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Maximizing wheat (*Triticum aestivum*) productivity and profitability using site specific nutrient management strategy

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ABSTRACT

Field experiment was conducted during rabi season of 2012-13 and 2013-14 at farmers' field at Panwari Village of Agra district (Uttar Pradesh) to study the effect of site specific nutrient management (SSNM) on productivity, profitability and uptake of nutrients by wheat [Triticum aestivum (L) emend Paul & Flori]. The experiment was laid out in randomized block design with ten treatments and three replications. Results, pooled over two years, indicated that the SSNM led to significant increase in grain and straw yield of wheat crop as compared to the state recommended NPK fertilizer treatment and farmers' practice. On an average, SSNM increased the grain yield of wheat by 33.8 and 41.8% over state recommended NPK fertilizers and farmer practice, respectively. The maximum net profits of Rs.62452 ha^{-1} with a B:C ratio of 2.31 was obtained from wheat under SSNM. The minimum net profits (Rs.35483 ha^{-1}) and B:C ratio (1.84) were recorded under farmer practice. Omission of nutrients caused grain yield reductions by 13.0% (-P), 15.1% (-K), 4.1 (-S) and 4.9% (-Zn) over SSNM treatment. The uptake of N, P, K, S and Zn by wheat grain and straw in SSNM plot was higher than that of the plot which received fertilizers as per farmer's practice. In general, minimum uptake values of these nutrients were recorded under farmer practice. The quality of produce in terms of protein content also improved with various treatments over farmer practice and maximum values were recorded under SSNM treatment.

Keywords: SSNM, productivity, profitability, quality, nutrient uptake, wheat

INTRODUCTION

Wheat (*Triticum aestivum L.*) is the most important staple food grain crop in Indian diet and main source of protein and calories for a large section of population. Wheat crop has been reported to show the sign of productivity decline. Major cause of this decline has been attributed to the imbalanced use of plant nutrients which has adversely impacted the physico-chemical and biological properties of soils (Singh *et al.* 2012, Sharma *et al.* 2015). Development of an appropriate nutrient management techniques is necessary to maintain the productivity of wheat crop because the burgeoning population pressure puts up a challenge and great threat to food security of India. Fertilizers played the pivotal role in boosting crop production. The loss of soil health due to unbalanced fertilizer use coupled with large mining of nutrients under intensive cropping system posed a threat to the sustainability of our farming system. Due to intensive cultivation, the Indian soils have become deficient in most of the macro and micronutrients; these have considerably decreased the productivity. After the harvest of wheat, a negative balance of nutrients has been commonly observed. Presently application of secondary (S) and micronutrient (Zn) has become as essential as N and P. In view of the above-mentioned facts, present investigation was undertaken to achieve attainable yield and profits from wheat crop, through improved nutrient management practices.

MATERIALS AND METHODS

Field experiment was conducted during rabi season of 2013-14 and 2014-15 at Panwari village of Agra district (Uttar Pradesh). The soil was sandy loam in texture, alkaline in reaction (pH 8.0), low in organic carbon (3.7 g kg^{-1}), deficient in available N (165 kg ha^{-1}), P (10.2 kg ha^{-1}), K (115 kg ha^{-1}), S (16.5 kg ha^{-1}) and DTPA-Zn (0.56 mg kg^{-1}). The experiment was laid out in randomized block design with three replications. Fertilizer treatments were based on soil test fertilizer recommendation of 150 kg N, 90 kg P_2O, 90 kg K_2O, 20 kg S, 4 kg Zn ha^{-1} and was considered as optimum treatment. The treatments were T_1 N_{150} P_{60} K_{90} S_{20} Zn_4, T_2 N_{150}

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P_{30} K_{90} S_{20} Zn_4, T_3 N_{150} P_0 K_{90} S_{20} Zn_4, T_4 N_{150} P_{60} K_{45} S_{20} Zn_4, T_5 N_{150} P_{60} K_0 S_{20} Zn_4, T_6 N_{150} P_{60} K_{90} S_0 Zn_4, T_7 N_{150} P_{60} K_{90} S_{20} Zn_0, T_8 N_{150} P_{60} K_{90} S_0 Zn_0, T_9 state recommended dose of NPK (N_{150}, P_{60}, K_{40}) and T_{10} farmer practice (N8 P57.5). Urea, diammonium phosphate, muriate of potash elemental sulphur and zinc oxide were used as sources of N, P, K, S and Zn, respectively. Wheat crop (var. PBW 343) was sown in second week of November in both the years/using 100 kg seed ha^{-1}. Appropriate management practices were adopted to raise the crop. The crop was harvested at maturity and grain and straw yields were recorded. The grain and straw samples were digested in di-acid mixture of HNO_3 : $HClO_4$ (10:4) and zinc content in the digest was determined on atomic absorption spectrophotometer. Phosphorus, K and S were determined by vanadomolybdo phosphoric yellow colour method, flamephotometer (Jackson, 1973) and turbidimetric method (Chesnin and Yien 1951), respectively. Nitrogen content in grain and straw samples was estimated by modified Kjeldahl method. The uptake of nutrients was obtained as product of their concentration and yield. The trend of results was similar during both the years, data were subjected to pooled analysis for results and discussion.

