Plant Archives Vol. 25, No. 1, 2025 pp. 777-780 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.000

EFFECT OF VARIOUS LEVEL OF NITROGEN AND SULPHUR ON GROWTH AND YIELD OF LATE SOWN WHEAT (*TRITICUM AESTIVUM* L.)

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(Date of Receiving-06-01-2025; Date of Acceptance-09-03-2025)

ABSTRACT

A field experiment was conducted during the *Rabi* season of 2023-24 at the Research Farm, Faculty of Agriculture, Tantia University, Sri Ganganagar in Factorial Randomized Block Design (FRBD) with three levels of nitrogen *viz.*, 80, 100, and 120 kg/ha, and three levels of Sulphur *viz.*, 20, 25, and 30 kg/ha. The experimental results revealed that nitrogen and Sulphur application significantly influence plant growth, yield attributes, and yield as well as economic of wheat cultivation. The significantly higher plant height, No. of leaves plant^{-1} and maximum No. of tillers per running meter and plant dry weight at 90 DAS as well as maximum Leaf Area Index of wheat were recorded with treatment combination of N_3S_3 (120 kg Nitrogen ha^{-1} + 30 kg Sulphur ha^{-1}). The significantly higher effective tillers, grains spike^{-1} and test weight (g) were recorded with treatment combination of N_3S_3 (120 kg Nitrogen ha^{-1} + 30 kg Sulphur ha^{-1}). Similarly, the significantly higher number of effective tillers per m^2, grain, straw and biological yield were recorded with treatment combination of N_3S_3 (120 kg Nitrogen ha^{-1} + 30 kg Sulphur ha^{-1}).

***Key words*:** FRBD, nitrogen, yield and Sulphur.

Introduction

Wheat (*Triticum aestivum* L.) is a staple food of the world and it is belonging to *poaceae* family. The India is one of the major wheats producing and consuming countries in the world. It is the most important food grain crop of the world which ranks second after rice in Asia and consumed by nearly 35% of the world population (Gadal *et al*., 2019). It is cultivated in 223.00 million hectares with the production of 687 million tones. In India total area under wheat cultivation is 34.1 million hectares with the production of 112.19 million tonnes with productivity of 3678 kg ha^{-1} (Anonymous, 2018). It contributes about 34% of the total food grain production of the country (Anonymous, 2023-24). Wheat ranks first in the world among the cereals both in respect of area (221.68 m ha) and production (798.2 million metric tonnes) with productivity of wheat 3.29 tonnes per hectare (Anonymous 2022). Rajasthan having second rank in wheat cultivated area of 3.25 million hectares as well as production of 11.32 million tonnes after pearl millet. The productivity of wheat in Rajasthan (37.60 q ha^{-1}) is much lower than other states *viz.*, Punjab and Haryana. Wheat is cultivated during the winter season in our country.

The nitrogen plays an important role in crop life. It is one of the most important nutrients needed by plants in large quantities. It is essential to know the best level of nitrogen application for getting a higher crop yield, so that maximum benefits could be achieved. In cereal crops, adequate nitrogen increases the plumpness of grains and their protein content (Kefale & Hawassa, 2016). Adequate nitrogen promotes vigorous vegetative growth and impart deep green color of foliage. Nitrogen had been recognized as one of the most limiting nutrients in higher crop productivity. Even under the best management practices, 30-50% of the applied N is lost and hence the farmer is compelled to apply more than the actual need of the crop to meet the losses (Mahmud *et al*., 2021). The loss of N not only harasses the farmers but it's also having hazardous impact on the environment**.** Higher application of chemical fertilizer for crop production cause

soil degradation and environmental pollution.

Increase in sulphur uptake by high yielding crops, leaching losses, wide spread soil erosion *etc.* are some of the important causes for occurrence of Sulphur deficiency in soil (Chaudhary *et al.*, 2023). It is estimated that annual crop uptake of Sulphur in India is about one million tonnes, whereas its addition through fertilizers is around 0.34 million tonnes, this gap is expected to be widened (Majumdar & Prakash, 2018). Unless it is bridged, sulphur deficiency could develop into a serious constraint in the crop production. sulphur shortage often impedes protein synthesis leading to accumulation of soluble nitrogen compounds. After entry into the plant, sulphate is the major form of transported as well as stored Sulphur (Nagesh *et al.*, 2024). The delivery of sulphate into plastids for assimilation, sulphate storage within the vacuoles, and the long-distance transport between organs to fulfill the source-sink demands during plant growth require specific sulphate transporter proteins. Sulphur is a building block of protein, enzymes and vitamins and is a key ingredient in the formation of chlorophyll. Sulphur is involved directly or indirectly in different metabolic pathways of plants and as a constituent of many metabolites. Sulphur deficient crop show stunted or tall spindly growth, general yellowing of younger leaves and reduced seed set. These compounds cause leaf crinkling and other morphological abnormalities (Zhou *et al.*, 2024). The total Sulphur requirement of wheat may approach the level of phosphorus. wheat takes up 12 to 15 kg sulphur ha^{-1} and for adequate nutrition 0.2 percent sulphur is desirable in wheat crop during mid-season (Aula *et al.*, 2019). It is an essential element for plant life and found in different amino acids *viz.*, cysteine, cystine and methionine. Its commercial uses are primarily in fertilizers, but it is also widely used in gunpowder, matches, Insecticide, and fungicide. The recognition of the importance of Sulphur for plant growth, vigour and crop yield as well as the nutritional importance of Sulphur for human and animal, has led to an increased emphasis on research on the sulphur fertilization (Mustafa *et al.*, 2022). The objective of the study is to check the effect of different Nitrogen and Sulphur levels, and its interaction effect on growth and yield of wheat.

