

Original Research Article

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Efficient Nutrient Management for High Crop Yield and Quality in Wheat Crop in Central Uttar Pradesh, India

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ABSTRACT

A field scale experiment was conducted on wheat crop in entisol of Crop Research Farm Nawabganj, C. S. Azad University of Agriculture and Technology, Kanpur during 2016-17 Indo-Gangetic alluvium of Central U.P. The treatments were Control, 100% NPK (120:60:60 kg ha⁻¹), 100% NPK+S₄₀, 100% NPK+Zn₅, 100% NPK+S₄₀+Zn₅, 125% NPK, 125% NPK+S₄₀, 125% NPK+Zn₅, 125% NPK+S₄₀+Zn₅ and 150% NPK. There were 10 treatments and 4 replications in R.B.D. In wheat, 125% NPK+S₄₀+Zn₅ gave 54.88 q ha⁻¹ as against the respective control of 22.69 q ha⁻¹. The yield increase was significantly higher in 125% NPK over 100% NPK and 150% NPK also gave significantly higher grain yield over 125% NPK. Addition of S to 100% NPK and 125% NPK gave significantly higher yield over the NPK levels without S. In case of 100% NPK+S the increase in yield due to S application was of the order of 25%. Similarly 125% NPK+S gave about 12% increase in yield over 125% NPK without S. Zn application to 100% NPK and 125% NPK increase the yield by 31% and 19%, respectively. When S+Zn both were applied in combination with 100% NPK and 125% NPK the magnitude of increase was 49.40% and 24.34%, respectively. Wheat protein content was also increased significantly (from 11.07 to 13.64%). The uptakes of NPK, S and Zn were also increased significantly due to different treatments. The treatment 125% NPK+S₄₀+Zn₅ gave the highest VCR 1.71 in wheat.

Keywords

Nutrient
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Introduction

Wheat is the foremost important staple food after rice, consumed by 65% of the population in India and is likely to increase further due to changes in food habits and rise in population. Wheat is mostly consumed in the form of chapati in our country for which bread wheat is cultivated in nearly 95 per cent of the cropped area. Durum wheat, which is most suitable for making macaroni, noodles,

semolina and pasta products, occupies about 4 to 5% of the area, and is predominantly grown in Central and Peninsular parts of India. The organized wheat research in India is almost a century old. It was primarily initiated at the then Imperial Agricultural Research Institute (IARI) Pusa, Bihar. During the sixties, the Indian Agricultural Research Institute (IARI), New Delhi served as flagship of the Indian wheat programme. The All India Coordinated Wheat Improvement Project initiated in 1965,

was subsequently upgraded in 1978 of the status of the Project Directorate and later on was shifted to its present location at Karnal in 1990. Through coordinated research efforts, more than 316 wheat varieties suited to different agro-ecological conditions and growing situations have been released so far.

The wheat production increased from a mere 12.5 million tonnes in 1964 to around 73 million tonnes in recent years. India has the capacity to become world leader in the production of wheat. The country has already overtaken USA and attained the 76.4 million tonnes mark in 1999-2000. It is now realized that sustaining wheat productivity is essential to provide food security to the population of India, which by the year 2020 A.D. will be about 1.25 billion. The projected demand for wheat by the year 2020 A.D. will be 109 million tonnes and to achieve this new technological advances are to be made. In the area of crop improvement emphasis would be to develop new genotypes that are responsive to high input management and capable of yielding beyond 7.0 t/ha. The wheat growing area in the country is classified into six major zones. Based on the state wise acreage currently wheat is being grown on an area of over 27 million hectares. About 72% of the area falls in two mega zones comprising of north western plain zone and north eastern plain zone followed by 17% in CZ while NHZ, PZ and SHZ constitutes about 11% area. Out of the total wheat area, 82-85% falls under irrigated conditions while the rest is under rainfed agriculture. In the current wheat production level of 73 million tonnes, north western plain zone alone produces about 56% followed by north eastern plain zone (less than half of north western plain zone) and Central zone. It is estimated that wheat production can be increased beyond 95 million tonnes if these gaps are bridged. North eastern plains zone and central zone are capable of contributing significantly in future although north western

plains continue to dominate in wheat production and are likely to increase further due to changes in food habits.

