Long-term Soil Fertility Experiment in Rice-Wheat Cropping System in West Bengal

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Abstract

A long-term experiment in rice-wheat cropping system was conducted in the New Alluvial Zone of West Bengal in India to develop a suitable integrated nutrient supply system using inorganic fertilizers with organic materials. The experiment was conducted for 9 years, starting from *kharif* (rainy season) 1986. Highest grain yield of rice was recorded in plots receiving 50% recommended NPK (nitrogen, phosphorus, potassium) through inorganic source and remaining 50% through green manure or 75% NPK through inorganic fertilizer and 25% N through green manure. In *rabi* (postrainy season) high grain yield of wheat was found with 100% NPK through fertilizer. There was a reduction in wheat yield when fertilizer applied to wheat was reduced. Total rice-wheat grain yield in a year was high when 75% of the recommended NPK through inorganic source was applied to rice along with 25% N through farmyard manure and 75% NPK to wheat. There was not much change in soil pH over years. Phosphorus and potash content of the soil increased to a small extent when 100% recommended NPK was applied in both seasons.

Introduction

In the Indo-Gangetic Plains of West Bengal, India rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) is an important crop sequence. Continuous cropping with rice and wheat may cause an imbalance in nutrition of the crops. Therefore, judicious application of nutrients through organic as well as inorganic sources is essential to realize higher production from the system without deterioration in soil fertility status. An experiment was conducted to develop a suitable integrated nutrient supply system for rice-wheat sequence.

Materials and Methods

The site where the experiment was conducted was a medium land where rice-fallow sequence was adopted before the start of the experiment. This experiment was initiated with transplanted rice (var IET-1444) with a spacing of 20 cm × 10 cm in *kharif* (rainy season) 1986. The experiment was conducted in a randomized block design with 4 replications of 12 treatments (Table 1). Plot size was 8 m × 8 m. The plots were prepared with the help of the country plow only in both seasons to avoid any transportation of soil from one plot to another plot. Soil of the experimental field was sandy loam having 49% sand, 34% clay, and 16.5% silt. It had 0.94% organic carbon, 0.054% total nitrogen (N), 15 kg ha^{-1} available phosphorus (P), and 73 kg available potassium (K) ha^{-1}, and the pH level was 7.5. The sources of NPK were urea (46% N), single super phosphate (16% P_20_5), and muriate of potash (60% K_2O). The contents of farmyard manure (FYM) were 0.66% N, 0.20% P_2O_5, and 0.30% K_2O; that of paddy straw were 0.40% N, 0.20% P_2O_5, and 0.30% K_2O; and of

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Kundu, A.L. and **Samul, R.C.** 2000. Long-term Soil Fertility Experiment in Rice-Wheat Cropping System in West Bengal. Page 63–67 *in* Long-term Soil Fertility Experiments in Rice-Wheat Cropping Systems (Abrol, I.P., Bronson, K. F., Duxbury, J. M. and Gupta, R. K. eds.). Rice-Wheat Consortium Paper Series 6. New Delhi, India: Rice-Wheat Consortium for the Indo-Gangetic Plains.

Table 1. Integrated nutrient supply system in rice-wheat cropping system in West Bengal, India.[1]

Treatment	*Kharif*	*Rabi*
T1	No fertilizer and organic manure (control)	No fertilizer and organic manure (control)
T2	50% recommended dose of NPK through fertilizer[2]	50% recommended dose of NPK through fertilizer
T3	50% recommended dose of NPK through fertilizer	100% recommended dose of NPK through fertilizer
T4	75% recommended dose of NPK through fertilizer	75% recommended dose of NPK through fertilizer
T5	100% recommended dose of NPK through fertilizer	100% recommended dose of NPK through fertilizer
T6	50% recommended dose of NPK through fertilizer + 50% through compost/FYM	100% recommended dose of NPK through fertilizer
T7	75% recommended dose of NPK through fertilizer + 25% through compost/FYM	75% recommended dose of NPK through fertilizer
T8	50% recommended dose of NPK through fertilizer + 50% through paddy straw	100% recommended dose of NPK through fertilizer
T9	75% recommended dose of NPK through fertilizer + 25% through paddy straw	75% recommended dose of NPK through fertilizer
T10	50% recommended dose of NPK through fertilizer + 50% through green manure	100% recommended dose of NPK through fertilizer
T11	75% recommended NPK through fertilizer + 25% through green manure	75% recommended dose of NPK through fertilizer
T12	Conventional farmers' practice (60 kg N, 40 kg P_2O_5, and 40 kg K_20 ha^{-1})	Farmers' practice (60 kg N ha^{-1})