Materials and Method

The experiment was conducted in *Rabi* Season of 2023-24 at Crop Research Farm, Department of Agronomy, Tantia University, Sri Ganganagar, Rajasthan, India. The experiment was conducted in Factorial Randomized Block Design (FRBD) using two factors and each factor having three levels and replicated thrice. Various growth and yield attributing traits studied where,

Table 1: Treatment combinations.

Sl. No.	Treat-ment	TC	Treatment Description
1.	T_1	N_1S_1	80 kg Nitrogen ha^{-1} + 20 kg Sulphur ha^{-1}
2.	T_2	N_1S_2	80 kg Nitrogen ha^{-1} + 25 kg Sulphur ha^{-1}
3.	T_3	N_1S_3	80 kg Nitrogen ha^{-1} + 30 kg Sulphur ha^{-1}
4.	T_4	N_2S_1	100 kg Nitrogen ha^{-1} + 20 kg Sulphur ha^{-1}
5.	T_5	N_2S_2	100 kg Nitrogen ha^{-1} + 25 kg Sulphur ha^{-1}
6.	T_6	N_2S_3	100 kg Nitrogen ha^{-1} + 30 kg Sulphur ha^{-1}
7.	T_7	N_3S_1	120 kg Nitrogen ha^{-1} + 20 kg Sulphur ha^{-1}
8.	T_8	N_3S_2	120 kg Nitrogen ha^{-1} + 25 kg Sulphur ha^{-1}
9.	T_9	N_3S_3	120 kg Nitrogen ha^{-1} + 30 kg Sulphur ha^{-1}
TC: Treatment combinations			

Growth attributes *viz.*, Initial plant population, Plant height, Number of tillers per running meter, Leaf area index (LAI) and Dry matter accumulation. Yield attributes *viz.*, Spike length, Number of grain $spike^{-1}$, Grain weight $spike^{-1}$, Test weight, Grain and straw yield, Harvest index. Treatment details given in Table 1.

Statistical analysis

Experimental data were processed in Microsoft Excel-2019 and analyzed with the help of analysis of variance (ANOVA) technique for Factorial Randomized Block Design (FRBD) (Gomez and Gomez, 1984). The significance of the treatments was tested using F test at 5% level of significance ($P \leq 0.05$) and means were compared using the critical difference (CD) test at $\alpha \leq 0.05$.

Results and Discussion

Effect of nitrogen and Sulphur on growth parameters

- **Plant height, number of leaves and leaf area**: Plant height, number of leaves and leaf area increased with increasing nitrogen levels (Table 2). Maximum plant height, number of leaves and leaf area was recorded with N3, followed by N2, while N1 resulted in the shortest plants and related traits. Among Sulphur treatments, S3 exhibited the highest plant height, number of leaves and leaf area which was statistically at par with S2, whereas S1 recorded the lowest height and related traits.

Nitrogen application might have increased the plant height due to its role in metabolism of growing plant. It is essential component of several enzyme systems which regulate the various metabolic activities of wheat plant. Similar effects were also reported by Pooniya & Shivay (2011). Plant height, number of leaves and leaf area increased with increasing levels of Sulphur up to 30 kg ha^{-1}. The increase in these parameters depend upon the better nourishment. Beneficial effect of Sulphur causes accelerates rate of photosynthesis, assimilation, cell division and vegetative growth. The increase in these parameters might be due to stimulation of cell division,

Table 2: Effect of different treatments on growth traits.

Treatment	PL	NLP	NTPRM	PDW	LAI
Nitrogen level					
N_1	93.49	45.00	131.32	144.18	2.48
N_2	95.30	45.87	133.86	146.97	2.52
N_3	102.99	49.57	144.67	158.83	2.73
SEd±	**3.06**	**1.47**	**4.30**	**4.72**	**0.08**
C.D. (P=0.05)	**6.26**	**3.01**	**8.79**	**9.65**	**0.17**
Sulphur level					
S_1	93.83	45.16	131.80	144.70	2.48
S_2	96.09	46.25	134.98	148.19	2.54
S_3	101.86	49.03	143.08	157.09	2.70
SEd±	**2.91**	**1.40**	**4.08**	**4.48**	**0.08**
C.D. (P=0.05)	**5.94**	**2.86**	**8.34**	**9.15**	**0.16**

PL: Plant height (cm); NLP: Number of leaves plant^{-1}; NTPRM: Number of tillers per running meter; PDW: Plant dry weight; LAI: Leaf area index

Table 3: Effect of different treatments on yield attributing traits.