Wheat (*Triticum aestivum* L. *em Thell.*) is the first important and strategic cereal crop for the majority of world's population. It is the most important staple food of about two billion people (36% of the world population). Worldwide, Wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman and Graur, 1995). It exceeds in acreage and production every other grain crops (including rice, maize, etc.) and is therefore, the most important cereal grain crop of the world.

Wheat is an edible grain, one of the oldest and most important of all the cereal crops. Though grown under a wide range of climates and soils, wheat is best adapted to temperate regions with rainfall between 30 and 90 cm. Winter and spring wheat's are the major two types of the crop, with the severity of the winter determining whether a winter or spring type is cultivated. The world's main wheat producing regions are China, India, United States, Russian Federation, France, Australia, Germany, Ukraine, Canada, Turkey, Pakistan, Argentina, Kazakhstan and United Kingdom (FAO, 2003). Common wheat or bread wheat (*T. aestivum*) – one of the hexaploid species that is most widely cultivated in the world. Spelt (*T. spelta*) – other hexaploid species cultivated in limited quantities. Spelt is sometimes considered as a subspecies of the closely related species common wheat (*T. aestivum*), and its botanical name is considered to be *T. aestivum* ssp. *spelta*. Tetraploid species. Durum (*T. durum*) – The only tetraploid form of wheat widely used today, and the second widely cultivated wheat. Khorasan (*T. turgidum* ssp. *turanicum*, also called *T. turanicum*) is a tetraploid wheat species. It is an ancient grain type; It refers to a historical region in modern-day Afghanistan

and the northeast of Iran. This grain is twice the size of modern-day wheat and is known for its rich nutty flavour. Diploid species. Einkorn (*T. monococcum*) – A diploid species with wild and cultivated variants. Domesticated at the same time as emmer wheat, but never had the same importance. Although most wheat is grown for human food and about only 10 percent is retained for seed and industry (for production of starch, paste, malt, dextrose, gluten).

Materials and Methods

To carry out present investigation, a field experiment was conducted at Nawabganj Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, during rabi season of 2016-17. The experiment was laid out in different fields to avoid the residual effects. Cultural operations adopted before sowing of maize and wheat, were similar during the year of experimentation. The farm is situated in the vicinity of Kanpur city to the east side about 1.2 Km from the main campus on G.T. Road in the Indo gangetic plain of central Uttar Pradesh. The district Kanpur is situated in sub-tropical and semi-arid zone falling between the parallels 25⁰26' to 26⁰58' north latitude and 79⁰31' to 80⁰34' east longitude, and is located at an elevated belt of Gangetic plains of Central Uttar Pradesh.

Soil samples were collected with the help of steel auger, air-dried and ground with pestle and mortar to pass through 2 mm sieve. The soil of experimental field is normal in EC and pH and low in organic carbon, available N₂ and available Zn but medium in case of available P, K and available S. The soil reaction (pH) and electrical conductivity (EC) were determined in saturation extract as per as procedure described by Jackson (1973). The soil organic carbon (OC) was estimated by wet digestion method of Walkley and Black

(1934) and available N of the soil was determined by Subbaiah and Asija (1956). The available phosphorus in the soil was extracted by employing Olsen extractant (0.5 M NaHCO₃) as described by Olsen *et al.*, (1954) and the available K in the soil was extracted by using neutral ammonium acetate and the content was determined by aspirating the extract into flame photometer (Jackson 1973). The available sulphur (S) in the soils was extracted with 0.15% CaCl₂.2H₂O solution as described by Williams and Steinbergs (1959) and the content of DTPA extractable micronutrients *viz.*, zinc (Zn) in soil was estimated using 1:2 soil to extractants ratio (Lindsay and Norvell 1978). The plant samples were taken simultaneously and washed with tap water followed by washing with 0.1N HCL and de-ionized water. The samples were air-dried and kept in oven at 60 to 70 °C for drying till the constant weight. The samples were ground in a steel Willey mill and digested with 4:1 di-acid mixture of HNO₃ and HClO₄ (Jackson 1973). The plant samples were also analysed for N P K, S and Zn. Nitrogen was determined by Kjeldal's method and phosphorus was determined calorimetrically. Potassium was determined by flame photometric method. Sulphur was determined by turbidimetric method (Chaudhary and Cornfield 1966) using spectrophotometer, while zinc content was determined by atomic absorption spectrophotometer (AAS).

