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Original Paper

The Effect of Npk Fertilizer on The Growth and Oil Production of Sunflower (*Helianthus Annuus L.*)

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***Abstract*—This electronic document is a "live" template and already defines the components of your paper [title, text, heads, etc.] in its style sheet. **CRITICAL: Do Not Use Symbols, Special Characters, Footnotes, or Math in Paper Title or Abstract.* (*Abstract*) This study aims to analyze the response of different doses of NPK compound fertilizer on the growth and oil production of sunflower (*Helianthus annuus L.*). It is necessary to increase the production of sunflower oil by applying the appropriate dose of NPK fertilizer to meet the demands of the oil market. This study used a Randomized Complete Block Design (RCBD), with 4 experimental treatments: NPK compound fertilizer doses of 2.5 g/plant, 3.75 g/plant, 5 g/plant and 6.25 g/plant. The results showed significant positive effects of NPK fertilization on vegetative growth parameters, specifically plant height and stem diameter. However, the fertilizer treatments did not show significant impact on sunflower oil production. Based on the observed results, the 3.75 g/plant dose (D2) was the most effective NPK dose for the parameters of leaf number, flower diameter, flower weight, seed wet weight, seed dry weight.**

***Keywords*— Sunflower oil extraction, oil yield analysis, fertilizer impact**

I. Introduction

Sunflower oil offers significant benefits and experiences high market demand Market analysis indicates that the sunflower oil is projected to reach 35.98 billion US Dollars, and it is estimated that in 2029 it will reach 48.26 billion US Dollars, during the forecast period (2024-2029) calculated to grow at a CAGR (Compound Annual Growth Rate) of 6.05% [1]. The current market demand for sunflower oil is not being met due to the suboptimal sunflower production in Indonesia. This issue is evidenced by the high volume of imports required to satisfy the demand. Indonesia in 2015 imported sunflower seeds amounting to 11,755,730 kg and increased in 2016 to 15,274,046 kg, while in 2015 Indonesia imported sunflower oil of 91 kg and in 2016 it increased significantly to 6,603 kg [2].

The high volume of sunflower oil imports is partly due to the inefficiency of the sunflower production and cultivation process in Indonesia. Sunflower production problems are partly caused by improper agricultural practices, one of which is soil fertility problems resulting in depletion of some nutrients and soil organic matter that affect agricultural production. This can be mitigated by the proper application of fertilizers [3;4;5;6]. Macro and micronutrients are essential for plant nutrition and play a crucial role in achieving higher crop yields. Plants require specific nutrients in precise forms and at optimal times for their growth and development [7;8]. Fertilizers are grouped into two categories organic and inorganic. The application of inorganic fertilizers offers the advantage of effectively adjusting soil chemical properties by supplementing essential nutrients [9;10]. One such fertilizer is NPK [11]. NPK fertilizer is a compound fertilizer known for its rapid and efficient application supplying nutrients in the form of nitrogen, phosphorus and potassium [10;12;13;14;15].

Research conducted by [16] demonstrated that an NPK fertilizer application of 100 kg/ha resulted in the highest number of flowers per plant among the tested dosages. However, that study primarily focused on plant growth and yield specifically the number of flowers and flowering duration, Given the significant health benefits of sunflower oil, as well as its applications in cosmetics and pharmaceutical industries. Therefore, further research is needed regarding the effect of NPK fertilizer on sunflower oil production. This research aims to analyze the effect of NPK fertilizer on the vegetative and generative growth of sunflower (*Helianthus annuus* L.), and crucially on the quantity of sunflower seed oil produced.

II. Material And Methods

A. Description of Study Area

The study was conducted at UG Technopark, Cianjur, West Java, at an altitude of 392 meters above sea level. The research period spammed March to July 2024. The average morning temperature during the study was 26.85℃ with 84% humidity, while the average afternoon temperature was 39.78℃ with 49% humidity. Conversely, the average evening temperature was approximately 31.09℃ with 65% humidity.

TABLE I. PLANT HEIGHT OF SUNFLOWER (CM)

Treatment	Plant Age (Week After Planting/ WAP)				
	4	8	12	14	15
D1 (100 kg/ha)	17.52 a	71.96	137.04	150.59	169.81
D2 (150 kg/ha)	15.71 ab	60.67	134.63	142.63	166.07
D3 (200 kg/ha)	14.50 ab	63.92	129.36	147.64	177.40
D4 (250 kg/ha)	13.59 b	52.94	128.62	139.35	163.85

Description: The numbers in the same column followed by the same letter are not significantly different at the DMRT test level $\alpha = 5\%$.

