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Integrated nutrient management in relation to soil fertility and yield sustainability under dryland farming*

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Application of organic materials to the soil will improve the hydro-physical environment and fertility level of the soil and sustain crop productivity level (Wani *et al.* 1994). However, due to paucity of organic sources to meet the total nutrient requirement of the crops, their integrated use with inorganic sources is desirable. In the subhumid zone of India, information on improvement of soil-fertility status and yield sustainability through integrated nutrient management is inadequately documented. Keeping these points in view a field experment was conducted to evaluate the change in soil-fertility status and sustainable-yield index of rice (*Oryza sativa* L.)–Lentil (*Lens culinaris* Medikus) cropping sequence through sole and conjunctive use of organic and inorganic nutrient sources under dryland condition.

A field experment was conducted during 1986–87 to 1993–94 at the research farm of the university at Varanasi. The soil was fine loamy mixed hyperthermic Udic-ustochrept. The surface (0–15 cm) soil had sand 15.21%, silt 22.37%, clay 62.42%, bulk density 1.42 Mg/m^3, *p*H 7.7, electrical conductivity 0.11 dS/m, organic carbon 2.77 g/kg soil, and total N, P and K respectively 1.31, 0.25 and 4.16 g kg/soil. Plant nutrients were applied through inorganic, organic and conjunctive use of inorganic and organic sources. The treatments were: T_1, the control, ie no application of nutrient source; T_2, application of recommended inorganic fertilizer @ 80 kg N/ha, 40 kg P/ha and 30 kg K/ha ($N_{80}P_{40}K_{30}$); T_3, 50% of T_2 ($N_{40}P_{20}K_{15}$); T_4, sole application of wheat straw @ 5 Mg/ha; T_5, sole application of farmyard manure @ 5 Mg/ha; T_6, $T_3 + T_4$; T_7, $T_3 + T_5$; T_8, only 20 kg N/ha (farmer's practice). These 8 treatments were laid out in randomized block design with 3 replications each. The treatments were applied only during the rainy season before sowing rice. The organic materials were incorporated 15 days earlier than the date of sowing the rice seed. Rice ('Akashi') and lentil ('PL 72') were taken as the test crops. Soil *p*H, electrical conductivity, organic carbon and the total nitrogen, phosphorus and potassium contents were estimated after completion of 1993–94 crop year, by following the standard methods (Page *et al.* 1982). Grain yield was recorded at the end of each cropping in rainy and winter seasons (*kharif* and *rabi*) each year. Sustainable yield indexes as (SYI) of individual crop as well as of the total sequence were analysed by following the equation proposed by Singh *et al.* (1990) as:

$$SYI = \bar{Y} - \sigma / Y_{max} \qquad ...(1)$$

where $\bar{Y}$, the estimated average yield during 1986–87 to 1993–94; σ, its estimated standard deviation; and Y_{max}, observed maximum grain yield.

During the course of the experimentation sole application of wheat straw and farmyard manure (T_4 and T_5) decreased the soil *p*H respectively to 6.5 and 6.6 compared with the initial status (6.7) of the soil (Table 1). The release of organic acids by these sources could be responsible for the decrease in soil *p*H value. Conjunctive use of inorganic fertilizer along with the organic one led to an increase (6.6–6.8) in soil *p*H value compared with the application of the nutrients either through the sole application of organic or inorganic source. Conjunctive use of both organic and inorganic sources decreased the concentration of released organic acids as well as hydrogen-ion concentration in the soil solution and thus was resoponsible for higher *p*H value under T_6 and T_7 treatments compared with T_2, T_4 or T_5. Electrical conductivity depends on the concentration of different bases in the soil solution. Incorporation of organic sources helps addition of cations like K^+, Na^+, Ca^{2+} and Mg^{2+} (Sarkar *et al.* 1989). Therefore electrical conductivity values under sole and conjunctive use of organic sources (T_4, T_5, T_6 and T_7) were notably higher compared with the initial status of the soil. Conjunctive or sole application of organic materials as nutrient sources increased the level of organic carbon in the soil by 6.8 under T_4 to 14.4% under T_5 than the inital status. Continuous application of inorganic fertilizer decreased the soil C : N ratio and also improved the activity of the micro-organisms responsible for nitrogen mineralization (Sarkar and Rathore 1992). As a result there was a decrease in organic carbon status by 19.4 and 11.9% respectively under T_3 and T_2 treatments compared with the initial status. Application of

