



E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(4): 162-166
Received: 16-01-2026
Accepted: 20-02-2026

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International Journal of Research in Agronomy

Effect of nitrogen and phosphorus level's on the growth & yield of sunflower (*Helianthus annuus* L.)

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i4c.5347>

Abstract

Sunflower (*Helianthus annuus* L.) is a major oilseed crop valued for its high-quality edible oil and adaptability to diverse agro-climatic conditions. Efficient nutrient management, particularly nitrogen and phosphorus, plays a vital role in enhancing sunflower growth and productivity. The present study was conducted during the spring-summer season of 2024-25 at the Research Farm of the School of Agricultural Sciences, G. D. Goenka University, Gurugram, Haryana, located in a semi-arid region of northern India. The objective of the experiment was to assess the Effect of nitrogen and phosphorus level's on the growth & yield of sunflower (*Helianthus annuus* L.). The experiment was laid out using sunflower variety CHP-10 with graded levels of nitrogen (0, 50, 75, and 100 kg ha⁻¹) and phosphorus (0, 40, 60, and 80 kg P₂O₅ ha⁻¹). Observations were recorded on plant height, number of leaves, dry matter accumulation, capitulum diameter, number of seeds per capitulum, test weight, seed yield, and harvest index at various growth stages. Results indicated rapid vegetative growth between 30 and 60 days after sowing & at harvest. Application of nitrogen and phosphorus significantly improved all growth and yield parameters over the control. The treatment receiving 100 kg N ha⁻¹ + 80 kg P₂O₅ ha⁻¹ recorded the highest plant height, leaf number, dry matter accumulation, head diameter, number of seeds per capitulum, test weight, seed yield, and harvest index and was statistically comparable with 100 kg N ha⁻¹ + 60 kg P₂O₅ ha⁻¹. The control treatment consistently produced the lowest values. It can be concluded that balanced fertilization with 100 kg N ha⁻¹ and 80 kg P₂O₅ ha⁻¹ is effective for achieving optimum growth and maximum seed yield of sunflower under semi-arid conditions.

Keywords: Sunflower, nitrogen–phosphorus fertilization, growth and yield, seed yield

Introduction

Sunflower (*Helianthus annuus* L.), a member of the family Asteraceae (Compositae), is commonly known as Suraj-mukhi. It originated in North America and has now become an important oilseed crop cultivated across many parts of the world. Major sunflower-producing countries include Russia, Ukraine, the European Union, Argentina, China, Turkey, the United States, and South Africa. Globally, sunflower are grown on about 29.80 million hectares, producing 55.23 million tonnes with an average productivity of 1.85 t ha⁻¹ (Anonymous, 2023) [27].

In India, sunflower occupies nearly 0.36 million hectares, with a production of 0.36 million tonnes and an average productivity of 996 kg ha⁻¹ during the year 2022-23. Karnataka is the leading sunflower-producing state, contributing about 0.23 Mt, followed by Haryana and Odisha with 0.02 Mt each. In Maharashtra, the crop is cultivated on approximately 0.30 lakh hectares, producing 0.15 lakh tonnes with a productivity of 498 kg ha⁻¹ (Anonymous, 2023).

Sunflower is valued as one of the major oilseed crops due to its high oil content, ranging from 41 to 52.8% (Balogun *et al.*, 2023) [4]. The seeds are rich in nutritionally important compounds such as oleic and linoleic acids. In addition, sunflower seeds and oil contain mono- and polyunsaturated fatty acids, proteins, and tocopherols, which contribute to several health benefits. These components are known for their antibacterial, anti-diabetic, anti-inflammatory, antihypertensive, and antioxidant properties, thereby supporting overall human health (Piracha *et al.*, 2022) [10]. They also play a role in improving brain function, digestion, and cardiovascular

