Received: 08 October 2024 | Revised: 10 December 2024 | Accepted: 15 December 2024

DOI: https://doi.org/10.69547/TSFJB.020206

TSF JOURNAL OF BIOLOGY

EISSN: 3006-0478
PISSN: 3006-0869

Website link: www.tsfjb.com

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To cite: Khoso SH, Laghari GM, Kaleri AA, Chachar AA, Manzoor D, Chachar AM, Rajput WA, Shah TH, Sodhro AA, Jiskani WM, Bhand SA. Effect of Different Phosphorous Doses on Growth and Yield of Sunflower (*Helianthus Annuus L.*). TSF Journal of Biology.2024; 2(2):58-69.

Article QR

Published online: 24 December 2024
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Research Article

Effect of Different Phosphorous Doses on Growth and Yield of Sunflower (*Helianthus Annuus L.*)

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ABSTRACT

The analysis of variance demonstrated a significant (P<0.05) effect of various phosphorous rates on sunflower. The application was comprised of different phosphorous rates, i.e., P=0 kg ha-1 (control), P=42 kg ha-1 (30% < Recommended), P=48 kg ha-1 (20% < Recommended), P=60 kg ha-1 (recommended), P=72 kg ha-1 (20% > Recommended), and P=78 kg ha-1 (30% > Recommended). Statistical analysis showed that varying phosphorous rates significantly impacted sunflower growth and yield when compared to the control level of 0.00 kg ha-1. The test revealed that adding 78 kg ha-1 (30% more than recommended) of phosphorous resulted in the highest plant height (170.59 ± 1.261a), stem girth cm (8.80 ±0.138a), head diameter (cm) plant-1 (8.80 ±0.138a), seeds head-1 (2013.7 ± 2.292a), seed index (1000-seed weight, g) (62.42 ± 0.223a), highest seed weight head-1 (g), (82.54 ± 1.494a), seed yield (kg ha-1) (2401.7 ± 9.643a), and the oil content % (42.49 ± 0.363a). However, phosphorous 0 kg ha-1 (control) demonstrated the minimum results and was observed with plant height cm 146.67 ±0.950e, stem girth 4.78 ±0.152e cm, head diameter (cm) 30.99 ± 0.633e cm, seeds head-1 (1105.7 ± 0.633e), seed index (1000-seeds weight) (41.55 ± 0.696e), seed weight head-1 (g) (62.06 ± 1.115e), and oil content of (32.96 ± 1.644e). The experiment's results demonstrated that a phosphorous rate of 72 kg/ha (20% more than recommended) was suitable for achieving the maximum sunflower yield, as there were no significant differences when the phosphorous level was increased to 78 kg/ha (30% more than recommended).

Keywords:
Phosphorus, Different Doses, Sunflower, Growth, Yield

1. INTRODUCTION

Sunflower (Helianthus annuus L.) is an important oilseed crop, the use of sunflower seed by industry has rapidly increased [1]. Sunflower is an outstanding comparison species for plant physiology studies given its complete life cycle, large stationary organ, large seeds, and short duration of growth. Sunflower, being a local and economic source, is oil-rich and globally grown for the needs of the industry [2]. Pakistan is currently severely deficient in edible oil. Consumption of edible oil in Pakistan is directly related to the population while the production of edible oil is decreasing year by year. The domestic production of edible oil is 565 million tones and import is 2489 million tones, 82% of the oil is imported, cost of edible oil imported is 142.1 billion rupees [3]. In domestic production major share comes from cotton seed contributing 53% of total domestic production;

