Original Research Article

Influence of phosphorus and sulphur on growth and yield of sunflower *(Helianthus annuus* L.*)*

ABSTRACT

A field experiment was conducted during *Kharif* 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P). To determine the "Influence of phosphorus and sulphur on growth and yield of sunflower *(Helianthus annuus* L.*)*", The results showed that treatment 9 [Phosphorus (60 kg/ha) + Sulphur 25 kg/ha] recorded significantly higher plant height (123.10 cm), higher plant dry weight (91.03 g). Where as, higher number of seeds/capitulum (412.00), higher test weight (50.50 g), higher seed yield (1.25 t/ha), higher Stalk yield (3.44 t/ha), higher oil content (40.37%), was recorded in treatment 9 [Phosphorus (60 kg/ha) + Sulphur 25 kg/ha). Similarly, maximum gross returns (83,440.00 INR/ha), higher net returns (55,851.25 INR/ha), and highest benefit cost ratio (2.02) was also recorded in treatment 9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)], as compared to other treatments.

Keywords: Phosphorus, Sulphur, Growth, Yield and Economics

INTRODUCTION

Sunflower is an essential oilseed crop. It is a potential remunerative crop due to its characters such as early maturity, adaptation to extensive climatic condition, soil and responsiveness to better production management practices. It 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. Sunflower oil content varies from 48-53% and it is premium oil with pale yellow in colour used for cooking and margarine. The oil of sunflower has a model combination of saturated and poly-unsaturated fatty acids, due to which it is considered very important in reducing of high serum cholesterol levels. The seed of sunflower have an adequate amount of oil approximately 35-40 % while some varieties ranges up to 50 %. 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. 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.

However, its contribution towards attaining self- sufficiency in edible oil as well as to "Yellow revolution" in the country noteworthy (**Rai, 2002**). Sunflower is an agronomic crop that is cultivated widely throughout the world (**Groove *et al.*, 2005).**

The production of sunflower in India is grown 0.22million hectare area and production is 0.23 million tons as well as yield or productivity is 1023 kg/ha in 2020-21. Maximum in production and area wise is Karnataka state then in Haryana, Odisha as well as other states of India. In Uttar Pradesh, cultivated area of Sunflower is 3241 hectare and production is 4727tonnes and productivity of this crop is 1.38 tons/ha in summer season. In Uttar Pradesh, district wise Kannuj is maximum in area wise is 2121 hectare as well as in production wise 2931 tons (**GOI, 2021**).

Phosphorus (P) is a major requirement for the growth of sunflower, its deficiency results in stunted growth, purplish discoloration of leaves. It also affects flowering, fruit formation and seed production. Flower size is reduced to half its normal size and fruit head is decreased to one- third. Uptake of major nutrients elements by sunflower has also been reported to be facilitated when P was applied at the rate of 40-60 kg ha-1(**Fagbayide and Adeoye, 1999**). Sulphur-deficiency symptoms are more often observed in crops at early stages of growth, because sulphur can be easily leached from the surface soil (**Hitsuda *et al.*,**

2005).

Phosphorus is an essential plant macronutrient which is required to build important molecules such as nucleic acids and phospholipids, and plays vital role during energy transfer in processes like NADPH, ATP and regulation of enzymatic and metabolic reactions.P is an essential plant nutrient required for higher and sustained productivity of oil from sunflower. Its influence on seed yield, oil yield and oil quality has been well established (**Bahl and Toor, 1999**). Sulphur is the fourth major nutrient in crop production. For oil crop producers, sulphur fertilizer is especially significant because oil crop require more sulphur than cereal grains. Sulphur is best known for its role in the formation of amino acids methionine (21% S) and cysteine (27% S);synthesis of proteins and chlorophyll oil content of the seeds (**Jamal *et al.*, 2005)**. The average increase in oil content due to Sulphur application in major oilseeds is 11.3 percent in groundnut, 9.6% in mustard, 6.0% in linseed and 3.8% in sunflower. Sulphur -deficient soils are widely distributed around the world. The positive effects of S application on overall sunflower plant growth was due to the role of sulphur in conversion of carbohydrates into oil, S also helps in the fatty acid synthesis in which an enzyme thiokinase is implicated which depends on sulphur **(Sreemannarayana *et al*., 1998).** Keeping in view the above facts, the present investigation was undertaken to find out "Influence of phosphorus and sulphur on growth and yield of sunflower *(Helianthus annuus* L.*)*".

