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Research Paper

Effect of site-specific nutrient management on productivity and economics of rice (*Oryza sativa*)–wheat (*Tritucum aestivum*) system

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ABSTRACT

A field study was conducted during two consecutive years 2006-08, to evaluate the response of site-specific nutrient management (SSNM) on productivity and economics of rice (*Oryza sativa* L.)–wheat {*Triticum aestivum* (L.) emend Fiori and Paol} cropping system. The total productivity of the cropping system in terms of rice yield equivalent (14.8 t/ha/annum) was the highest with the application of SSNM treatment *i.e.* $N_{150}P_{60}K_{120}S_{40}B_5Mn_{20}Zn_{25}$ in rice and $N_{150}P_{60}K_{120}$ in wheat, which was 66.4% higher over farmer's practice and 28.2% over state recommended practice. All the yield attributing characters as well as yield of both rice and wheat showed beneficial effects of site-specific nutrient management. Highest net returns of ₹67,033/ha/annum obtained with SSNM treatment, which was ₹31,681 and ₹16,905/ha/ annum higher over that of farmer's practice and state recommended doses, respectively. Thus, nutrients in rice–wheat cropping system may be applied on site-specific soil test basis including micronutrients along with major nutrients for higher productivity and profitability.

Key words : Economics, Rice–wheat system, Site-specific nutrient management

Rice–wheat cropping system is the most important irrigated agro-ecosystem of India. Presently, about 10.5 million hectares land is occupied by this system, and a major share lies in the Indo-Gangetic plain region (IGPR) (Prasad, 2005). About 33% of India's rice and 42% of wheat is grown in this system. Nearly 65% of total fertilizer used in the country is applied to rice and wheat crops alone (Yadav and Kumar, 2009). Heavy dressing of N and continued neglect of emerging deficiencies of other nutrients have led to stagnation of annual productivity levels. Such unbalanced fertilizer use not only aggravates the deficiency of phosphorus (P), potassium (K), sulphur (S) and a number of micro-nutrients, but also proves uneconomic (Sharma *et al.* 2003).

Continuous use of high analysis fertilizers (containing N, P, K only) has resulted in deficiency of S, Zn and Fe in soils and these show signs of fatigue as judged by the decline in the yields of rice and wheat (Yadav *et al.,* 1998). The current stagnation/decline in productivity of rice–wheat system can be overcome or improved through site–specific nutrient management (SSNM) coupled with improved crop husbandry practices because multi-nutrient, especially micro-nutrients, deficiencies are constraining optimum response of applied NPK. The site-specific nutrient management practices based on soil test basis would be most effective in improving crop productivity along with maintaining good soil health. Therefore, the presently experiment was under taken to study the effect of site-specific nutrient management including macro and micronutrients on growth, yield and economics of rice and wheat crops grown in sequence under eastern Uttar Pradesh condition.

MATERIALS AND METHODS

A field experiment was conducted during two consecutive years (2006-2008) to study the response of site-specific nutrient management (SSNM) on productivity of rice–wheat cropping system. The soil of the experimental site was silty loam in texture having pH 7.4, low nitrogen (148 kg N/ha), medium phosphorus (20 kg P/ha) and potash (195 kg K/ha). There were following twelve treatments : $N_{150}P_{60}K_{120}S_{40}B_5Mn_{20}Zn_{25}$ in rice (RT_1) followed by $N_{150}P_{60}K_{120}$ in wheat (WT_1), $N_{150}P_{30}K_{120}S_{40}B_5Mn_{20}Zn_{25}$ in rice (RT_2) followed by $N_{150}P_{30}K_{120}$ in wheat (WT_2), $N_{150}P_0K_{120}S_{40}B_5Mn_{20}Zn_{25}$ in rice (RT_3) followed by $N_{150}P_0K_{120}$ in wheat (WT_3), $N_{150}P_{60}K_{80}S_{40}B_5Mn_{20}Zn_{25}$ in rice

