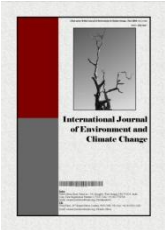

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Effect of Nitrogen and Sulphur on Yield and Economics of Wheat (*Triticum aestivum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *Rabi* 2021-20222 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36 %), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The experiment was laid out on Randomized Block Design with nine treatments each replicated thrice on the basis of one year experimentation. Variety of wheat DBW-187, Furrow Irrigated Raised Bed technique for irrigation. The treatments which are T_1: Nitrogen 80 kg/ha,+ Sulphur 15 kg/ha, T_2: Nitrogen 80 kg/ha + Sulphur 30 kg/ha, T_3: Nitrogen 80 kg/ha + Sulphur 45 kg/ha, T4: Nitrogen 100 kg/ha + Sulphur 15 kg/ha, T_5: Nitrogen 100 kg/ha + Sulphur 30 kg/ha, T_6: Nitrogen 100 kg/ha + Sulphur 45 kg/ha, T_7: Nitrogen 120 kg/ha + Sulphur 15 kg/ha, T_8: Nitrogen 120 kg/ha + Sulphur 30 kg/ha, T_9: Nitrogen 120 kg/ha + Sulphur 45 kg/ha are used. The results showed that application of Nitrogen 120 kg/ha + Sulphur 45 kg/ha was recorded significantly maximum No. of Grains/spike (47.34), Test weight (38.30 g), Grain yield (6.14 t/ha), Straw yield (9.52 t/ha), gross returns (Rs.99911.66/ha), net return (Rs.67591.73/ha) and benefit cost ratio (2.09) was obtained as compared to other treatments.

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1. INTRODUCTION

"Wheat (*Triticum aestivum* L.), which triggered Green revolution in the Indian subcontinent, is an important food grain providing nourishment nearly to 35 per cent people of the world. On global scale, the crop is grown over an area of 211.06 million ha with a production of 566.8million tonnes. India is the second largest producer of wheat in the world next only to China and the crop has provided the fastest pace of growth to Indian agriculture . Among cereals, wheat is next to rice in area (24.23 million ha) and production (75.6 million tonnes)" [1]. Wheat contributes around 60% of the daily protein requirement and more calories to the global diet than any other food crop. Wheat will continue to gain importance as a key staple food in the years to come, both from a grain productivity and quality point of view. One of India's most significant cereal crops, wheat has a variety of uses. Since soil nutrients have been greatly depleted as a result of intensive farming, crops' need for nutrients has grown significantly during the past few years.

The massive importance of wheat can be understood with the figures of grown area of 215.48 mha with annual production of 731.46 mt and productivity of 33.9 q/ha during 2018- 19 worldwide (USDA 2020). In India, huge portion of total cultivation devoted under this crop, nearly 29.14 mha area with annual production of 102.19 mt carrying average productivity of 3506.8 kg/ha in year 2018-19 (Pocket book of Agricultural Statistics 2019). Wheat is basically a temperate region crop but can also be grown under different sub-tropical and tropical conditions successfully. If we look at the current population growth rate of India which is 0.99%, in that manner the demand for wheat will reach 140 million tonnes in the country by the end of 2050. Under least possibility of area expansion under wheat cultivation, there is only way of vertical improvement as yield per unit of production area. There are considerable yield gaps between major wheat growing states in India viz. productivity of Punjab is 5183 kg/ha while productivity of Haryana, UP, Bihar and Uttarakhand is 4925 kg/ha, 3432 kg/ha, 2922 kg/h a and 2880 kg/ha respectively (Agricultural statistics at a glance 2019).