1. Kharif=rainy season; rabi=postrainy season; NPK=nitrogen, phosphorus, potassium; FYM=farmyard manure.
2. Recommended dose of NPK fertilizer was 100 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}.

dhaincha (*Sesbania aculeata* Poir.) green manure were 0.80% N, 0.15% P_2O_5, and 0.40% K_2O.

At the time of final land preparation entire phosphate, potash, green manure (dhaincha), FYM, paddy straw, and 50% of N as per treatment was applied and thoroughly mixed. The rest of the 50% N was applied in two equal splits at active tillering and panicle initiation stages of crop growth. The recommended dose of fertilizer was 100 kg N ha^{-1} + 60 kg. P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1} in both transplanted rice and wheat. The crops were harvested so that straw and grains were removed, and only stubbles were left in the field.

The soil samples for chemical analysis were collected from 15 cm depth from each plot with the help of screw-type soil auger. The samples were air-dried, ground, and analyzed. Soil pH was determined with the help of a pH meter with glass electrode assembly in 1:2.5 soil-water ratio. Organic carbon was determined following Walkley Black's wet digestion method; total N content in the soil was determined by modified Micro-Kjeldahl method, and available P was determined colorimetrically using Olsen's extractant (Jackson 1967). Available K was determined with the help of flame photometer using neutral ammonium acetate as extractant.

Results and Discussion

Three years rolling average of the yield data of rice are presented in Figure 1. The grain yield of rice was lowest in control plot irrespective of the year. It was highest in T11 where 75% NPK was applied through inorganic fertilizer and remaining 25% N through green manure. This trend was followed up to 1989–91. But from 1990–92 onwards grain yield of rice was highest in T7 where 75% NPK was supplied through inorganic fertilizer and 25% N through FYM closely followed by T10 and T11. The higher grain yield of rice in combined application of nutrients through inorganic and organic sources might be due to availability of nutrients throughout the growth period as well as addition of some P and K through organic sources. The results corroborate findings of Jayaram et al. (1990). There was a slight decline in rice yield over the years as compared to initial year but the decline was less where nutrients were applied partly through organic and part through inorganic sources (Fig. 1). In *rabi* (postrainy season), wheat was grown in sequence after rice and wheat grain yield was lowest when no fertilizer and no organic manure was applied to crops (i.e., control) (Fig. 2). The grain yield of wheat up to 1990–92 was highest in T8 where 100% NPK was applied to wheat through inorganic source and the previous rice crop was supplied with 50% NPK through inorganic and remaining 50% through paddy straw. However, in subsequent years wheat grain yield was higher in T10 where 100% NPK to wheat was applied through inorganic source and previous rice crop was supplied with 50% NPK through inorganic source and remaining 50% through green manure. The results also indicated that wheat grain yield was comparatively higher where 100% NPK was applied through inorganic source. However, the grain yield of wheat with 100% NPK through inorganic source was low as compared with combined application of nutrients through organic and inorganic sources to rice and 100% NPK through inorganic source to wheat. There was no reduction in grain yield of wheat over years (Fig. 2). Combined yield was highest in T10 followed by T8. Lowest yield was recorded in control plot and there was a reduction in yield over years (Fig. 3).

