



Original Paper

Effect of NPK Fertilizer and Liquid Organic Fertilizer on Growth and Production of Sunflower (*Helianthus annuus* L.)

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Abstract— Sunflowers are economically valuable plants that have been introduced and cultivated in Indonesia. The use of appropriate fertilizers plays a crucial role in enhancing plant growth and yield. This study aimed to study the impact of NPK and POC fertilizers on the growth and yield of sunflowers. The experiment was conducted from February to May 2025 in the UG Carte UG Technopark. A factorial randomized complete block design (RCBD) with two factors: NPK fertilizer doses (0, 2.5, 5, 7.5, and 10 g/plant) and liquid organic fertilizer (LOF) doses (0, 5, and 10 ml/L). Each treatment was replicated three times. Each treatment unit consisted of four plants, resulting in a total of 180 experimental units. Data were analyzed using analysis of variance (ANOVA) with the SAS System for Windows 9.0. When significant differences were detected at $P < 0.05$, Duncan's Multiple Range Test (DMRT) was performed at a 5% significance level. The results showed that NPK fertilizer significantly increased plant height at 4–8 weeks after planting (WAP), number of leaves at 4 and 6 WAP, stem diameter at 4–10 WAP, leaf area, flower diameter, tubular floret diameter, number of ribbon florets, number of seeds per flower, and seed weight per flower. In contrast, LOF treatment did not significantly affect sunflower growth or yield, and no interaction was observed between NPK and LOF treatments on these parameters.

Keywords— growth, NPK fertilizer, plant production, sunflower.

I. INTRODUCTION

The sunflower (*Helianthus annuus* L.) is an introduced species from the Asteraceae family with high economic value and significant development potential in Indonesia. This plant thrives in hot climates and full sunlight, providing diverse benefits across the food, industrial, health, and renewable energy (biodiesel) sectors [1;2;3].

Globally, sunflowers make a significant economic contribution. In 2023, the value of global sunflower oil exports reached IDR 300 trillion, with Ukraine, Russia, and Argentina as the primary producers [4]. Additionally, sunflower seeds and meal are important commodities in international trade. However, Indonesia remains highly dependent on vegetable oil imports, with domestic production meeting only about 3% of demand. One reason for this is the low interest among farmers in cultivating sunflowers, which is believed to be influenced by limited information on cultivation techniques and market opportunities [5;6].

To increase production, the application of appropriate cultivation technologies is essential, one of which is fertilization. NPK 16-16-16 fertilizer is an inorganic compound fertilizer containing nitrogen (N), phosphorus (P), and potassium (K), and has been shown to enhance sunflower plant production and vegetative growth [7;8]. However, the continuous use of chemical fertilizers can have long-term adverse effects on soil fertility [9].

As an alternative solution, liquid organic fertilizer (LOF) is gaining traction due to its organic-based ingredients rich in amino acids, growth hormones, and macro- and micronutrients. Organic fertilizers (LOF) can improve soil quality and naturally stimulate plant growth [10;11]. The use of LOF has shown positive results in horticultural crops, particularly in increasing plant height, leaf number, and yield [12]. However, to date, there has been limited research examining the effectiveness of LOF on sunflower production. Based on this background, this study was conducted to investigate the impact of NPK fertilizers and liquid organic fertilizers (LOF) on sunflower growth and production.

II. MATERIALS AND METHOD

A. Research Area Description

This study was conducted from February to May 2025 in the UG Carte UG Technopark Zone, Jamali Mulyasari Village, Mande District, Cianjur Regency, situated at an elevation of 392 meters above sea level in West Java.

B. Experimental Materials and Tools

The equipment and materials used included 40 x 40 cm polybags, hoes, watering cans, seedling trays, digital scales, stationery, plant labels, sprayers, and measuring instruments. The materials utilized in this investigation comprised sunflower seeds of the Kanigara IPB variety, manure, NPK 16-16-16 fertilizer, organic fertilizer (LOF) containing 14.05% organic carbon, 1.84% organic nitrogen, 5.79% N + P + K, as well as several micronutrients and growth regulators, and chemical pesticides.

