Annals of Plant and Soil Research 19(1): 105 – 109 (2017)

Effect of balanced use of nutrients on productivity and economics of wheat (*Triticum aestivum*)

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Received: October 2016, Revised accepted January, 2017

ABSTRACT

A field experiment was conducted at farmers field at Panwari (Agra) during rabi seasons of 2010 -11 and 2011-12 to study the effect of balanced use of nutrients on yield, uptake of nutrients and economics of Wheat (Triticum aestivum) in alluvial soil. The experiment was conducted in randomized block design with six treatments comprising different levels of N,P K with Zn and S. Results reveled that application of 120 kg N+46 kg P_2O_5 ha^{-1} as farmers fertilizer practice produced lowest grain (3.58 t ha^{-1}) and strow (5.44 t ha^{-1}) yields. Increasing NPK levels up to 150 % increased the yield by 50.1 and 21.5 and 48.3and 19.7% over farmers practice and state recommendation, respectively. Application of 150 % NPK + 20 kg S+ 4 0 kg Zn ha^{-1} produced the highest grain (5.78 t ha^{-1}) and straw (8.78 t ha^{-1}) yield , which increased by 30.8 and 61.4 % over SR (N_{120},P_{60}, K_{40}) and farmers practice, respectively. Application of 150 % NPK+20 Kg S + 4 kg Zn ha^{-1} provided the highest net monetary returns of Rs.51564 ha^{-1} and B:C ratio of 3.58 in wheat crop. The uptake of nutrients by the crop improved with NPK levels and maximum values were recorded under 150% NPK+ S +Zn treatment. The crop grown in farmers practice utilized the lowest amounts of various nutrients. The fertility status of post harvest soil increased with increasing levels of NPK and maximum values of organic carbon (4.6 g kg^{-1}), available N (252 kg ha^{-1}), P (18.8 kg ha^{-1}), K (154 kg ha^{-1}) S (12.6 mg kg^{-1}) and Zn (0.66 mg kg^{-1}) were recorded with 150 % NPK+S + Zn treatment. Omission of S and Zn caused a reduction in soil S and Zn status over initial values.Thus, balanced use of fertilizers not only provided higher productivity but also sustained the soil fertility.

Keywords: Balanced, nutrients, productivity, nutrient uptake, economics, wheat

INTRODUCTION

Wheat *(Triticum aestivum)* is the most important food grain crop among cereal and stands next only to rice in our country. Wheat is a good supplement for nutritional requirement of human body as it contains 9-10% protein and 60-80% carbohydrates. Wheat is a heavy nutrient feeder and leads to large withdrawal of plant nutrients from soil. This depletion will result in decline in yield of the crop. In intensive cropping without balanced fertilization had led to depletion of major as well as micro nutrients from the soil (Prasad, 2006). This has deteriorated soil health and has lead to a decrease in crop productivity in several regions of the country. Balanced fertilization results in the supply of nutrients in a well balanced ratio, leading to their efficient utilization. Among various nutrients, sulphur and zinc play a crucial role in wheat production. Sulphur is now recognized as fourth element, whose deficiency is wide spread in India. Results of TSI-FAI-IFA project showed that, on an average, 46 % of cropped soils were deficient in sulphur and another 30% are potentially deficient (Morris, 2006). Sulphur deficiency is observed primarily due to high crop yield and therefore higher rates of S removal by crop and lesser use of S containing fertilizers. Zinc plays a key role as a structural constituent or regulatory cofactors of wide range of different enzymes and protein in many important biochemical pathways. These are mainly concerned with carbohydrate metabolism, both in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation the maintenance of the integrity of biological membranes, the resistance to infection by certain pathogens. Zinc deficiency is a common phenomenon in cereals, particular in coarse textured, soil of semi arid regions. Balanced fertilization is the key to achieve higher productivity and nutrient use efficiency. There is a growing deficiency of macro and micro nutrients due to intensive cropping with use of high analysis fertilizers. Proper soil diagnosis and adoption of site specific nutrient and crop management ushers in highest productivity, efficiency and profitability (Sharma and Singhal 2016). The concept of balanced

fertilizations paves the way for optimum plant nutrient supply to realize full yield potential of crop. Keeping in view, an experiment was conducted to study the effect of balanced use of nutrients on yield, uptake of nutrients and economics of wheat.