Treatment	NET	NSP	SLP	NGS	TW
Nitrogen level					
N_1	459.26	12.49	12.86	35.35	42.43
N_2	468.15	12.73	13.11	35.84	43.25
N_3	505.93	13.76	14.16	37.92	46.74
SEd±	**30.10**	**0.41**	**0.42**	**1.80**	**1.39**
C.D. (P=0.05)	**61.47**	**0.84**	**0.86**	**2.30**	**2.84**
Sulphur level					
S_1	460.92	12.53	12.90	35.44	42.58
S_2	472.04	12.84	13.21	36.05	43.61
S_3	500.38	13.61	14.01	37.62	46.23
SEd±	**28.56**	**0.39**	**0.40**	**1.79**	**1.39**
C.D. (P=0.05)	**58.32**	**0.79**	**0.82**	**2.20**	**2.84**

NET: Number of effective tillers m^{-2}; NSP: Number of spike plant^{-1}; SLP: Spike length plant^{-1} (cm); NGS: Number of grains spike^{-1}; TW: Test weight (g)

elongation and enlargement. Similar findings were also reported by Das *et al*., (2011).

• **Number of tillers and dry matter accumulation:** Dry matter accumulation and number of tillers of wheat increased with increasing levels of nitrogen upto 40 kg ha^{-1} (Table 2). Favorable response of nitrogen in the plant system resulting in better growth and development with increasing levels of nitrogen, might have positive correlation with dry matter accumulation and number of tillers per m^2. Wasaya *et al*., (2017) also reported similar results.

Number of tillers and dry matter accumulation increased with increasing doses of Sulphur up to 30 kg ha^{-1}. Sulphur is not a constituent of chlorophyll but it takes part in the chlorophyll formation. It also associates in synthesis of vitamin B complex *viz*. biotin and thiamin, metabolism of carbohydrate and protein. Thus, Sulphur application might have influenced the vegetative growth. These results corroborate with findings of Panchal *et al*., (2008).

Effect of nitrogen and Sulphur on yield and yield attributing characters

• **Number of effective tillers per m^2, Number of Spike and spike length:** (Table 3) The highest number of effective tillers per m^2, number of spike and spike length were recorded with increasing levels up to 120 kg nitrogen ha^{-1} and 30 kg Sulphur ha^{-1} could be explained on the basis of balanced nutrient supply which enhanced cell division, photosynthesis and later on converted into reproductive phase results a greater number of effective tillers per m^2, number of spike and spike length. This may be because of improved physical condition of soil, thereby improving the efficiency in utilization of native as well as applied nutrients. The results closely related to findings of Usharani *et al*., (2019).

• **Number of grains per plant and test weight:** The maximum number of grains per plant and test weight also increased with increasing levels of nitrogen (Table 3). Application of nitrogen might have produced more dry matter after photosynthesis from vegetative parts to reproductive parts resulting in formation of a greater number of grains per plant and test weight. These results were closely related with findings of Bhattacharya & Bhattacharya, (2021).

The number of grains per plant and test weight also increased with increasing levels of Sulphur application. Sulphur application helps in vegetative and reproductive phase thus, it results in a greater number of grains per

Table 4: Effect of different treatments on yield.

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index
Nitrogen level			
N_1	38.33	58.86	39.44
N_2	40.08	61.43	39.48
N_3	41.65	63.39	39.65
SEd±	**0.83**	**1.29**	**0.006**
C.D. (P=0.05)	**1.76**	**2.73**	**0.013**
Sulphur level			
S_1	38.68	59.28	39.48
S_2	40.32	61.73	39.51
S_3	41.06	62.68	39.58
SEd±	**0.83**	**1.29**	**0.006**
C.D. (P=0.05)	**1.76**	**2.73**	**0.013**

plant and test weight. The results were in close conformity with the findings of Varghese *et al*., (2024).

- **Grain yield, straw yield and harvest index:** Application of nitrogen 40 kg ha^{-1} brought conspicuous effect on grain and straw yield (Table 4). However, harvest index varies at all. The yield and harvest index might have increased due to good improvement in growth and yield attributes by the application of nitrogen. Similar findings were also reported by Sharma & Bali, 2017).

The yield of grain and straw increased with increasing application of Sulphur up to 30 kg ha^{-1}. Yield was the resultant of co-ordinate effect of growth and yield attributing parameters. The variation in yield of grain and straw as well as harvest index by Sulphur application might be attributed to pivotal role of Sulphur in improving growth and development activities. Application of Sulphur also produced a greater number of grains per plant and test weight. These ultimately result in higher yield of grain and straw as well as harvest index. The findings are in accordance to Ram *et al*., (2014).

Conclusion

Based on the findings of the present investigation, it may be concluded that the wheat performed well with application of 120 kg Nitrogen and 30 kg Sulphur per hectare in terms of better growth, yield attributes and yield of wheat as well as better profitability. Based on the above findings it can recommended that wheat grown with application of 120 kg Nitrogen with 30 kg Sulphur per hectare can successfully sustain the productivity and profitability of wheat.

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