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Response of wheat (*Triticum aestivum L*) to sulphur under balanced and imbalanced fertilizer application

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ABSTRACT

A field experiment was conducted during rabi season of 2015-16 and 2016-17 at Panwari village of Agra district to study the response of wheat (Triticum aestivum L.) to sulphur under balanced and imbalanced fertilizer application. Treatments consisted of application of balanced (NPK) and imbalanced (NP and NK) fertilizer application along with sulphur. The experiment was laid out in a randomized block design with six treatments and three replications. Results revealed that balanced fertilizers (NPK) application proved superior in respect of growth yield and utilization of nutrients over imbalanced fertilizer application. The application of NPKS (150 kg N + 60 kg P_2O_5 + 40 kg K_2O + 30 kg S ha^{-1}) significantly increased the plant height (95 cm) length of ear (103.cm grain/ear (51.8), ear/m^2 (50.8) and test weight (40.4g) compared with other treatments. Significantly higher grain (56.39 q ha^{-1}) and straw (71.15 q ha^{-1}) yield were recorded with NPKS treatment over other treatments. Application of NPKS significantly increased the uptake of nitrogen by wheat crop over other treatments Protein content in grain (13%) and protein yield (733.0 kg ha^{-1}) were also higher with NPKS treatment. The lowest values of all these parameters were recorded under NK treatment. However, NK and NP treatments statistically at par in respect of growth and yield of wheat crop.

Keywords: Sulphur, quality, nutrient uptake, yield, wheat

INTRODUCTION

Wheat (*Triticum aestivum L.*) is the most important food crop and is grown under different soil and agro-climatic conditions. In India, it is the second most important food crop after rice. Nowadays, a general slowdown in increase in the productivity of wheat has been noticed. Stagnation in wheat production, lower productivity and inferior quality of produce is due to various constraints including inadequate and imbalanced nutrition. Optimum nutrition is required for getting maximum yield and good quality of produce sulphur is an essential nutrient after nitrogen, phosphorus and potassium whose deficiency is widespread in cereals growing soils (Singh, 2015). Sulphur deficiencies are often observed in low organic carbon soils where S-free fertilizers are continuously used in crop production. Sulphur deficiency in crop plants has been recognized as a limiting factor not only for crop growth and yield but also for poor quality of produce, because S is a constituent of several essential compounds such as cysteins, methionine, cystine, coenzynes, thioredoxine and sulpholipids etc. It has a role to play in increased chlorophyll formation and aiding photosynthesis. For wheat crop, sulphur nutrition exerts a large influence on crop growth and grain yield (Singh, 2021). In sulphur deficient environments it is expected that a higher N uptake will enhance nitrogen use efficiency when S is added. Therefore, a field experiment was conducted to study the effect of sulphur application along with balanced (NPK) and imbalanced (NP, NK) fertilizer on wheat yield grown on sulphur deficient soil of Agra district.

MATERIALS AND METHODS

A field experiment was conducted in sulphur deficient fields of Panwari Village of Agra district during rabi seasons of 2015-16 and 2016-17. The study site is characterized by semi-asid climate with extreme temperature during summer (45 to 48° C) and very low temperature during winter (as low as 2° C). The average rainfall is about 650mm, most of wheat is received from June to September. The soil was sandy loam in texture with alkaline reaction (pH 708), low in organic carbon (3.1 g ka^{-1}). The soil was low in available N (170 kg ha^{-1}), P (9.2 kg ha^{-1}) and medium in K (130 kg ha^{-1}). The soil was deficient in sulphur (17.0 kg ha^{-1}). The experiment was laid out in a completely randomized design with six treatments and four

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replications. The treatments, included NP, NK, NPK, NPS, NKS and NPKS in NPK treatments, 150 kg N, 60 kg P_2O_5 and 40 kg P_2O was applied. In NP and NK treatments, 150 kg N and 60 kg P_2O_5 ha^{-1} and 150 kg N and 40 kg K_2O ha^{-1}, were applied, respectively. Sulphur was applied at 30 kg S ha^{-1} in respective treatments. Nitrogen, P, K and S were applied through urea, diammonium phosphate, mureate of potash and elemental sulphur, respectively. Wheat variety HD 2329 was sown (100 kg ha^{-1}) on second week of November in both the years and harvested at the time of maturity. Grain and Straw yields and yield attributes were recorded at harvest. The grain and straw samples wee digested in di-acid mixture (3:1 of HNO_3: $HClO_4$) and analyzed for P by molybdovanadate yellow colour method, K by flame photometer and sulphur by turbid metric method (Chesnin and yien, 1951). Nitrogen content in grain and straw was determined by modified Kjeldahl method (Jackson, 1973). The uptake of nutrients was computed from their concentration in grain and straw and respective yield data. The mean data on various parameters obtained from the consecutive two years were statistically analyzed as per procedure given by Gomez and Gomez (1984). Least significant difference vaues at P = 0.05% were used to determine the significance of difference between treatment means.