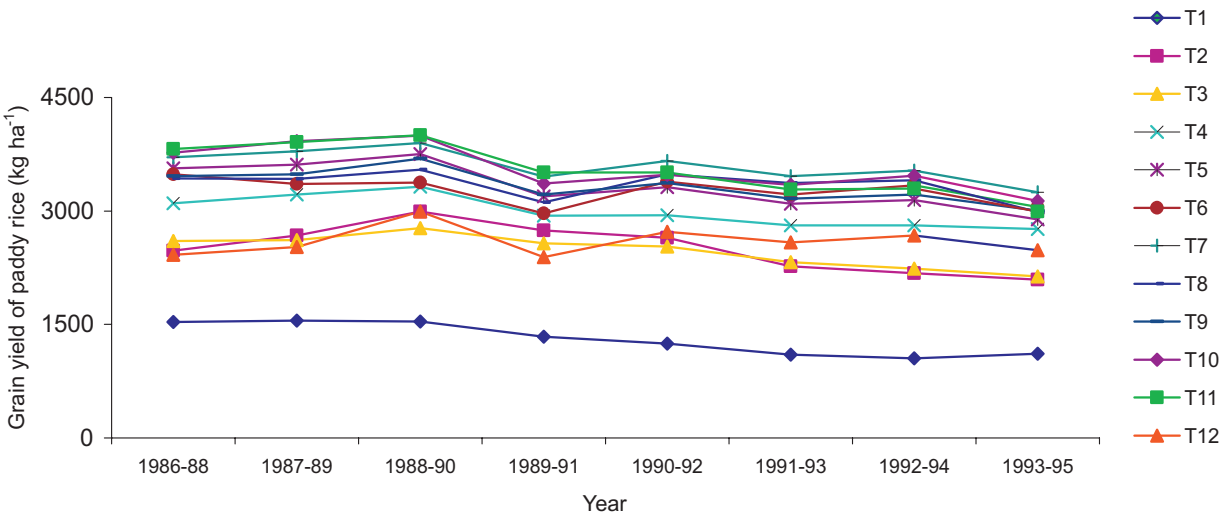

Figure 1. Rolling average of three years grain yield of rice during 1986–95 in rice-wheat cropping system in West Bengal, India.

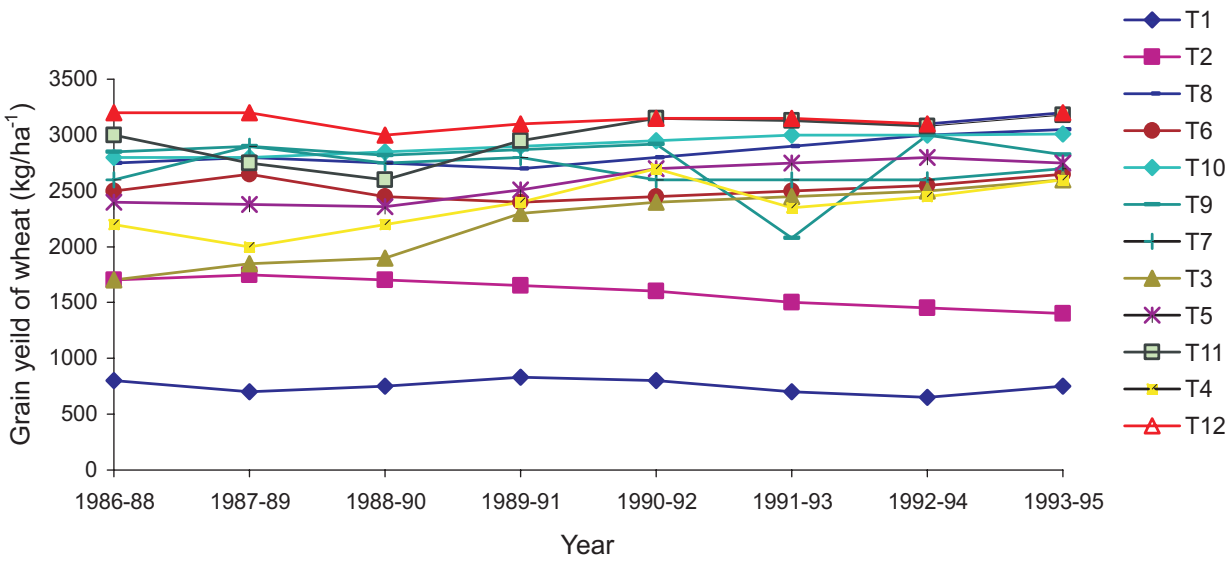

Figure 2. Rolling average of three years grain yield of wheat during 1986–95 in rice-wheat cropping system in West Bengal, India.

