



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

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**Abstract:** A field experiment was conducted during the *Zaid* season 2015 in Randomized Block Design with twelve treatment combinations and replicated thrice. The results revealed that highest plant height (117.93 cm), leaf area (91.07 dm<sup>2</sup>), leaf area index (6.75) and Crop Growth Rate (14.27 g/m<sup>2</sup>/day). Yield and yield attributes viz., seed yield (2248.33 kg ha<sup>-1</sup>), stover yield (3048.00 kg ha<sup>-1</sup>), harvest index (42.45%) and seed index (4.98 g) were highest recorded in treatment T<sub>6</sub> (60 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>).

**Key words:** Phosphorus, Sulphur, Sunflower, *Helianthus annuus* L.

### Introduction

Sunflower (*Helianthus annuus* L.), which used to be an ornamental plants in India, has in recent times become an important source of edible oil. Globally, sunflower ranks second to soybean among annual field crops grown for edible oil. The quantity of sunflower oil represents about 15% of the total world production of major vegetable oils. Sunflower seeds are one of the most nutritious and healthy foods. It was introduced to India in 1969 as an oilseed crop. Since it is a photo-insensitive crop, it can be grown throughout the year. Our country is facing acute shortage of edible oils mainly because of heavy demand due to population pressure, raised standard of living and high demand from oil consuming industries. Phosphate plays an important role in energy transfer within the plant and is therefore vital during the periods of rapid growth. In early growth stages it promotes root development, which is also important for efficient uptake of other nutrients. It is an important constituent of nucleotides, nucleic acids, and phospholipids and maintains the cell structure and promotes root development, early flowering, and ripening. The majority of soils will have sufficient phosphate to satisfy the early demand. Later in the season phosphate is required for early flowering and plays an important role within the energy storage and transfer process, therefore it is important for the oilseed crop to be supplied with sufficient phosphate to increase the oil and the protein content of the seeds (Maity *et al.*, 2003). Functionally, sulphur significantly influences the yield and quality of crops, improves odour and flavors and imparts resistance to cold and hence it is generally considered a "quality nutrient". However, the deficiency of sulphur is known to decrease the yield as well as quality, especially when soils are deficient. Sulphur-deficient soils are widely distributed around the world. 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).

### Materials and Methods

The experiment was carried out during *Zaid* season 2015 at Crop Research Farm, Department of Agronomy, Allahabad

School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, which is located at 25°24' 42" N latitude, 81° 50' 56" E longitude and 98 m altitude above the mean sea level. It consists of four levels of phosphorus 40, 60, 80 and 100 kg ha<sup>-1</sup>, three levels of sulphur 20, 30 and 40 kg ha<sup>-1</sup>. The full dose of sulphur in the form of elemental sulphur was applied at 20, 30 and 40 kg ha<sup>-1</sup> and full dose of phosphorus in the form of diammonium phosphate was applied at 40, 60, 80 and 100 kg ha<sup>-1</sup> at the time of sowing as per the treatments. The recommended dose of nitrogen and potassium were applied at the rate of 120:20 kg. N and K<sub>2</sub>O per hectare in the form of urea and muriate of potash. Remaining 50 % of nitrogen was top dressed at 30 days after sowing. The crop was sown on February 26<sup>th</sup> 2015. Ideal weather conditions are prevailed during the crop growth. The observation on plant height, number of green leaves, dry matter, leaf area, leaf area index, head diameter, head weight, seed index, seed yield, stover yield, harvest index and oil content were recorded at the time of harvesting and the observation recorded were statistically analyzed.

### Results and Discussion

**Effect of growth parameter on sunflower:** Data presented in (Table-1) At 30 DAS, the highest value of plant height was registered non-significantly in the treatment T<sub>6</sub> (60 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>), with 31.87 cm, whereas lowest plant height (27.80 cm) was recorded in treatment T<sub>1</sub> (40 kg phosphorus ha<sup>-1</sup> + 20 kg sulphur ha<sup>-1</sup>). At 60 DAS, the highest plant height (104.07 cm) was recorded significantly in treatment T<sub>6</sub> (60 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>), whereas lowest plant height (92.60 cm) was recorded in treatment T<sub>1</sub> (40 kg phosphorus ha<sup>-1</sup> + 20 kg sulphur ha<sup>-1</sup>). At 90 DAS, the highest plant height (117.93 cm) was observed significantly in T<sub>6</sub> (60 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>), whereas lowest plant height (115.53 cm) was recorded in treatment T<sub>1</sub> (40 kg phosphorus ha<sup>-1</sup> + 20 kg sulphur ha<sup>-1</sup>). It was observed that plant height increased with the increasing levels of phosphorus and sulphur. In the present investigation. This might be due to the direct effect of sulphur on

**Table-1:** Effect of different levels of phosphorus and sulphur on the growth parameters of sunflower (*Helianthus annuus* L.)