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(RT_4) followed by $N_{150}P_{60}K_{80}$ in wheat (WT_4), $N_{150}P_{60}K_{40}S_{40}B_5Mn_{20}Zn_{25}$ in rice (RT_5) followed by $N_{150}P_{60}K_{40}$ in wheat (WT_5), $N_{150}P_{60}K_0S_{40}B_5Mn_{20}Zn_{25}$ in rice (RT_6) followed by $N_{150}P_{60}K_0$ in wheat (WT_6), $N_{150}P_{60}K_{120}S_{40}B_5Mn_{20}Zn_0$ in rice (RT_7) followed by $N_{150}P_{60}K_{120}$ in wheat (WT_7), $N_{150}P_{60}K_{120}S_{40}B_5Mn_0Zn_{25}$ in rice (RT_8) followed by $N_{150}P_{60}K_{120}$ in wheat (WT_8), $N_{150}P_{60}K_{120}S_{40}B_0Mn_{20}Zn_{25}$ in rice (RT_9) followed by $N_{150}P_{60}K_{120}$ in wheat (WT_9), $N_{150}P_{60}K_{120}S_0B_5Mn_{20}Zn_{25}$ in rice (RT_{10}) followed by $N_{150}P_{60}K_{120}$ in wheat (WT_{10}), $N_{120}P_{60}K_{60}Zn_{25}$ in rice (RT_{11}) followed by $N_{250}P_{60}K_{60}$ in wheat (WT_{11}), which is the state recommendation and $N_{90}P_{30}$ in rice (RT_{12}) followed by $N_{90}P_{30}$ in wheat (WT_{12}), which is the general farmers' practice. These treatments were arranged in randomized block design with four replications having a plot area of 30 m^2 in fixed layout for both the crops and years. Hybrid rice 'PHB 71' was transplanted in first week of July and wheat variety 'PBW 343' was sown on second week of November during both the years. Half of the nitrogen dose and full quantity of other nutrients as per Table 1 was applied to rice as basal during puddling. Top dressing of the remaining nitrogen was done in two equal applications one each at maximum tillering (25 DAT) and at panicle initiation stage (50 DAT). The carry over effect of site-specific nutrient management treatments (Table 1) applied to rice was studied on succeeding wheat, which received only N, P and K, as per treatment combinations mentioned in Table 2. In wheat, full dose of P and K and half dose of nitrogen were applied as basal and the remaining nitrogen was applied in two equal splits as top dressing at 25 and 50 days after sowing. Both the crops were raised using recommended cultural practices during both the years.

RESULTS AND DISCUSSION

Yield attributes and yield of rice

The yield attributing characters viz. plant height, number of panicles/m, panicle length, grains/panicle and 1,000-grains weight increased with higher doses of NPK along with use of S, B, Mn and Zn (as per treatments) as compared to farmer's practice ($N_{90}P_{30}$). The SSNM treatment ($N_{150}P_{60}K_{120}S_{40}B_5Mn_{20}Zn_{25}$) gave the highest yield and values of yield attributes of rice. Reduction or omission of phosphorus dose from the SSNM treatment resulted in reduction in yield attributes of rice (Table 1). Similarly, Zn, Mn, B and S also influenced yield attributes of rice positively during both the years and if omitted, a notable reduction was observed in yield. The performance of site-specific nutrient management treatment was better over recommended practice for rice. It indicates that we need to revise the recommendation domain of rice owing to ever declining soil health, especially for some of the macro and micro nutrients.