C. Experimental Method

This study used a Randomized Complete Block Design (RCBD) with two factors. Factor I was NPK fertilizer applied at five levels: N0 (0 g), N1 (2.5 g), N2 (5 g), N3 (7.5 g), and N4

(10 g) per plant. Factor II consisted of three levels: no fertilizer (P0), 5 ml/L fertilizer (P1), and 10 ml/L fertilizer (P2). The experiment included 15 treatments with three replications, resulting in 45 experimental units, each comprising four plants, for a total of 180 plants. Data were analyzed using Analysis of Variance (ANOVA) with SAS for Windows 9.0. When the analysis yielded a P-value < 0.05, indicating a significant difference, or a P-value < 0.01, indicating a highly significant difference, further comparisons were conducted using Duncan's Multiple Range Test (DMRT) at the 5% significance level.

The study began by sowing sunflower seeds in a planting medium consisting of a 1:1 mixture of manure and rice husk charcoal. Seedlings were transplanted to the field after three weeks or once they had developed 3–4 leaves [13]. The research was conducted at UG Carte UG Technopark, covering an area of 10 m² with a width of 7.67 m. Planting was carried out in polybags filled with soil, arranged in a randomized design with spacing of 60x50 cm between polybags.

Seedlings were planted in the afternoon, placed in watered holes, and then covered to protect the roots. Fertilization with NPK fertilizer was applied at doses of N0 (0 g), N1 (2.5 g), N2 (5 g), N3 (7.5 g), and N4 (10 g) per plant. This was done twice, at 15 and 40 days after planting (DAP), by sprinkling the fertilizer around the roots [14;13]. LOF was applied every two weeks after transplanting at concentrations of 0 mL/L, 5 mL/L, and 10 mL/L, with a volume of 100 mL per plant, by watering around the roots [12].

Maintenance included replanting up to seven days after transplanting, weeding, and regular watering in the morning and evening. Stake installation and pest control were also performed using pesticides containing the active ingredients deltamethrin

(25 g/L) and cypermethrin (50 g/L), applied alternately every three days at a concentration of 1 ml/L of water. Harvesting was conducted 90 to 105 days after transplanting, indicated by mature flowers, yellowing stems, drying petals, and black seeds with white stripes [15].

III. RESULTS AND DISCUSSION

A. The Growth of Sunflower

1) Equations

Based on the analysis of variance, NPK fertilizer application significantly affected sunflower plant height at 4, 6, and 8 weeks after planting (WAP). Table I shows that the treatment without NPK fertilizer (N0) consistently produced the lowest growth compared to the other treatments, with a plant height of 166.72 cm at 10 WAP. Application of NPK fertilizer at doses N1 through N4 caused plant height to increase significantly week by week, with the highest growth rate observed in the NPK fertilizer treatment N3, reaching 205.92 cm at 10 WAP. This finding is consistent with the research by [16], which demonstrated that applying NPK fertilizer at a dose of 7.5 g/plant significantly increased sunflower plant height.

Increasing the NPK fertilizer dose generally leads to a significant enhancement in vegetative plant growth, particularly in terms of plant height, as reported in a study by [17]. This study found that higher NPK fertilizer doses positively impact plant height. The nitrogen component of NPK fertilizer is essential for the development of vegetative tissues, including stems and leaves. This assertion is supported by [18], who stated that nitrogen is the primary nutrient responsible for increased vegetative growth in plants.

TABLE I. PLANT HEIGHT OF SUNFLOWER

Treatment	Plant Age (weeks)				
	2	4	6	8	10
NPK fertilizer:					
	Plant Height (cm)				
0 g/plant (N0)	34.69	60.15c	99.54c	148.22b	166.72
2.5 g/plant (N1)	34.14	68.68bc	123.37b	179.39ab	197.75
5 g/plant (N2)	37.28	83.87a	148.22a	193.31a	199.44
7.5 g/plant (N3)	38.65	84.62a	147.61a	198.17a	205.92
10 g/plant (N4)	35.45	75.21ab	132.20ab	175.08ab	182.94
LOF:					
0 ml/L (P0)	35.6	75.21	132.64	179.37	188.72
5 ml/L (P1)	37.42	78.44	135.96	183.83	196.58
10 ml/L (P2)	35.1	69.86	121.97	173.3	186.37
Interaction	tn	tn	tn	tn	tn

Description: According to the DMRT test, values in the same column with the same letter at a significance level of 5% do not differ significantly. tn = no significant difference.