MATERIALS AND METHODS

The experiment was conducted during the *Kharif* season 2022 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P.). The soil of the field constituting a part of central Gangetic alluvial is neutral and deep. The soil of the experimental field was sandy loamy in texture, nearly neutral in soil reaction (pH 8.0), low level of organic carbon (0.28%), available N (225 kg/ha), P (38.2kg/ha), K (240.7 kg/ha). The treatment consists of three different levels of phosphorus *viz,* 40kg/ha, 50kg/ha, 60kg/ha with combination of different levels of Sulphur *viz*, 15, 20, 25 kg/ha. The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations are Treatment 1 – Phosphorus (40 kg/ha) + Sulphur (15 kg/ha), Treatment 2 – Phosphorus (40 kg/ha) + Sulphur (20 kg/ha), Treatment 3 – Phosphorus (40 kg/ha) + Sulphur (25 kg/ha), Treatment 4 – Phosphorus (50 kg/ha) + Sulphur (15 kg/ha), Treatment 5 – Phosphorus (50 kg/ha) + Sulphur (20 kg/ha), Treatment 6 – Phosphorus (50 kg/ha) + Sulphur (25 kg/ha), Treatment 7 – Phosphorus (60 kg/ha) +

Sulphur (15 kg/ha), Treatment 8 – Phosphorus (60 kg/ha) + Sulphur (20 kg/ha), Treatment 9 – Phosphorus (60 kg/ha) + Sulphur (25 kg/ha), Treatment 10- Control (RDF : 80:60:40 Kg/ha). The data recorded on different aspects of crop *viz.*, growth parameters, yield attributes and economics were subjected to statistical analysis by variance method **Gomez and Gomez**, (**1984**).

RESULT AND DISCUSSION

Growth parameters

Plant height (cm)

The data recorded that significant and higher plant height (123.10 cm) was observed in treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)]. However, treatment-8 [Phosphorus (60kg/ha) +Sulphur (20kg/ha)] were statistically at par with treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)] [Table 1]. Significant and higher plant height (cm) was observed with the application of phosphorus (60kg/ha) might be due to phosphorus is known to help in the development of more extensive root system and thus enables plants to absorb more water and nutrients from depth of the soil, resulted higher plant height. Similar findings were obtained by **Vali *et al.* (2020)** in Groundnut. Further, higher plant height was observed with the application of Sulphur (25kg/ha) might be due to increasing levels of sulphur which may have increased solubility of different nutrients in soil which leads to increase in plant growth. Similar results are in support with **Kumar *et al. (*2016)**.

Plant dry weight (g)

Significant and higher plant dry weight (91.03 g) was recorded treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)]. However, treatment -8 [Phosphorus (60kg/ha) +Sulphur (20kg/ha)] and treatment-6 [Phosphorus (50kg/ha) +Sulphur (25kg/ha)] were statistically at par with treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)] [Table 1]. Significant and higher plant dry weight was with the application of phosphorus (60kg/ha) might be due to it helps in the development of more extensive root system and thus enables plant absorb more water and nutrients from the depth of the soil and enhance the plants ability to produce more assimilates which were reflected in the enhanced biomass production, resulted higher plant dry weight. Similar findings are obtained by **Sagar *et al*. (2020)** in groundnut**.** Further, significant and higher plant dry weight was observed with the application of sulphur (25kg/ha) could be due to better photosynthesis and also sulphur is a constituent of succinyl Co-A which involved in chlorophyll in leaves and their activation at cellular level accelerate photosynthesis, which leads to more accumulation of plant dry weight. Similar findings are in support with **Deepika *et al.* (2022).**

Crop growth rate (g/m^2/day)

The data revealed that during 60-80 DAS, treatment-3 [Phosphorus (40kg/ha) +Sulphur (25kg/ha)] recorded higher crop growth rate (30.22 g/m^2/day) and though there was no significant difference among the treatments [Table 1].

Relative growth rate (g/g/day)

The data revealed that during 60-80 DAS, treatment-1 [Phosphorus (40kg/ha) +Sulphur (15kg/ha)] recorded higher relative growth rate (0.0193 g/g/day) and though there was no significant difference among the treatments [Table 1].

Yield attributes

Number of seeds/capitulum

The data found that significant and higher number of seeds/capitulum (412.00) was recorded in treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)], However, treatment-8 [Phosphorus (60kg/ha) +Sulphur (20kg/ha)] and treatment-6 [Phosphorus (50kg/ha) +Sulphur (25kg/ha)], were statistically at par with treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)] [Table 2]. The significant and higher number of seeds/capitulum was observed with the application of Phosphorus (60kg/ha) might be due to it plays a fundamental role in the process of achene formation since its absorption occurs until the filling stage of achenes, supplying the development of capitulum through a source-drain relationship, resulted higher number of seeds/capitulum. Similar findings were obtained by **Soares *et al.* (2020).** Further, significant and higher number of seeds/capitulum was observed with the application of Sulphur (25kg/ha), might be due to it play a vital role in the creation of amino acids, due to partitioning of photosynthetic from source to sink, resulted higher number of seeds/capitulum. similar results are in support with **Rahul *et al.* (2021)**.