RESULTS AND DISCUSSION

Yield

The grain and straw yields ranged with nutrient management options, but highest pooled average grain (59.00 q ha^{-1}) and straw (76.28 q ha^{-1}) yield were registered under complete treatment (T1) supplying N, P, K, S and Zn in adequate and balanced amounts. The higher yield in this treatment may be ascribed to better yield attributes due to adequate and balanced supply of nutrients as per crop demand. Pathak (2014) and Singh (2016) reported similar results. Application of 60 kg P_2O_5 ha^{-1} enabled the crop to produce 2.42 and 7.60 q ha-1 more grain yield than 30 kg P_2O_5 ha^{-1} and without P, respectively. Similarly, application, of 90 kg K_2O ha^{-1} gave 2.92 and 8.89 q ha-1 more grain yield over 45 kg K_2O ha^{-1} and no potassium, respectively. The magnitude of difference in yield was more with K application than that of P. The state recommended dose of NPK (150 + 60 + 40 kg ha^{-1}) produced higher yield than farmers practice but was inferior to balanced use of nutrients highlighting the effects of inadequate nutrient supply (Gupta *et al.* 2009, Singh 2016). The lowest yields of grain (41.58 q ha^{-1}) and straw (53.36 q ha^{-1}) were recorded under farmers' practice. The lowest yield under this treatment may be attributed to inadequate and imbalance nutrition of wheat crop. Sharma *et al.* (2014) and Singh *et al.* (2012) also reported lowest yield under farmer practice. Application of S and Zn in wheat crop caused significant effect on grain and straw production of wheat. Optimum fertilization (T_1) was also compared against treatments omitting P, K, S and Zn in order to isolate the individual response of nutrients. The grain yield of wheat decreased by 13.0, 15.1, 4.1 and 6.9% with omission of P, K, S and Zn, respectively, over complete treatment (T_1). The corresponding reductions in straw yields were 14.0, 17.0, 6.6 and 12.8 per cent. The yield data revealed that P, K, S and Zn are the main limiting factors under the present experimental set up. Similar results were reported by Singh *et al.* (2012) and Singh (2016). Zinc application significantly increased the grain and straw yield of wheat which may be attributed to the beneficial effects on yield of wheat due to addition of zinc under condition of zinc deficiency. Similar observations due to zinc application in zinc deficient soil were also reported by Pandey and Kumar (2017). Sulphur application also enhanced the grain and straw yield of wheat (Pandey and Kumar, 2017).

Quality

The protein content in grain and straw of wheat ranged from 10.0 to 12.8 and 2.7 to 3.9 per cent, respectively. The complete treatment (T_1) had significantly higher protein content in grain and straw. The increase in protein content with complete treatment (T_1) might be due to improved nutritional environment in the rhizosphere as well as in plant system leading to enhanced translocation of N and P to reproductive parts (Singh, 2016 and Sharma *et al.* 2015). The phosphorus and potassium omissions had markedly lower protein content than the optimum treatment (T_1). The lower values of protein content in grain and straw was erecorded in farmers practice. Omission of S and Zinc alone or in combination reduced the protein content in grain and straw of wheat. Similar results were reported by Pandey and Kumar (2017) and Singh (2016).

Table 1: Effect of nutrient management practices on the yield (mean of 2 years)

Treatment	Yield (t ha^{-1})		Protein (%)		Net returns (Rs ha^{-1})	B:C ratio
	Grain	Straw	Grain	Straw		
T_1 N_{150} P_{60} K_{90} S_{20} Zn_4	59.00	76.28	12.8	3.9	62452	2.31
T_2 N_{150} P_{30} K_{90} S_{20} Zn_4	56.58	71.85	12.2	3.7	58903	2.28
T_3 N_{150} P_{00} K_{90} S_{20} Zn_4	51.40	65.64	12.4	3.3	50977	2.14
T_4 N_{150} P_{60} K_{45} S_{20} Zn_4	56.08	70.85	12.8	3.7	57141	2.22
T_5 N_{150} P_{60} K_{00} S_{20} Zn_4	50.11	63.31	11.7	3.3	46910	2.02
T_6 N_{150} P_{60} K_{90} S_0 Zn_4	56.60	71.22	11.7	3.3	57256	2.23
T_7 N_{150} P_{60} K_{90} S_{20} Zn_0	54.94	69.77	11.7	3.1	55526	2.20
T_8 N_{150} P_{60} K_{90} S_0 Zn_0	52.21	66.48	11.1	2.8	51327	2.13
T_9 N_{150} P_{60} K_{40} (SR)	44.09	56.58	10.6	2.7	37811	1.86
T_{10} farmer practice (N_{80} $P_{57.5}$)	41.58	53.36	10.0	2.7	35483	1.84
CD (P=0.05)	2.41	3.07	0.20	0.11		