health (Shafique *et al.*, 2022) ^[11]. Nitrogen is a key nutrient required for plant growth and achieving optimum crop yields (Tabuchi *et al.*, 2007; Heuer *et al.*, 2017) ^[18, 21]. However, the efficiency of nitrogen fertilizer use worldwide remains relatively low, generally ranging between 40 and 53% (Chen *et al.*, 2021b; Wang *et al.*, 2023a) ^[20, 28, 31]. This often results in excessive fertilizer application beyond crop requirements, leading to higher production costs and environmental concerns (Nie *et al.*, 2022; Wang *et al.*, 2022a) ^[9, 30]. Overuse of nitrogen fertilizers contributes to environmental pollution and the emission of greenhouse gases such as nitrous oxide (N₂O), which has a high global warming potential (Chen & Graedel, 2016 ^[20, 28]; Ma *et al.*, 2019 ^[2]; Kong *et al.*, 2021; Ren *et al.*, 2021; Wu *et al.*, 2023) ^[7, 13, 15]. Sunflower possesses a strong and deep root system that enables efficient uptake of nitrogen from deeper soil layers, thereby improving nutrient utilization and crop yield (Kiniry *et al.*, 1992; Ma *et al.*, 2021; Thorup-Kristensen *et al.*, 2020) ^[1, 16]. Phosphorus is another essential macronutrient that plays a crucial role in improving crop growth and productivity (Singh *et al.*, 2017) ^[19]. Sunflower can grow well under a wide range of soil and climatic conditions (Nasim *et al.*, 2018) ^[17]. Earlier studies have shown that phosphorus application significantly enhances sunflower growth and yield attributes. Sial *et al.* (2022) ^[12] reported that the application of 60 kg ha⁻¹ phosphorus, along with sulfur, resulted in higher plant height, dry matter accumulation, number of seeds per capitulum, test weight, seed yield, stalk yield, and oil content. Phosphorus is involved in key physiological processes such as energy transfer, photosynthesis, root development, and flowering, and it plays a vital role in improving seed formation and overall crop performance (Ghani *et al.*, 2024) ^[3]. Phosphorus is particularly important during the early stages of sunflower growth, as it supports strong root development and proper crop establishment (Patel & Soni, 2023) ^[6]. Being a high-yielding crop, sunflower requires adequate phosphorus for effective flower formation, seed setting, and oil synthesis. Soil phosphorus availability directly influences seed weight, oil content, and final yield (Jabeen *et al.*, 2022) ^[8]. Several studies have also confirmed that phosphorus fertilization in phosphorus-deficient soils significantly improves sunflower yield and seed oil quality (Mujtaba *et al.*, 2023) ^[5].

Materials and Methods

The field experiment was conducted during the spring summer season of 2024-25 at the Research Farm of the School of Agriculture Sciences, G. D. Goenka University, Gurugram, Haryana, located at 29°10' N latitude and 75°46' E longitude at an elevation of 215.2 m above mean sea level. Gurugram (Haryana) has a semi-arid and subtropical climate with desiccating and hot-dry winds during the summer and severe cold during the winter season. During the hot summer months of May-June, the maximum temperature may rise to about 48°C. The annual average rainfall is about 400 mm, out of which 70-80% received during the monsoon period and the rest during the winter and spring seasons. The monthly mean maximum and minimum temperature's during all the stages of crop growth range from 16.0 °C to 28.9 °C and 3.0 °C to 13.4 °C, respectively; the maximum temperature 28.9 °C, was recorded in the month of March, whereas the minimum temperature 3.0 °C, was observed in the month of January. The monthly mean morning and evening relative humidity ranged from 56% to 100% and 24.7% to 75%, respectively. The seed of sunflower variety CHP-10 was obtained from the agronomy department of the school

of, agricultural sciences, G. D. Goenka University, Gurugram, Haryana. The seed was treated with Agrosan (3 g kg⁻¹ seed). The sowing was done by dibbling 2 to 3 seeds per hill to a depth of 4 to 5 cm at a spacing of 60 X 30 cm. Observations on plant height (cm), number of leaves, dry matter accumulation plant⁻¹(gm), diameter of capitulum (cm), number of seeds per capitulum, test weight (g), seed yield (q ha⁻¹), harvest index (%) were recorded at various stages of crop growth up to harvest and are presented in the Table. These characters generally indicate growth of the crop. Five plants were selected from each net plot at random. The same five plants were observed at various stages of crop growth up to harvest for the study of various characters except dry matter studies. The five plants were harvested separately for assessing individual plant yield also.