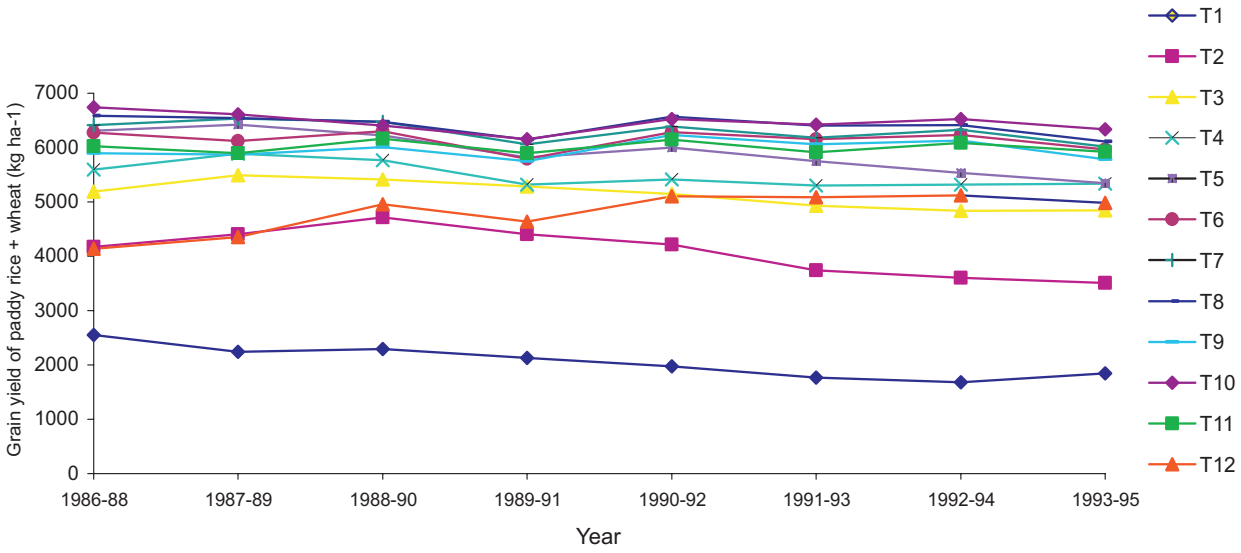

Figure 3. Rolling average of three years grain yield of rice and wheat during 1986–95 in rice-wheat cropping system in West Bengal, India.

There was not much variation in soil pH, organic carbon content, and available P content in soil among treatments (Table 2). Slight decline in soil pH was noticed after 9 years when compared to that in 1986/87 also. Organic carbon content declined at the end of 1995/96 as compared to 1986/87. There was not much variation in total N, available K content among treatments during both *kharif* and *rabi* (postrainy) seasons. Total N content was slightly reduced in *kharif* 1995/96 as compared to the initial year. Available K content increased during 1995/96.

Table 2. Effect of fertilizers on fertility status of soil in rice-wheat cropping system in West Bengal, India.

Treatment[1]	pH		Organic carbon (%)		Available P (kg ha^{-1})		Available K (kg ha^{-1})		Total N (%)	
	1986/87	1995/96	1986/87	1995/96	1986/87	1995/96	1986/87	1995/96	1986/87	1995/96
T1	7.4	7.3	0.85	0.75	14.0	–	71.5	118	0.051	0.060
T2	7.5	7.3	0.88	0.68	14.5	–	72.0	124	0.050	0.052
T3	7.5	7.2	0.83	0.71	15.0	–	74.5	140	0.050	0.055
T4	7.4	7.2	0.85	0.74	14.5	–	74.0	126	0.056	0.058
T5	7.5	7.3	0.85	0.72	16.1	–	73.0	124	0.057	0.050
T6	7.4	7.1	0.86	0.67	15.0	–	73.5	128	0.058	0.048
T7	7.5	7.2	0.86	0.77	14.5	–	73.0	116	0.053	0.059
T8	7.4	7.2	0.88	0.74	15.0	–	73.0	118	0.054	0.056
T9	7.4	7.1	0.85	0.69	14.5	–	73.5	114	0.500	0.054
T10	7.3	7.3	0.81	0.65	16.5	–	75.0	118	0.055	0.054
T11	7.4	7.1	0.82	0.70	15.0	–	73.5	130	0.055	0.055
T12	7.4	7.3	0.85	0.74	14.5	–	72.0	120	0.054	0.056

1. See Table 1 for treatments.

Conclusion

It is concluded from the experiment that nutritional requirements of the crops in rice-wheat sequence can be met with a combination of inorganic and organic sources in 50:50 or 75:25 to rice, and in wheat 100% recommended NPK has to be applied through inorganic source to get high yields.

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