Uptake of Nutrients

The uptake of nutrients in grain and straw of wheat was significantly influenced by the various treatments over farmers' practice (Table 2). The uptake of nutrients by wheat grain ranged from 56.6 to 103.0 kg ha^{-1} for N, 6.2 to 9.6 kg ha^{-1} for P, 16.8 to 25.2 kg ha^{-1} for K, 5.1 to 9.5 kg ha^{-1} for S and 55 to 98 g ha^{-1} for zinc. The corresponding values of uptake of nutrients by straw were from 17.5 to 36.5 kg ha^{-1}, 5.8 to 9.0 kg ha^{-1}, 79.1 to 122.7 kg ha^{-1}, 4.8 to 8.5 kg ha^{-1} and 88 to 166 g ha^{-1}. The results showed that the complete treatment (T_1) maintained higher uptake values of all the five nutrients (N, P, K, S and Zn) most probably due to the higher yields recorded in this treatments (Sharma and Singhal, 2014, Singh 2017). These results again emphasize the importance of balanced fertilization in providing adequate nutrition to the plants. The farmer practice (T_{10}) recorded the lowest uptake values, which is again the reflection of the lowest yield recorded in this treatment. Similar results were reported by Gupta *et al.* (2009) and Singh (2016).

Table 2: Effect of nutrient management on uptake of N, P, K, S (kg ha^{-1}) and Zn (g ha^{-1})

Treatments	Nitrogen		Phosphorus		Potassium		Sulphur		Zinc	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	103.0	36.5	9.6	9.0	25.2	122.7	9.5	8.5	98	166
T_2	94.3	34.4	8.8	8.2	23.9	114.8	8.9	7.9	89	149
T_3	87.1	29.8	7.6	7.1	21.5	104.1	8.0	7.2	82	139
T_4	97.7	34.0	8.9	8.2	22.9	111.5	8.6	7.9	89	149
T_5	79.9	28.7	7.8	7.2	20.2	97.5	7.4	6.8	81	134
T_6	89.3	28.4	8.9	8.3	23.2	113.8	7.4	6.8	81	134
T_7	87.4	26.4	9.0	8.1	22.9	111.4	7.9	7.6	74	115
T_8	79.2	23.4	8.3	7.5	21.8	104.6	6.9	6.2	71	111
T_9	63.5	18.5	6.8	6.2	18.0	85.8	5.7	5.6	59	94
T_{10}	56.6	17.5	6.2	5.8	16.8	79.1	5.1	4.8	55	88
CD (P=0.05)	9.0	4.7	0.41	0.38	1.33	5.75	0.67	0.63	5.73	13.23

Net profit

The maximum net profit of Rs.62452 In wheat was obtained with soil test based SSNM (T_1) fertilizer practice. It may be due to higher grain yield of wheat with this fertilizer practice. Therefore, the balanced use of nutrients could be the most accepted treatment to obtain maximum benefit from the wheat (Singh 2017, Singh, 2016). The minimum net profit of Rs.35483 in wheat was obtained with state fertilizer recommendation (Gupta, *et al.* 2009). Hussain *et al.* (2013) also reported higher net returns and benefit: cost ratio with higher dose of

fertilizers. Cost of cultivation differed marginally on an account of nutrient omissions but resulted in large decrease in net profit. Potassium omission reduced the net returns markedly and phosphorus proved to be the second most limiting nutrient in wheat production. The effect of S and Zn omission on net proft was only marginal (Singh, 2016).

Based on results of on farm trials, it may be concluded that site-specific nutrient management (SSNM) increased the grain yield and net profits from the wheat as compared to the state recommendation of fertilizer. Variability introduced due to treatments was reflected in the uptake of nutrient by the crop. Higher yields of wheat with SSNM approach over SR and FP clearly indicates that the site and crop specific balanced fertilization in addition to maintaining food security will also help to fetch higher economic benefits.

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