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Breaking yield barrier in wheat (*Triticum aestivum*) through site-specific nutrient management

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ABSTRACT

On farm trial was conducted for two years (2014-15 and 2015-16) at Panwari villege of Agra district (Ottar Pradesh) to evaluate the effect of site-specific nutrient management (SSNM) on wheat productivity. Six treatments were evaluated in randomized block design with three replications. The results revealed that the SSNM significantly increased the grain and straw yield of wheat as compared to the state recommended dose of NPK fertilizer and other treatments. On an average, SSNM increased the grain and straw yield by 25.0 and 29.2% over, respectively over the state recommended dose. Omitting a nutrient from the SSNM resulted in marked reduction in yields of wheat crop. Decline in mean wheat grain yield was highest with nitrogen omission (44.6%) followed by phosphorus (32.4%), potassium (28.7%) and S+Zn (7.8%) over the full dose of SSNM treatment (NPK S Zn). Reduction in wheat straw yield due to omission of corresponding nutrients amounted to 46.1, 34.1, 29.6 and 8.3%, respectively. The quality of produce in terms of protein content improved with SSNM + S + Zn and reduced with omission of nutrients, maximum beingh with N omission. SSNM + S + Zn treatment provided the highest net returns (Rs.67366.5 ha^{-1}) and B:C ratio of 2.3 in wheat crop. 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 state recommended NPK dose. In general, minimum uptake values of these nutrients were recorded under SSNM-N treatment.

Keywords: Breaking yield barrier, SSNM, wheat, yield

INTRODUCTION

Wheat (*Triticum aestivum*) is the most important winter season food crop of India and improvement in its productivity has played a key role in making the country self sufficient in food grain. Wheat being highly exhaustive, demands good nutrient management. Wheat production has been reported to show the sign of decline. Major cause of this decline has been attributed to the imblanced use of plant nutrients which has an adverse effect of on soil fertility (Singh *et al.* 2016).Site specific nutrient management is a widely use term in all the parts of the world, generally with reference to addressing nutrient differences which exist with in and between fields and making adjustments in nutrient application to match the location or soil differences (Johnston *et al.* 2009). The SSNM provided the field specific recommendations to a farmer in a cost effective and timely fashion. Development of an appropriate nutrient management technique is necessary to maintains the production potential of wheat because the burgeoning population pressure puts up a challenge and great threat to food security of India. In this context, site specific nutrient management can play a major role in overcoming stagnation in wheat production. Presently S and zinc application has become as essential as N and P. In view of the above mentioned facts, present investigation was undertaken to achieve attainable yield of wheat crop through site specific nutrient management.

MATERIALS AND METHODS

The field experiment was conducted at Panwari Village of Agra district (Uttar Pradesh) during rabi season of 2014-15 and 2015-16. The soil was sandy loam in texture and alkaline in reaction (pH 7.8). It has soluble salt concentration 0.21 dSm^{-1}, organic carbon 3.9 g kg^{-1}, available N 161 kg ha^{-1}, phosphorus 10.7 kg ha^{-1}, potassium 123 kg ha^{-1}, sulphur 16.8 kg ha^{-1} and DTPA-Zn 0.54 mg kg^{-1}. The experiment was laid out in randomized block design with three replications. The treatments were T_1 SSNM + S + Zn, T_2 (SSNM-S-Zn), T_3 state recommended dose of NPK fertilizer (150 + 60 +40 kg ha^{-1}), T_4 SSNM – N, T_5 SSNM – P and T_6 SSNM – K. Urea, diammonium phosphate and muriate of

potash were used as sources for N, P and K, respectively. In nitrogen omission treatment phosphorus was applied as single superphosphate, Sulphur (20 kg S ha^{-1}) was applied as elemental sulphur one week before sowing. Zinc was supplied @ 4 kg ha^{-1} through zinc oxide. Wheat crop (PBW 343) was sown in second week of November in both the years. All standard prackage of practices were followed for growing a good crop. The crop was harvested in second week of April in both the years. At harvest, yield data of the crop (grain and straw) were recorded. The nitrogen content in grain and straw was analyzed by micro Kjeldahl method (Jackson, 1973). Phosphorus, potassium, sulphur and zinc in diacid (HNO_3 $HClO_4$) digest were determined by vanadomolybdate yellow colour method. flamephotometer, turbidimetric method (Chesnin and Yien 1951) and atomic absorption spectrophotometer, respectively. Uptake of nutrients was calculated by multiplying nutrient contents in grain and straw with their respective yield. The economic analysis of different nutrient management options are in terms of net returns and B:C ratio.

