



Effect of balanced use of nutrients on yield attributes, yield and protein content of wheat (*Triticum aestivum*)

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ABSTRACT

The present investigation was carried out with wheat in *rabi* season of 2015-16 at Nawabganj Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India to study the effect of balanced use of nutrients on yield, yield attributing characters, uptake of nutrients and quality of wheat grain. A field experiment was conducted with 10 different treatment combinations comprising of different levels of N, P, K, S and Zn. Results revealed that the combined application of S@40 kg/ha and Zn@5kg/ha along with 125% NPK (T₉) proved to be the best nutrient management option for getting higher yield with better grain protein content and quality. Combined use of S and Zn along with 125% NPK produced highest biological yield (130.63 q/ha) which was 66% higher than 100% NPK treatment. Significant increase in yield attributing characters and nutrient uptake (N, P, K, S and Zn) was also observed under T₉ treatment. As far as nutritional quality of wheat grain is concerned, about 22% higher protein content was found in wheat grain with T₉ treatment over control.

Key words: Grain quality; Macronutrient; Micronutrient; Wheat; Yield

Wheat (*Triticum aestivum* L.) is the staple food of half of world's entire population and covers an area of around 217 million ha accounting to be highest among cereals (Rizwan *et al.* 2017; Ramadas *et al.* 2019). Wheat grain yield and quality is influenced by genotype, agronomic management practices and environment (Nuttall *et al.* 2017). Nitrogen (N) and sulfur (S) being vital for plant growth and at the same time widely deficient in Indian soils makes it the most important limiting factor for high wheat productivity. Zinc (Zn) has been found to be indispensable for crop production because of its considerable role in high grain production and quality of grain protein (Tao *et al.* 2018). It has been seen that external supplementation of N, S and Zn could significantly improve wheat yield and grain protein content over control (Ercoli *et al.* 2013; Keram *et al.* 2014; Hřivna *et al.* 2015). The application of Zn @ 20 kg/ha significantly increased crude protein content in wheat grain by 23.03% and grain

and straw yields by 20.15 and 14.26 %, respectively, over control (Keram *et al.* 2014). Supplementation of S has shown increase in number of ears per unit area to the tune of 10–70% while decreasing the unproductive tiller count (Hřivna *et al.* 2015). Thus adoption of balanced nutrient management practices particularly with respect to efficient combination of nutrients is quite necessary for higher production of agricultural crops. Although wheat grain has abysmally low protein content (7% to 22% of the dry weight), but the large dependence on wheat for energy and carbohydrate makes it a considerable source of protein (20%) (Gfar.net 2019). Further, the nutritional quality of grain is quite important particularly while formulating the feed of livestock because the essential amino acids like lysine cannot be synthesised by animals and hence must be provided in the diet (Shewry 2007). Thus the present study was carried out with the objective of assessing the effect of balanced use of N, P, K, S and Zn on the yield attribute, yield and as well as protein content of wheat.

MATERIALS AND METHODS

A field experiment was conducted with wheat crop during *rabi* season of 2015-16 at Nawabganj Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, U P (25°26' to 26°58' N latitude and 79°31' to 80°34' E longitude). The study was laid out in triplicates following randomized block design (RBD) taking wheat variety PBW-343 as a test crop. The different treatment

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combinations were, T_1 = control (no external fertilization), T_2 = 100% NPK, *i.e.* 120:60:60 kg/ha (N:P₂O₅:K₂O), T_3 = 100% NPK + S @ 40 kg/ha, T_4 = 100% NPK+ Zn @ 5 kg/ha, T_5 = 100% NPK+ S @ 40 kg/ha + Zn @ 5 kg/ha, T_6 = 125% NPK, T_7 = 125% NPK+ S @ 40 kg/ha, T_8 = 125% NPK + Zn @ 5 kg/ha, T_9 = 125% NPK + S @ 40 kg/ha + Zn @ 5 kg/ha and T_{10} = 150% NPK. Recommended dose of N was applied to each plot in 3splits (50% at sowing, 25% each at tillering and stem elongation) through urea. Full dose of P, K, S, and Zn were applied at basal as per treatment through DAP, muriate of potash (MOP), elemental S, and zinc sulfate. Yield attributes such as plant height, test weight of 1000 grain, ear length, effective tillers m⁻², plant stand m⁻¹, number of grain ear⁻¹, grain weight ear⁻¹ were recorded. Grain and straw yields of crop were recorded per plot and converted into quintal/ha. Harvest index (HI) was estimated using following formula:

