and K in the soil due to addition of organic matter and increased availability of P and K (Swarup and Singh, 1989; Nambiar and Abrol, 1989).

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