sunflower 33%; rape seed 9% and canola 5%. Potential crops, which can meet some requirements of edible oil in the country, include sunflower, rape seed mustard and canola [4]. The sunflower crop has tolerance to drought and high temperatures. Consequently, sunflower is an alternative for rural producers located in semiarid regions [5]. In addition to adapting to semiarid regions, sunflower has desirable agronomic characteristics, such as a short cycle, good productivity, and high oil quality and yield, allowing the producer to obtain a human and animal food source and economic returns in the short term [6]. Highly productive crops are achieved through the careful adjustment of agricultural practices such as tillage, fertilization, weed management, and phytosanitary control [7] and [8]. For sunflower, balanced nutrition directly affects the production of achenes, oil, and fatty acid content [9]. Considering various causes that lead to low yields, management of fertilizers might be of great significance [10]. As mentioned in other studies it has also been noted that 88% of the Pakistani soils are low in phosphorous [11]. To improve the yield and quality of sunflower oil, especially phosphorous fertilization should be given attention [12]. Phosphorous, one of the most necessary mineral elements for general plant growth and development plays a basic function found both in nucleic acids and nucleoproteins, which drive the DNA and RNA molecular activity [13]. Phosphorus is one of the essential nutrients for the growth and development of plants. It plays an important role in the regulation of various physiological processes [14]. High oil content in the seed is significant; it contributes to the transportation of carbohydrates and protein synthesis, it occupies an important place in the energy transfer reactions of photosynthesis and respiration, by increasing the number of flowers and filling developing grains, it also increases the size and weight of the grain [15],[16],[17]. It has a function akin to that of chlorophyll and, by its configuration, enables carbohydrates as well as proteins to be converted into fat. In this research, the impact of the various phosphorus perfusion doses on the yield and yield parameters of the plant in the Ziyareddin variety seeded in the soils with characteristics simulating the conditions of the system: Kayseri was investigated [18]. The amount of phosphorus in the soil depends on management practices, and it is prone to environmental loss and transformation. Short-term crop production and optimum nutrient factor levels can be ensured if the nutrient supply rates can be matched with the crop uptake pattern [19]. The effects of phosphorus dose are tenable and a primary component of agronomic sunflower. Phosphorus uptake and translocation are positively correlated with grain yield. When phosphorus is not available in sufficient quantities, plant growth is stunted and its yield is decreased [20], [21].

2. MATERIALS AND METHODS

2.1 Methodology

The objective of the field experiment was to find to evaluate the effect of phosphorus rate on the growth and yield of sunflower and to find out the suitable dose of phosphorus for obtaining maximum yield of sunflower. A complete randomized block design was used for the experiment, and the net plot size was 6 m x 3 m = 18 m2. The recommended methods for getting the land ready for sunflower crops were put into practice. Three replications of the study were conducted, with a focus on the local variety HO-1. Phosphorus was one of the fertilizers added to the soil. The sunflower crop received two timely irrigations, and measures were taken to control diseases, weeds, and pests at the experimental sites.

2.2 Culture Practices

Two rounds of ploughing and surface leveling were used to meticulously prepare the soil.

Throughout the first ten days after crop formation, five plants from each plot were chosen at intervals of five days in order to observe the agronomical characteristics of the plants. All of which were recorded.

2.3 Different Treatments of Phosphorus

T_1 = Phosphorus 00 kg ha^{-1} (control)
T_2 = phosphorus less than 30% 42 kg ha^{-1}
T_3 = phosphorus less than 20% 48 kg ha^{-1}
T_4 = phosphorus 60 kg ha^{-1} (recommended rates)
T_5 = phosphorus more than 20% 72 kg ha^{-1}
T_6 = phosphorus more than 30% 78 kg ha^{-1}

Fifteen plants were taken from each experimental unit throughout the maturity stage in order to determine their plant height (cm), stem girth (cm), head diameter (cm). The seed heads were separated from each plant, threshed, and used to calculate the number of seeds head-1, seed weight head-1 (g), weight of 1000 seeds (seed index), seed yield (kg ha-1), and oil content (%).

2.4 Analytical Statistics

Using the computer program Statistix-8.1, the gathered data was treated to an ANOVA (Statistics, 2006). LSD (Least Significant Difference) was used to analyzed treatment differences at P<0.05.

3. RESULTS

3.1 Plant Height (cm) Plant^{-1}

Table 1 Analysis of variance (p <0.05) showed that varying phosphorous rates significantly impacted sunflower growth and yield. The sunflower yielded results at various levels of phosphorus. The highest plant height (cm) of (170.59 ± 1.261a) was recorded in Treatment 6 = phosphorus, more than 30 % 78 kg ha^{-1}. Followed by Treatment 5 = phosphorus, more than 20% 72 kg ha^{-1} plant height (cm) of (167.58 ±0.772a). Further, the minimum plant height (cm) of (146.67 ±0.950e) was observed in control Treatment 1 = phosphorus 0 kg ha^{-1} (control).

3.2 Stem Girth (cm)

Table 1 Analysis of variance (p <0.05) showed that varying phosphorous rates significantly impacted sunflower growth and yield. The sunflower yielded results at various levels of phosphorus. The stem girth (cm) of 8.80 ±0.138a was recorded in Treatment 6 = phosphorus, more than 30% 78 kg ha-1. Followed by Treatment 5 = phosphorus, more than 20% 72 kg ha-1 stem girth (cm) of 8.76 ±0.125a. Further, the least stem girth (cm) of 4.78 ±0.152e was observed in control Treatment 1 = Phosphorus 0 kg ha-1 (control).