RESULTS AND DISCUSSION

Yield

The grain and straw yields of wheat ranged from 35.10 to 63.44 and 45.44 to 84.28 q ha^{-1},respectively. Mean grain and straw yields of wheat were highest (63.44 and 84.28 q ha^{-1}) under NPKSZn (SSNM) treatment and lowest (35.10 and 63.44 q ha^{-1}) under PKS Zn (N-omission) treatment (Table 1).The increase in yield of wheat due to SSNM is attributed to improvement in growth, which in turn resulted in higher production and translocation of photosynthates and nutrients, ultimately reflected in to higher grain and straw production. These results corroborate the findings of Singh (2016).The yields of wheat were significantly higher under SSNM treatment as compared to NPK (T_3) treatment based on state recommendation or any other treatment. On an average, the SSNM treatment out-yielded the state recommended NPK fertilizer dose by an average of 12.74 q ha^{-1} or 25.0 per cent. The decline in grain yield was maximum with N omissim (44.6%) followed by P (32.4%), K (28.7%) and S + Zn (7.8%) omissions over the full dose of SSNM treatment (NPK S Zn). Omission of nutrients from the fertilizer schedule resulted in a marked yield loss indicating the significance of replenishment of the nutrients for achieving high yield target. These data confirm that nitrogen deficiency is a general feature of wheat crop in Agra district. Singh *et al.* (2016) also reported similar results. The state recommended NPK dose recorded 20.1% lower grain yield than the SSNM treatment. The effect of S and Zn application (T_1) on the grain and straw yield of wheat was positive and significant. The increase in wheat grain yield with S + Zn application was 8.4% higher than the no S + Zn treatment. The increase in yield due to S + Zn may be attributed to low status of S and Zn in experimental soil. Similar results were reported by Pandey and Rana (2016).

Table 1: Effect of nutrient management bractices on yield and economics of wheat (mean of 2 years)

Treatments	Grain Yield (q ha^{-1})	% decrease over SSNM	Straw yield (q ha^{-1})	Protein (%)		Net returna (Rs ha^{-1})	B:C ratio
				Grain	Straw		
SSNM + S + Zn	63.44	-	84.28	12.6	3.8	67366.5	2.34
SSNM + S_0 + Zn_0	58.50	7.8	77.22	11.8	3.5	60678.0	2.18
SR	50.70	20.1	65.20	11.2	3.5	48964.5	1.79
SSNM – N	35.10	44.6	45.44	10.8	3.2	26616.0	0.99
SSNM – P	42.90	32.4	55.54	11.0	3.3	37654.5	1.39
SSNM – K	45.24	28.7	59.33	11.1	3.3	37575.0	1.35
CD (P=0.05)	2.11	-	2.47	0.015	0.011	-	-

SR = State recommended dose of NPK fertilizers

Quality

The protein content in grain and straw of wheat varied from 10.8 to 12.6% and 3.2 to 3.8%, respectively. The SSNM treatment had significantly higher protein content in grain and straw over other treatments. The increase in protein content with SSNM treatment 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). The nitrogen and P omissions had significantly lower protein content than the SSNM treatment. The reductions in protein content in grain and straw were higher due to N omission followed by P omission.