Increasing levels of nutrients probably exerted a positive effect on the development of source and sink strength of the plants, which ultimately resulted in the higher yield attributing traits. This might be due to either direct or cumulative effect of supplied macro and micro nutrients on metabolic processes of rice. Availability of nutrients, especially the micro nutrients at optimum level has direct impact on accelerated cell division and enlargement, root growth and plant vigour. Boron and zinc are known to influence translocation of metabolites and improving sink strength in plants. Zinc is a constituent of several enzymes namely carbonic anhydrase, tryptophan synthetase, alcohol dehydrogenase etc. which are responsible for better photosynthesis and auxin metabolism directly affecting source strength leading to better tillering, growth, yield attributing characters like panicle number, grain number and weight, which ultimately increased crop yield. Inclusion of B and sulphur further improved crop growth and yield (Table 1). Similar finding was also reported by Singh *et al.* (2008), Khurana *et al.* (2008) and Singh and Bansal (2010).

Grain and straw yields of rice increased significantly when NPK was added more than recommended dose along with other components of SSNM (S, B, Mn and Zn). The maximum grain yield of 7.7t/ha was obtained with SSNM treatment (RT_1 *i.e.* $N_{150}P_{60}K_{120}S_{40}B_5Mn_{20}Zn_{25}$), which was significantly higher to other treatments except omission of boron and manganese from SSNM and reduction of potassium dose from 120 kg/ha to 80 and 40 kg potassium/ha. Grain yield advantage with treatment RT_1 *i.e.* $N_{150}P_{60}K_{120}S_{40}B_5Mn_{20}Zn_{25}$ was 60% higher over farmer's practice and 30.6% over state recommended practice.

Reduction of phosphorus from SSNM treatment to 30 and 0 kg/ha resulted decrease in grain yield by 9 and 21.3%, respectively. Unlike phosphorus, omission of potassium from the SSNM treatment also decreased grain yield by 16%. Omission of zinc and sulphur resulted in a decrease of grain yield by 9.4 and 10%, respectively (Table1). Grain yield was found to be positively correlated with yield attributing traits (Fig 1.) namely panicles/m^2, (R^2=0.660), panicle length (R^2=0.993), fertile grains/panicle (R^2= 0.829) and 1,000-grain weight (R^2=0.995).

Increase in grain yield with NPK along with application of S, B, Mn and Zn might be attributed to significantly larger and higher panicles/m^2 having higher and heavier grains, which have positive correlation with grain yield. Similar results were also reported by Shinde *et al.* (2005), Misra and Abidi (2006), Zhang *et al.* (2006), Gill (2006), Mubarak and Bhattacharya (2006), and Rui Yu *et al.* (2007).

Table 1. Yield and yield attributes of rice as influenced by site-specific nutrient management treatments (Pooled data over two years)

Treatment		Plant height (cm)	Panicles/ m^2	Panicle length (cm)	Grains/ panicle	1,000-grains weight(g)	Grain yield (t/ha)	Straw yield (t/ha)
RT_1	$N_{150}P_{60}K_{120}S_{40}B_5Mn_{20}Zn_{25}$	132	568	31.5	231	24.2	7.7	11.7
RT_2	$N_{150}P_{30}K_{120}S_{40}B_5Mn_{20}Zn_{25}$	123	411	29.1	189	23.2	7.1(9.1)	10.1 (15.2)
RT_3	$N_{150}P_0K_{120}S_{40}B_5Mn_{20}Zn_{25}$	116	369	26.9	167	22.1	6.3(21.2)	9.1 (27.8)
RT_4	$N_{150}P_{60}K_{80}S_{40}B_5Mn_{20}Zn_{25}$	129	524	31.1	223	24.1	7.6(0.9)	11.3 (2.9)
RT_5	$N_{150}P_{60}K_{40}S_{40}B_5Mn_{20}Zn_{25}$	129	529	30.4	215	23.8	7.4(3.5)	11.1 (5.5)
RT_6	$N_{150}P_{60}K_0S_{40}B_5Mn_{20}Zn_{25}$	117	402	27.6	175	22.3	6.6(15.8)	9.8 (18.5)
RT_7	$N_{150}P_{60}K_{120}S_{40}B_5Mn_{20}Zn_0$	120	422	29.1	192	22.9	7.0(9.9)	10.1 (15.8)
RT_8	$N_{150}P_{60}K_{120}S_{40}B_5Mn_0Zn_{25}$	126	453	29.9	206	23.6	7.4(4.1)	10.4 (11.7)
RT_9	$N_{150}P_{60}K_{120}S_{40}B_0Mn_{20}Zn_{25}$	127	437	29.9	203	23.5	7.4(4.5)	10.2 (14.4)
RT_{10}	$N_{150}P_{60}K_{120}S_0B_5Mn_{20}Zn_{25}$	125	434	28.8	198	23.1	7.0.(9.9)	9.6 (21.4)
RT_{11}	$N_{120}P_{60}K_{60}Zn_{25}$ (RP)	113	389	24.9	183	21.3	5.8(23.4)	8.1 (44.4)
RT_{12}	$N_{90}P_{30}$ (FP)	110	345	21.9	146	19.6	4.8(59.9)	7.7 (51.8)
	SEm ±	2.4	7.6	0.6	4.54	0.4	0.18	0.25
	CD (P=0.05)	7.1	22.2	1.8	13.16	1.4	0.54	0.72