"The most important role of N in the plant is its presences in the structure of protein, the most important building substances from which the living material or protoplasm of every cell is made. In addition, nitrogen is also found in chlorophyll, the green colouring matter of leaves. Nitrogen occupies a conspicuous place in plant metabolism. All vital processes in plant are associated with protein, of which nitrogen is an essential constituent. Although greater N application has produced higher yields, this is not a linear relationship (see below) and there is an economic optimum application offsetting incremental yield increase against the cost of additional N inputs, which needs to be determined for individual cultivars" (Foulkes et al., 1998, King et al., 2003). Throughout all stages of crop development, the availability of N has an impact. It influences seedling establishment, tillering, canopy growth, and grain filling, all of which have the potential to influence final yield and together define the crop's N requirements. "Sulphur is another one of the essential nutrient in all plant nutrients and component of amino acids which are the building block of protein. In the cereal crops, sulphur contain in the ranges from 0.16 -0.20%. Sulphur performs many physiological functions like synthesis of sulphur containing amino acids which have positive role in improving quality of grain" [2]. "Sulphur is a structural constituent of organic compounds, some of which are uniquely synthesized by plants, providing human and animals with essential amino acids (methionine cystine and cysteine). It is involved in chlorophyll formation, activation of enzymes and is a part of vitamins biotin and thiamine (B1)" (Hegde and Sudhakara babu, 2007). Due to ongoing usage of sulphur-free fertilisers, high yielding crop types, intense multiple cropping systems, and better productivity, sulphur deficiency in crops is rapidly becoming more common.

2. MATERIALS AND METHODS

The current examination was carried out during *Rabi* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, UP, which is located at 25.28^{o}N latitude, 81.54^{o}E longitude and 98 m altitude above the mean sea level. The experiment laid out in Randomized Block Design which consisting of nine treatments with T_1: Nitrogen 80 kg/ha + Sulphur 15 kg/ha, T_2: Nitrogen 80 kg/ha + Sulphur 30 kg/ha, T_3: Nitrogen 80 kg/ha + Sulphur 45 kg/ha, T4: Nitrogen 100 kg/ha + Sulphur 15 kg/ha, T_5: Nitrogen 100 kg/ha + Sulphur 30 kg/ha, T_6:

Nitrogen 100 kg/ha + Sulphur 45 kg/ha, T_7: Nitrogen 120 kg/ha + Sulphur 15 kg/ha, T_8: Nitrogen 120 kg/ha + Sulphur 30 kg/ha, T_9: Nitrogen 120 kg/ha + Sulphur 45 kg/ha are used. The results showed that application of Nitrogen 120 kg/ha + Sulphur 45 kg/ha were replicated thrice.

The experimental site was uniform in topography and sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in Organic carbon (0.38%), medium available N (225 kg ha ^{1}), higher available P (19.50 kg ha^{1}) and medium available K (213.7 kg ha^{1}), EC (0.29 dS/m). Nutrient sources were DAP, MOP to fulfill the necessity of phosphorous and potassium. The fertilizers were applied as basal at the time of sowing. Whereas urea and gypsum are applied for Nitrogen and Sulphur as per the treatment details. Variety of wheat DBW-187, Furrow Irrigated Raised Bed technique for irrigation. Several yield parameters were recorded those parameters like No. of Grains/spike, Test weight, Grain yield, Straw yield were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984) and in economics part Cost of cultivation, net returns, gross returns and B: C ratio was calculated.

3. RESULTS AND DISCUSSION

3.1 Yield Attributes

3.1.1 Number of grains/spike

Significantly Maximum Number of Grain/spike (47.34) was recorded with the treatment of application of Nitrogen 120 kg/ha + Sulphur 45 kg/ha over all the treatments. However, the treatments Nitrogen 100 kg/ha + Sulphur 45 kg/ha (46.61) and Nitrogen 120 kg/ha + Sulphur 30 kg/ha (47.03) which were found to be statistically at par with Nitrogen 120 kg/ha + Sulphur 45 kg/ha. Significant increase in number of grains/spike is due to increase in higher doses of Nitrogen by which more spikelets are produced due to increased rates of spikelets primordial production, similar results were found by Bhatta et al., [3].