MATERIALS AND METHODS

Field experiment at farmer's field was conducted during rabi season of 2010 – 11 and 2011 – 12 at Panwari village (Agra). Physico – chemical characteristics of the experimental soil was sandy loam texture, alkaline in reaction (7.8), low in organic carbon (3.2 gkg^{-1}), available N (147 kg ha^{-1}), available P (8.5 kg ha^{-1}), available K (115 kg ha^{-1}), available S (8.0 mg kg^{-1}) and available Zn (0.55 mg kg^{-1}). The treatments namely T_1 farmer fertilizer practice(120 kg N and 46 kg P_2O_5 ha^{-1}), T_2 100 % NP(120+60 kg ha^{-1}), T_3 100% NPK (120+60+40 kg ha^{-1}), T_4 150 % NPK (180+90+60 kg ha^{-1}), T_5 (150% NPK + 20 kg S+ 4 kg Zn ha^{-1}), T_6 150% NP + 20 kg S + 4 kg Zn ha^{-1} were replicated four times in randomized block design. Fertilizer sources for N, P and K were urea, single superphosphate and muriate of potash, respectively. Half nitrogen and total quantity of P and K were applied at the time of sowing, while remaining N was applied after one month of sowing. Wheat (var. –PBW 343) was sown @100 kg ha^{-1} in second week of November in 2010 and 2011 and harvested in first week of April in 2011 and 2012. All improved packages of practices were followed to raise the crop. Grain and straw yields of wheat were recorded at harvest. Grain and straw samples of the crop collected at harvest were analyzed for their N content by modified Kjeldahl method (Jackson, 1973). Phosphorus was determined by molybdovanadate yellow color method in di-acid (HNO_3 and $HClO_4$) digest. Potassium in acid digest was determined by flame photometer, S by turbidimetric method (Chesnin and Yien, 1951) and zinc by atomic absorption spectrophotometer. The uptake of nutrients was calculated by using grain and straw yield data in conjunction with their respective nutrient contents. Economics of wheat with varying treatments was worked out on the basis of prevailing market prices of inputs and produce. The soil samples collected after harvest of the crop were analyzed for organic carbon, available N (Subbiah and Asija 1956), P (Olsen *et al.* 1954) and K (Jackson 1973), available S (Chesnin and Yien 1951) and DTPA – Zn (Lindsay and Norvell 1978).

RESULTS AND DISCUSSION

Crop productivity

The yield of wheat grain ranged from 3.58 t ha^{-1} under farmers fertilizer practice to as high as 5.78 t ha^{-1} under balanced use of fertilizers (150% NPK + 20 kg S + 4kg Zn ha^{-1}). The balanced fertilizers treatment, wherein nutrient were applied not only to meet the crop demands but also to avoid any mining from soil reserve, outyielded by 50.1 and 61.7 % over FFP. The mean yield difference of 0.41 t ha^{-1} between 150% NPK and 150% NPK + S+ Zn was partly ascribed to inclusion of S and Zn (Table 1). The extremely low available K content of the experimental soil was very much reflected in crop performance and also in yield response to K fertilizer. Inclusion of 40 kg K_2O ha^{-1} alone in state recommendation of N and P produced an additional grain yield of 0.61 t ha^{-1}. Like grain yield, strow yield was also significantly affected by the different treatments under study. The highest strow yield of 8.78 t ha^{-1} was recorded with 150 % NPK + 20 kg S + 4 kg Zn ha^{-1} followed by 5.37 t ha^{-1} in 150 % NPK alone. Lowest strow yield (5.54 t ha^{-1}) was recorded in farmers practice. The higher yield of wheat seemed to be the cumulative effect of yield attributes which was boosted by balanced nutrient supply. These clearly indicate that the highest crop response in terms of yield was found with balanced application of fertilizers.These findings are supported by those of Sharma and Jain (2014), Hussain *et al.* (2013) and Singh *et al.* (2016). Application of 20 kg S+4 kg Zn ha^{-1} was beneficial for enhanced crop productivity. These elements produced higher grain and straw over 100% and 150% NPK alone. Thus, the balalnced use fertilizer in combination with S and Zn is necessary for sustaining productivity. Chauhan *et al.* (2013), Singh *et al.* (2014) and Pandey and Chauhan (2016) also reported similar findings.