Plant height growth results from cell division and elongation in the apical meristem tissue. After division, cells enlarge and elongate until they reach a specific size, at which point growth ceases [19]. Therefore, applying NPK fertilizer at the appropriate dosage can optimize the vegetative growth of sunflower plants, particularly by increasing plant height.

2) Leaf Number (Leaves)

Based on the analysis of variance results, NPK fertilizer application had a highly significant effect on the number of sunflower leaves at 4 and 6 weeks after planting (WAP). However, no significant effect was observed at 2, 8, and 10 WAP.

TABLE II. PLANT HEIGHT OF SUNFLOWER

Treatment	Plant Age (weeks)				
	2	4	6	8	10
NPK fertilizer:	Leaf Number (Leaves)				
0 g/plant (N0)	13.22	19.08c	19.19c	18.94	16.02
2.5 g/plant (N1)	12.44	23.34b	21.25bc	21.94	19.3
5 g/plant (N2)	13.94	25.53ab	23.11ab	21.47	17.06
7.5 g/plant (N3)	13.61	25.56ab	22.69ab	20.33	17.14
10 g/plant (N4)	13.69	26.13a	24.50a	21.83	17.19
LOF:					
0 ml/L (P0)	13.48	23.58	22.28	20.45	16.85
5 ml/L (P1)	13.6	24.53	22.38	21.05	17.7
10 ml/L (P2)	13.07	23.7	21.78	21.22	17.48
Interaction	tn	tn	tn	tn	tn

Description: According to the DMRT test, values in the same column with the same letter at a significance level of 5% do not differ significantly. tn = no significant difference.

Based on Table II, NPK fertilization without nitrogen (N0) resulted in the lowest number of leaves, with only 16.02 leaves observed at 10 WAP. In contrast, NPK fertilizations with nitrogen levels N1, N2, N3, and N4 produced higher leaf counts at 10 WAP, specifically 19.30, 17.06, 17.14, and 17.19 leaves, respectively. These results are consistent with the findings of [20], which reported that NPK fertilization significantly increased leaf number at 2, 4, 6, and 8 WAP.

This increase highlights the crucial role of macronutrients, particularly nitrogen, which is essential for promoting the growth of vegetative plants. Nitrogen supports the formation of chlorophyll and leaf tissue, while phosphorus and potassium contribute to cell division and overall plant metabolism. According to [21], increasing the dosage and frequency of NPK fertilizer application can accelerate leaf formation. This assertion is further supported by [22], who reported that high nitrogen content enhances chlorophyll synthesis and boosts photosynthesis. Optimal photosynthesis leads to greater accumulation of photosynthates, which are subsequently distributed to vegetative organs such as leaves. This process results in leaf elongation and an increase in leaf number, thereby supporting overall plant growth [23].

3) Stem Diameter

Based on the results of the analysis of variance, NPK fertilizer application significantly affected sunflower stem diameter from 4 to 10 WAP. However, there was no significant effect at 2 WAP. Table III shows that the NPK fertilizer treatment without application (N0) produced the lowest recorded stem diameter of 13.60 mm at 10 WAP. In contrast, the NPK fertilizer treatments (N1, N2, N3, and N4) showed a gradual increase, with the highest stem diameter observed at N4, measuring 20.60 mm at 10 WAP. This finding aligns with the research by [24], which demonstrated a significant effect of NPK fertilizer on stem diameter at 4 WAP.