Table 1. Agronomic traits of sunflower are affected by sole and integrated applied soil fertilizers

Treatments	Plant height (cm)	Stem girth (cm)	Head diameter (cm)
T_1 = Phosphorus 00 kg ha^{-1} (Control)	146.67 ±0.950e	4.78 ±0.152e	30.99 ± 0.633e
T_2 = Phosphorus less than 30% 42 kg ha^{-1}	150.71 ±4.274d	5.51 ±0.068d	36.71 ± 0.317d
T_3 = Phosphorus less than 20% 48 kg ha^{-1}	154.81 ±1.163c	6.63 ±0.037c	40.55 ± 1.082c
T_4 = Phosphorus 60 kg ha^{-1} (Recommended rates)	164.78 ±0.988b	7.64 ±0.036b	44.19 ± 0.647b
T_5 = Phosphorus more than 20% 72 kg ha^{-1}	167.58 ±0.772a	8.76 ±0.125a	48.68 ± 0.259a
T_6 = Phosphorus more than 30% 78 kg ha^{-1}	170.59 ± 1.261a	8.80 ±0.138a	49.70 ± 2.292a
S.E.±	1.6252	0.0895	0.9070
LSD 0.05	2.228	2.228	2.228
P-value	0.0000	0.0000	0.0000

3.3 Head Diameter (cm) Plant

Table 1 Analysis of variance ($p < 0.05$) showed that varying phosphorous rates significantly impacted sunflower growth and yield. The results demonstrated a significant impact on sunflower growth and yield at various levels of phosphorus. The head diameter (cm) plant-1 of 8.80 ±0.138a was recorded in Treatment 6 = phosphorus, more than 30% 78 kg ha-1. Followed by Treatment 5 = phosphorus, more than 20% 72 kg ha-1 head diameter (cm) plant-1 of (8.76 ±0.125a). Further, the minimum head diameter (cm) plant-1 of 4.78 ±0.152e was observed in control Treatment 1 = Phosphorus 0 kg ha-1 (control).

3.4 Seeds Head

Table 2 Analysis of variance ($p < 0.05$) showed that varying phosphorous rates significantly impacted sunflower growth and yield. The sunflower yielded results at various levels of phosphorus. The seeds head-1 of (2013.7 ± 2.292a) was recorded in treatment Treatment 6 = phosphorus, more than 30% 78 kg ha-1. Followed by Treatment 5 = phosphorus more than 20% 72 kg ha-1 seeds head-1 of (1815.7 ± 0.259b). Further, the minimum seeds head-1 of (1105.7 ± 0.633e) was observed in control Treatment 1 = Phosphorus 0 kg ha-1 (control).

3.5 Seed Index (1000-Seed Weight, g)

Table 2 Analysis of variance ($p < 0.05$) showed that varying phosphorous rates significantly impacted sunflower growth and yield**.** The result showed that a seed index (1000-seed weight, g) was (62.42 ± 0.223a) in Treatment 6 = phosphorus, which is more than 30% 78 kg ha-1. T5 = phosphorus more than 20% 72 kg ha-1 seed index (1000-seed weight, g) of (61.64 ± 0.640a). Additionally, the least seed index (1000-seed weight, g) of (41.55 ± 0.696e) was recorded in control T1 = Phosphorus 0 kg ha-1 (control).

3.6 Seed Weight Head (g)

Table 2 Analysis of variance ($p < 0.05$) showed that varying phosphorous rates significantly impacted sunflower growth and yield. The results indicated that the seed weight head-1 (g) in treatment T6 = phosphorus increased by more than 30% at 78 kg ha-1. Applying T5 = phosphorus at a rate of more than 20% at 72 kg ha-1 resulted in seeds with a weight head-1 (g) of 82.27 to 0.475a. Further, the minimum seed weight head-1 (g) of (62.06 ± 1.115e) was observed in control T1 = Phosphorus 0 kg ha-1 (control).