Results and Discussion Plant Height (cm)

The plant height (sunflower) increased fast from 30 days of crop age to 60 days of crop age, from 17.14 cm to 131.46 cm. This indicated that the growth rate was four times faster between the 30 and 60 DAS period, which may be due to the active vegetative growth phase of the plant. After 60 days, the mean plant height increased but at a relatively slow rate and attained its maximum of 133.44 cm on the 90th day and 135.16 cm at harvest. The Treatment T₁₀, T₉, and T₈ Nitrogen with Phosphorus application significantly improved the plant height over no Nitrogen and Phosphorus applications at all the crop growth stages. Further, at 30, 60, and 90 DAS and at harvest, application of 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ registered significantly higher plant height over 75 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ (T₇) and T₆, T₅, T₄, T₃, T₂, and T₁. The plant height increased significantly with each successive higher levels of nitrogen with phosphorus applied, and at all stages, the plant height recorded with the 100 kg N + 80 P₂O₅ kg ha⁻¹ level was significantly the highest (135.16) at harvest, and it was more than the rest of the levels. The differences between the nitrogen with phosphorus treatments i.e., T₁₀-100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ and T₉-100 N kg ha⁻¹ + 60 P₂O₅ kg ha⁻¹ were significant and they were at par with each other at 30DAS, 60 DAS, 90 DAS, and at harvest stages of observations.

Number of leaves per plant

Maximum leaves were recorded in 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ which were significantly higher than treatments of Nitrogen 50 and 75 kg ha⁻¹ with phosphorus 40, 60 and 80 kg per hectare but at par with 100 N kg ha⁻¹ + 60 P₂O₅ kg ha⁻¹ at all stages. However, T₁- Control could not produce significantly more number of leaves than any N and P treatment levels at any of the growth stage. Number of green leaves per plant differed significantly due to fertilization of nitrogen and phosphorus at all the growth stages in sunflower. More number of green leaves per plant was retained at 90 days (above 65 and 90 DAS) in treatment T₁₀-100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ as compared to other treatments. At 60 DAS, the treatments receiving 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ retained higher number of green leaves per plant (17.40) as compared to 100 N kg ha⁻¹ + 40 P₂O₅ kg ha⁻¹ (15.40) and control (8.60). However, maximum number of green leaves plant⁻¹ (28.3) was observed in the treatment receiving 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ fertilizer level as compared to all other treatments except (T₉) 100 N kg ha⁻¹ + 60 P₂O₅ kg ha⁻¹ which showed at par results with (T₁₀) 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹.

Dry Matter Accumulation/plant (GM)

The dry matter accumulated per plant due to 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ level was significantly more than rest of the nitrogen with phosphorus levels (5.34, 45.31 and 47.10 g plant⁻¹). However, it was at par with nitrogen with phosphorus applied at 100 N kg ha⁻¹ + 60 P₂O₅ kg ha⁻¹ (5.22, 44.30 and 46.12 g plant⁻¹) at 30, 60, and 90 DAS stages of sunflower, respectively.

Diameter of capitulum (CM)

Nitrogen and phosphorus fertilizer application had significant effect on head diameter of sunflower. The treatment receiving N 100 and P₂O₅ 80, 60 kg ha⁻¹ produced larger heads (19.49, 19.42 cm diameter respectively) as compared to N 50 and 75 kg ha⁻¹ with P₂O₅ 40, 60, and 80 kg ha⁻¹ (17.23 to 18.98 cm diameter) and control (16.47 cm diameter). The head diameter was increased as maximum head diameter of 19.49 cm was recorded at harvest of sunflower. The application of nitrogen and phosphorus at 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ and 100 N kg ha⁻¹ + 60 P₂O₅ kg ha⁻¹ were equally effective in increasing head diameter. However, 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ was always superior over control and all other treatments. Data given in Table 4 indicated that the differences in the diameter of head by various nitrogen and phosphorus levels as 50 N kg ha⁻¹ + 60 P₂O₅ kg/ha, 50 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹, 75 N kg ha⁻¹ + 40 P₂O₅ kg ha⁻¹ and 75 N kg ha⁻¹ + 60 P₂O₅ kg ha⁻¹ were not significant.

Number of seeds per capitulum

The application of nitrogen at 100 kg ha⁻¹ with 80 kg ha⁻¹ P₂O₅ produced significantly higher number of seeds head⁻¹ (741.00) over the rest of Nitrogen with phosphorus application levels. However, it was at par with the application of 100 kg N ha⁻¹ (736.93). Number of seeds head⁻¹ increased with nitrogen and phosphorus utilization efficiency because of improvement of crop growth which shows that increasing nitrogen and phosphorus consumption caused higher light utilization efficiency especially at all growth stage of sunflower crop. These results are in line with the findings of Rao^[26] and Reddy (1985).