$$HI = (\text{grain yield (kg/ha)} / \text{biological yield (kg/ha)}) \times 100$$

Computation of uptake of the N, P, K, S and Zn at harvest in both grains as well as straw was done by following formula.

$$\text{Uptake of nutrient (kg/ha)} = \frac{\text{Nutrient content (\%)} \times \text{Yield (kg/ha)}}{100}$$

Total nitrogen in grain samples was determined by micro-Kjeldahl method (AOAC 1970) and protein content in grain was calculated by multiplying the values with a factor 6.25 (Nicholas and Nason 1957).

$$\text{Protein \%} = \text{N\%} \times 6.25$$

Lysine content in wheat grain was determined by colorimetric method at 400 nm as suggested by Tsai *et al.* (1972). All the data recorded were subjected to statistical analysis as outlined by Gomez and Gomez (1984) using analysis of variance technique (ANOVA) for randomized block design.

RESULTS AND DISCUSSION

Yield and yield attribute of wheat

The different treatment combinations had a significant effect on the yield and yield contributing attributes of the wheat crop (Table 1). Highest yield was found in T_9 (125% NPK+S₄₀+Zn₅) producing 57.68 q/ha (grain) and 72.95 q/ha (straw) which was significantly higher over control. Application of S and Zn along with NPK (T_9) increased economic and biological yield significantly, irrespective of the dose of NPK. The treatment T_9 showed a 17% higher biological yield than T_5 (108.47 q/ha) where recommended dose of fertilizer (RDF) of NPK (100%NPK+S₄₀+Zn₅) was applied. The increase in yield could be due to higher yield attributing characters which were caused by higher dose of NPK application. The result was in conformity with Sharma *et al.* (2013), where 100% NPK dose produced around 25% higher grain yield than 50% NPK. Combined application of S and Zn along with NPK (both 100% and 125% RDF) could produce much promising results in both grain and straw yields compared to application S or Zn with NPK. The treatment T_5 where combined application of S and Zn along with 100% NPK was done could produce around 15% and 12% higher yield (both grain and straw) than T_4 (100% NPK + S) and T_3 (100% NPK + Zn), respectively. Similar results were also reported by Singh (2017) and Jan *et al.* (2018). It is apparent from the data presented in Table 1 that harvest index (HI) remained unaffected by different treatment combinations. The values of HI of wheat in all the treatments were around 44%.

The yield attributing characters of wheat was markedly influenced by different nutrient combinations (Table 1). Plant height was recorded highest in T_9 (90.50 cm) which was significantly higher than control (78.20 cm). In case of treatments where only NPK was added, the plant height of wheat was found to increase significantly in concurrence with increasing dose of NPK, *i.e.* 80.52 cm at 100% NPK,

Table 1 Effect of different treatments on yield and yield attributes of wheat.