Results and Discussion

Grain yield

There were significant variations in the data under different treatments. It varied from (22.69 to 54.88 q ha⁻¹) with a mean value of 44.31 q ha⁻¹. Among NPK levels 125% NPK gave significantly higher yield to 100% NPK to the tune of about 40% in grain yield. Among NPK levels 150% NPK gave

significantly higher yield over 125% NPK to the tune of about 21% in grain yield. Addition of sulphur to 100% NPK also caused significant increase of about 24%. At 125% NPK addition of S resulted in significant increase of about 9%. Addition of zinc to 100% NPK also caused significant increase of about 30%. At 125% NPK, addition of Zn gave significant increase of about 19%. Addition of S+Zn to 100% NPK also caused significant increase of about 48%. At 125% NPK addition of S+Zn resulted in significant increase of about 21%. Results of this study are in agreement with those of following workers Shukla and Shrama (1994) and Kumar and Ahalawat (2006) (Table 1).

Straw yield

There were significant variations in the data under different treatments. During first year it varied from 28.99 to 73.14 q ha⁻¹ with a mean value of 56.41 q ha⁻¹. Among NPK levels 125% NPK gave significantly higher yield over to 100% NPK to the tune of about 43% in straw yield. Further increase in NPK doses to 150% the increase in yield was significant. Addition of sulphur to 100% NPK caused significant increase of about 30% in grain yield. However, there were small but significant increases in straw yield due to individual addition of S to 125% NPK.

Addition of zinc to 100% NPK also caused significant increase of about 34%. At 125% NPK addition of Zn also caused significant increase in the straw yield. Addition of S+Zn to 100% NPK also caused significant increase of about 52%. At 125% NPK addition of S+Zn resulted significant increase of about 27%. Results in this study are in agreement with those of following worker Soffi *et al.*, (2004), Onasanya *et al.*, (2009) and Barsoum (1995). Thus it was indicated that addition of S, Zn and S+Zn to NPK caused positive effect on the increase in grain and straw yield to a

significant extent and the results justifiably pruned the balancing effect of nutrients.

Nutrient content and uptake

The concentration and uptake of N, P, K, S and Zn were estimated in grain and straw after the harvest of the crop. It was revealed that the concentration of nutrients and the biomass *per se* increased with the increasing doses of NPK from control to 150% NPK. Furthermore, at each level of NPK the concentrations of NPK S and Zn were increased at the significant level. This was the region that uptake (nutrient concentration × biomass yield) increased significantly (Table 2–5).

Nitrogen

Nitrogen content varied from 1.97 to 2.18% in grain and from 0.42 to 0.53% in straw. The highest values were obtained in treatment 125% NPK+S₄₀+Zn₅ and this increase was 42% higher in case of grain and 29% higher in case of straw over control. Mean nitrogen uptake varied from (44.69 to 119.63) kg ha⁻¹ in grain and from (11.88 to 39.49) kg ha⁻¹ in straw. The highest values were obtained in treatment 125% NPK+S₄₀+Zn₅ and this increase was 175% higher in case of grain and 200.25% higher in case of straw over control, indicating that the nitrogen absorption increased appreciably under different treatments. Similar results were given by Singh and Brar (2006) and Stevenson *et al.*, (2005).