Treatment combinations	Plant height (cm)			Leaf area (dm <sup>2</sup> )			Leaf area Index <sup>1</sup>			Crop growth rate (g/m <sup>2</sup> /day)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	45 DAS	60 DAS	0-30 DAS	30-60 DAS	60-90 DAS
T <sub>1</sub>	27.80	92.60	98.47	14.15	67.77	69.75	0.99	4.73	4.90	0.50	11.05	0.52
T <sub>2</sub>	29.60	93.67	99.73	15.03	76.93	76.92	1.11	5.07	5.07	0.60	11.42	1.10
T <sub>3</sub>	30.20	96.33	101.00	15.42	74.21	75.77	1.09	5.36	5.39	0.59	11.66	1.49
T <sub>4</sub>	30.20	97.60	107.73	13.87	76.90	70.56	1.02	5.61	5.55	0.59	12.55	1.11
T <sub>5</sub>	29.40	96.07	115.33	15.16	74.21	77.41	1.14	5.98	6.16	0.51	13.99	0.74
T <sub>6</sub>	<b>31.87</b>	<b>104.07</b>	<b>117.93</b>	<b>15.83</b>	<b>86.79</b>	<b>91.07</b>	<b>1.16</b>	<b>6.57</b>	<b>6.75</b>	<b>0.96</b>	<b>14.27</b>	<b>1.66</b>
T <sub>7</sub>	28.20	95.00	108.07	14.39	85.73	87.27	1.15	5.60	6.06	0.64	14.07	1.09
T <sub>8</sub>	31.20	94.00	100.67	14.44	79.56	82.23	1.06	5.65	6.19	0.73	13.28	0.93
T <sub>9</sub>	30.13	95.93	109.73	15.62	79.11	80.26	1.06	5.79	6.23	0.70	12.84	0.89
T <sub>10</sub>	29.40	94.13	110.00	13.86	81.33	82.22	1.11	5.97	6.46	0.68	12.97	1.48
T <sub>11</sub>	28.60	95.53	105.07	15.64	79.46	78.47	1.14	6.09	6.60	0.72	12.05	0.71
T <sub>12</sub>	30.40	94.67	106.87	15.61	75.17	85.85	1.07	6.26	6.74	0.71	12.40	1.43
F test	N S	S	N S	N S	N S	S	N S	N S	S	S	N S	N S
SEd(+)	1.83	2.21	5.06	1.13	5.78	5.32	0.08	0.24	0.12	0.03	0.84	0.54
CD (P=0.05)	-	4.59	-	-	-	11.04	-	-	0.25	0.07	-	-

**Table-2:** Effect of different levels of phosphorus and sulphur on the yield and yield attributes of sunflower (*Helianthus annuus* L.)

Treatment combinations	Seed yield (kg ha <sup>-1</sup> )	Stover yield (kg ha <sup>-1</sup> )	Harvest index (%)	Seed index (g)
T <sub>1</sub>	1893.33	2636.67	40.21	4.50
T <sub>2</sub>	1913.33	2642.33	42.00	4.57
T <sub>3</sub>	1921.00	2653.33	42.00	4.62
T <sub>4</sub>	1924.33	2658.33	41.99	4.66
T <sub>5</sub>	1926.33	2680.00	41.82	4.70
T <sub>6</sub>	2248.33	3048.00	42.45	4.98
T <sub>7</sub>	1946.00	2894.67	41.79	4.73
T <sub>8</sub>	2130.00	2943.33	41.99	4.77
T <sub>9</sub>	2090.00	2942.00	41.55	4.78
T <sub>10</sub>	2010.00	2901.67	40.93	4.82
T <sub>11</sub>	2118.33	2881.67	42.37	4.83
T <sub>12</sub>	2156.67	2973.33	42.05	4.85
F test	S	S	N S	S
SEd(+)	43.87	56.83	0.83	0.01
CD (P=0.05)	90.98	117.87	-	0.03