Table 2. Agronomic traits of sunflower are affected by sole and integrated applied soil fertilizers

Treatments	Seeds head^{-1}	Seed index (1000-seeds weight, g)	Seed weight head^{-1} (g)
T_1 = Phosphorus 00 kg ha^{-1} (Control)	1105.7 ± 0.633e	41.55 ± 0.696e	62.06 ± 1.115e
T_2 = Phosphorus less than 30% 42 kg ha^{-1}	1350.3 ± 0.317d	46.15 ± 0.236d	65.91 ± 0.654d
T_3 = Phosphorus less than 20% 48 kg ha^{-1}	1581.3 ± 1.082c	48.60 ± 0.652c	71.45 ± 1.003c
T_4 = Phosphorus 60 kg ha^{-1} (Recommended rates)	1791.0 ± 0.647b	56.09 ± 0.730b	75.54 ± 1.263b
T_5 = Phosphorus more than 20% 72 kg ha^{-1}	1815.7 ± 0.259b	61.64 ± 0.640a	82.27 ± 0.475a
T_6 = Phosphorus more than 30% 78 kg ha^{-1}	2013.7 ± 2.292a	62.42 ± 0.223a	82.54 ± 1.494a
S.E.±	74.002	0.3596	0.8229
LSD 0.05	2.228	2.228	2.228
P-value	0.0000	0.0000	0.0000

Table 3. Agronomic traits of sunflower are affected by sole and integrated applied soil fertilizers

Treatments	Seed yield (kg ha^{-1})	Oil content (%)
T_1 = Phosphorus 00 kg ha^{-1} (Control)	1532.3 ± 35.019d	32.96 ± 1.644e
T_2 = Phosphorus less than 30% 42 kg ha^{-1}	1691 ± 45.825c	35.80 ± 0.478d
T_3 = Phosphorus less than 20% 48 kg ha^{-1}	1710 ± 86.863c	37.74 ± 0.350c
T_4 = Phosphorus 60 kg ha^{-1} (Recommended rates)	1815.3 ± 10b	39.58 ± 0.530b
T_5 = Phosphorus more than 20% 72 kg ha^{-1}	2380 ± 12.583a	42.39 ± 0.625a
T_6 = Phosphorus more than 30% 78 kg ha^{-1}	2401.7 ± 9.643a	42.49 ± 0.363a
S.E.±	31.962	0.6884
LSD 0.05	2.228	2.228
P-value	0.0000	0.0000

3.7 Seed Yield (kg ha^{-1})

Table 3 Analysis of variance ($p < 0.05$) showed that varying phosphorous rates significantly impacted sunflower growth and yield. The sunflower seed yield kg ha^{-1} at different phosphorus levels was found to be 2401.7 ± 9.643a kg ha-1, with more than 30% more seeds (78 kg ha-1) in treatment T6 = phosphorus. Followed by T_5 = phosphorus, more than 20% 72 kg ha^{-1} seed yield (kg ha^{-1}) of (2380 ± 12.583a). Further, the least seed yield (kg ha^{-1}) of (1532.3 ± 35.019d) was observed in control T_1 = Phosphorus 0 kg ha^{-1} (control).

3.8 Oil Content (%)

Table 3 Analysis of variance ($p < 0.05$) showed that varying phosphorous rates significantly impacted sunflower growth and yield. The result proved in sunflower at various levels of phosphorus: oil content (%) of (42.49 ± 0.363a) was recorded in treatment T_6 = phosphorus, more than 30% 78 kg ha^{-1}. Followed by T_5 = phosphorus, more than 20% 72 kg ha^{-1} oil content (%) of (42.39 ± 0.625a). Further, the minimum oil content (%) of (32.96 ± 1.644e) was observed in control T_1 = Phosphorus 0 kg ha^{-1} (control).