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (HI)	Plant height (cm)	Test weight (1000 grain weight)	Ear length (cm)	Effective tillers (m ⁻²)	number of plants (m ⁻²)	Number of grains/ear
T_1 Control	22.94	28.82	51.76	44.45	78.20	29.13	8.12	238.14	82.00	41.09
T_2 100% NPK	31.84	39.90	71.74	44.46	80.52	30.33	9.38	300.91	83.50	42.66
T_3 100% NPK+S ₄₀	40.39	51.05	91.44	44.26	84.30	30.71	10.30	339.80	83.50	43.79
T_4 100% NPK+Zn ₅	42.00	53.16	95.16	44.18	85.16	30.87	10.55	341.17	84.00	44.04
T_5 100% NPK+S ₄₀ +Zn ₅	47.96	60.51	108.47	44.25	86.52	32.09	12.01	387.92	83.50	44.13
T_6 125% NPK	45.24	56.99	102.23	44.29	85.54	30.58	10.49	342.16	84.00	43.75
T_7 125% NPK+S ₄₀	49.18	62.10	111.28	44.17	86.38	30.94	10.80	413.33	82.50	43.89
T_8 125% NPK+Zn ₅	53.90	68.13	122.03	44.28	87.27	31.60	10.90	414.21	83.00	44.01
T_9 125% NPK+S ₄₀ +Zn ₅	57.68	72.95	130.63	44.22	90.50	33.35	14.36	454.41	84.00	45.98
T_{10} 150% NPK	53.81	68.08	121.89	44.14	87.06	30.82	11.20	416.60	84.50	43.87
SE (d)	0.480	0.606	5.603	3.72	0.375	0.109	0.231	1.026	0.447	0.116
CD (P=0.05)	0.985	1.244	11.86	N.S.	0.771	0.225	0.474	2.105	N.S.	0.239

Table 2 Simple correlation matrix showing relationship between yield attributes and yield of wheat

	Grain yield	Plant height	Ear length	Effective tillers	Number of grains/ear	Test weight
Plant height	0.9637	1				
Ear length	0.8169	0.8796	1			
No of ear bearing tillers	0.9749	0.9374	0.8411	1		
No of grains/ear	0.8868	0.9372	0.9172	0.8781	1	
Test weight	0.8130	0.8631	0.9350	0.8389	0.8982	1

85.54 cm at 125% NPK and 87.06 cm at 150% NPK. Increasing doses of NPK resulted in higher vegetative growth causing increase in plant height (Hussain *et al.* 2002). Application of S@ 40 kg/ ha and Zn@ 5 kg/ ha in combination with NPK could produce significantly higher plant height as compared to single application of S or Zn along with NPK. However, treatment T₉ (125%NPK) resulted in significantly higher plant height of 90.50 cm as compared to T₅ (86.52 cm). Application of S and Zn improved nutritional environment of rhizosphere as well as enhancing nutrient availability and uptake by plant ultimately enhancing metabolic activity and growth (Dewal and Pareek 2004; Yadav *et al.* 2017). Similarly, other yield attributes of wheat, viz. test weight, ear length, effective tillers and number of grain per ear showed similar trends in all the treatments as that of yield (Table 1). The number of plant count per m⁻² was similar in all the treatments. A positive correlation of yield with yield attributing characters, viz. plant height ($r=0.9637$), ear length ($r=0.8169$), number of effective tillers ($r=0.9749$), number of grains/ear ($r=0.8868$) and test weight ($r=0.8130$) was seen (Table 2).

Nutrient uptake in wheat crop

Data pertaining to nutrient uptake in wheat crop as affected by various treatment combinations are presented in table 3. A pronounced increase in uptake of nutrients,

viz. N, P, K, S and Zn was observed in treatment where combine application of S and Zn was done with 125% NPK (T₉). The uptake of N, P, K, S and Zn in wheat grain in T₉ was found to be 124.01, 19.03, 17.88, 12.68 kg/ha and 1908.63 g/kg, respectively; corresponding values for wheat straw was 38.66, 13.13, 159.03, 13.13 kg/ ha and 2650.27 g/ kg. Such high uptake of nutrient was a clear indication of synergistic effect of balanced fertilization and inclusion of S and Zn into the fertilizer recommendation (Singh 2017). Further such high uptake could also be attributed to a higher yield and nutrient content in both grain and straw of treatment T₉ (125% NPK+S₄₀+Zn₅). These results were in concurrence with the findings of Singh and Pandey (2018). All the treatments produced significantly higher N, P, K, S and Zn uptake by both grain and straw irrespective of the fertilizer combination over control. Significant increase in nutrient uptake was observed by increasing the dose of NPK from 100% RDF (T₂) to 125% RDF (T₆). On an average around 30% higher uptake of N, P, K and S in both wheat grain and straw was observed in T₆ over T₂. In case of Zn, the uptake in wheat grain and straw of T₆ was higher to the tune of 48% and 40%, respectively over T₂. However, the extent of increase of uptake of these nutrients was not similar when the RDF of NPK was increased from 125% NPK to 150% NPK (T₁₀). Comparable results were obtained in case of treatments where S or Zn was applied along with