**Treatment combinations in table 1 and 2:** T<sub>1</sub>: P 40 kg ha<sup>-1</sup> + S 20 kg ha<sup>-1</sup>; T<sub>2</sub>: P 40 kg ha<sup>-1</sup> + S 30 kg ha<sup>-1</sup>; T<sub>3</sub>: P 40 kg ha<sup>-1</sup> + S 40 kg ha<sup>-1</sup>; T<sub>4</sub>: P 60 kg ha<sup>-1</sup> + S 20 kg ha<sup>-1</sup>; T<sub>5</sub>: P 60 kg ha<sup>-1</sup> + S 30 kg ha<sup>-1</sup>; T<sub>6</sub>: P 60 kg ha<sup>-1</sup> + S 40 kg ha<sup>-1</sup>; T<sub>7</sub>: P 80 kg ha<sup>-1</sup> + S 20 kg ha<sup>-1</sup>; T<sub>8</sub>: P 80 kg ha<sup>-1</sup> + S 30 kg ha<sup>-1</sup>; T<sub>9</sub>: P 80 kg ha<sup>-1</sup> + S 40 kg ha<sup>-1</sup>; T<sub>10</sub>: P 100 kg ha<sup>-1</sup> + S 20 kg ha<sup>-1</sup>; T<sub>11</sub>: P 100 kg ha<sup>-1</sup> + S 30 kg ha<sup>-1</sup>; T<sub>12</sub>: P 100 kg ha<sup>-1</sup> + S 40 kg ha<sup>-1</sup>

increasing the solubility of different nutrients in soil. Similar results were obtained by Patra *et al.* (2013) in sunflower and Increase in plant height was found to be significant up to 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> according to Gaur *et al.* (2003). At 30 DAS, highest leaf area (15.83 dm<sup>2</sup>) was observed non-significantly in the treatment T<sub>6</sub> (60 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>), whereas lowest leaf area was recorded in treatment T<sub>1</sub> (40 kg phosphorus ha<sup>-1</sup> + 20 kg sulphur ha<sup>-1</sup>) with 14.15 dm<sup>2</sup>. At 60 DAS, recorded non-significantly highest leaf area (86.79 dm<sup>2</sup>) in T<sub>6</sub> (60 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>), while lowest leaf area (67.77 dm<sup>2</sup>) was observed in treatment T<sub>1</sub> (40 kg phosphorus ha<sup>-1</sup> + 20 kg sulphur ha<sup>-1</sup>). At 90, calculated significantly higher leaf area (91.07 dm<sup>2</sup>) in treatment T<sub>6</sub> (60 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>), where it was at par with treatment T<sub>9</sub> (80 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>) with 80.26 dm<sup>2</sup>, T<sub>10</sub> (100 kg phosphorus ha<sup>-1</sup>

+ 20 kg sulphur ha<sup>-1</sup>) with 82.22 dm<sup>2</sup>, T<sub>8</sub> (80 kg phosphorus ha<sup>-1</sup> + 30 kg sulphur ha<sup>-1</sup>) with 82.23 dm<sup>2</sup>, T<sub>12</sub> (100 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>) with 85.85 dm<sup>2</sup> and T<sub>7</sub> (80 kg phosphorus ha<sup>-1</sup> + 20 kg sulphur ha<sup>-1</sup>) with 87.27 dm<sup>2</sup>, while lower leaf area 69.75 dm<sup>2</sup>, was observed in treatment T<sub>1</sub> (40 kg phosphorus ha<sup>-1</sup> + 20 kg sulphur ha<sup>-1</sup>).

