International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(12): 211-215
www.biochemjournal.com
Received: 18-10-2025
Accepted: 22-11-2025

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Effect of Sulphur and Foliar spraying Nano Urea on growth and yield of Wheat (*Triticum aestivum* L.)

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DOI: https://www.doi.org/10.33545/26174693.2025.v9.i12Sc.6493

Abstract

Wheat (*Triticum aestivum* L) ranked first in the world for both acreage and production of cereals. Known as the "king of cereals," wheat is a member of the Poaceae family. A cereal grain that is a staple diet around the world, wheat is a grass that is frequently produced for its seed. In the majority of the planet, wheat is grown. During the Rabi season of 2024, the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) conducted an experiment titled "Effect of Sulphur and Foliar spraying Nano Urea on growth and yield of Wheat (Triticum aestivum L.)." The three levels of Sulphur (15, 20, and 25 kg/ha) and nano urea (2, 3 and 4 ml/lit). Ten treatments were administered to each replicant three times in a Randomized Block Design experiment. The experimental field soil had a sandy loam texture, a pH of 7.2, a medium level of available organic carbon (0.662%), a low level of available nitrogen (249.5 kg/ha), and a very high level of accessible potassium (240.8 kg/ha) and phosphorus (28.7 kg/ha). Higher plant height (100.23 cm), more tillers per plant (76.49), and higher dry weight (28.67g) were all substantially higher growth metrics, according to the results. greater test weight (30.7 g), more effective tillers/plants (12.25), more grains/spike (47.60), more grain yield (4.90 t/ha), more straw yield (8.38 t/ha), and the highest harvest index (46.73%) was recorded in treatment 9 [Nano Urea 4 ml/lit + Sulphur 25 kg/ha]. In comparison to the control, treatment 9 [Sulphur 25 kg/ha + Nano Urea 4 ml/lit] had the highest gross return (1,54,405 INR/ha), net return (1,03,109.85 INR/ha), and benefit cost ratio (2.01).

Keywords: Wheat, Sulphur, Nano Urea, growth, yield and economics

Introduction

Wheat (*Triticum aestivum* L) places first in the world for both acreage and production of cereals. Wheat is a member of the Poaceae family and is referred regarded as the "king of cereals." A cereal grain that is a staple diet worldwide, wheat is a grass that is frequently produced for its seeds. In most regions of the world, wheat is grown. For most people in both industrialized and developing nations, it is a staple diet. In terms of nutritional value, wheat is comparable to other significant cereals. Compared to other cereals, it has a higher protein content. Wheat contains 60-68% starch, 8-15% protein, fat, sugar, cellulose, minerals, and vitamins. Approximately 220 million hectares of wheat are grown worldwide, with a record production of 763.06 million tons of grain. India has the largest area planted to wheat (14%), followed by Russia (12.43%), China (11.14%), and the USA (6.90%), which combined make up almost 45% of the world's total area. With a record production of 136 million tonnes, China is the leading producer of wheat, followed by India (98.51 mt), Russia (85 mt), and the United States (47.35 mt). Traditional wheat-growing nations like China, India, Russia, the United States, Canada, Ukraine, and Pakistan have produced about 449 million tons of wheat, or 58% of the total. In India, the Rabi season is when wheat is grown. Typically, it is planted in November and harvested in March or April. At the national level, wheat cultivation has increased from 29.04 million hectares to 30.54 million hectares, representing a net gain in area of 1.5 million hectares (5%). With 9.75 million hectares (32%), Uttar Pradesh has the greatest area share, followed by Madhya Pradesh (18.75%), Punjab (11.48%), Rajasthan (9.74%), Haryana (8.36%), and Bihar (6.82%). The two main factors that significantly increased the area under wheat production were the government's procurement and the substantial increase in the minimum support price.