Table 1: Effect of balanced use of nutrients on yield, quality and economics of wheat (mean of 2 years)

Treatment	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	% response grain yield	Protein (%)		Protein yield (kg ha^{-1})	Net Protit (Rs ha^{-1})	B:C ratio
				Grain	Straw			
FP	3.58	5.54	-	11.87	3.50	425.0	23487.0	2.40
100 % NP	3.81	5.75	6.4	12.50	3.62	476.1	26065.0	2.57
100%NPK	4.42	6.74	23.5	12.81	3.81	566.2	33113.0	2.95
150 % NPK	5.37	8.07	50.1	13.12	4.06	704.4	44015.0	3.39
150 % NPK+ S+ Zn	5.78	8.78	61.7	13.25	4.12	765.5	51564.0	3.58
150% NP+S+Zn	5.21	7.85	45.6	13.19	4.00	687.1	43238.0	3.28
CD (P=0.05)	0.32	0.55	-	0.25	0.11	25.5	-	-

Quality

Protein content in wheat grain and straw was significantly with different treatments. The protein contain in grain and straw ranged from 11.87 to 13.25% and 3.5 to 4.12%, respectively. The maximum values of protein content in gram (13.25%) and straw 4.12%) were recorded under 150% NPK + 20 kg S + 4 kg Zn ha^{-1}. This may be due to the fact that the plants accumulated more nitrogen with this treatment and ultimately showing more protein content. Similar results were reported by Singh and Kumar (2015) and Pandey and Chauhan (2016). The protein yield ranged from 425.0 kg hg^{-1} at farmer practice to 765.5 kg ha^{-1} at 150% NPK + 20 kg S + 4 kg Zn ha^{-1}.The minimum protein yield of wheat grain was recorded under farmers practice. This may be attributed to lower yield of wheat grain. The maximum protein yield was recorded with 150% NPK + 20 kg S + 4 kg Zn ha^{-1}. This increase in protein yield may be attributed to increased grain production and protein content in grain. Singh and Kumar (2015) and Pandey and Chauhan (2016) reported similar results.

Uptake of nutrients

Successive increase in fertilizer levels significantly increased N, P and K uptake by wheat grain and straw over farmer practice (Table 2). The maximum uptake values of these nutrients (NPK) were recorded with 150% RDNPK dose which proved significantly superior to 100% NPK alone. Application of 100% NP also resulted in higher uptake of N, P and K by wheat grain and straw over farmers practice. Similarly, 100% NPK proved superior to 100% NP and farmer practice in respect of N, P and K uptake by wheat crop.The nutrient uptake is a function of yields and nutrient concentrations in the plant. Thus, significant improvement in uptake of N, P and K might be attributed to higher yields and increased concentrations in grain and strae under 150 % NPK. Our findings confirm the results of Singh and Kumar (2015).

Table 2: Uptake of N,P,K,S (kg ha^{-1}) and Zn (g ha^{-1}) by wheat crop (mean of two years)

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur		Zinc	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
FP	68.0	31.0	6.8	5.4	17.5	73.8	9.3	7.2	107.4	121.8
100 % NP	76.1	33.3	8.0	6.3	18.2	104.5	10.3	8.1	122.0	132.2
100%NPK	90.2	41.0	9.7	8.1	22.5	128.1	12.0	10.1	150.1	161.6
150 % NPK	112.7	52.4	12.3	11.2	29.5	158.0	15.0	12.1	182.5	193.2
150%NPK+S+Zn	122.3	58.0	13.3	12.2	32.4	172.8	17.8	14.0	231.2	263.4
150% NP+S+Zn	110.0	50.2	11.5	10.2	26.5	150.0	15.6	12.5	208.1	235.4
CD(P=0.05)	6.26	2.48	0.70	1.00	1.5	10.4	0.91	0.85	12.4	15.3

Addition of 150 % NPK also significantly improved the uptake of S and Zn by wheat grain and strawr. Addition of 20 kg S + 4 kg Zn ha^{-1} along with 150 % NPK recorded maximum S and Zn uptake by grain and straw over other treatments. Increased uptake of S and Zn may be due to increase in concentrations of these nutrients in grain and straw yield. Singh *et al.*

(2014) also reported similar results. Integration of S and Zn with 150% NPK resulted in the maximum uptake of N (122.3 and 58.0 kg ha^{-1}), P (13.3 and 12.2 kg ha^{-1}), K (32.4 and 172.6 kg ha^{-1}), S (17.8 and 14.0 kg ha^{-1}) and Zn (231.2 and 263.4 g ha^{-1}) by grain and straw, respectively over rest of the treatments. This may probably be due to enhanced nutrient availability and higher grain and straw yield of wheat (Chauhan *et al.* 2013).