RESULTS AND DISCUSSION

Growth and yield attributes

Plant height improved with S application with NP, NK and NPK and highest (95cm) with NPKS application. The lowest value of plant height (90.7 cm) was recorded with NK application alone. Length of ear of what was significantly higher (11.2 cm) with NPKS application compared with other treatments. The lowest value (10.1 cm) of ear length was recorded with NK application. The NP and NK applied alone or with combination with S did not differ significantly among themselves in respect of ear length. Balanced application of fertilizers with or without sulphur resulted in significant increase in grain per ear compared with imbalanced fertilizer application. The maximum value (51.8) of grains per ear was recorded with sulphur application along with NPK. However number of grains per ear increased significantly over NPK application alone. Number of tillers per m^2 increased significantly with application of balanced NPK fertilizers as compared to the imbalanced (NP and NK) fertilizer application.

The maximum number (508) of tillers was noted under NPKS treatment and lowest (471) with NK application. Test weight of wheat also increased significantly with sulphur application along with NP and NK fertilizers and balanced (NPK) fertilizer application. The maximum value of test weight (40.4g) was noted with NPKS treatment and minimum (34.6g) with NP fertilizer application. Sulphur is involved in synthesis of S-containing amino-acids, various enzymatic processes and oxidation-reduction reactions of plant resulting in greater meristematic activities and apical growth thereby improving overall plant growth. Similar results were reported by Singh and Singh (2020).

Table 1: Effect of various treatments on growth, yield attributes and yield of wheat (data polled for two years)

Treatment	Plant height (cm)	Length of ear (cm)	Grains per ear	Ear/m^2	Test weight (g)	Yield (t ha^{-1})		Protein content in grain (%)	Protein yield (kg ha^{-1})
						Grain	Straw		
NP	91.2	10.2	49.0	475	34.6	46.36	59.01	12.4	574.4
NK	90.7	10.1	50.0	471	35.0	45.37	57.85	12.2	553.5
NPK	93.0	10.8	51.2	494	39.1	51.89	64.85	12.7	659.0
NPS	92.5	10.3	49.3	480	36.5	48.83	61.47	12.5	610.3
NKS	92.3	10.3	49.2	477	37.0	47.91	59.72	12.6	603.6
NPKS	95.0	11.2	51.8	508	40.4	56.39	71.15	13.0	733.0
CD (P=0.05)	0.41	0.21	0.32	14.5	1.36	4.61	6.11	0.19	75.14

Yield

Application of NPK fertilizers proved significantly superior to those of NP and NK application. The lowest yields among these three treatments were recorded with NK fertilizers. Application of sulphur with balanced and imbalanced fertilizer application increased the grain and straw yield of wheat (Table 1). Application of NPKS treatment increased the

grain and straw yield of wheat by 8.6 and 9.7% over alone NPK fertilizer application. Similarly, application of NPS and NKS also increased the grain and straw yield of wheat over NP and NK application, respectively. Thus, application of S with balanced NPK fertilizer application proved superior than that of application of S with imbalanced (NP and NK) fertilizer application. Grain yield of wheat is mainly governed by the number of tillers per unit area. As the S application increased the number of tillers and hence the grain yield. Application of S in soil increases the availability of sulphate (SO_4) sulphur in soil which may have helped the crop to achieve better growth and yield. Various other investigations have shown that the yield of wheat and yield components significantly responded to the application of sulphur fertilizer (Ram *et al.* 2014, Singh *et al.* 2015, Singh and Singh 2020 and Singh 2021).