The amount of Sulphur (S) in these crops has a significant impact on the production quality. Proteins, vitamins, and chlorophyll are all dependent on Sulphur. One of the primary causes the lack of Sulphur in Indian soils is the use of fertilizers devoid of Sulphur. For oilseed crops to grow well, a balanced fertilizer that includes Sulphur is required. One of the most crucial elements in raising yields is the use of Sulphur. Amino acid synthesis, protein synthesis, chlorophyll, and oil production all depend on Sulphur. Sustained production of high yield levels requires the balanced usage of Sulphur in accordance with crop requirements and soil nutrient condition. The synthesis of proteins, lipids, and vitamins depends on Sulphur. It is necessary for the synthesis of proteins and contains amino acids. Dry matter production was considerably higher due to the application of N and P as well as the sources and amounts of S; however, the application of gypsum resulted in even higher dry matter production. The primary reasons of a Sulphur deficiency are greater crop yields, which lead to a higher rate of sulfate removal by crops, and reduced use of fertilizers containing sulphur.

The goal of nano urea, a low concentration liquid fertilizer made possible by nanotechnology, is to fertilize plants in an effective and sustainable way. By improving nitrogen use efficiency, environmental effect, and likely crop yields, it provides a superior alternative to traditional urea. However, in agriculture, nano fertilizers provide a significant amount of nutrients that enhance crop growth, yield, and quality indices. They improve fertilizer usage efficiency, reduce production costs, and are highly effective in precisely controlling nutrients in precision agriculture. According to Qureshi *et al*. (2018), nano fertilizers provide plants more surface area to respond to various metabolic processes. This increases the rate of photosynthesis, which in turn increases the generation of dry matter and crop output. One of the goods that has transformed the nation's agriculture is nano urea, which is produced by several firms. By starting to produce nano urea commercially, India has advanced to become the world's second-largest user. The Fertilizer Control Order of 1985 covers nano urea, which is the only nano fertilizer authorized by the Indian government. According to Rani *et al*. (2024) [15], nitrogen nano-fertilizer formulations may lessen nitrogen loss by leaching, emissions, and soil microbial immobilization. Due to their importance in increasing agricultural yields, micronutrients play a major role in the growth and development of plants. In actuality, their contribution to improving soil productivity and plant nutrition is crucial, making it much more significant. Due to the use of high analysis main and secondary nutrient fertilizer and intensive crop cultivation with high yielding varieties, Abbas *et al*. (2020) [1] showed high levels of occurrence of micronutrient deficiencies.

Material and Methods

During the Rabi season of 2024, a field study on the "Effect of Sulphur and Foliar spraying Nano Urea on growth and yield of Wheat (Triticum aestivum L.)" was carried out at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.). The experimental field's soil had a sandy loam texture, a pH of 7.1, a low amount of organic carbon (0.48%), available N (87.0 kg/ha), available P (20.5 kg/ha), and available K (225.0 kg/ha). Ten treatments and three replications were used in the Randomized Block Design experiment. The treatment combinations are., T_1: Sulphur 15 kg/ha + Nano Urea 2 ml/lit, T_2: Sulphur 15 kg/ha + Nano Urea 3 ml/lit, T_3: Sulphur 15 kg/ha + Nano Urea 4 ml/lit, T_4: Sulphur 20 kg/ha + Nano Urea 2 ml/lit, T_5: Sulphur 20 kg/ha + Nano Urea 3 ml/lit, T_6: Sulphur 20 kg/ha + Nano Urea 4 ml/lit, T_7: Sulphur 25 kg/ha + Nano Urea 2 ml/lit, T_8: Sulphur 25 kg/ha + Nano Urea 3 ml/lit, T_9: Sulphur 25 kg/ha + Nano Urea 4 ml/lit, T_{10}: Control (150-60-40 NPK kg/ha). Using a hand hoe, 4-5 cm deep furrows were dug along the seed rows to deliver nutrients as a spreading technique. Once germination occurred, the gaps were closed by transplanting ten days following sowing. Seedlings were clipped off as needed to keep a distance of 25 cm by 10 cm. Intercultural operations were conducted between 25 and 45 DAS intervals to lower crop density and weed competition. The crop was harvested on October 12, 2024. Plant growth characteristics, including plant height (cm), dry weight (g/plant), CGR, and RGR, were measured at regular intervals from germination until harvest. At 25, 50, 75, and 100 DAS, yield metrics were measured at harvest, including spikes/plant, seed/spikes, test weight (g), seed yield (kg/ha), straw yield (kg/ha), and harvest index (%). The observed data of ten treatments were statistically examined using analysis of variance (ANOVA) in relation to randomized block design (Gomez and Gomez, 1984).

