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Effect of nitrogen and sulphur levels on growth and yield of sunflower (*Helianthus annuus* L.)

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Abstract
A field experiment was conducted during *kharif* season of 2021, at crop research farm of Department of Agronomy at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj in North Eastern plains of Eastern Uttar Pradesh with the objective to study the effect of nitrogen and sulphur on growth and yield Sunflower (*Helianthus annuus* L.) Var. DRSH - 1 under Randomized block design comprising of 10 treatments of which treatment T_1 is control and (T_2-T_{10}) with different combination of nitrogen along with sulphur which are replicated thrice. The experimental results revealed that application of 120 kg N/ha + 45 kg S/ha recorded Maximum plant height (150.36 cm), plant dry weight (60.53 g), test weight (40.57 g), Capitulum diameter (15.63 cm), seed yield (1446.20 kg/ha) and stover yield (2794.39 kg/ha).

Keywords: Growth, nitrogen, sulphur, sunflower, yield

Introduction
Oil seed production ranks second in importance next to food production. The shortage of edible oil has become a chronic economic and dietary problem in India with increasing demographic pressure. To increase the production of existing oilseeds and to bridge the gap between demand and supply, several attempts were made in the country during recent past through horizontal and vertical expansion including introduction of new oilseed crops for enhancing the oilseed production. Sunflower (*Helianthus annuus* L.) crop, native of South America and Mexico was introduced into India in the year 1969 with a view to supplement the yield of traditional oilseed crops. It has established as an efficient oilseed crop and replaced several less profitable crops and also as a contingent crop under adverse climatic conditions, an intercrop and option as a catch crop in multiple cropping systems.

Sunflower is one of the most important oil seed crops grown in temperate countries. It is a major source of vegetable oil in the world. In India it has gained popularity due to the national priority of vegetable oil production. India is one of the largest producers of oilseed crop in the world. Oilseeds occupy an important position in the Indian agricultural economy. It is an important oil seed crop contributes 14% of the total oilseed production from other major oil seed crops. The genus Helianthus means Helio = Sun, anthus = flower. Sunflower is known as 'suryajmuki'. It is the third most important oilseed crop of world after Soyabean, Rapeseed & Mustard. The helio tropic movement is of great importance.

Sunflower is one of the fastest growing oilseed crops in India. Farmers find sunflower as a highly profitable crop, especially in Southern peninsula, consisting of Northern Karnataka, Marathwada and Rayalaseema, where the crop is largely cultivated under rainfed conditions during late kharif/rabi season. Karnataka accounts for nearly half the area under sunflower in the country and ranks first with respect to area and production followed by AP. The highest productivity was recorded by UP followed by Tamil Nadu.

Sunflower oil is considered as premium when compared to other vegetable oils. Sunflower is the oil of preference among the consumers the world over due to its health appeal and in India too, sunflower oil is the largest selling oil in the branded oil segment. Sunflower oil content varies from 48-53% and it is premium oil with pale yellow in colour used for cooking and margarine. Sunflower is a rich source of linoleic acid (64%) which helps in reducing cholesterol deposition in the coronary arteries of the heart. Oil contains high level of alpha tocopherol, a form of vit. E. Sunflower is also a crop of choice for farmers due to its wider adaptability, high yield potential, shorter duration and profitability.

Among nutrients, nitrogen plays an important role in growth and yield of sunflower. Nitrogen is crucial for growth and development while, sulphur fertilization is most critical for oil and protein synthesis besides seed yield enhancement. The nitrogen requirement for sunflower is high. Oil content in sunflower seed is also affected by changes in the proportion of nitrogen. Nitrogen plays an important role in increasing the productivity of sunflower. Nitrogen is a major essential element and is responsible for increasing the photosynthetic surface area and in turn increases the translocation of photosynthates to sink and results in increase in productivity.