Soil fertility

Organic carbon content varied from 3.0 to 4.6 g kg^{-1} and maximum value was recorded with 150% NPK+20 kg S+4 kg Zn ha^{-1} treatments.This increase in organic carbon might be due to improvement in root and shoot growth and thus higher production of biomass, which in turn, increased the organic carbon content in soil (Sabina Ahmed *et al.* 2014). Available N, P, K, S and Zn status of post harvest soil was significantly higher than farmers practice under almost all the treatments. Improvement in N,P and K status was noted due to increase in the rate of NPK from 100 to 150 % recommended dose. Available N content ranged from 140 to 252 kg ha^{-1} and that the highest value of available N was found associated with 150 % NPK + 20 kg S + 4 kg Zn ha^{-1}. A reduction in available P content observed in farmer's fertilizer practice occurred due to removal of P by the crop in the absence of P supplementation through external source. A marked build up of available P status of soil was observed under 150 % NPK +20 kg S+ 4 kg Zn ha^{-1} treatment. In the plots treated with 100% NP, the available K decreased by 28 kg ha^{-1} over 100% NPK treatment. The maximum decline was observed in case of farmer fertilizer practice followed by 100% NP and 150% NP+20 kg S + 4 kg Zn ha^{-1}. This reduction in available K may be due to omission of K. The increases in available S and Zn with 150 % NP+S+Zn and 150% NPK + S + Zn were 0.60 and 0.20 mg kg^{-1}, respectively. Over 150 % NPK Improvement in the status of available S and Zn in soil after harvest of the crop were due to addition of these nutrients through the application of chemical fertilizers. Available S and Zn status of the soil reduced in the soil from their initial status in S and Zn free treatments (Barthwal *et al.* 2013).

Table 3: Effect of various treatments on available nutrients in post harvest soil

Treatments	Org.Carbon (g kg^{-1})	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Sulphur (mg kg^{-1})	Zinc (mg kg^{-1})
FP	3.0	140	8.2	103	7.6	0.52
100 % NP	3.5	200	12.6	108	7.8	0.53
100%NPK	3.7	215	14.0	136	8.4	0.53
150 % NPK	3.9	240	16.2	148	8.8	0.54
150%NPK+S+Zn	4.6	252	18.8	154	12.6	0.66
150% NP+S+Zn	4.3	246	15.6	126	12.0	0.64
CD (P=0.05)	0.19	10.4	2.3	8.5	1.1	0.12

Economics

The net returns and benefit cost ratio obtained from wheat were significantly affected by doses of fertilizers applied to wheat crop (Table 1). Application of 150 % NPK resulted in significantly higher net returns of Rs.44015 ha^{-1} with higher B:C ratio (3.39) over the farmers practice and 100 % NPK. Application of 150 % NPK+20 kg S+ 4 kg Zn ha^{-1} resulted significantly higher net returns (`. 51564 $ha^{-1}$) with higher benefit: cost ratio (3.58) and fetched additional net returns of `. 18431 ha^{-1} over 150 % NPK. Depletion of K (150 % NP + 20 kg S + 4 kg Zn ha^{-1}) resulted in significantly lower net returns of `.44015 ha^{-1} over 150 % NPK + 20 kg S + 4 kg Zn ha^{-1} treatment. The highest returns under 150% NPK+20 kg S+4 kg Znha^{-1} might be owing to more yields of wheat which led to proportionally higher gross returns than cost of cultivation. Minimum net returns and benefit: cost ratio was observed under farmer's practice which may be attributed lowest yields of wheat (Sharma and Singhal, 2014, Mauriya *et al.* 2013).

It may be concluded from the present investigation that 180 kg N+ 90 kg P_2O_5+ 60 kg K_2O +20 kg S + 4 kg Zn ha^{-1}might be beneficial under semi arid condition of Agra region of Uttar Pradesh for achieving higher productivity and

profitability of wheat besides maintaining soil fertility.

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