Test weight (G)

Each higher level of Nitrogen and Phosphorus up-to 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ respectively, showed significantly enhanced the test weight over control and all other lower level of

nitrogen and phosphorus applied in various treatments. The application of nitrogen at 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ (T₁₀) recorded significantly maximum test weight than rest of the treatments applied with different levels of nitrogen and phosphorus. However, test weight at 100 N kg ha⁻¹ + 40 P₂O₅ kg ha⁻¹ (50.51 g) was found at par with 100 N kg ha⁻¹ + 60 P₂O₅ kg ha⁻¹ (52.69 g). This may be due to ability of the plant to access to more nitrogen and phosphorus increasing reproductive and productive parts.

Seed yield (Q Ha-1)

The application of nitrogen and phosphorus at 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ (T₁₀) produced significantly higher yield of seeds hectare⁻¹ than all other levels of nitrogen and phosphorus applied in sunflower. However, the yield of seeds per hectare at 100 N kg ha⁻¹ + 40 P₂O₅ kg ha⁻¹ (19.76 q ha⁻¹) was found at par with 100 N kg ha⁻¹ + 60 P₂O₅ kg ha⁻¹ (20.47 q ha⁻¹). The present findings are in line with those of Hocking *et al.* (1987)^[25] and Mahal *et al.* (1998)^[24]. These results are in the accordance with the results observed by Nawaz *et al.* (2003)^[23].

Harvest Index (%)

There was significant increase in the harvest index (%) with increasing levels of nitrogen with phosphorus; 100 N kg ha⁻¹ + 80 P₂O₅ kg ha⁻¹ was significantly superior to 50 N kg ha⁻¹ + 40 P₂O₅ kg ha⁻¹ and 75 N kg ha⁻¹ + 40 P₂O₅ kg ha⁻¹ was significantly superior to (Control treatment) no nitrogen and phosphorus application per hectare in sunflower crop. However, 100 N kg ha⁻¹ + 40 P₂O₅ kg ha⁻¹ and 100 N kg ha⁻¹ + 60 P₂O₅ kg ha⁻¹ were at par with harvest indices of 25.23% and 25.84% respectively. Application of 100 kg Nitrogen with 80 kg P₂O₅ ha⁻¹ over no Nitrogen and Phosphorus application significantly improved the harvest index. The differences between 50 and 75 kg Nitrogen and 40, 60 and 80 kg ha⁻¹ P₂O₅ ha⁻¹ were not showed significant difference. Whereas under 50, 75 and 100 kg N ha⁻¹, the significant response to phosphorus application was limited to 4. And 60 kg P₂O₅ ha⁻¹. but result found as significantly decrease in harvest index under control treatment (T₁) and application of 50 N kg ha⁻¹ + 40 P₂O₅ kg ha⁻¹ (T₂).

Table 1: Effect of Nitrogen and phosphorus on plant height (cm), Number of Leaves plant-1, Dry Matter Accumulation Plant-1 (GM) of sunflower crop

Treatments	Plant Height (CM)				Number of Leaves plant-1			Dry Matter Accumulation Plant-1 (GM)		
	30 days	60 days	90 days	At harvest	30 days	60 days	90 days	30 days	60 days	90 days
T ₁ - Control	11.14	118.94	119.27		119.60	5.07	8.60	9.47	2.26	34.23
T ₂ -50 N kg ha ⁻¹ + 40 P ₂ O ₅ kg ha ⁻¹	11.82	121.25	121.70		122.16	5.40	9.40	10.53	2.41	34.84
T ₃ -50 N kg ha ⁻¹ + 60 P ₂ O ₅ kg ha ⁻¹	12.66	122.38	123.74		125.10	5.53	9.87	11.20	2.95	36.57
T ₄ -50 N kg ha ⁻¹ + 80 P ₂ O ₅ kg ha ⁻¹	13.34	123.76	125.25		126.74	7.67	12.07	13.47	3.19	37.68
T ₅ -75 N kg ha ⁻¹ + 40 P ₂ O ₅ kg ha ⁻¹	14.11	126.81	128.36		129.91	8.00	13.07	14.53	3.43	38.45
T ₆ -75 N kg ha ⁻¹ + 60 P ₂ O ₅ kg ha ⁻¹	14.97	128.10	129.78		131.46	8.20	13.47	15.00	4.12	39.08
T ₇ -75 N kg ha ⁻¹ + 80 P ₂ O ₅ kg ha ⁻¹	15.52	128.84	130.62		132.40	9.07	14.67	16.27	4.56	40.75
T ₈ -100 N kg ha ⁻¹ + 40 P ₂ O ₅ kg ha ⁻¹	16.01	129.53	131.37		133.21	9.20	15.40	17.07	4.81	42.97
T ₉ -100 N kg ha ⁻¹ + 60 P ₂ O ₅ kg ha ⁻¹	16.76	130.64	132.59		134.30	9.93	16.67	18.40	5.22	44.30
T ₁₀ -100 N kg ha ⁻¹ + 80 P ₂ O ₅ kg ha ⁻¹	17.14	131.46	133.44	135.16	10.40	17.40	19.20	5.34	45.31	47.10
SE(m)	0.38	0.41	0.42	0.48	0.32	0.40	0.44	0.27	0.83	0.84
CD@0.5%	1.12	1.20	1.23	1.38	0.94	1.17	1.29	0.79	2.40	2.45