The increase in stem diameter aligns with the roles of each macronutrient in NPK fertilizer. Nitrogen supports the formation of vegetative tissue, phosphorus promotes healthy root development to enhance nutrient absorption, and potassium strengthens cell walls and improves metabolic efficiency. These three elements collectively support chlorophyll formation, protein synthesis, and the overall structure of plant tissue [25]

TABLE III. STEM DIAMETER OF SUNFLOWER

Treatment	Plant Age (weeks)				
	2	4	6	8	10
NPK fertilizer:	Stem Diameter (mm)				
0 g/plant(N0)	5.78	8.55c	11.36c	12.86c	13.69c
2.5 g/plant (N1)	5.61	11.08b	14.72b	16.72b	18.11b
5 g/plant (N2)	6.25	13.29a	16.17ab	17.75ab	18.88ab
7.5 g/plant (N3)	6.53	13.36a	17.33a	19.25a	20.59a
10 g/plant (N4)	6.17	12.80a	17.15a	19.23a	20.60a
LOF:					
0 ml/L (P0)	6.37	12.33	15.68	17.43	18.58
5 ml/L (P1)	6.15	11.93	15.25	17.11	18.36
10 ml/L (P2)	5.68	11.19	15.13	16.94	18.18
Interaction	tn	tn	tn	tn	tn

Description: According to the DMRT test, values in the same column with the same letter at a significance level of 5% do not differ significantly. tn = no significant difference.

4) Leaf Area

Based on the results of the analysis of variance, NPK fertilizer application had a highly significant effect on sunflower leaf area. As shown in Table IV, the NPK treatment (N3) produced the largest leaf area, measuring 251.27 cm², while the control treatment without NPK fertilizer (N0) resulted in the smallest leaf area, at 110.69 cm². The other NPK treatments (N1,

N2, and N4) yielded intermediate average leaf areas of 181.26 cm², 211.74 cm², and 231.01 cm², respectively. These findings are consistent with the research by [12], which demonstrated that NPK fertilization significantly influences plant leaf area.

TABLE IV. STEM DIAMETER OF SUNFLOWER

Treatment	Leaf Area (cm ²)
NPK fertilizer:	
0 g/plant (N0)	110.69c
2.5 g/plant (N1)	181.26b
5 g/plant (N2)	211.74ab
7.5 g/plant (N3)	251.27a
10 g/plant (N4)	231.01a
LOF:	
0 ml/L (P0)	190.51
5 ml/L (P1)	192.55
10 ml/L (P2)	208.52
Interaction	tn

Description: According to the DMRT test, values in the same column with the same letter at a significance level of 5% do not differ significantly. tn = no significant difference.

The increase in leaf area indicates that the macronutrients in NPK fertilizer, particularly nitrogen, play a crucial role in leaf development and chlorophyll synthesis. Adequate nitrogen availability accelerates the rate of photosynthesis, thereby supporting optimal growth of vegetative tissues [26]. Photosynthesis produces carbohydrates, which serve as the primary energy source for plants; the greater the energy available, the more effectively the plant can absorb nutrients [27]. Enhanced nutrient absorption, in turn, boosts photosynthetic output, contributing to the expansion of leaf surface area. These photosynthates also promote cell enlargement and differentiation, thereby influencing overall leaf size and area [28]. Therefore, applying NPK fertilizer at the appropriate dosage is essential for supporting vegetative growth in sunflowers, particularly in increasing leaf area.

Based on Tables I, II, III, and IV, the LOF application had no discernible impact on plant height, leaf number, stem diameter, or leaf area of sunflowers at any plant age. This

finding aligns with the results of [26], who demonstrated that LOF treatment did not significantly affect the vegetative phase. This outcome is likely because the application rates of 0 ml/L, 5 ml/L, and 10 ml/L LOF, administered biweekly at 100 ml per plant, were not optimal for the vegetative growth stage. This is supported by research from [12], which also showed that ineffective LOF application was insufficient to consistently promote plant growth. Furthermore, there was no significant interaction effect between the NPK and LOF fertilizer treatments on the vegetative growth of the plants.