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Table 1 Change in soil-fertility status in relation to integrated nutrient management

Treatment	pH	Electrical conductivity (ds/m³)	Total nutrient (g/kg)			
			Organic C	N	P	K
T_1	6.1	0.09	2.77	1.26	0.17	3.87
T_2	6.0	0.065	2.73	1.30	0.23	4.06
T_3	6.2	0.055	2.46	1.29	0.21	4.23
T_4	6.5	0.1	3.06	1.71	0.34	6.94
T_5	6.6	0.145	3.17	1.58	0.29	5.88
T_6	6.6	0.105	2.96	1.65	0.3	6.14
T_7	6.8	0.14	3.02	1.54	0.26	5.56
T_8	6.9	0.09	2.68	1.28	0.19	4.12
LSD (P=0.01)	0.2	0.009	0.13	0.05	0.03	0.16
CV (%)	3.39	8.53	4.00	3.68	10.30	2.77

Details of treatments are given in text

organic material helped in addition of organic forms of nitrogen, phosphorus and potassium to the soil. The organic form of N is available to the plant only through mineralization. Under dryland condition the rate of mineralization is also slow. Therefore the total N status increased in the soil. Similarly, total P content of the soil also increased under T_4, T_5, T_6 and T_7. Field crops mostly consumed more K from the soil. Besides, this addition of organic materials increased the value of cation exchange capacity of the loamy soil. These 2 factors independently (as with T_5 and T_7) or collectively (as with T_4 and T_6) are responsible for higher K concentration in the soil under these 4 treatments compared with the initial status. Addition of inorganic fertilizer for 7 years did not have any effect on total soil-nitrogen status but improved the total P status marginally and decreased the total K status of the experimental soil. Cultivation of rice and lentil in a sequence without the application of nutrients made no significant change in the chemical properties of the soil.

The mean grain yield of rice (Table 2) was the highest under T_2, where the nutrient source was recommended fertilizer dose ($N_{80}P_{40}K_{30}$). This was closely followed (3.2% less) by T_7, where farmyard manure along with 50% of the recommended inorganic fertilizers were applied to the soil. In the first year (1986–87) the gap in yield of rice between T_2 and T_7 was wider (9.1%), which subsequently narrowed down with the continuation of the experimental trial. In the seventh year (1993–94), however, T_7 gave 2.8% more grain yield of rice than T_2. Grain yield of rice was at a moderate level with application of nutrients either through organic source, ie farmyard manure (T_5) or half the recommended ($N_{40}P_{20}K_{15}$) fertilizer dose (T_3, Table 2). Sole application of undecomposed organic materials like wheat straw (T_4) increased the period of immobilization, particularly under dryland condition, decreasing the mean yield of rice (0.872 Mg/ha). Addition of $N_{40}P_{20}K_{15}$ as inorganic fertilizer (T_6) increased the rice-grain yield to 1.164 Mg/ha, which was 33.5% higher than that of T_4. A slow and steady nutrient-release pattern under T_7, was responsible for higher residual nutrient status of the soil after harvesting rice. As a result, the

Table 2 Mean grain yield in rice–lentil cropping sequence as influenced by integrated nutrient management

Treatment	Mean grain yield (mg/ha)		
	Rice	Lentil	Total
T_1	0.761	0.656	1.417
T_2	1.488	0.912	2.4
T_3	1.126	0.804	1.93
T_4	0.872	0.718	1.59
T_5	1.17	0.968	2.138
T_6	1.164	0.826	1.99
T_7	1.439	1.141	2.58
T_8	1.017	0.673	1.69
LSD (P=0.01)	0.103	0.097	0.184
CV (%)	6.71	7.52	8.38

Details of treatments are given in text

magnitude of lentil-grain yield was highest under T_7 in all the years. T_5 gave the second highest yield, and it was 5.8% more than that of $N_{80}P_{40}K_{30}$. The grain yield of lentil under the sole application of wheat straw (T_4) was even better than that of the control, when compared with that of rice. The total grain yield was highest under T_7 in the rice–lentil cropping sequence under dryland farming (Table 2). Sole application of farmyard manure was also useful as per the total yield of the component crops. Application of wheat straw along with $N_{40}P_{20}K_{15}$ gave moderate yield of the cropping system.