Phosphorus

Mean phosphorus content varied from 0.30 to 0.34% in grain and from 0.11 to 0.18% in straw on the basis of mean of two years. The highest values were obtained in treatment 125% NPK+S₄₀+Zn₅ & this increase was 14% higher in case of grain and 63% higher in case of straw over control.

Table.1 Yield % increased over control

Treatments combination	Grain yield in q ha ⁻¹	% Increase over control	Grain yield in q ha ⁻¹	% Increase over control
Control	22.69		28.99	
100% NPK	32.36	29.88	39.94	27.41
100% NPK+S ₄₀	40.42	43.86	51.42	43.62
100% NPK+Zn ₅	42.05	46.04	53.71	46.02
100% NPK+S ₄₀ +Zn ₅	47.97	52.69	60.80	53.31
125% NPK	45.28	49.88	57.38	49.47
125% NPK+S ₄₀	49.24	53.92	62.34	53.49
125% NPK+Zn ₅	54.16	58.10	68.43	57.63
125% NPK+S ₄₀ +Zn ₅	54.88	58.65	73.14	60.36
150% NPK	54.14	58.09	67.98	57.35
S.E. (d)	0.489		0.661	
C.D. (P=0.05)	1.005		1.356	

Table.2 Effect of different treatments on content of N, P, K, S and Zn

Treatment	N (%)		P (%)		K (%)		S (%)		Zn (ppm)	
	Grain	Straw								
T1	1.97	0.41	0.30	0.11	0.21	1.74	0.12	0.12	19.10	24.39
T2	2.02	0.45	0.31	0.12	0.23	1.93	0.17	0.13	21.61	26.73
T3	2.08	0.48	0.32	0.13	0.24	1.95	0.18	0.13	24.39	29.31
T4	2.05	0.47	0.31	0.13	0.25	1.97	0.19	0.13	26.71	32.31
T5	2.09	0.51	0.33	0.15	0.28	2.07	0.22	0.16	31.17	34.23
T6	2.07	0.47	0.31	0.13	0.24	1.94	0.18	0.14	26.31	31.20
T7	2.12	0.50	0.32	0.14	0.25	1.97	0.19	0.14	29.70	34.13
T8	2.14	0.49	0.31	0.14	0.27	1.99	0.21	0.15	32.89	36.22
T9	2.18	0.54	0.34	0.18	0.31	2.19	0.24	0.18	34.43	36.71
T10	2.10	0.50	0.32	0.14	0.25	1.95	0.17	0.14	30.64	32.70
SE±	0.015	0.008	0.005	0.005	0.006	0.005	0.006	0.003	0.854	0.863
C.D. (P=0.05)	0.030	0.018	0.011	0.011	0.013	0.010	0.012	0.008	1.752	1.772

Table.3 Effect of different treatments on uptake of N, P, K, S and Zn

Treatment	N (kg ha ⁻¹)		P(kg ha ⁻¹)		K (kg ha ⁻¹)		S (kg ha ⁻¹)		Zn (g 100kg ⁻¹)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T1	44.69	11.88	6.80	3.18	4.76	50.44	2.72	3.47	433.37	707.06
T2	65.36	17.97	10.03	4.79	7.44	77.08	5.50	5.19	699.29	1067.59
T3	84.07	24.68	12.93	6.68	9.70	100.26	7.27	6.68	985.84	1507.12
T4	86.20	25.24	13.03	6.98	10.51	105.80	7.98	6.98	1123.15	1735.37
T5	100.25	31.00	15.83	9.12	13.43	125.85	10.07	9.72	1495.22	2081.18
T6	93.72	26.96	14.03	7.45	10.86	111.31	8.15	8.03	1191.31	1790.25
T7	104.38	31.17	15.75	8.72	12.31	122.80	9.35	8.72	1462.42	2127.66
T8	115.90	33.53	16.78	9.58	14.62	136.17	11.37	10.76	1781.32	2478.53
T9	119.63	39.49	18.65	13.16	17.01	160.17	13.17	13.16	1889.51	2684.96
T10	113.69	33.99	17.32	9.51	13.53	132.56	9.20	9.51	1658.84	2222.94
SE±	1.317	0.480	0.432	0.341	0.724	1.221	0.485	0.278	0.633	0.815
C.D. (P=0.05)	2.703	0.985	0.886	0.700	1.487	2.505	0.996	0.571	1.838	1.672