Test weight (g)

The data recorded that no significant difference among all the treatments. However, higher test weight (50.50 g) was observed in treatment-9 [Phosphorus (60kg/ha) +Sulphur

(25kg/ha)] [Table 2].

Seed yield (kg/ha)

The significant and higher seed yield (1.25 t/ha) was recorded in treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)]. However, treatment-8 [Phosphorus (60kg/ha) +Sulphur (20kg/ha)] and treatment-6 [Phosphorus (50kg/ha) +Sulphur (25kg/ha)] were statistically at par with treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)] [Table 2]. The significant and higher seed yield was observed with the application of phosphorus (60kg/ha) that could be due to ascribed to a better translocation of photosynthates towards yield attributes and yield. Similar findings were obtained by **Singh *et al.* (2017).** Further, increase in seed yield was observed with the application of sulphur (25kg/ha) might be due to it enhancing the photosynthesis rate and high carbohydrate metabolism, resulted higher seed yield. Similar results are in support with **Ramamoorthy *et al.* (2021).**

Stalk yield (kg/ha)

Results revealed that treatment 9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)] recorded significant and higher stalk yield (3.44 t/ha). However, treatment-8 [Phosphorus (60kg/ha) +Sulphur (20kg/ha)] and treatment-7 [Phosphorus (60kg/ha) +Sulphur (15kg/ha)] were statistically at par with treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)] [Table 2]. The significant and higher stalk yield was observed with the application of Phosphorus (60kg/ha) and Sulphur (25kg/ha) might be due to better vegetative growth as indicated by more dry matter production/ plant, resulted higher stalk yield. Similar findings were obtained by **Kumar *et al.* (2016).**

Harvest Index (%)

The data showed that no significant difference among all the treatments. However, highest harvest index (28.41%) was recorded in treatment-1 [Phosphorus (40 kg/ha) +Sulphur (15 kg/ha)] and treatment-6 [Phosphorus (50 kg/ha) + Sulphur (25kg/ha)] [Table 2].

Oil content(%)

The Significant and higher oil content (40.37%) was recorded in treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha). However, treatment-2 [Phosphorus (40kg/ha) +Sulphur (20kg/ha)], treatment-3 [Phosphorus (40kg/ha) +Sulphur (25kg/ha)], treatment-5

[Phosphorus (50kg/ha) +Sulphur (20kg/ha)], treatment-6 [Phosphorus (50kg/ha) +Sulphur (25kg/ha)] and treatment-8 [Phosphorus (60kg/ha) +Sulphur (20kg/ha)] were statistically at par with treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)] [Table 2]. The significant and higher oil content was observed with the application of phosphorus (60kg/ha) might be due to it play an important role in carbohydrate metabolism and helps in conversion of carbohydrate into oil, resulted higher oil percentage. Similar findings were obtained by **Kalaiyarasan *et al.* (2019).** Further, significant and higher oil content was observed with the application of sulphur (25kg/ha) might be due to biosynthesis of oil and it is involved in the formation of glucosides and glucosinolates and sulphydril-linkage and activation of enzymes, which aid in biochemical reaction within the plant, resulted higher oil percentage. Similar findings are in support with **Patra *et al.* (2013).**

Economics

The result revealed that maximum gross return (83,440.00 INR/ha), higher net returns (57,251.25 INR/ha), and highest benefit cost ratio (2.02) was recorded in treatment 9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)] as compared to other treatments [Table 3].Higher gross return, net return and benefit cost ratio was recorded with the application of Phosphorus (60 kg/ha) and Sulphur (25 kg/ha) might be due to increased in economic performance of crop which were responsible for higher marketable seed and stover yield. These results are in conformity with those observed by **Sahoo *et al.* (2021)** in Yellow mustard.

Table 1 Influence of phosphorus and sulphur on growth parameters of sunflower.