3.1.2 Test weight (g)

Significantly highest Test weight (38.30 g) was recorded with the treatment of application of Nitrogen 120 kg/ha + Sulphur 45 kg/ha over all the treatments. However, the treatments Nitrogen 100 kg/ha + Sulphur 45 kg/ha (37.67 g) and Nitrogen 120 kg/ha + Sulphur 30 kg/ha (38.00 g) which were found to be statistically at par with Nitrogen 120 kg/ha + Sulphur 45 kg/ha. The availability of sufficient sulphur throughout the entire period of crop growth for better vegetative growth and development of wheat was the reason for the increase in value of yield-contributing features with greater dosages of sulphur. The results were found to be similar with Sharma et al. [4]. Test weight, a crucial factor in predicting yield, is a hereditary trait and is least affected by the environment. This may be a result of more light energy conversion into chemical energy and subsequent transfer of that energy from source to sink. Similar findings were observed by Saha et al., [5].

3.1.3 Grain yield (t/ha)

Significantly highest Grain yield (6.14 t/ha) was recorded with the treatment application of Nitrogen 120 kg/ha + Sulphur 45 kg/ha over all the treatments. However, the treatments with (5.96 t/ha) in Nitrogen 100 kg/ha + Sulphur 45 kg/ha and with (6.05 t/ha) in Nitrogen 120 kg/ha + Sulphur 30 kg/ha which were found to be statistically at par with Nitrogen 120 kg/ha + Sulphur 45 kg/ha.

Grain yield was increased due to application of higher doses of nitrogen, which increases the photosynthetic activity and might have increased vegetative growth and yield attributes also improved ultimately increased grain yield. Similar findings have been observed by Pandey et al., [6].

“The increment in number of grains/spike with increasing dose of sulphur application might be better for root growth, cell multiplication, elongation and cell expansion in the plant body by higher dose of sulphur application, which ultimately increased the grain yield”. The results were found to be similar with Yadav et al. [7].

3.1.4 Straw yield (t/ha)

Significantly highest Straw yield (9.52 t/ha) was recorded with the treatment application of Nitrogen 120 kg/ha + Sulphur 45 kg/ha over all the treatments. However, the treatments with (9.23 t/ha) in Nitrogen 100 kg/ha + Sulphur 45 kg/ha and with (9.34 t/ha) in Nitrogen 120 kg/ha + Sulphur 30 kg/ha which were found to be statistically at par with Nitrogen 120 kg/ha + Sulphur 45 kg/ha. Adequate availability of

Table 1. Effect of nitrogen and sulphur on yield attributes and yield of wheat

Treatments	Grains/spike	Test Weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
1. Nitrogen 80 kg/ha + Sulphur 15 kg/ha	44.56	35.75	5.04	8.16	38.19
2. Nitrogen 80 kg/ha + Sulphur 30 kg/ha	44.87	36.05	5.17	8.33	38.30
3. Nitrogen 80 kg/ha + Sulphur 45 kg/ha	45.73	36.63	5.52	8.78	38.62
4. Nitrogen 100 kg/ha + Sulphur 15 kg/ha	45.16	36.26	5.35	8.54	38.49
5. Nitrogen 100 kg/ha + Sulphur 30 kg/ha	46.37	37.32	5.82	9.17	38.84
6. Nitrogen 100 kg/ha + Sulphur 45 kg/ha	46.61	37.67	5.96	9.23	39.24
7. Nitrogen 120 kg/ha + Sulphur 15 kg/ha	45.96	37.05	5.66	8.89	38.87
8. Nitrogen 120 kg/ha + Sulphur 30 kg/ha	47.03	38.00	6.05	9.34	39.30
9. Nitrogen 120 kg/ha + Sulphur 45 kg/ha	47.34	38.30	6.14	9.52	39.21
F test	**S**	**S**	**S**	**S**	**NS**
S. Em (±)	0.25	0.26	0.07	0.10	0.29
CD (P = 0.05)	0.75	0.76	0.21	0.31	-