Table.4 Effect of different fertilizer treatments on protein and lysine in wheat

Treatments combination	Protein Lysine		Lysine	
	(%)	yield kg ha ⁻¹	(%)	yield kg ha ⁻¹
Control	11.07	251.17	0.55	12.47
100% NPK	12.05	389.93	0.52	16.82
100% NPK+S ₄₀	12.44	502.42	0.51	20.61
100% NPK+Zn ₅	12.42	522.26	0.45	18.92
100% NPK+S ₄₀ +Zn ₅	13.20	633.20	0.43	20.62
125% NPK	12.61	570.98	0.41	18.56
125% NPK+S ₄₀	13.08	644.05	0.37	18.21
125% NPK+Zn ₅	12.88	697.58	0.37	20.03
125% NPK+S ₄₀ +Zn ₅	13.64	748.56	0.34	18.65
150% NPK	12.88	697.32	0.34	18.40
S.E. (d)	0.241			
C.D. (P=0.05)	0.494			

Table.5 Economic impact evaluation of different treatments in wheat crop

Treatments combination	Value cost ratio (N:C) of Wheat
Control	NIL
100% NPK	0.29
100% NPK+S ₄₀	0.58
100% NPK+Zn ₅	0.71
100% NPK+S ₄₀ +Zn ₅	1.30
125% NPK	1.12
125% NPK+S ₄₀	1.36
125% NPK+Zn ₅	1.53
125% NPK+S ₄₀ +Zn ₅	1.71
150% NPK	1.53

Mean phosphorus uptake varied from 6.80 to 18.65 kg ha⁻¹ in grain and from 3.18 to 13.16 kg ha⁻¹ in straw.

The highest values were obtained in treatment 125% NPK+S₄₀+Zn₅ and this increase was 179% higher in case of grain and 313 % higher in case of straw over control, indicating that the phosphorus absorption was increased appreciably under different treatments. Similar results were followed by Sunar and Galantini (2012) and Rashid M. and M. Iqbal (2012).

Potassium

Unlike other nutrients the concentration of Potassium was maximum in the maize crop. Potassium content varied from 0.21% to 0.31% the corresponding value in straw 1.74 (minimum) to 2.19% (maximum values) were given by control and 125% NPK+S₄₀+Zn₅, respectively. The percentage increase in best treatment over control was 48% in grain and 27% in straw. The mean potassium uptake ranges from (4.76 to 17.01) kg ha⁻¹ and (50.00 to 159.60) kg ha⁻¹ in grain and straw,

respectively. The corresponding magnitude of percentage increase in treatment 125% NPK+S₄₀+Zn₅ over control were about 274 and 220, in grain and straw respectively. The high magnitude of increase might be attributed to the increase in large concentration of potassium and simultaneous increase in plant biomass under balanced fertilizer treatments. Similar result were followed by Rashid and Iqbal (2012) and Rajdhar and Singh (1990).

Sulphur

The average sulphur content varied from 0.12% in control to 0.24% in 125% NPK+S₄₀+Zn₅ and 0.12% to 0.18% in grain and straw, respectively. The increases in sulphur content under different treatment were significant. Similarly the average uptake of sulphur varied from (2.62 to 12.92) and (3.46 to 13.15) kg ha⁻¹ in grain and straw respectively. In both the cases the minimum and maximum value were obtained in control and 125% NPK+S₄₀+Zn₅. The magnitude of increase in sulphur uptake in best treatment was about 4.93 times and 3.8 times greater over control. Again this increase might be ascribed to the increase in concentration of sulphur and biomass under balanced nutrition. Similar results were followed by Tiwari (1997).