The highest result in terms of sustainable yield index (Fig 1) in the rice–lentil cropping sequence was attained by the sole application of decomposed organic material, ie farmyard manure (T_5) as the nutrient source in the fine loamy mixed hyperthermic Udicustochrept of the subhumid zone of eastern Uttar Pradesh. This was closely followed by T_7 (Fig 1). The recommended (T_2) as well as lower dose of inorganic fertlizer (T_3) and sources (T_8) resulted in moderate degree of sustainable yield index. The magnitude of sustainable yield index was lowest when undecomposed organic materials (T_4) were solely applied to the soil, whereas addition of $N_{40}P_{20}K_{15}$ as the inorganic fertilizer along with it increased the sustainable yield index by 11.5% (Fig 1).

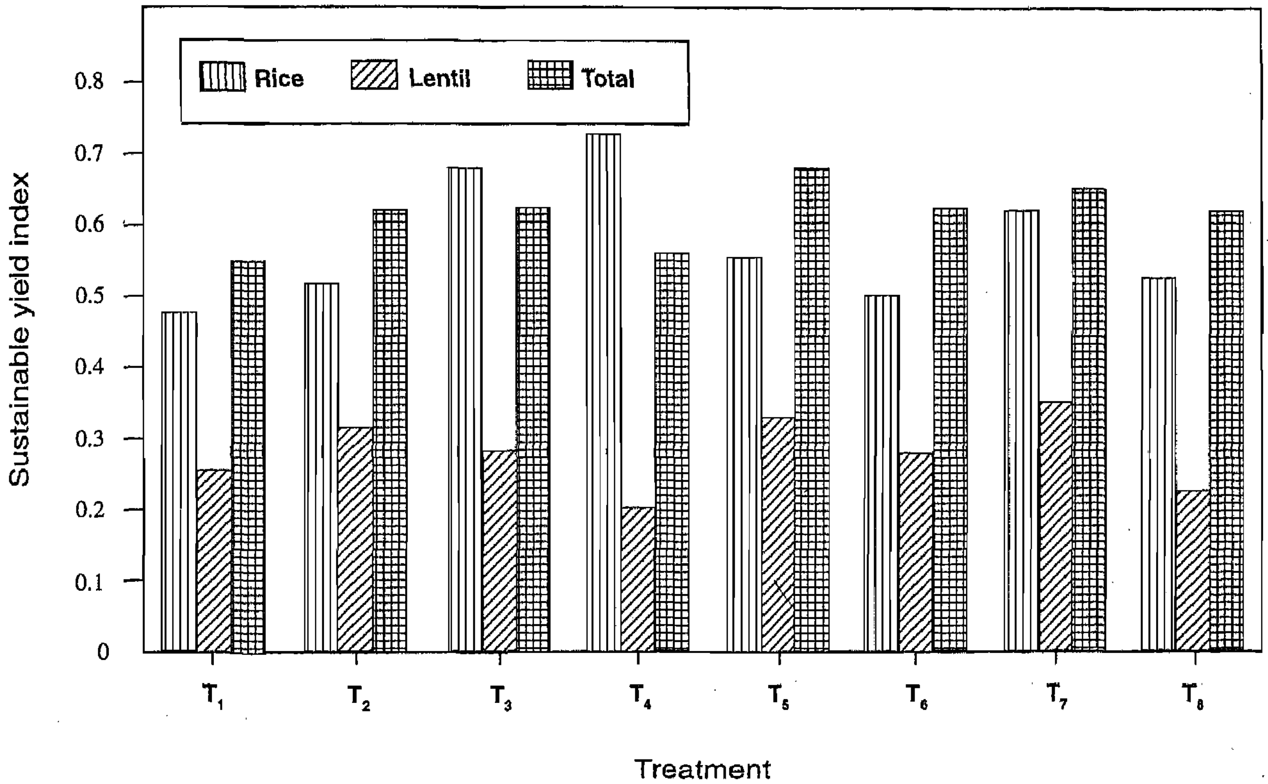

Fig 1 Effect of integrated nutrient management on sustainable yield index in rice–lentil sequence

It can be concluded that application of farmyard manure with or without the inorganic fertilizer helps improve the soil-fertility status and gives higher yield potential and better yield sustainability in the rice–lentil cropping system under dryland farming in the subhumid zone of eastern Uttar Pradesh.

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