Significant responses in terms of LA to P application up to 60 kg ha<sup>-1</sup> were also reported by Hemalatha *et al.* (2013), It was observed that leaf area increased with the increasing levels of sulphur. Higher leaf area noticed that sulphur being a constituent of succinyl Co-A involved in chlorophyll in leaves and their activation at cellular level by promoting photosynthesis which seemed to have promoted vegetative growth and in addition to timely sowing of the crop which provided congenial climatic condition for better growth and high plant dry weight by sunflower plant. Similar results were also reported by Rasool *et al.* (2013). At 30 DAS, highest leaf area index (1.16) was recorded non-significantly in the treatment T<sub>6</sub> (60 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>), whereas a lowest leaf area index (0.99) was recorded in treatment T<sub>1</sub> (40 kg phosphorus ha<sup>-1</sup> + 20 kg sulphur ha<sup>-1</sup>). At 60 DAS, highest leaf area index (6.57) was calculated non-significantly in treatment T<sub>6</sub> (60 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>), while lowest leaf area index (4.73) was with treatment T<sub>1</sub> (40 kg phosphorus ha<sup>-1</sup> + 20 kg sulphur ha<sup>-1</sup>). At 90 DAS, higher leaf area index (6.75) was observed significantly in treatment T<sub>6</sub> (60 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>), where it was at par with treatment T<sub>11</sub> (100 kg phosphorus ha<sup>-1</sup> + 30 kg sulphur ha<sup>-1</sup>) with (6.60) and treatment T<sub>12</sub> (100 kg phosphorus ha<sup>-1</sup> + 40 kg sulphur ha<sup>-1</sup>) with (6.74), while lower leaf area index (4.90) was with treatment T<sub>1</sub> (40 kg phosphorus ha<sup>-1</sup> + 20 kg sulphur ha<sup>-1</sup>). Increase in LAI was significant in sunflower at 20 DAS, flowering and at harvest by application of phosphorus up to 30 kg P ha<sup>-1</sup>, and further increase in P level resulted in inconsistent increase in LAI. Onasanya *et al.* (2009) who observed that leaf area was increased with increasing levels of phosphorus fertilizers application.

Leaf area index is often used as indicator plant growth for evaluating assimilation, transpiration rate and is major factor determining the solar radiation interception, canopy photosynthesis. In the present investigation, higher leaf area index was observed with 40 kg S ha<sup>-1</sup>

with sulphur over the rest of the treatments. Similar results were also reported by Shekhawat and Shivay (2009). The highest crop growth rate ( $\text{g m}^{-2} \text{day}^{-1}$ ) at 30 DAS was observed significantly in  $T_6$  (60 kg phosphorus  $\text{ha}^{-1}$  + 40 kg sulphur  $\text{ha}^{-1}$ ) with 0.96, whereas lowest crop growth rate ( $\text{g m}^{-2} \text{day}^{-1}$ ) was recorded in treatment  $T_1$  (40 kg phosphorus  $\text{ha}^{-1}$  + 20 kg sulphur  $\text{ha}^{-1}$ ) with 0.50. At 31-60 DAS, a highest crop growth rate ( $\text{g m}^{-2} \text{day}^{-1}$ ) was recorded non-significantly in the treatment  $T_6$  (60 kg phosphorus  $\text{ha}^{-1}$  + 40 kg sulphur  $\text{ha}^{-1}$ ), with 14.27, while lowest crop growth rate ( $\text{g m}^{-2} \text{day}^{-1}$ ) was observed in treatment  $T_1$  (40 kg phosphorus  $\text{ha}^{-1}$  + 20 kg sulphur  $\text{ha}^{-1}$ ) with 11.05.

At 61-90 DAS, a highest crop growth rate ( $\text{g m}^{-2} \text{day}^{-1}$ ) was recorded non-significantly in the treatment  $T_6$  (60 kg phosphorus  $\text{ha}^{-1}$  + 40 kg sulphur  $\text{ha}^{-1}$ ), with 1.66, while lowest crop growth rate ( $\text{g m}^{-2} \text{day}^{-1}$ ) was observed in treatment  $T_1$  (40 kg phosphorus  $\text{ha}^{-1}$  + 20 kg sulphur  $\text{ha}^{-1}$ ) with 0.52. Increase of crop growth rate ( $\text{g m}^{-2} \text{day}^{-1}$ ) at different intervals might be due to sulphur showed higher nutrient uptake by sunflower from soil, which may have enhanced the biomass and translocation of photosynthates. Similar findings were reported by Khalid *et al.* (2005).