Zinc

The average Zinc content varied from (18.69 to 33.76) and (24.55 to 36.52) ppm in grain and straw, respectively. The lowest and highest concentrations were obtained in control and 125% NPK+S₄₀+Zn₅, respectively. The variation trends are in zinc content due to different treatment were similar to dose described for sulphur. Similar results were followed by Nandram (1996) and Singh and Tripathi (2008). The results were significant with Uptake of zinc the range of variation on

mean bases was (433.37 to 1889.51) and (707.06 to 2684.96) g 100 kg⁻¹ in grain and straw, respectively. The zinc uptake in straw was roughly 1.40 times as compared to grain. It appeared that the treatments under balance nutrition were responsible for significant increases in zinc concentration and plant biomass.

Quality of wheat

In this study an attempt has been made to see the possibility of improvement in wheat quality through balanced nutrition. Protein is the major consideration in wheat derived foods, marketing and exports of wheat. In several countries the market price of wheat is determined on the basis of its true protein content in grain. It is notable that in many parts of the world nitrogen is applied in much higher doses without maintaining balance with other major and micronutrients. The practice gives higher grain yield but its quality is deteriorated due to accumulation of soluble nitrogen in higher proportion. The real answer to this problem is to balance the high dose of nitrogen with other nutrient like P, K, S and Zn in particular. Therefore the present study was conducted by applying 100% NPK, 125% NPK and 150% NPK and former two levels were combined with S, Zn and S+Zn. The results obtained are discussed below.

Protein

Protein varied from 11.07 in control to 13.64 % in 125% NPK+S₄₀+Zn₅ and latter considered the best treatment. The protein varied significantly under different treatments. Addition of S and Zn also increased the protein content significantly. The increase in protein content due to addition of sulphur may be ascribed to the reason that the sulphur is a component of protein. To obtain quantitative evaluation of protein yield was computed from the data on

yield and protein content of grain. Protein yield varied from 251.17 (control) to 748.56 kg ha⁻¹ (125% NPK+S₄₀+Zn₅). It meant that the nutrient application resulted in 3 time increase in protein harvest. Results of this study are in agreement with those of following workers: Karasu (2012), Stewart and Porter *et al.*, (1969), Das and Datta (1973).

Lysine

The lysine content was analysed in triplicate on composite sample. It varied from 0.53% to 0.37 % and all the fertilizers treatment had depressing effect on lysine content. In other words the highest value was recorded in control. The lysine availability was worked out as a function of protein yield and lysine content was expressed as kg ha⁻¹. The lowest (12.47 kg ha⁻¹) and the highest (20.62 kg ha⁻¹) values were found in control and 125% NPK+S₄₀+Zn₅. Thus it was observed that the lysine harvest was mainly governed by the yield of protein and not its concentration. Similar results have been reported by Majumdar *et al.*, (2012).

Economic impact evaluation of different treatment in wheat

VCR value is the reliable parameter for assessment of value cost ratio. Which may be explained as the net profit obtained for investment of one rupee. In the best treatment 125%NPK+S₄₀+Zn₅ was 1.71 in wheat, which means investment of one rupee gave net profit of rupees one 171 in wheat making allowance for yield due to the native soil nutrients. The cost of the input and those of yield were calculated on the prevailing rates at the time of harvest. Finally, it was evident that the yield of wheat crop wheat grain 54.88 q ha⁻¹ and in straw 73.14 q ha⁻¹ was also utilized by 150 kg N, 90 kg P, 90 kg K, 40 kg S and 5 kg Zn.

In the condition obtained during the experimentation in the respect of soil varieties and other factors *inter alia* application of 125% NPK+S₄₀+Zn₅ gave the best results in the respect of growth parameters, yield, nutrient uptake, protein, lysine content in wheat. The highest yield was observed 54.88 q ha⁻¹ in wheat. Followed by 100% NPK + S + Zn (with 47.97 q ha⁻¹). The former treatment was adoptive for yield maximization and the latter treatment is useful for the farmers endowed with lesser investment.

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