Several workers have reported that, application of optimum dose of sulphur to sunflower crop receiving an adequate supply of nitrogen enhances both quantity and quality of the produce (Legha and Giri, 1999 and Ajai singh *et al*. 2000) [4, 1]. N loss is more prone in light textured soils. Organic manure is source of both N and S. Intensive cultivation with high yielding varieties, continuous use of S – free high analysis fertilizers and declining addition of organic manures is resulting in low organic matter, low fertility and low N and S, Prolonged use of chemical fertilizers alone in intensive cropping system leads to low or no organic manure and is gradually resulting in low organic carbon in soil. Hence, working our optimum dose of N and S is crucial for different soils for realizing higher yields.

Chorey and Thosar (1997) [3] indicated that the productivity of the crop is limited to the extent of 54% due to inadequate and imbalanced application of fertilizers. In recent days, poor seed setting in lower oil recovery percentage and large percentage of hollow seeds in its capitulum with poor germination is increasing due to crop cultivation under low fertility soils.

Sunflower crops removes about 63.5 kg N, 10.9 kg P, 105 kg K and 11.6 S per ton of seed yield (Aulakh *et al*. 1985) [2]. After N, P and K, S is the fourth nutrient, whose deficiency is wide spread in India (Sakal *et al*. 2001) [8]. N and S deficiencies are common as the crop is grown mostly on energy starved conditions with poor organic matter content.

Reports from 12 Indian State Co-operative studies of TSI, FAI and IFA at National centers revealed that an average 30-35% of cropped soils were deficit in S and another 35% potentially deficient indicating wide spread soil S hunger. Sulphur deficiency is observed primarily due to high crop yield and S removal by crops along with use of S-free fertilizers and no organic manures or crop residues.

Sulphur is important nutrient for sunflower. Sulphur is also increasingly being recognized as the fourth major plant nutrient next to nitrogen, phosphorus and potassium. For oil crop producers, S fertilizer is especially important because oil crops require more sulphur than cereal grains. Sulphur is best known for its role in the synthesis of cysteine, methionine, chlorophyll and oil content of oil seed crops. Hence, an experiment was planned to study the influence of N, S on productivity of sunflower.

Materials and Methods

A field experiment was conducted during kharif season of 2021, at Crop research farm of Department of Agronomy at Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj which is located at 25º 24' 42" N latitude, 81º 50' 56" E longitude and 98 m altitude above the mean sea level (MSL). To assess the effect of nitrogen and sulphur on growth and yield of Sunflower (*Helianthus annuus* L.). The experiment was laid out in Randomized Block Design comprising of 10 treatments which are replicated thrice. Each treatment net plot size is 3m × 3m. The treatment are categorized as with recommended dose of Nitrogen through Urea, Phosphorus through DAP and Potash through Muriate of Potash, in addition with sulphur when applied in combinations as follows, (T_1) Control, (T_2) 60 kg N/ha + 15 kg S/ha, (T_3) 60 kg N/ha + 30 kg S/ha, (T_4) 60 kg N/ha + 45 kg S/ha, (T_5) 80 kg N/ha + 15 kg S/ha, (T_6) 80 kg N/ha + 30 kg S/ha, (T_7) 80 kg N/ha + 45 kg S/ha, (T_8) 120 kg N/ha + 15 kg S/ha, (T_9) 120 kg N/ha + 30 kg S/ha, (T_{10}) 120 kg N/ha + 45 kg S/ha. The sunflower crop was harvested treatment wise at harvesting maturity stage. Growth parameters *viz*. plant height (cm), dry matter accumulation (g/plant) were recorded manually on five randomly selected representative plants from each plot of each replication separately and after harvesting, seeds were separated from each net plot and were dried under sun for three days. Later winnowed, cleaned and grain yield/ha was computed and expressed in kg/hectare. After complete drying under sun for 10 days stover yield from each net plot was recorded and expressed in kg/hectare. The data was computed and analysed by following statistical method of Gomez and Gomez (1984). The benefit: cost ratio was worked out after price value of seed with stover and total cost included in crop cultivation.