Note: Figures in parentheses are percent decrease in grain and straw yields relative to SSNM treatment RT_1
RP-Recommended practice of state, FP-Farmer's practice

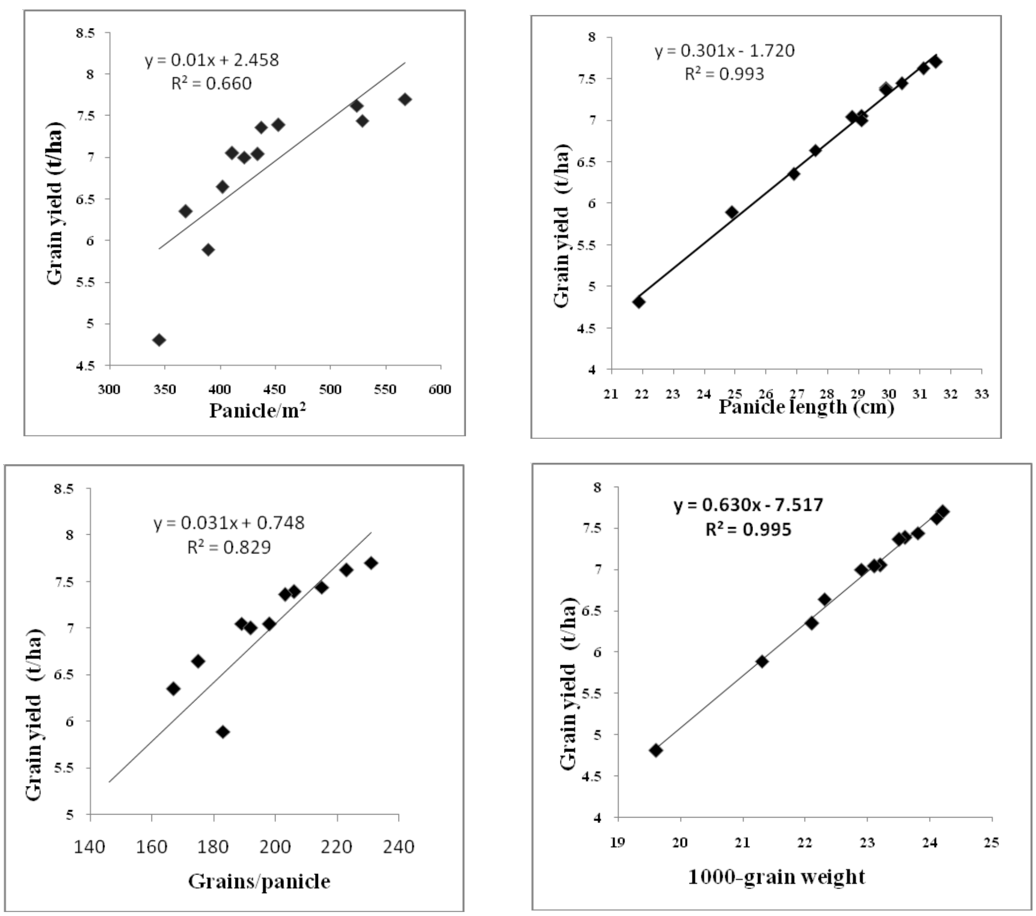

Fig. 1. Relationship between yield attributes and grain yield of rice

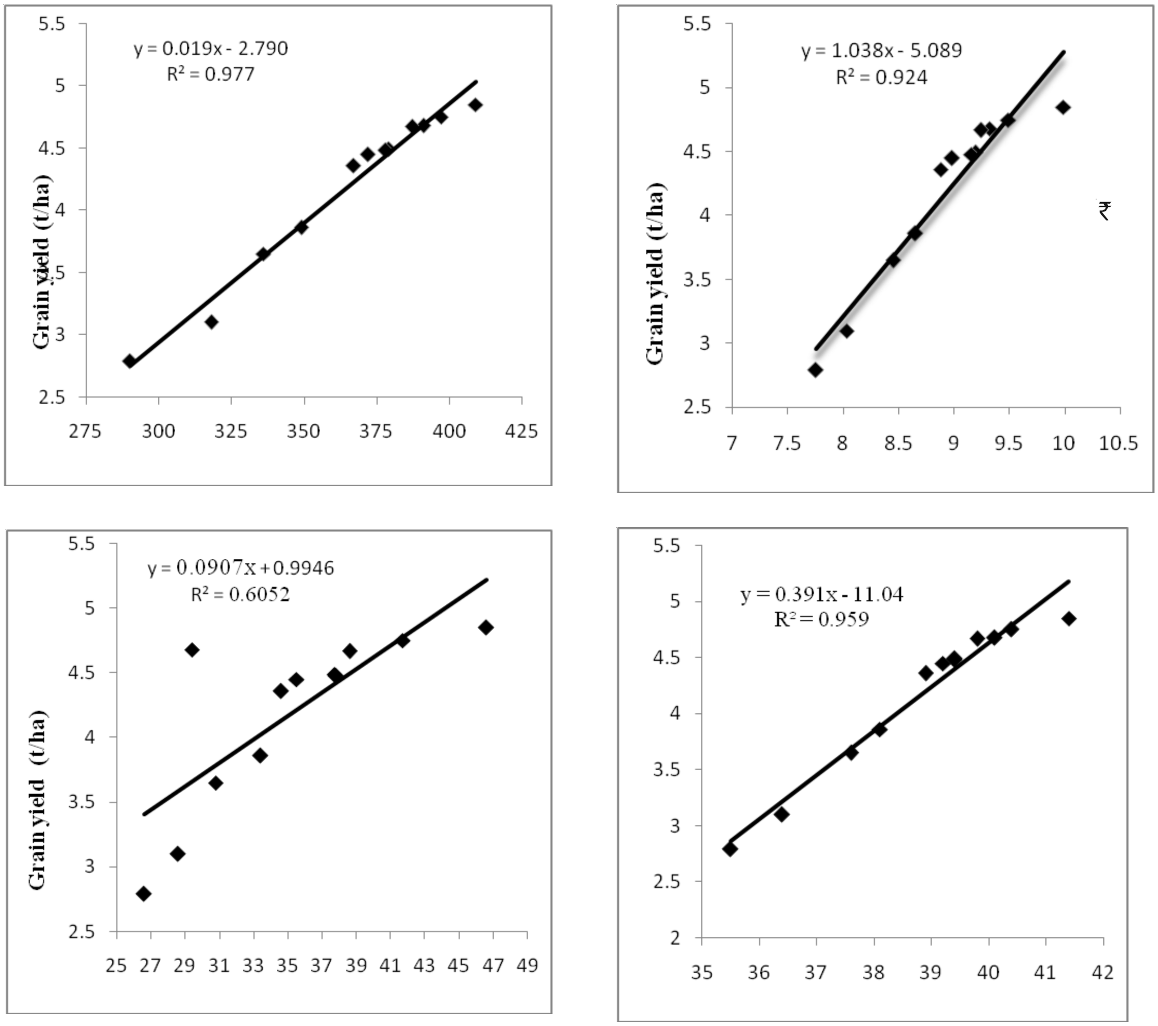

Fig. 1. Relationship between yield attributes and grain yield of wheat

Table 2. Effect of site-specific nutrient management (SSNM) treatment on yield and yield attributes of succeeding wheat crop. (Pooled data over two years)

Treatment applied in wheat after rice		Plant height (cm)	Spikes/ m^2	Spike length (cm)	Grains/ spike	1,000-grains weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