B. The Harvest of Sunflowers

1) Flowering Age

The analysis of variance revealed that the use of NPK fertilizer had no significant effect on sunflower flowering time. As shown in Table V, the NPK (N2) treatment resulted in the earliest flowering time, at 52.50 days after planting (DAP), while the NPK (N1) treatment had the latest flowering time, at 57.58 DAP. Similarly, the application of LOF fertilizer had no significant impact on flowering time. Furthermore, no interaction effect was observed between NPK and LOF fertilizer treatments on sunflower flowering time. It is likely that flowering time is primarily influenced by genetic factors specific to each variety, such that the application of NPK and LOF fertilizers does not substantially alter the timing of flowering. This suggests that plants will flower at approximately the same time regardless of the different treatments. According to the description of the Kanigara IPB sunflower variety, flowering occurs at 6-7 WAP. This observation is supported by [29], who stated that flowering time is strongly influenced by genetic factors, particularly the plant variety used in cultivation.

TABLE V. FLOWERING AGE, FLOWER DIAMETER, FLOWER WEIGHT, NUMBER OF RAY FLORETS, DIAMETER OF DISC FLORETS

Treatment	Flowering Age (DAP)	Flower Diameter (mm)	Flower Weight (g)	Number of Ray Florets (fruit)	Diameter of Disc Florets (mm)
NPK fertilizer:					
0 g/plant (N0)	57.28	131.56b	75.08b	27.42c	76.95 b
2.5 g/plant (N1)	57.58	160.05a	114.83a	32.61b	94.29a
5 g/plant (N2)	52.5	164.38a	121.86a	35.72a	98.93a
7.5 g/plant (N3)	54.61	170.75a	122.31a	34.58ab	98.51a
10 g/plant (N4)	54.25	163.36a	123.03a	36.81a	98.82a
LOF:					
0 ml/L (P0)	53.33	157.17	105.6	34.15	91.78
5 ml/L (P1)	55.65	161.11	118.57	32.93	95.48
10 ml/L (P2)	56.75	155.79	110.1	33.2	93.24
Interaction	tn	tn	tn	tn	tn

Description: According to the DMRT test, values in the same column with the same letter at a significance level of 5% do not differ significantly. tn = no significant difference.

2) Flower Diameter, Diameter of Disc Florets, Number of Ray Florets, and Flower Weight

Generative parameters are essential indicators for evaluating the success of sunflower cultivation, as they directly influence yield potential and production quality. The parameters observed included flower diameter, disc floret diameter, number of ray florets, and flower weight. According to the analysis presented in Table V, the application of NPK fertilizer had a significant effect on all four parameters.

The NPK treatment at level N3 produced the largest flower diameter, measuring 170.75 mm, whereas the NPK treatment at level N0 resulted in a diameter of only 131.56 mm. This finding contrasts with the study by [24], which reported no significant

effect of NPK on flower diameter. Regarding the diameter of disc florets, the NPK treatment at level N2 yielded the greatest diameter (98.93 mm), while the N0 treatment (without fertilizer) produced the smallest diameter (76.95 mm). The number of ray florets also increased significantly with higher NPK dosages. The NPK treatment at level N4 produced the highest number of ray florets (36.81), whereas the N0 treatment produced the lowest (27.42). Similarly, the greatest flower weight was observed in treatment N4 (123.03 g), and the lowest in treatment N0 (75.08 g). However, these results are inconsistent with those reported by [24].

The role of macronutrients significantly influences these yields. Nitrogen plays an essential role in the development of

plant tissue, phosphorus is crucial for flowering and seed development, and potassium aids in the distribution of photosynthates and strengthens the flower structure. These four generative parameters are interrelated; an increase in flower diameter tends to correspond with an increase in the diameter of tubular flowers, the number of ray flowers, and the overall flower weight. Reference [30] reported a significant and positive relationship between flower head diameter and flower head weight. This finding is supported by the results of [24], which showed that increased flower diameter is directly proportional to increased flower weight, both wet and dry. Therefore, flower diameter can serve as an important indicator for determining the overall yield potential of sunflowers.