Result and Discussion

Growth and Yield attributes

Plant height (cm)

There were notable variations amongst the treatments. The effects of iron and nano urea on wheat plants were found to steadily increase with crop age, peaking at harvest. Treatment 9 [Sulphur 25 kg/ha + Nano Urea 4 ml/lit] showed a significant and greater plant height (100.23 cm) at 100 DAS. Nevertheless, it was discovered that treatment T_8 [Sulphur 25 kg/ha + Nano Urea 3 ml/lit] was statistically comparable to treatment T_9. The high absorption of nitrogen, protein synthesis, cell division, elongation, and iron's aiding role in enzymatic activities and chlorophyll creation could all account for the significant increase in plant height caused by the addition of nano urea: 3.5 ml/l with iron 0.75%. Kumar *et al.* (2021) [8] reported the same outcomes. This is because plant growth regulators' retardant qualities cause a notable decrease in plant height throughout the growing season, even with a higher nitrogen dosage. Kesarwani *et al*. (2018) [9] reported similar results.

Plant dry weight (g)

The dry weight of wheat that was sown and cultivated in the study gradually increased at 100 DAS. Treatment 9 [Sulphur 25 kg/ha + Nano Urea 4 ml/lit] had a significant and maximum plant dry weight (28.67 g) that was statistically comparable to treatment T_9. T_8 [Sulphur 25 kg/ha + Nano Urea 3 ml/lit], nevertheless, The increased nitrogen supply, which improved morphological traits, photosynthetic, and nutritional uptake and hastened the accumulation of dry matter, was the explanation for the significant growth in the dry weight of Nano urea 4 ml/l with Sulphur 25 kg/ha. Iron's function in chlorophyll and enzyme activity also contributed to biomass production. These findings are consistent with the findings by Saurabh *et al.* (2019) [16] and Kumar *et al.* (2021) [8].

Number of effective tillers/plants

Application of [Sulphur 25 kg/ha + Nano Urea 4 ml/lit] in Treatment 9 showed notable and increased effective tillers (12.25). Nonetheless, it was discovered that treatment T_8

[Sulphur 25 kg/ha + Nano Urea 3 ml/lit] and treatment T_7 [Sulphur 25 kg/ha + Nano Urea 2 ml/lit] were statistically equivalent to treatment T_9. The greatest number of productive tillers or plants can be attributed to an adequate supply of nitrogen, which promotes improved root development and increased nutrient absorption. Applying Sulphur also aids with encouraging the growth enzymes that initiate tillers. Dubey *et al*. (2018) [3] also reported similar results.

Number of Grains/spikes

Treatment 9 [Sulphur 25 kg/ha + Nano Urea 4 ml/lit] showed a significant and maximum number of grains/spike (47.60). On the other hand, it was discovered that treatment T_8 [(Sulphur 25 kg/ha + Nano Urea 3 ml/lit)] and treatment T_7 [Sulphur 25 kg/ha + Nano Urea 2 ml/lit] were statistically equivalent to treatment T_9. Better nitrogen uptake and efficient photosynthate translocation to the spike during the grain filling stage may be the cause of higher grains/spike. Dubey *et al*. (2018) [3] and Narayan *et al*. (2017) [11] both reported similar results. This could be because the use of a plant growth regulator decreased the plants' height and growth, which causes photosynthates to be converted to the plant's reproductive organs. which causes formation of more Number of grain/spikes (Gupta *et al*. 2019) [6].

Test Weight (g)

Although there was no discernible difference between the other treatments, treatment T_9 [Sulphur 25 kg/ha + Nano Urea 4 ml/lit] had a higher test weight (30.47g). The results showed that these treatments were not significant. Zinc-enhanced enzymatic activity involved in grain filling and protein and starch buildup may be the cause of higher test weight. Muhammad *et al*. (2017) [10] also reported similar findings.