Quality

The quality of wheat grain with different fertilizer application strategies was assessed through protein content. The mean value of protein content varied between 12.2 and 13.0% in different treatments (Table 1). Average protein content in wheat grain was highest (13.0%) with NPKS application and the lowest with NK application. Average protein content in wheat grain followed the trend similar to that overage gain yield and nitrogen content in wheat grain. Application of sulphur along with NP and NK fertilizers also improved the protein content in wheat over alone application of NP and NK fertilizers, respectively. Among the NP, NK and NPK fertilizer application, higher value of protein content was recorded under NPK application. Nitrogen, being the precursor of protein, increased grain protein content accordingly. This increase in protein content with S application along with balanced and imbalanced fertilizer application may be attributed to the fact that S is an integral part of S-containing amino-acids. Similar results were reported by Singh (2021). The protein yield increased significantly from 553.5 kg ha^{-1} with NK application alone to 733.0 kg ha^{-1} with NPKS treatment. The protein yield is more influenced by grain yield and thus followed almost trend similar to grain yield (Yadav and Singh, 2021).

Table 2: Effect of various treatments on the uptake of nutrients (kg ha^{-1}) by wheat crop (mean of 2 years)

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
NP	92.6	33.7	10.1	7.0	20.4	114.4	9.7	7.0
NK	89.8	32.3	9.1	5.8	21.3	114.5	9.0	6.4
NPK	106.0	39.0	11.9	7.8	25.4	130.0	11.4	8.4
NPS	99.1	35.5	11.7	8.6	22.4	120.0	11.7	8.6
NKS	97.8	34.6	11.0	7.5	23.0	117.2	11.5	9.0
NPKS	117.1	44.0	13.5	9.9	28.0	145.1	14.6	12.0
CD (P=0.05)	7.3	3.99	0.72	0.68	1.63	11.2	0.76	0.59

Nutrients uptake

Nitrogen uptake by wheat grain and straw increased significantly with application of NPK fertilizers over NP and NK fertilizers. The results indicated the importance of balanced fertilization in enhancing the absorption of nitrogen by the crop. Application of sulphur with balanced and imbalanced fertilization significantly increased the nitrogen uptake by wheat grain and straw averaged over two years, application of NPKS increased the N uptake by wheat grain and straw by 10.4 and 12.8% over NPK alone, respectively. Since N uptake is the product of N concentration and yield, so highest N uptake was also observed with NPKS treatment. Similar results were reported by Singh and Singh (2020). The mean uptake of phosphorus in wheat grain ranged from 9.1 to 13.5 kg ha^{-1}. The corresponding range for P uptake in straw was from 5.8 to 9.9 kg ha^{-1}. The highest mean P uptake by grain (13.5 kg ha^{-1}) and straw (9.9 kg ha^{-1}) was recorded under NPKS treatment. The P uptake by wheat crop under imbalanced (NP and NK) fertilizer application tended to decrease as compared to balanced fertilization indicating the adverse effect of imbalanced fertilization sulphur improves the growth of roots and shoots

of the plants in S deficient soil, so plant roots enhance the uptake rate of phosphorus. Application of S decreased the pH of an alkaline soil and increased P uptake as reported by Singh (2018).

The uptake of potassium by wheat grain and straw increased significantly with balanced fertilization (NPK) over imbalanced fertilizer application (NP and NK). Potassium uptake by wheat was further increased with S application along with imbalanced and balanced fertilizer application and maximum values of K uptake by grain (28 kg ha^{-1}) and straw (145.1 kg ha^{-1}) were recorded with NPKS treatment. Higher uptake of K by wheat crop might be due to higher grain and straw yield. Similar results were reported by Singh *et al.* (2015). The minimum values of K uptake by wheat grain (20.4 kg ha^{-1}) and straw (111.4 kg ha^{-1}) were recorded under NP treatment which may be due to omission of K application. There was a marked increase in sulphur uptake by wheat grain and straw with NPK application over NP and NK application. Sulphur uptake by wheat crop was further significantly increased with sulphur application along with NP, NK and NPK fertilizer application. The maximum values of sulphur uptake by wheat grain (14.6 kg ha^{-1}) and straw (12.0 kg ha^{-1}) were recorded with NPKS application. This could be due to the balanced nutritional environment inside the plant and higher photosynthetic efficiency which may favour better growth and crop yield and ultimately higher uptake of sulphur (Ram *et al.* 2014, Singh 2021). Minimum value of sulphur uptake by crop was recorded without sulphur application indicating the role of sulphur in crop production.

From the results, it may be concluded that the yield of wheat with sulphur application was higher in sulphur deficient soil. Balanced use of fertilizers with S application resulted in higher yield and uptake of nutrients by wheat crop. The production capacity of wheat grown in S-deficient soil was highest with NPKS application as compared to other treatments. The quality of wheat grain in terms of protein content also improved with balanced fertilization along with sulphur application.

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