Nutrient uptake

The N, P and K uptake by wheat crop was highest in SSNM plot and lowest in N-omitted plot. The nitrogen uptake by grain and straw ranged from 43.3 to 102.4 and 19.6 to 48.9 kg ha^{-1}, respectively. The corresponding increase in P uptake was from 5.1 to 11.7 and 5.0 to 10.9 kg ha^{-1}. The ranges of K uptake by grain and straw were from 14.5 to 32.7 and 59.5 to 137.1 kg ha^{-1}. The uptake values of N, P and K by wheat crop due to state recommended dose of NPK fertilizerS were lower than SSNM treatment. The higher uptake of N, P and K with SSNM may be attributed to high grain and straw yield and concentrations of N, P and K in crop by providing balanced nutritional environment inside the plant, higher photosynthetic efficiency, which favoured higher yields, resulted in more up take of nutrients (Gupta *et al.* 2009, Singh, 2016). By comparison, total uptake of nutrients under nutrient omission treatments appeared to decrease. In general, the lowest uptake of N, P and K were recorded under SSNM-N, SSNM-P and SSNM-K treatments, respectively. Among these omission treatments, N omission had far greater impact on the uptake of nutrients by wheat crop. This was because the N omission strongly depressed the grain and straw production of wheat (Singh 2016). The uptake of S by wheat grain and straw was higher with SSNM (NPKS Zn) over state recommended dose of NPK fertilizers (Table 2). On the other hand, there was a reduction in S uptake by wheat crop with out N, P and K over state recommended dose of NPK fertilizers. The sulphur uptake was improved by 2.9 kg ha^{-1} by grain and 2.7 kg $ha^{-1}$by straw with SSNM + S + Zn over.SSNM – S – Zn. This reduction may be attributed to absence of sulphur dose in this treatment (SSNM – Zn – S). On an average, sulphur uptake by grain and straw increased by 38.7 and 57.0% over state recommended dose of NPK fertilizers with SSNM without S and Zn (SSNM – S – Zn). The minimum values of sulphur uptake by wheat crop were recorded with SSNM – N (nitrogen omission) treatment, which may be ascribed to lower grain and straw yield of wheat with this treatment. The uptake of zinc by wheat grain and straw was significantly higher in the treatment receiving SSNM + S + Zn over other treatments. The zinc uptake by grain increased from 68 g ha^{-1} at state recommended dose of NPK fertilizers to 117 g ha^{-1} with SSNM + S + Zn. The corresponding increase in Zn uptake by wheat straw was from 124 to 218 g ha^{-1}. This increase in Zn uptake by wheat crop may be attributed to higher yields and Zn concentrations with Zn application. Similar results were reported by Pandey and Kumar (2017). The uptake of Zn by wheat grain and straw was reduced with SSNM – N, SSNM – P and SSNM – K treatments as compared to state recommended dose of NPK fertilizers. The lowest values of zinc uptake by wheat grain and straw were noted under SSNM – N treatment, which may be due to low yield of wheat grain and straw.

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

Treatments	Nitrogen		Phosphorus		Potassium		Sulphur		Zinc	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	102.4	48.9	11.7	10.9	32.7	137.1	11.7	11.2	117	218
T_2	92.2	42.8	10.2	9.9	29.3	122.5	8.6	8.5	87	159
T_3	70.8	31.1	7.9	7.2	22.8	93.3	6.2	5.4	68	124
T_4	63.3	19.6	5.1	5.0	14.5	59.5	4.0	3.0	52	93
T_5	54.5	25.0	5.4	4.9	18.1	74.7	4.6	3.3	65	116
T_6	60.0	28.0	6.9	6.6	18.0	81.2	5.4	4.6	69	129
SEm±	1.41	0.55	0.17	0.21	0.44	1.11	0.22	0.33	2.45	4.18
CD (P = 0.05)	3.06	1.19	0.36	0.45	0.95	2.41	0.47	0.72	5.32	9.07

Economics

The net returns and benefit: cost ratio obtained from wheat were significantly affected by various treatments (Table 1). Application of SSNM (T_2) resulted in significantly higher net returns of Rs.60678.00 ha^{-1} with higher B:C ratio (2.18) over the state recommended dose of NPK fertilizers. Application of SSNM + S + Zn resulted significantly higher net returns (Rs.67366.5 ha^{-1}) with higher B:C ratio (2.34) and fetched additional net returns of Rs.6688.5 ha^{-1} over SSNM (T_2). Omission of N resulted in significantly lower net returns of Rs.26616.0 ha^{-1} as compared SSNM + S + Zn (T_1). The highest returns under SSNM S Zn (T_1) treatment might be owing to more yields of wheat which led to proportionally higher gross returns than cost of cultivation. Similar results were reported by Singh *et al.* (2015) in pearl millet. The minimum net returns and benefit: cost ratio were observed under N omission treatment which may be attributed to lower yields of wheat grain and straw.

It may be concluded from the results that SSNM (NPK S Zn) treatment might be beneficial under semi arid condition of Agra region of Uttar Pradesh for achieving higher productivity and profitability of wheat. Nitrogen is the most limiting nutrient and its omission resulted in drastic reduction in yield and productivity of wheat.

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