Original Research Article

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

ABSTRACT

A field experiment to determine the "Influence of phosphorus and sulphur on growth and yield of sunflower *(Helianthus annuus* L*)* was conducted during *Kharif* 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology a~~A~~nd Sciences, Prayagraj (U.P). The experiment was laid out in a Randomized Block Design with 10 treatments each replicated thrice. The treatment combinations were 1 – Phosphorus (40 kg/ha) + Sulphur (15 kg/ha), 2 – Phosphorus (40 kg/ha) + Sulphur (20 kg/ha), 3 – Phosphorus (40 kg/ha) + Sulphur (25 kg/ha), 4 – Phosphorus (50 kg/ha) + Sulphur (15 kg/ha), 5 – Phosphorus (50 kg/ha) + Sulphur (20 kg/ha), 6 – Phosphorus (50 kg/ha) + Sulphur (25 kg/ha), 7 – Phosphorus (60 kg/ha) + Sulphur (15 kg/ha), 8 – Phosphorus (60 kg/ha) + Sulphur (20 kg/ha), 9 – Phosphorus (60 kg/ha) + Sulphur (25 kg/ha) and 10-Control (RDF : 80:60:40 Kg/ha). Data collected were growth parameters, yield attributes and economics were subjected to statistical analysis of variance. Results showed that treatment 9 [Phosphorus (60 kg/ha) + Sulphur 25 kg/ha] recorded high plant height (123.10 cm), dry weight (91.03 g); number of seeds/capitulum (412.00), test weight (50.50 g), seed yield (1.25 t/ha), oil content (40.37%). The same treatment recorded maximum gross returns (83,440.00 INR/ha), high net returns (55,851.25 INR/ha)~~,~~ and highest benefit cost ratio (2.02).

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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 % (Reference). 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 contributinges 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 on 0.22million hectare area and production is 0.23 million tons as well as yield or productivity wais 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 ofis 2121 hectare as well as in production wise 2931 tons (**GOI, 2021**).

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**). 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 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).** 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**). 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.*)*".

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MATERIALS AND METHODS

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The experiment was conducted during the *Kharif* season 2022 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology aAnd 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 neutralin 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 consisteds 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 Randomized Block Design with 10 treatments each replicated thrice. The treatment combinations wereare ~~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

Comment [H1]: What was the level of sulphur prior to the experiment?

– 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) and , 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 ofby variance method by **Gomez and Gomez**, (**1984**).

RESULT AND DISCUSSION

Growth parameters

Plant height (cm)

Results showed 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 deepth of the soil profile, resultinged in 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) and might be due to increasing levels of sulphur which may have increased solubility of different nutrients in soil which leadings to increase in plant growth. The findings are supported by that of 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 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 1]. Significant and higher plant dry weight was induced by with the application of phosphorus (60kg/ha) whichmight be due to it helps in the development of more extensive root system and thus enables plant absorb more water and nutrients from the deepth of the soil profile and enhance the plants ability to produce more assimilates which were reflected in the enhanced biomass production, resultinged in higher plant dry weight. Similar findings wereare obtained by **Sagar *et al.* (2020)** in groundnut**.** Further, significant and higher plant dry weight was

observed with the application of sulphur (25kg/ha) which could be due to desirable~~better~~ photosynthesis considering that ~~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. The ~~Similar~~ findings are ~~in~~ supported by those of ~~with~~ **Deepika *et al.* (2022).**

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

Despite lack of significant difference among the treatments ~~The~~ results~~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].~~ while in , treatment-1 [Phosphorus (40kg/ha) +Sulphur (15kg/ha)] results revealed that during 60-80 DAS higher relative growth rate (0.0193 g/g/day) was recorded [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 and Test weight (g)

The results in [Table 2] have shown ~~data found that~~ significant differences with ~~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 significance~~t~~ and higher number of seeds/capitulum was observed with the application of Phosphorus (60kg/ha) which could ~~might~~ be due to the fundamental role 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 that~~,~~ resulted in 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), which could ~~might~~ be due to vital role it plays ~~a vital role~~ in the creation of amino acids, due to partitioning of photosynthetic from source to sink that~~,~~ resulted in the high~~er~~ number of seeds/capitulum and ~~.~~ similar results were obtained ~~are in support with~~ by **Rahul *et al.* (2021)**. Results on test weight showed no significant differences among the treatments h~~H~~owever, ~~-~~high~~er~~ test weight (50.50 g) was observed in treatment-9 [Phosphorus (60kg/ha) +Sulphur (25kg/ha)] [Table 2].

Seed yield (kg/ha)

The results showed significant differences and high~~er~~ 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 significanc~~et~~ and high~~er~~ 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 and~~.~~ **Singh *et al.* (2017 reported s**~~S~~imilar 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~~,~~ result~~ed~~ing in ~~ed~~ high~~er~~ seed yield. Similar results were~~are~~ obtained by ~~in support with~~ **Ramamoorthy *et al.* (2021).**

Stalk yield (kg/ha) and Harvest Index (%)

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 significanc~~et~~ and high~~er~~ stalk yield was observed with the application of Phosphorus (60kg/ha) and Sulphur (25kg/ha) which might be due to better vegetative growth as indicated by more dry matter production/ plant, resulted higher stalk yield as ~~. Similar~~ findings ~~were obtained~~ by **Kumar *et al.* (2016).** Despite no significant difference among ~~all~~ the treatments on harvest index~~. 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 Significancet 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 significancet 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 as reported . Similar findings are in support with by **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) which could 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
	Mean	?	?	?	?
	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
	Mean	?	?	?	?	?	?
	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 of the study it can be concluded that application of Phosphorus 60kg/ha +Sulphur 25kg/ha has outperformed the other treatment combinations ~~better~~ in growth parameters and yield attributes of Sunflower and also proven profitable.

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