Results and Discussion

Effect of nitrogen and sulphur on growth parameters:

Plant height

It is evident from Table 1. that plant height measured increased with advancement in crop growth. At harvest the treatment T_{10} (120 kg N/ha + 45 kg S/ha) recorded maximum height of 150.36 cm. At harvesting stage maximum plant height was measured in T_{10} and treatments T_9 is found statistically at par to T_{10}. Plant height of sesame was influenced by nitrogen and sulphur. The increase in plant height with higher levels of nitrogen was probably due to its beneficial effect on cell elongation which might have resulted in internodal elongation. Thus, adequate supply of nitrogen (120 kg N/ha) might have helped the plants to grow taller in comparison to 60 and 80 kg N/ha. Similar findings were also reported by Taha *et al*. (2001) [13] and Sarkar and Mallick (2009) [9]. Plant height increases with Sulphur uptake as it increases cell multiplication, elongation & cell expansion throughout the entire period of crop growth, higher levels of Sulphur in protein and carbohydrate metabolism, activating many enzymes which influences shoot length. Similar results were reported by Reddi Ramu and Maheshwara reddy (2003) [7].

Table 1: Effect of Nitrogen and Sulphur on growth parameters of Sunflower.

S. No	T. No.	Treatments	Plant height (cm)	Dry matter accumulation (g /plant)
1	T_1	80 : 60 : 40 NPK kg/ha (Control)	133.34	51.17
2	T_2	60 kg N/ha + 15 kg S/ha	131.05	50.15
3	T_3	60 kg N/ha + 30 kg S/ha	135.83	52.16
4	T_4	60 kg N/ha + 45 kg S/ha	138.77	53.29

5	T_5	80 kg N/ha + 15 kg S/ha	139.45	53.83
6	T_6	80 kg N/ha + 30 kg S/ha	141.78	54.49
7	T_7	80 kg N/ha + 45 kg S/ha	145.97	57.69
8	T_8	120 kg N/ha + 15 kg S/ha	143.53	56.51
9	T_9	120 kg N/ha + 30 kg S/ha	148.63	59.67
10	T_{10}	120 kg N/ha + 45 kg S/ha	150.36	60.53
		S.Em (±)	0.70	0.47
		CD (P - 0.05)	2.07	1.41

Table 2: Effect of Nitrogen and Sulphur on yield and yield attributing characters of Sunflower.

S. No	T. No	Treatments	Capitulum diameter (cm)	Seed Yield (kg /ha)	Stover Yield (kg /ha)
1	T_1	80 : 60 : 40 NPK kg/ha (Control)	12.87	1088.97	2331.54
2	T_2	60 kg N/ha + 15 kg S/ha	12.53	1026.37	2215.33
3	T_3	60 kg N/ha + 30 kg S/ha	13.20	1133.70	2356.14
4	T_4	60 kg N/ha + 45 kg S/ha	13.50	1190.70	2433.04
5	T_5	80 kg N/ha + 15 kg S/ha	13.80	1230.17	2505.87
6	T_6	80 kg N/ha + 30 kg S/ha	14.17	1271.60	2580.83
7	T_7	80 kg N/ha + 45 kg S/ha	14.97	1338.10	2663.08
8	T_8	120 kg N/ha + 15 kg S/ha	14.53	1307.80	2631.34
9	T_9	120 kg N/ha + 30 kg S/ha	15.17	1384.17	2685.69
10	T_{10}	120 kg N/ha + 45 kg S/ha	15.63	1446.20	2794.39
		S.Em (±)	0.18	33.53	71.12
		CD (P - 00.05)	0.53	99.63	211.29

Dry matter accumulation

The treatment T_{10} (120 kg N/ha + 45 kg S/ha) recorded maximum dry matter accumulation of 59.67 (g) at the harvesting stage and T_9 treatments is found statistically at par to maximum dry matter accumulation. Dry matter accumulation is more important because all other vegetative characters contained it. The dry weight of sunflower increased significantly due to application of nitrogen and sulphur. Dry matter production related to grain productivity contributes an important factor in source – sink relationship. Higher dry matter production with 120 kg N/ha along with 45 kg S/ha could be attributed to enhanced photosynthesis accumulation. Sulphur helps in better photosynthesis means more dry matter accumulation as Sulphur is a constituent of succinyl Co-A which involved in chlorophyll in leaves and their activation at cellular level accelerate photosynthesis. Thus, the overall increase in dry matter produced with application of higher levels of nitrogen and Sulphur could be ascribed to overall improvement in plant vigour due to increased availability of nutrients resulting in better assimilation. These results are in conformity with those reported by Reddi Ramu and Maheshwara Reddy (2003) [7] and Sarkar and Mallick (2009) [9].