Table 2. Effect of nitrogen and sulphur on economics of wheat

Treatments		Cost of cultivation	Gross returns	Net returns	B:C Ratio
1.	Nitrogen 80 kg/ha + Sulphur 15 kg/ha	30867.25	68373.33	37506.08	1.22
2.	Nitrogen 80 kg/ha + Sulphur 30 kg/ha	31200.26	73720.00	42519.74	1.36
3.	Nitrogen 80 kg/ha + Sulphur 45 kg/ha	31450.37	78794.00	47343.63	1.51
4.	Nitrogen 100 kg/ha + Sulphur 15 kg/ha	31635.04	77169.66	45534.62	1.44
5.	Nitrogen 100 kg/ha + Sulphur 30 kg/ha	31124.87	86935.00	55810.13	1.79
6.	Nitrogen 100 kg/ha + Sulphur 45 kg/ha	31885.15	94079.66	62194.51	1.95
7.	Nitrogen 120 kg/ha + Sulphur 15 kg/ha	31736.81	83721.00	51984.19	1.64
8.	Nitrogen 120 kg/ha + Sulphur 30 kg/ha	32069.82	97428.33	65358.51	2.04
9.	Nitrogen 120 kg/ha + Sulphur 45 kg/ha	32319.93	99911.66	67591.73	2.09

nutrients resulted in enhanced growth attributes and yield attributes. Incorporation of biofertilizer not only increased the growth and yield attributing characters but also increased the straw yields of wheat, reported by Kaur et al., [8]. “Straw yield is dependent on vegetative growth as use of balanced and optimum use of fertilizer increased plant height, green leaves per hill, and dry matter production, which finally resulted in higher straw yield”. The results were in accordance with Jat et al. [9].

3.1.5 Harvest index (%)

There was no significant difference among the treatments. However, highest harvest index (39.30%) was recorded with the treatment application of Nitrogen 120 kg/ha + Sulphur 45 kg/ha, whereas, lowest harvest index (38.19%) was recorded with the application of Nitrogen 80 kg/ha + Sulphur 15 kg/ha.

"Highest harvest index was observed due to improved cell activities, enhanced cell multiplication and enlargement and luxuriant growth and yield attributes of the crops probably due to more absorption and utilization of available nutrients leading to overall improvement of crop growth reflected to source-sink relationship, which in turn enhanced the yield attributes that ultimately more yield" which was reported by Singh et al., [10,11].

3.2 Economics

3.2.1 Gross returns (INR/ha)

Data in Table 2 revealed that Higher Gross returns have been recorded with the Nitrogen 120 kg/ha + Sulphur 45 kg/ha (Rs.99911.66/ha) over rest of the treatments followed by Nitrogen 120 kg/ha + Sulphur 30 kg/ha (Rs.97428.33/ha) whereas minimum gross return was recorded with Nitrogen 80 kg/ha + Sulphur 15 kg/ha (Rs.68373.33/ha).

3.2.2 Net returns (INR/ha)

Data in Table 2 revealed that Higher Net returns have been recorded with the treatment Nitrogen 120 kg/ha + Sulphur 45 kg/ha (Rs.67591.73/ha) over rest of the treatments followed by Nitrogen 120 kg/ha + Sulphur 30 kg/ha (Rs.65358.51/ha) whereas minimum Net returns was recorded with Nitrogen 80 kg/ha + Sulphur 15 kg/ha (Rs.37506.08/ha).

3.2.3 Benefit cost ratio (B: C)

Data in Table 2 revealed that Higher Benefit cost ratio have been recorded with the treatment Nitrogen 120 kg/ha + Sulphur 45 kg/ha (2.09) over rest of the treatments followed by Nitrogen 120 kg/ha + Sulphur 30 kg/ha (2.04) whereas lower Benefit cost ratio was recorded with Nitrogen 80 kg/ha + Sulphur 15 kg/ha (1.22).

4. CONCLUSION

It is concluded that application of treatment Nitrogen 120 kg/ha + Sulphur 45 kg/ha was recorded significantly higher Grain yield (6.14 t/ha), higher gross returns (Rs.99911.66/ha), net returns (Rs.67591.73/ha) and benefit cost ratio (2.09) as compared to other treatments. Since, the findings based on the research done in one season.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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