Grain Yield (t/ha)

The highest grain yield (4.90 t/ha) was recorded by Treatment 9 [Sulphur 25 kg/ha + Nano Urea 4 ml/lit]. Nevertheless, it was discovered that treatment T_8 [Sulphur 25 kg/ha + Nano Urea 3 ml/lit] and treatment T_7 [Sulphur 25 kg/ha + Nano Urea 3 ml/lit] were statistically comparable to treatment T_9. A bigger, photosynthetically active canopy is produced by adequate nitrogen levels, increasing the amount of energy the plant can produce to support grain formation (Singh *et al*., 2005) [17]. The application of a plant growth regulator may have increased the amount of dry matter accumulated in the grain and the number of grains per spike, resulting in a higher grain yield. Rahman *et al*. (2011) [14] also corroborated this conclusion. Bahrami *et al*. (2014) [2] also found that height reduction at tillering led to higher tiller survival and enhanced fertile tillers, which resulted in higher yield.

Straw Yield (t/ha)

Treatment 9's application of [Sulphur 25 kg/ha + Nano Urea 4 ml/lit] resulted in a higher stover yield (8.38 t/ha). Nevertheless, it was discovered that treatment T_8 [Sulphur 25 kg/ha + Nano Urea 3 ml/lit] and treatment T_7 [Sulphur 25 kg/ha + Nano Urea 3 ml/lit] were statistically comparable to treatment T_9. considerably increased stover yield; this could be the result of better development in terms of plant height, dry matter accumulation, and seedling emergence, all of which increase photosynthetic efficiency. Similar to Upendra *et al*. (2014) [20], more photosynthetic accumulation in vegetative components results in superior vegetative development, which raises stover production.

Harvest Index (%)

Although there was no discernible difference between the other treatments, treatment T_9 [Sulphur 25 kg/ha + Nano Urea 4 ml/lit] had the highest harvest index (46.73%). The effective allocation of dry matter to reproductive tissues may be the cause of this.

Economics

The table displays information on the economics as affected by different treatments. 3. The economics of growing wheat The following are shown: net return, cultivation costs, gross returns, and benefit cost ratios for various treatments.

Cost of cultivation (INR/ha)

Cost of cultivation (51295.15 INR/ha) was found to be highest in treatment T_9 [Sulphur 25 kg/ha + Nano Urea 4 ml/lit].

Gross return (INR/ha)

Gross returns (154405.00 INR/ha) were found to be highest in treatment T_9 [Sulphur 25 kg/ha + Nano Urea 4 ml/lit].

Net returns (INR/ha)

Data pertaining to the net returns as influenced by various treatments are presented in Table Net returns (103109.85 INR/ha) was found to be highest in treatment T_9 [Sulphur 25 kg/ha + Nano Urea 4 ml/lit].

4.3.4 Benefit cost ratio (B:C)

Treatment 9 [Sulphur 25 kg/ha + Nano Urea 4 ml/lit] was shown to have the highest benefit cost ratio (2.01), according to data on the B:C ratio as affected by several treatments. The application of Sulphur resulted in higher gross return, net return, and benefit cost ratios, which may have been caused by improved growth and yield characteristics that increased the production of grain and straw. comparable outcome published by Dubey *et al.* (2018) [3].

Conclusion

The highest plant height, plant dry weight, number of spikes per square meter, number of grains per spike per square meter, grain yield, and straw yield for wheat were found when nano urea 3.5 ml/l and iron 0.75% were applied.

Acknowledgement

The authors express their gratitude to Dr. Joy Dawson, Professor and Head of the Department of Agronomy, Naini Agricultural Institute, Prayagraj, Sam Higginbottom University of Agriculture Technology and Sciences, (U.P.) India, for providing the facilities required to carry out the research.

Table 1: Influence of Sulphur and Nano urea on growth attributes of Wheat.