Effect of nitrogen and sulphur on Yield and Yield Attributes

Capitulum diameter (cm)

Significant effect was observed by the statistical analysis of Capitulum diameter. Treatment 120 kg N/ha + 45 kg S/ha recorded significant and highest capitulum diameter (15.63 cm). However, treatment 120 kg N/ha + 30 kg S/ha was found to be statistically on par with 120 kg N/ha + 45 kg S/ha. Significant increase in head diameter was favoured by higher levels of nitrogen. Improved stem elongation and accumulated photosynthates as manifested by higher LAI and dry matter might have been responsible for larger head (Capitulum) diameter under 120 Kg N /ha. Thus, higher Photosynthetic activity with adequate nitrogen fertilization enabled the plant to accumulate more dry matter and greater translocation of photosynthates to the developing head resulting in larger flower heads. Similar results were also obtained by Reddy *et al*. (2002) [6], Reddi and Reddy (2003) [7] and Sarkar and Mallick (2009) [9]. Application of Sulphur at different levels along with recommended fertilizer had a significant effect on head diameter. This significant and positive influence of Sulphur on head diameter is due to improved growth through increased nutrient assimilation which in turn accelerated the crop to put forth larger heads. The influence of Sulphur in enhancing the head diameter was also reported by Ajai singh *et al.* (2000) [1], Maity and Gajendra Giri (2003) [5], Satish kumar and Singh (2005) [10] and Thorat *et al.* (2007) [14], Shivay and Shekawat (2008) [12].

Seed yield

Seed yield was significantly influenced with different combinations of Nitrogen and sulphur along with Phosphorus and Potassium The highest seed yield was obtained with the treatment 120 kg N/ha + 45 kg S/ha (1446.20 kg), however 120 kg N/ha + 30 kg S/ha was found to be statistically on par with 120 kg N/ha + 45 kg S/ha. The seed yield of sunflower increased significantly with increase in nitrogen and sulphur. Higher seed yield under higher nitrogen and Sulphur application was due to good growth and availability of adequate nitrogen and Sulphur might lead to increased accumulation of amino acid and amide substance and their translocation to the reproductive organs has improved the seed yield through increased seed setting and filling. Seed yield of sunflower was closely associated with plant height, dry matter accumulation and partitioning of dry matter at seed filling stage. Nitrogen applied at 120 kg/ha in combination with 45 kg S/ha recorded significantly higher seed yield over rest of the treatment combination. Similar results of increased seed yield due to nitrogen and Sulphur were reported by Seshadri Reddy *et al*. (2002) [11], Reddi Ramu and Maheswara Reddy (2003) [7] and Sarkar and Mallick (2009) [9].

Stover yield

Highest stover yield (2794.39 kg/ha) was recorded 120 kg N/ha + 60 kg P/ha, however, 120 kg N/ha + 30 kg S/ha, 120 kg N/ha + 15 kg S/ha, 80 kg N/ha + 45 kg S/ha was found to

be statistically on par with 120 kg N/ha + 45 kg S/ha. Higher stover yield under higher nitrogen and Sulphur application was due to good growth and availability of adequate nitrogen and Sulphur might lead to increased accumulation of amino acid and amide substance and their translocation to the reproductive organs has improved the seed yield through increased seed setting and filling. Stover yield of sunflower was closely associated with plant height, dry matter accumulation and partitioning of dry matter at seed filling stage. Nitrogen applied at 120 kg/ha in combination with 45 kg S/ha recorded significantly higher stover yield over rest of the treatment combination. Similar results of increased stover yield due to nitrogen and Sulphur were reported by Seshadri Reddy *et al*. (2002) [11], Reddi Ramu and Maheswara Reddy (2003) [7] and Sarkar and Mallick (2009) [9].

Conclusion

Treatment, T_{10} 120 kg N/ha + 45 kg S/ha recorded maximum in all growth parameters and yield attributes, and also recorded highest grain yield (1446.20 kg/ha) and hence, can be recommended to the farmers.

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