3) Number of Seeds per Flower, Fresh Seed Weight per Flower, and 100-Seed Weight

NPK fertilizer application generally has a significant impact on sunflower yield, particularly regarding the number of seeds per flower and the fresh seed weight per flower. The results showed that plants not treated with NPK fertilizer (N0) produced the lowest yields, averaging 367.56 seeds per flower and a fresh seed weight of 21.53 g per flower. This finding indicates that macronutrients—especially potassium, phosphorus, and nitrogen—are essential for seed formation and filling. However, these results contradict the findings of [24], which reported no

significant effect of NPK application on the fresh seed weight per flower in sunflower plants.

Increasing the NPK fertilizer dosage to a certain level, particularly in the N2 and N4 treatments, resulted in a significant increase in both seed number and weight. The combination of these three nutrients promotes the development of fuller seeds, as evidenced by the rise in fresh seed weight per flower. According to [31], phosphorus—second only to nitrogen in importance—plays a crucial role in various plant physiological processes, including root growth, photosynthesis, and the development of flowers, fruits, and seeds.

Meanwhile, regarding 100-seed weight, the application of NPK fertilizer did not result in a statistically significant difference; however, there was a trend toward increased weight with higher dosages. The NPK (N4) treatment produced the highest weight at 5.72 g, while the NPK (N0) treatment yielded the lowest weight at 4.86 g. This suggests that NPK fertilizer tends to have a greater impact on the overall quantity and total weight of the harvest rather than improving individual seed quality in terms of size or weight per 100 seeds. According to [6], high seed weight reflects a plant’s ability to adapt well to its environment, whereas low seed weight indicates suboptimal adaptation.

TABLE VI. NUMBER OF SEEDS PER FLOWER, FRESH SEED WEIGHT PER FLOWER, AND 100-SEED WEIGHT

Treatment	Number of Seeds per Flower (seeds)	Fresh Seed Weight per Flower (g)	100-seed weight (g)
NPK fertilizer:			
0 g/plant (N0)	367.56b	21.53b	4.86
2.5 g/plant (N1)	579.69a	35.08a	5.58
5 g/plant (N2)	617.44a	34.42a	5.25
7.5 g/plant (N3)	593.61a	35.94a	5.67
10 g/plant (N4)	633.33a	35.44a	5.72
LOF:			
0 ml/L (P0)	527.13	30.63	4.98
5 ml/L (P1)	582.98	35.08	5.73
10 ml/L (P2)	564.87	31.73	5.53
Interaction	tn	tn	tn

Description: According to the DMRT test, values in the same column with the same letter at a significance level of 5% do not differ significantly. tn = no significant difference

The organic fertilizer (LOF) treatment had no significant effect on any of the parameters listed in Tables V and VI for sunflower plants. This finding suggests that macronutrients from inorganic fertilizers have a greater influence on the formation of reproductive organs than those from liquid organic fertilizers at the tested concentrations. This conclusion is supported by [32], who reported that a compound NPK fertilizer with a 16-16-16 composition contains 16% each of nitrogen, phosphorus pentoxide, and potassium oxide, with nitrogen divided into ammonium (9.5%) and nitrate (6.5%). In contrast, the organic fertilizer contains 14.05% organic carbon, 1.84% organic nitrogen, and 5.79% total N + P + K [33]. Furthermore, the results in Tables V and VI indicate no interaction between NPK and liquid organic fertilizer (LOF) applications on any of the observed parameters in sunflower plants.

IV. CONCLUSION AND SUGGESTION

Based on the research results, it can be concluded that the application of NPK fertilizer significantly increased plant height at 4 to 8 weeks after planting (WAP), leaf number at 4 and 6 WAP, stem diameter from 4 to 10 WAP, leaf area, flower

diameter, diameter of disc florets, number of ray florets, number of seeds per flower, and seed weight per flower. Conversely, the application of LOF showed no significant effect on any growth or production parameters, and no interaction was observed between NPK and LOF fertilizer applications on sunflower growth or production.

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