S. No	Treatment combination	Pre Harvest Observation	
		Plant Height (cm)	Plant Dry weight (g)
1	Sulphur 15 kg/ha + Nano Urea 2 ml/lit	90.93	25.94
2	Sulphur 15 kg/ha + Nano Urea 3 ml/lit	91.70	26.24
3	Sulphur 15 kg/ha + Nano Urea 4 ml/lit	92.75	26.65
4	Sulphur 20 kg/ha + Nano Urea 2 ml/lit	93.32	27.04
5	Sulphur 20 kg/ha + Nano Urea 3 ml/lit	94.75	27.26
6	Sulphur 20 kg/ha + Nano Urea 4 ml/lit	95.51	27.76
7	Sulphur 25 kg/ha + Nano Urea 2 ml/lit	96.21	28.01
8	Sulphur 25 kg/ha + Nano Urea 3 ml/lit	98.62	28.22
9	Sulphur 25 kg/ha + Nano Urea 4 ml/lit	100.23	28.67
10	Control (150-60-40 NPK kg/ha)	78.18	22.98
	F - Test	S	S
	S.Em (±)	2.71	0.52
	CD (p = 0.05)	8.6	2.41

Table 2: Influence of Sulphur and Nano urea yield and yield attributes of Wheat.

S. No		No. of Effective tillers/plant	No. of grains/ Spike	Test Weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
1	Sulphur 15 kg/ha + Nano Urea 2 ml/lit	9.71	38.19	29.66	3.68	5.19	40.95
2	Sulphur 15 kg/ha + Nano Urea 3 ml/lit	9.97	38.11	29.94	3.75	5.45	40.42
3	Sulphur 15 kg/ha + Nano Urea 4 ml/lit	10.35	35.02	29.99	3.95	5.93	39.58
4	Sulphur 20 kg/ha + Nano Urea 2 ml/lit	10.56	39.92	29.54	4.02	6.24	38.78
5	Sulphur 20 kg/ha + Nano Urea 3 ml/lit	10.97	40.72	28.06	4.09	6.52	38.32
6	Sulphur 20 kg/ha + Nano Urea 4 ml/lit	11.29	42.33	29.77	4.16	6.96	37.58
7	Sulphur 25 kg/ha + Nano Urea 2 ml/lit	11.47	42.78	29.32	4.28	7.16	37.20
8	Sulphur 25 kg/ha + Nano Urea 3 ml/lit	11.80	46.53	29.49	4.46	7.45	37.36
9	Sulphur 25 kg/ha + Nano Urea 4 ml/lit	12.25	47.60	30.47	4.90	8.38	36.95
10	Control (150-60-40 NPK kg/ha)	8.56	37.98	28.31	3.63	4.13	46.73
	F - Test	S	S	NS	S	S	NS
	S.Em (±)	0.38	1.96	0.67	0.16	0.23	1.08
	CD (p = 0.05)	1.13	5.85	-	0.48	0.70	-

Table 3: Influence of Sulphur and Nano Urea on Economics of Wheat.

S. No.	Treatment Combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1.	Sulphur 15 kg/ha + Nano Urea 2 ml/lit	46083.79	109340.00	63256.21	1.37
2.	Sulphur 15 kg/ha + Nano Urea 3 ml/lit	47901.97	113577.15	65675.18	1.38
3.	Sulphur 15 kg/ha + Nano Urea 4 ml/lit	49720.15	119517.5	69797.35	1.40
4.	Sulphur 20 kg/ha + Nano Urea 2 ml/lit	46871.29	122883.00	76011.71	1.62
5.	Sulphur 20 kg/ha + Nano Urea 3 ml/lit	48689.47	126032.50	77343.03	1.58
6.	Sulphur 20 kg/ha + Nano Urea 4 ml/lit	50507.65	130241.75	79734.10	1.58
7.	Sulphur 25 kg/ha + Nano Urea 2 ml/lit	47658.79	133910.00	86251.21	1.80
8.	Sulphur 25 kg/ha + Nano Urea 3 ml/lit	49476.97	139620.50	89843.53	1.81
9.	Sulphur 25 kg/ha + Nano Urea 4 ml/lit	51295.15	154405.00	103109.85	2.01
10	Control (150-60-40 NPK kg/ha)	40206.52	101981.25	61775.25	1.51

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