S. No.	Treatment combinations	80 DAS		60-80 DAS	
		Plant Height (cm)	Plant dry Weight (gm/plant)	Crop growth rate ($g/m^2/day$)	Relative growth rate (g/g/day)
1.	Phosphorus 40kg/ha +Sulphur 15kg/ha	115.30	84.20	29.70	0.0193
2.	Phosphorus 40kg/ha +Sulphur 20kg/ha	116.60	85.30	29.92	0.0192
3.	Phosphorus 40kg/ha +Sulphur 25kg/ha	117.40	85.80	29.92	0.0191
4.	Phosphorus 50kg/ha +Sulphur 15kg/ha	117.80	86.40	28.82	0.0181
5.	Phosphorus 50kg/ha +Sulphur 20kg/ha	119.60	86.67	26.69	0.0164
6.	Phosphorus 50kg/ha +Sulphur 25kg/ha	121.60	89.47	29.11	0.0175
7.	Phosphorus 60kg/ha +Sulphur 15kg/ha	118.60	86.90	27.83	0.0172
8.	Phosphorus 60kg/ha +Sulphur 20kg/ha	122.30	89.47	28.56	0.0172
9.	Phosphorus 60kg/ha +Sulphur 25kg/ha	123.10	91.03	29.51	0.0175
10.	Control (RDF-80:60:40 kg/ha)	114.20	83.00	29.13	0.0192
	F-test	S	S	NS	NS
	SEm±	0.43	1.07	1.26	0.0007
	CD at 5%	1.27	3.18	--	--

Table 2. Influence of Phosphorus and Sulphur on yield attributes of Sunflower.

S.No	Treatments	Seeds/capitulum	Test weight (g)	Seed yield (t/ha)	Stalk yield (t/ha)	Harvest Index (%)	Oil content (%)
1.	Phosphorus 40kg/ha +Sulphur 15kg/ha	354.00	47.20	0.97	2.44	28.41	36.52
2.	Phosphorus 40kg/ha +Sulphur 20kg/ha	366.00	47.60	0.98	2.55	25.97	38.22
3.	Phosphorus 40kg/ha +Sulphur 25kg/ha	380.00	48.80	1.05	2.73	27.83	39.27
4.	Phosphorus 50kg/ha +Sulphur 15kg/ha	371.00	48.10	0.99	2.87	25.58	37.18
5.	Phosphorus 50kg/ha +Sulphur 20kg/ha	386.00	49.20	1.15	3.00	27.78	38.44
6.	Phosphorus 50kg/ha +Sulphur 25kg/ha	402.00	50.30	1.21	3.04	28.41	40.06
7.	Phosphorus 60kg/ha +Sulphur 15kg/ha	376.00	48.60	1.01	3.37	23.08	37.75
8.	Phosphorus 60kg/ha +Sulphur 20kg/ha	399.67	49.90	1.19	3.40	25.94	39.04
9.	Phosphorus 60kg/ha +Sulphur 25kg/ha	412.00	50.50	1.25	3.44	26.62	40.37
10.	Control(RDF-80:60:40 kg/ha)	351.00	46.90	0.91	2.57	26.18	32.61
	F test	S	NS	S	S	NS	S
	SEm ±	4.91	0.98	0.03	0.12	1.31	0.75
	CD at 5%	14.59	--	0.10	0.36	--	2.24

Table 3. Influence of Phosphorus and Sulphur on economics of Sunflower.

S No	Treatments	Total cost of cultivation (INR)	Gross Returns (INR/ha)	Net Returns (INR/ha)	B:C ratio
1	Phosphorus 40kg/ha +Sulphur 15kg/ha	25172.98	64520.00	37947.02	1.42
2	Phosphorus 40kg/ha +Sulphur 20kg/ha	25441.78	65270.00	38428.22	1.43
3	Phosphorus 40kg/ha +Sulphur 25kg/ha	25710.58	69930.00	42819.42	1.58
4	Phosphorus 50kg/ha +Sulphur 15kg/ha	25412.12	66230.00	39417.88	1.47
5	Phosphorus 50kg/ha +Sulphur 20kg/ha	25680.92	76600.00	49519.08	1.83
6	Phosphorus 50kg/ha +Sulphur 25kg/ha	25949.72	80480.00	53130.28	1.94
7	Phosphorus 60kg/ha +Sulphur 15kg/ha	25651.15	68010.00	40958.85	1.51
8	Phosphorus 60kg/ha +Sulphur 20kg/ha	25919.95	79560.00	52240.05	1.91
9	Phosphorus 60kg/ha +Sulphur 25kg/ha	26188.75	83440.00	55851.25	2.02
10	Control(RDF-80:60:40 kg/ha)	24844.65	60810.00	34565.35	1.32

CONCLUSION

Based on above findings it can be concluded that application of Phosphorus 60kg/ha +Sulphur 25kg/ha has performed better in growth parameters and yield attributes of Sunflower and also proven profitable.

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