WT_1	$N_{150}P_{60}K_{120}$	105	409	9.99	46.6	41.4	4.85	6.68
WT_2	$N_{150}P_{30}K_{120}$	103	367	8.88	34.6	38.9	4.36 (11.3)	6.37 (4.8)
WT_3	$N_{150}P_0K_{120}$	95	318	8.03	28.6	36.4	3.10 (56.2)	4.25 (57.2)
WT_4	$N_{150}P_{60}K_{80}$	102	391	9.32	29.4	40.1	4.68 (3.7)	6.40 (4.3)
WT_5	$N_{150}P_{60}K_{40}$	100	379	9.19	37.7	39.4	4.49 (8.1)	6.00 (11.4)
WT_6	$N_{150}P_{60}K_0$	98	336	8.45	30.8	37.6	3.65 (32.9)	4.91 (36.1)
WT_7	$N_{150}P_{60}K_{120}$	99	378	9.16	37.8	39.4	4.48 (8.3)	6.22 (7.3)
WT_8	$N_{150}P_{60}K_{120}$	100	387	9.24	38.6	39.8	4.67 (3.9)	6.34 (5.4)
WT_9	$N_{150}P_{60}K_{120}$	99	397	9.49	41.7	40.4	4.75 (2.0)	6.28 (6.3)
WT_{10}	$N_{150}P_{60}K_{120}$	99	372	8.98	35.5	39.2	4.45 (9.1)	5.86 (14.0)
WT_{11}	$N_{120}P_{60}K_{60}$ (RP)	96	349	8.65	33.4	38.1	3.86 (25.6)	5.43 (23.0)
WT_{12}	$N_{90}P_{30}$ (FP)	91	290	7.75	26.6	35.5	2.79 (73.9)	4.21 (58.7)
	SEm±	1.9	7.3	0.20	0.89	0.6	0.14	0.16
	CD (P=0.05)	5.7	21.4	0.59	2.58	2.0	0.42	0.46

Figures in parentheses are percent decrease in grain and straw yields relative to SSNM treatment WT_1

Table 3. Grain yield of rice, wheat, rice yield equivalent and economics of rice–wheat cropping system as influenced by site-specific nutrient management (Pooled data over two years)