Table 2: Effect of Nitrogen and phosphorus on Diameter of Capitulum (cm), Number of seeds capitulum-1, Test weight (gm), Seed yield (q ha-1), Harvest Index (%) of sunflower

Treatment	Diameter of Capitulum (CM)	Number of seeds capitulum-1	Test weight (GM)	Seed yield (q ha-1)	Harvest Index (%)
T ₁ - Control	16.47	657.20	44.39	17.13	23.70
T ₂ -50 N kg ha ⁻¹ + 40 P ₂ O ₅ kg ha ⁻¹	17.23	668.13	45.05	17.97	24.49
T ₃ -50 N kg ha ⁻¹ + 60 P ₂ O ₅ kg ha ⁻¹	18.44	671.47	46.11	18.25	24.73
T ₄ -50 N kg ha ⁻¹ + 80 P ₂ O ₅ kg ha ⁻¹	18.59	692.60	46.93	18.57	24.31
T ₅ -75 N kg ha ⁻¹ + 40 P ₂ O ₅ kg ha ⁻¹	18.73	701.93	47.45	18.89	24.59
T ₆ -75 N kg ha ⁻¹ + 60 P ₂ O ₅ kg ha ⁻¹	18.98	704.80	48.64	19.08	24.68
T ₇ -75 N kg ha ⁻¹ + 80 P ₂ O ₅ kg ha ⁻¹	19.10	710.60	49.32	19.36	24.89
T ₈ -100 N kg ha ⁻¹ + 40 P ₂ O ₅ kg ha ⁻¹	19.19	711.93	50.51	19.76	25.23
T ₉ -100 N kg ha ⁻¹ + 60 P ₂ O ₅ kg ha ⁻¹	19.42	736.93	52.69	20.47	25.84
T ₁₀ -100 N kg ha ⁻¹ + 80 P ₂ O ₅ kg ha ⁻¹	19.49	741.00	55.79	21.63	26.70
SE(m)	0.24	4.45	0.68	0.18	0.20
CD@0.5%	0.69	12.95	1.99	0.52	0.59

Conclusion

The results of the study clearly demonstrated that sunflower growth, yield attributes, and productivity were significantly influenced by increasing levels of nitrogen and phosphorus. Rapid plant height increase between 30 and 60 DAS reflected active vegetative growth, which was further enhanced by higher nutrient application. Among all treatments, the application of 100 kg N ha⁻¹ + 80 kg P₂O₅ ha⁻¹ consistently produced superior plant height, number of leaves, dry matter accumulation, capitulum diameter, number of seeds per head, test weight, seed yield, and harvest index. This treatment was often statistically at par with 100 kg N ha⁻¹ + 60 kg P₂O₅ ha⁻¹, indicating that higher nutrient availability improved nutrient uptake efficiency and overall crop performance. In contrast, the control and lower fertilizer levels resulted in poor growth and yield. Therefore, balanced application of nitrogen and phosphorus, particularly at 100 kg N ha⁻¹ with 80 kg P₂O₅ ha⁻¹, can be recommended for achieving optimum growth, higher seed yield, and improved harvest index in sunflower cultivation.

Acknowledgement

I express my gratitude to all the faculty members of the Department of Agronomy, School of Agriculture Sciences, G.D. Goenka University, Gurugram Haryana, India for the support and direction I have received from them to finish the experiment.

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