TABLE II. STEM DIAMETER OF SUNFLOWER (MM)

Treatment	Plant Age (Week After Planting/ WAP)				
	4	8	12	14	15
D1 (100 kg/ha)	7.87 a	20.09	28.71	29.80	31.37
D2 (150 kg/ha)	6.56 ab	16.62	28.29	28.66	29.36
D3 (200 kg/ha)	6.35 ab	17.80	28.29	28.09	29.58
D4 (250 kg/ha)	5.77 b	15.38	28.29	22.35	23.75

Description: The numbers in the same column followed by the same letter are not significantly different at the DMRT test level $\alpha = 5\%$.

Stem diameter was significantly affected at 4 weeks after planting. At 4 WAP, the plants received the initial 75% dose of compound NPK fertilizer, coinciding with the vegetative growth phase. The vegetative phase is a period of rapid growth that necessitates ample nutrient availability. Adequate nutrient supply during this phase can enhance plant productivity [23]. Nitrogen, in particular, plays a crucial role in the development of vegetative plant components, such as stems and roots. [24;25].

TABLE III. NUMBER OF LEAVES SUNFLOWER (BLADE)

Treatment	Plant Age (Week After Planting/ WAP)				
	4	8	12	14	15
D1 (100 kg/ha)	12.25	18.15	20.85	22.55	18.20
D2 (150 kg/ha)	11.55	16.80	21.60	25.60	24.65
D3 (200 kg/ha)	11.55	16.55	21.55	25.75	23.65
D4 (250 kg/ha)	10.60	14.70	21.35	21.85	18.65

The number of leaves parameter indicated that varying doses of compound NPK fertilizer did not yield a significant effect. In line with Primayani's research [26], it states that NPK fertilizer was found to have no significant impact on leaf count. This is because the plant nutrients are not sufficient, especially in nitrogen nutrients which act as a stimulator of growth rates in order to increase plant height and number of leaves [27;28]. An increase in soil nitrogen content facilitates chlorophyll formation in leaves, thereby enhancing the photosynthesis process, which, in turn, promotes leaf development [29]. Photosynthesis Influenced the expansion of leaf blades due to the process of translocating most of the food reserves to the vegetative organs of the plant. Consequently, an increase in the number of leaves will affect the increase in leaf number contributes to a higher photosynthate content, which affects overall plant growth and development [30].

The application of NPK fertilizer at varying doses revealed that the highest dose, D4 (250 kg/ha), resulted in the lowest average values for plant height, stem diameter, and leaf number. This observation aligns with findings reported by [31;32], which suggest that excessive fertilizer application leads to nutrient imbalance in the soil and disrupts plant physiological processes thereby inhibiting the growth rate.

B. Experimental Materials

The equipment employed in this research included a drip irrigation system, 72-cell seedling trays, mulch, water drum, water pumps, automatic switchs, a timer, a automatic float, parallel cables, 16 mm and 7 mm PE hoses, sockets (T, L), nipple, drip sticks, digital scales, vernier calipers, a dehydrator, an OLP-ZY66 seed press machine, pesticide sprayer, and yellow sticky traps. The materials utilized were Russian Mammoth sunflower seeds, NPK fertilizer 16:16:16, goat manure, soil, vegetable, and synthetic pesticide with theactive ingredient profenofos.

C. Experimental Design

This study employed a single factor Randomized Complete Block Design (RCBD). The experiment comprised 4 treatment levels of NPK fertilizer 16:16:16 ratio, consisting of 4 experimental levels: NPK compound fertilizer doses of 100 kg/ha (2.5 g/plant), 150 kg/ha (3.75 g/plant), 200 kg/ha (5 g/plant) and 250 kg/ha (6.25 g/plant). Each treatment was replicated 5 times, resulting in 20 experimental units. Four plants were utilized per experimental unit, yielding a total of 80 experimental units. NPK fertilizer was applied in two stages: the first fertilization after the age of the plant reached Day After Planting (DAP) with the application of 75% fertilizer dose, and the second dose was applied as much as 25% at 50 DAP.