Treatment	Applied in rice	Applied in wheat after rice	Rice yield equivalent (t/ha/annum)	Total cost of cultivation ($\times 10^3$ /ha/annum)	Gross income ($\times 10^3$ /ha/annum)	Net returns ($\times 10^3$ /ha/annum)	Benefit: cost ratio
T_1	$N_{150}P_{60}K_{120}S_{40}B_5Mn_{20}Zn_{25}$	$N_{150}P_{60}K_{120}$	14.8	50.3	117.3	67.0	1.33
T_2	$N_{150}P_{30}K_{120}S_{40}B_5Mn_{20}Zn_{25}$	$N_{150}P_{30}K_{120}$	13.5	49.3	106.6	57.2	1.6
T_3	$N_{150}P_0K_{120}S_{40}B_5Mn_{20}Zn_{25}$	$N_{150}P_0K_{120}$	10.9	48.4	85.7	37.2	0.77
T_4	$N_{150}P_{60}K_{80}S_{40}B_5Mn_{20}Zn_{25}$	$N_{150}P_{60}K_{80}$	14.5	49.7	114.5	64.8	1.30
T_5	$N_{150}P_{60}K_{40}S_{40}B_5Mn_{20}Zn_{25}$	$N_{150}P_{60}K_{40}$	14.0	49.1	110.6	61.5	1.25
T_6	$N_{150}P_{60}K_0S_{40}B_5Mn_{20}Zn_{25}$	$N_{150}P_{60}K_0$	12.0	48.5	93.7	45.2	0.93
T_7	$N_{150}P_{60}K_{120}S_{40}B_5Mn_{20}Zn_0$	$N_{150}P_{60}K_{120}$	13.6	47.3	106.4	59.1	1.25
T_8	$N_{150}P_{60}K_{120}S_{40}B_5Mn_0Zn_{25}$	$N_{150}P_{60}K_{120}$	14.2	46.4	112.2	65.8	1.47
T_9	$N_{150}P_{60}K_{120}S_{40}B_0Mn_{20}Zn_{25}$	$N_{150}P_{60}K_{120}$	14.4	48.7	112.6	64.0	1.32
T_{10}	$N_{150}P_{60}K_{120}S_0B_5Mn_{20}Zn_{25}$	$N_{150}P_{60}K_{120}$	13.6	48.3	106.4	58.2	1.20
T_{11}	$N_{120}P_{60}K_{60}Zn_{25}$ (RP)	$N_{120}P_{60}K_{60}$ (RP)	11.6	41.3	91.4	50.1	1.22
T_{12}	$N_{90}P_{30}$ (FP)	$N_{90}P_{30}$ (FP)	8.9	35.8	71.1	35.3	0.99

Yield attributes and yield of wheat

The residual effect of micronutrients applied through SSNM treatments in rice was observed in succeeding wheat. Plant height, spikes/m^2, spike length, grains/spike and 1000-grains weight were significantly higher in SSNM treatment (WT_1) over farmer's and state recommended doses (Table 2). Yield attributing characters of wheat reduced with decrease in phosphorus doses from 60 kg P/ha to 30 and 0 kg P/ha and potassium from 120 to 40 and 0 kg K/ha. The carry over effect of SSNM treatments applied to rice crop on grain and straw yields of succeeding wheat was quite apparent in all the SSNM treatments. The maximum grain (4.85 t/ha) and straw (6.68 t/ha) yields were recorded with SSNM treatment which showed an advantage of 2.06 t/ha (74%) in grain yield and 2.47 t/ha (58.8%) in straw yield as compared to farmer's practice (N_{90} and P_{30} applied both in rice and wheat).

Omission of phosphorus and potassium in wheat drastically reduced grain yield by 56.3 and 32.9%, respectively. Grain yield of wheat was positively and significantly correlated with yield attributes (Fig. 2), namely spikes/m^2 (0.977), spike length (0.924), grains/spike (0.605) and 1,000-grain weight (0.959). The results are corroborated with the findings of Kulandaivel *et al.* (2003), who have also reported that application of 40 kg zinc sulphate per hectare to preceding rice crop significantly improved ear bearing shoot and grain and straw yields of succeeding wheat crop. Gill (2006) also advocated the use of balanced site specific nutrient management in combination with micronutrients, which may break the cereal yield barrier with an advantage of 3–4 t/ha/annum more yields of rice and wheat.

Economics

The variations in the cost of cultivation under different treatments were recorded due to variable cost of macro and micro-nutrients. Grain and straw yields were the major factors which caused differences in gross and net returns. Maximum net returns of ₹67,033/ha/annum was obtained with complete SSNM treatment (RT_1 + WT_1 *i.e.* $N_{150}P_{60}K_{120}S_{40}B_5Mn_{20}Zn_{25}$ in rice followed by $N_{150}P_{60}K_{120}$ in wheat) in rice–wheat system, which was ₹31,681 and ₹16,905/ha/annum higher over those of farmer's practice and state recommended fertilizer doses. Yadav and Kumar (2009) also reported similar results from rice–wheat system using site-specific nutrient management.