Table 3 Effect of different treatments on nutrient uptake(grain and straw) and protein and lysine content in wheat grain.

Treatments		Grain							Straw				
		N (kg/ha)	P (kg/ha)	K (kg/ha)	S (kg/ha)	Zn (g/kg)	Protein (%)	Lysine (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (kg/ha)	Zn (g/kg)
T ₁	Control	43.75	6.64	4.58	2.52	419.02	11.02	0.51	12.10	3.17	49.57	3.45	712.14
T ₂	100% NPK	61.76	9.55	6.68	5.09	603.92	12.01	0.52	17.95	4.78	76.20	5.18	1047.37
T ₃	100% NPK+S ₄₀	81.58	12.52	9.28	6.46	945.12	12.41	0.50	23.99	6.12	98.52	6.63	1382.94
T ₄	100% NPK+Zn ₅	86.52	12.60	10.08	7.56	1107.12	12.39	0.49	23.92	6.91	103.66	7.44	1602.24
T ₅	100% NPK+S ₄₀ +Zn ₅	100.23	15.34	12.46	10.07	1459.90	13.17	0.44	30.86	9.07	124.04	9.07	2063.39
T ₆	125% NPK	90.48	14.02	9.95	7.69	1156.78	12.55	0.45	26.21	6.83	109.42	7.40	1771.24
T ₇	125% NPK+S ₄₀	99.83	15.73	11.80	9.34	1421.79	13.04	0.43	30.42	8.07	121.09	8.69	2107.05
T ₈	125% NPK+Zn ₅	105.64	16.70	13.47	10.78	1750.67	12.89	0.43	32.02	9.53	134.21	10.21	2454.72
T ₉	125% NPK+S ₄₀ +Zn ₅	124.01	19.03	17.88	12.68	1908.63	14.11	0.40	38.66	13.13	159.03	13.13	2650.27
T ₁₀	150% NPK	109.23	16.68	12.91	9.14	1597.08	12.85	0.41	34.04	9.53	131.39	8.85	2209.87
SE (d)		1.044	0.323	0.370	0.297	0.913	0.079	0.043	0.721	0.360	0.921	0.306	0.741
CD (P=0.05)		2.143	0.663	0.759	0.609	1.874	0.163	N.S.	1.479	0.740	1.891	0.629	1.521

NPK (100% and 125% RDF).

Quality of wheat grain

Protein content of wheat as affected by different fertilizer combinations are presented in Table 3. On an average the grain protein content varied between 11 to 14% in all the treatments with lowest being in control (11.02%). The treatment T₉ (125% NPK+S₄₀+Zn₅) recorded highest (14.11%) protein content which was 22% higher over control. All the treatments showed protein content greater than 11.5% indicating that the wheat grain could be suitably used for making pasta, a high-value end product (Hare 2017). The lysine content seemed to decrease with increase in dose of N fertilization. However, the lysine content was obtained highest in control plot (0.51%) and lowest in 150% NPK (0.41%). This was quite natural because the lysine content is expected to decrease with increase in dose of N fertilization (Järvan *et al.* 2008).

Conclusion

From present investigation it can be concluded that the incorporation of both Zn and S along with recommended dose of NPK is very important for getting high production with high quality of produce. Further, it can be inferred that application of 125%NPK+S @40 kg /ha+Zn@5 kg/ha to wheat crop could be an effective option for getting high and better quality yield and therefore, may be recommended.

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