Russian Mammoth sunflower seeds, previously cultivated in Semarang City, Central Java, were utilized in this study. Sunflower seedlings were transplanted at the age of 10-14 days after sowing (DAS) [17]. The prepared land used was formed into 2.5 x 1 meter raised beds, with a 50 cm spacing between beds [18]. Goat manure was applied at a rate of 10 tons/ha [19] or 2.5 kg/bed to enrich the soil during a 7 day incubation period.

Maintenance involved daily morning irrigation of the sunflowers using a drip irrigation system. Supplementary fertilization was conducted in two stages: the first after the age of the plant reaches 25 DAP with the application of 75% fertilizer dose, and the second dose is applied as much as 25% at 50 DAP [20]. Fertilization utilized NPK fertilizer 16:16:16 at doses of 100 kg/ha, 150 kg/ha, 200 kg/ha and 250 kg/ha. Pest management incorporated both mechanical and chemical methods by applying curacron pesticide.

Sunflower growth parameters of sunflowers were measured starting 28 days after planting (DAP) with subsequent measurements taken at two-week intervals. These parameters included plant height (cm), flower diameter (mm), and number of leaves (blade). Harvest parameters consisted of flower diameter (cm), flower weight (g), seed wet weight (g), seed dry weight (g), and oil (g) oil yield (%).

D. Data Collection and Analysist

The collected data were initially subjected to a normality test. If the data were normally, distributed, they were then analyzed using The SAS System for Windows 9.0 through analysis of variance (ANOVA) with a significance level of $\alpha = 5\%$ and a highly significant level of $\alpha = < 0.01$. In cases where the ANOVA revealed a significant effect (F count > F tabel) then a further test with DMRT test (Duncan's Multiple Range

Test) level α = 5%. If the ANOVA indicated no significant effect, the optimal treatment was determined by identifying the highest yield data among the treatment levels.

III. Result and Discussion

A. The Growth of Sunflower

Plant height parameters exhibited a significant effect at 4 weeks after planting. This can be attributed to the plant's vegetative phase at this age and the application of the initial 75% fertilizer dose, resulting in a discernible difference in plant height. Fertilization is a crucial practice for optimal productivity, as it ensures adequate nutrient supply [21 Consistent with the findings of [22], vegetative growth including plant height and stem diameter, demonstrates a strong response to NPK fertilization.

TABLE IV. Plant Height of Sunflower (cm)

Treatment	Plant Age (Week After Planting/ WAP)				
	4	8	12	14	15
D1 (100 kg/ha)	17.52 a	71.96	137.04	150.59	169.81
D2 (150 kg/ha)	15.71 ab	60.67	134.63	142.63	166.07
D3 (200 kg/ha)	14.50 ab	63.92	129.36	147.64	177.40
D4 (250 kg/ha)	13.59 b	52.94	128.62	139.35	163.85

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TABLE V. Stem Diameter of Sunflower (mm)

Treatment	Plant Age (Week After Planting/ WAP)				
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TABLE VI. Number Of Leaves Sunflower (Blade)

Treatment	Plant Age (Week After Planting/ WAP)				
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D2 (150 kg/ha)	11.55	16.80	21.60	25.60	24.65
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The application of NPK fertilizer at varying doses revealed that the highest dose, D4 (250 kg/ha), resulted in the lowest average values for plant height, stem diameter, and leaf number. This observation aligns with findings reported by [31;32], which suggest that excessive fertilizer application leads to nutrient imbalance in the soil and disrupts plant physiological processes thereby inhibiting the growth rate.

B. The Harvest of Sunflower

The average flower diameter yield indicated that the dose of NPK fertilizer 150 kg/ha (D2) resulted in the largest flower diameter compared to other treatments. Consistent with the findings of [16], a 150 kg/ha NPK fertilizer dose produced a larger sunflower diameter than a 100 kg/ha dose. Reference [33], demonstrated that the application of NPK fertilizer can accelerate plant growth and development, enhance plant resistance to pest infestations, and improve yield quantity and quality. While higher NPK fertilizer doses generally lead to larger sunflower diameters, the 250 kg/ha dose exhibited the lowest results. It is hypothesized that sunflowers possess a maximum nutrient absorption capacity, making the 150 kg/ha NPK fertilizer dose optimal.