**Yields attributes and yield of sunflower:** The results indicated that The mean yield obtained in the treatment  $T_6$  (60 kg phosphorus  $\text{ha}^{-1}$  + 40 kg sulphur  $\text{ha}^{-1}$ ) with 2248.33  $\text{kg ha}^{-1}$ , was significantly superior over rest of the treatments, whereas lowest seed yield obtained from treatment  $T_1$  (40 kg phosphorus  $\text{ha}^{-1}$  + 20 kg sulphur  $\text{ha}^{-1}$ ) with 1893.33  $\text{kg ha}^{-1}$ . Application of higher doses of phosphorus and sulphur (60 kg phosphorus  $\text{ha}^{-1}$  + 40 kg sulphur  $\text{ha}^{-1}$ ) might have increased the uptake of nitrogen, phosphorus and potassium which in turn reduced the sulphur deficiency ultimately increased the yield of sunflower. The increase in seed yield of sunflower with increasing rate of sulphur application has also been reported by Kumar and Singh (2011). The higher stover yield 3048.00  $\text{kg ha}^{-1}$ , recorded significantly in treatment  $T_6$  (60 kg phosphorus  $\text{ha}^{-1}$  + 40 kg sulphur  $\text{ha}^{-1}$ ) where it was at par with treatment  $T_9$  (80 kg phosphorus  $\text{ha}^{-1}$  + 40 kg sulphur  $\text{ha}^{-1}$ ) with 2942  $\text{kg ha}^{-1}$ ,  $T_8$  (80 kg phosphorus  $\text{ha}^{-1}$  + 30 kg sulphur  $\text{ha}^{-1}$ ) with 2943.33  $\text{kg ha}^{-1}$  and  $T_{12}$  (100 kg phosphorus  $\text{ha}^{-1}$  + 40 kg sulphur  $\text{ha}^{-1}$ ) with 2973.33  $\text{kg ha}^{-1}$ , whereas compared to rest of the preceding levels of phosphorus and sulphur, while lower stover yield under treatment  $T_1$  (40 kg phosphorus  $\text{ha}^{-1}$  + 20 kg sulphur  $\text{ha}^{-1}$ ) with 2636.67  $\text{kg ha}^{-1}$  recorded at harvest. The higher stover yield was associated with higher dose of and sulphur due to better vegetative growth as indicated by more dry matter production plant<sup>-1</sup> compared to preceding levels of phosphorus and sulphur. Similar results were reported by Birbal and Nema (2004). studied the effect of P fertilizer on yield and uptake (N, P, S) of sunflower. They reported that seed and straw yields were increased up to the highest rate of P. Mc Kenzie *et al.* (2003) and Turk *et al.* (2002) also found that high rates of phosphorus increased seed yield significantly which confirms the present findings.

The highest harvest index was observed non-significantly with the application of  $T_6$  (60 kg phosphorus  $\text{ha}^{-1}$  + 40 kg sulphur  $\text{ha}^{-1}$ ) with 42.45%, while lowest harvest index was recorded in  $T_1$  (40 kg phosphorus  $\text{ha}^{-1}$  + 20 kg sulphur  $\text{ha}^{-1}$ ) with 40.21%. The significant effect of sulphur and phosphorus application on head diameter has also been reported Malik *et al.* (2006), Nasim *et al.* (2011). Larger

heads harvested with SP application were associated with more number of grains thus giving more yield. The highest seed index 4.98 g, was recorded significantly in treatment  $T_6$  (60 kg phosphorus  $\text{ha}^{-1}$  + 40 kg sulphur  $\text{ha}^{-1}$ ). However, lowest seed index 4.50 g, was recorded in treatment  $T_6$  (40 kg phosphorus  $\text{ha}^{-1}$  + 20 kg sulphur  $\text{ha}^{-1}$ ). This might be due to higher availability of and sulphur lead to improve seed formation and high seed weight, which was reflected in seed index and ultimately results in higher seed yield. Similar results were reported by Birbal *et al.* (2004). Plants that received fertilizer 60 kg  $\text{P}_2\text{O}_5 \text{ ha}^{-1}$  produced the highest 1000-seed weight (56.51 g). Minimum 1000 seed weight was recorded in control plots (44 g). The reason for the improved seed size might be due to increased root length, better crop development and resultantly greater uptake. Turk *et al.* (2002) who reported that phosphorus and sulphur nutrition increased the test weight of seed up to 60 kg P  $\text{ha}^{-1}$  + 40 kg S  $\text{ha}^{-1}$ .

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