4. DISCUSSION

Sunflower (*Helianthus annuus* L.), one of the world's most adaptable and widely distributed oilseed crops, accounts for more than 12% of edible vegetable oil and is the fourth most produced oil crop worldwide [22]. Behind oil palm, soybean, and rapeseed, which together account for more than 87% of the world's vegetable oil output [23]. Globally, people consume this essential oilseed due to its high content of unsaturated fatty acids and low cholesterol, both essential for a balanced diet [24]. Our research produced the following results: Statistical analysis showed that varying phosphorous rates significantly impacted sunflower growth and yield when compared to the control level of 0.00 kg ha-1. Adding 78 kg ha-1 (30% more than what is recommended) of phosphorous led to the highest plant height (170.59 ± 1.261a), stem girth cm (8.80 ±0.138a), head diameter (cm) plant-1 (8.80 ±0.138a), seeds head-1 (2013.7 ± 2.292a), seed index (1000-seed weight, g) (62.42 ± 0.223a), highest seed weight head-1 (g), (82.54 ± 1.494a), seed yield (kg ha-1) (2401.7 ± 9.643a), and the oil content % (42.49 ± 0.363a). According to the study findings, there was a significant interaction between phosphorus and nitrogen in the achene yield [25]. These results are consistent with those published by [26], [27] of the HO-1 variety of sunflower reported the maximum plant height and Highest stem girth in sunflower varieties treated with N 90 kg ha-1, P 45 kg ha-1, and K 45 kg ha-1, Applying 150% and 125% RDF, above 100% RDF, significantly increased grain yield by 14.34% and 11.47%, respectively. [28] Observed that enhanced yield-attributing characteristics, such as head diameter, number of packed seeds, and test weight, may be responsible for the greater grain production. [29] found that applying 150% RDF (2104 kg ha-1) significantly increases grain yield compared to 100% RDF (1840 kg ha-1), but it is comparable to applying 125% RDF (2051 kg ha-1). After applying 135 kg P2O5 ha-1, researchers measured a head diameter of 16.81 cm, which was greater than that of 45 kg P2O5 ha-1, but comparable to applying 90 kg P2O5 ha-1. The control Treatment recorded the lowest head diameter, measuring 13.55 cm [30]. Among the P levels, 135 kg P2O5 ha-1 and 0 kg P2O5 ha-1 significantly produced the highest and lowest number of filled seeds head-1, respectively [31]. Similarity, the amount of packed seeds head-1 at 135 kg P2O5 ha-1 was equivalent to 90 kg P2O5 ha-1. However, when compared to 1000 grain weights (g), the amounts of phosphorus and sulphur may not be significant [32]. [33] Observed a similar association between higher phosphorus levels and higher seed yields. Applying 135 kg P2O5 ha-1, or 90 kg P2O5 ha-1, produced a significantly larger seed yield (1750 kg ha-1) than the equivalent lower level of 45 kg P2O5 ha-1, which produced the lowest seed yield (1263 kg ha-1) [34] reported similar results. Therefore, it is concluded that a balanced fertilizer is better than the application of treatments alone [35]. It is recommended that characteristics that contribute to the yield of sunflower remain substantially influenced by the use of phosphorus. P at 100 kg ha-1, followed by P5 at 75 kg ha-1, is the most effective fertilizer for the development and seed yield of sunflower [36]. Phosphorus (P) fertilizer has been shown to increase plant growth and production [37]. Phosphorus plays a vital role in plant development, and its application increases during the early, active phase of development when it increases the above physiological parameters [38]. However, [39] observed that the application of phosphorus may also have contributed to increases in seed yield factors and parameters. Phosphorus level application significantly impacted sunflower growth and seed yield compared to the control (no fertilizer) [40] According to previous results, [41] also examined how applying phosphorus at the right time and quantity significantly improved growth and seed yield. However, as the quantity of phosphorus increases, the seed yield increases as well. Similar to this, increasing phosphorus dosages led to an increase in grain production [42]. Plant growth and seed yield in sunflowers have strongly responded to the increasing availability of phosphorus [43]. Phosphate fertilizers contain significant amounts of solvable phosphorus, and when rainwater occurs shortly after their application, it can lead to an increase and a decrease in the absorption of phosphorus in the soil [44]. Increasing the external application of phosphorus can result in both soil interaction replacements and plant absorption [45]. Even in the absence of additional phosphorus supplementation, the roots and shoots of sunflower plants exhibit this substitution [46]. However, the plot fertilized with phosphorus at 100 kg ha-1 produced the maximum grain yield of sunflower; it is therefore recommended at 75 kg ha-1 that for obtaining higher development and grain yield of sunflower, phosphorus should be applied at 75 kg ha-1. Furthermore, [47] confirmed that the recommended dose of phosphorus fertilizer for sunflowers (75 kg ha-1) resulted in a higher seed yield and came highly recommended for local farmers.

5. CONCLUSIONS

The results demonstrated that varying phosphorus dosages positively and significantly impacted sunflower growth and yield. However, the data suggests that T6 = phosphorous more than 30% @ 78 kg ha-1 led to superior sunflower growth and yield, while T5 = phosphorous more than 20% @ 72 kg ha-1 yielded the best results. To make this research practically useful, the emphasis should be placed on the development of guidelines for the phosphorus application rates depending on the type of soil and conditions in which the fertilizer is to be applied. Engage farmers in the field to conduct experiments on the field to get results from real-life practices. Provide simple phosphorus application charts and stress on the cost of yield ratio in order to encourage the use of phosphorus. Also, include overviews of the topic suggesting how phosphorus management boosts the ground's fertility capabilities and future crop. These recommendations can be supported by on-field experiments undertaken with the farmers. In addition, the use of cost benefit analysis will assist farmers in minimizing the input costs while at the same time maximizing on yield. Thus, it is possible to avoid the disconnection between research findings and on-farm application of the results and achieve long-term sustainability of agriculture and its economic profitability.

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