Thus, it may be concluded that site-specific nutrient management approach may break the yield barrier of rice and wheat by enhancing yield through judicious exploitation of available nutrients by plants. Nutrients applied to rice crop have definite carry over beneficial effects on enhancing yield of succeeding wheat crop. This indicates for a cautious and balanced use of nutrients (macro and micro) for enhancing systems productivity and profitability without endangering soil and human health.

REFERENCES

Gill, M.S. 2006. Sustaining high yield of rice–wheat system through site-specific nutrient management in Punjab. *Indian Journal of Fertilizers* **2**(5): 45–50.

Khurana H.S., Singh B., Bovermann A., Phillips S.B., Siddhu A.S. and Singh Y. 2008. Site-specific nutrient management performance in rice–wheat cropping system. *Better Crops* **92**(4): 26–28.

Kulandaivel, S., Mishra, B.N. and Mishra, P.K. 2003. Direct and residual effect of levels of zinc and iron and their mode of application on productivity of rice–wheat cropping system. *Annals of Agricultural Res*earch **24**(2): 221–26.

Misra, J.P. and Abidi, A.B. 2006. Effect of zinc sulphate doses on yield and yield attributing characters of hybrid rice varieties. *Farm Science Journal* **15**(1): 13–14.

Mubarak, T. and Bhattacharya, B. 2006. Response of hybrid rice cultivars to various levels of nitrogen and potassium grown on Gangetic alluvial soil in summer season. *Environment and Ecology* **245**: 515–17.

Prasad, R. 2005. Rice–wheat cropping systems. *Advances in Agronomy* **86**: 255–339.

Rui, Yu, L., Yi Yuan, L., Bi Qiong, C. and Xiang Yang, C. 2007. Characteristics of nutrient accumulation and partitioning in yield formation process of different rice cultivars. *Zhongguo Shengtai Nongye Xuebao Chinese Journal of Economic Agri*culture **15**(5): 139–46.

Sharma, M.P., Bali, P. and Gupta, J.P. 2003. Long-term effect of chemical fertilizers on rice–wheat productivity and fertility of an Inceptisol. *Annals of Agricultural Research* **24**(1): 91-94.

Shinde, D.R., Dixit, A.J. and Thorat, S.T. 2005. Response of 'Sahydri' hybrid rice to different spacings, seed rates and fertilizer levels under drilled condition in Konkan Region of Maharashtra. *Journal Maharashtra Agricultural Uni*versity **30**(3): 357–59.

Singh H. and Bansal S.K. 2010. A review of crop productivity and soil fertility as related to nutrient management in the Indo-Gangatic plane of India. *Better Crops–South Asia:* 27–29.

Singh V.K., Tiwari K.N., Gill M.S., Sharma S.K. Dwivedi B.S., Shukla A.K. and Mishra P.P. 2008. Economic viability of site-specific nutrient management in rice–wheat cropping system. *Better Crops* **92**(3): 28–30.

Yadav, D.S. and Kumar, A. 2009. Long-term effect of nutrient management on soil health and productivity of rice (*Oryza sativa*)–wheat (*Tritucum aestivum*) System. *Indian Journal of Agronomy* **54**(1): 15–23.

Yadav, R.L., Prasad, K. and Gangwar, K.S. 1998. Analysis of eco-regional production constraint in rice–wheat cropping system. *PDCSR Bullettin No. 98–2*, Project Directorate for Cropping System Research Modipuram (U.P.), India: **68**.

Zang, Q., Wang, G.H., Feng, Y.K., Sun, Q.Z., Witt, C. and Dobermann, A. 2006. Changes in soil phosphorus fractions in a calcareous paddy soil under intensive rice cropping. *Plant and Soil* **288**(1/2): 141–54.