TABLE VII. Flower Diameter (g)

Treatment	flower diameter (cm)
D1 (100 kg/ha)	16.15
D2 (150 kg/ha)	18.82
D3 (200 kg/ha)	17.47
D4 (250 kg/ha)	14.80

Flower diameter exhibits a correlation with flower weight, as demonstrated by [20], which reported a highly significant and positive correlation between flower head diameter and flower head weight. The average yield of flower weight shows that the dose of NPK fertilizer did not significantly affect flower weight. However, agronomically the yield of flower weight at a dose of 150 kg/ha (D2) produces the highest flower diameter compared to other treatments.

TABLE VIII. Weight of Sunflower (g)

Treatment	flower Weight (g)
D1 (100 kg/ha)	296.76
D2 (150 kg/ha)	304.58
D3 (200 kg/ha)	236.65
D4 (250 kg/ha)	172.66

Also supported by the findings of [34], flower diameter, number of seeds and seed weight are positively correlated through genotypic and phenotypic tests. This correlation is evident in Tables 4, 5, and 6 where the 150 kg/ha dose exhibited the highest average yield. Therefore, it can be inferred that larger flower diameters correspond to increased

seed fresh weight and seed dry weight. This trend is reflected in the flower diameter, flower weight, seeds wet weight and seed dry weight that the compound NPK dose with the highest average value is 150 kg/ha and stated to have no significant effect on the application of compound NPK fertilizer.

TABLE IX. SEED WET AND DRY WEIGHT OF SUNFLOWER (G)

Treatment	seed wet weight (g)	seed dry weight (g)
D1 (100 kg/ha)	46.34	296.76
D2 (150 kg/ha)	55.59	304.58
D3 (200 kg/ha)	50.66	236.65
D4 (250 kg/ha)	40.97	172.66

Dosing with the lowest results on the parameters of flower diameter, flower fresh weight, seed wet weight and seed dry weight is shown at the maximum dose of 250 kg/ha. Sunflower production is directly proportional to growth rate; therefore any disruption in growth will result in sub-optional yield. This is supported by [35] which reported that excessive fertilizer applicayion can induce plant toxicity, leading to disruptions in both vegetative and generative development stages.

Sunflower seed oil weight and oil yield percentage were not significantly affected by the NPK fertilizer dose, with the 100 kg/ha treatment (D1) exhibiting the highest average values. Non-uniform seed maturation, leading to the presence of immature seeds at harvest, is a contributing factor to the formation of empty seeds in sunflowers [36]. Suboptimal photosynthesis is another factor associated with hollow seed development. Consistent with the findings of [37], inter-plant competition can promote the formation of empty seeds.

TABLE X. SEED WET AND DRY WEIGHT OF SUNFLOWER (G)

Treatment	oil (g)	oil yield (%)
D1 (100 kg/ha)	1.96	11.08
D2 (150 kg/ha)	1.93	7.41
D3 (200 kg/ha)	1.56	6.14
D4 (250 kg/ha)	1.75	9.48

The extraction process significantly influences sunflower seed oil quantity and yield, particularly when using a mechanical screw oil press process. The water content in sunflower seed simplisia can affect the yield. The maximum water content in sunflower seeds is 9.5-10% [38]. In addition, temperature and heating time affect the yield. High temperatures and long heating can affect the quality oil pressing [39]. The next factor can be caused by the amount of pressure applied. Prolonged pressing times can diminish oil quality by accelerating the rancidity process [40].

IV. CONCLUSION AND SUGGESTION

A. Conclusion

The results of giving doses of NPK fertilizer have a significant effect on sunflower growth, specifically plant height and stem diameter at 4 weeks after planting (WAP). The 150 kg/ha dose (D2) resulted in the highest values for leaf number, flower diameter, flower weight, seed fresh weight, and seed dry weight. NPK fertilizer dosing did not significantly affect sunflower oil yield. However, the 100 kg/ha dose (D1) yielded the highest average oil yield.

B. Suggestion

Headings, or heads, are organizational devices that guide the The optimal dosage of compound NPK fertilizer is 150 kg/ha. Increasing the dose beyond 150 kg/ha is not recommended; as it may prove ineffective and potentially hinder both the growth and production of sunflower plants.

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