Application of NPK Fertilizer and Paclobutrazol on Growth

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Abstract. The low quality of sunflower cultivation as cut flowers is currently unable to meet local market demands. It is necessary to improve cultivation through fertilization and the provision of plant growth regulator. Sustainable agriculture in floriculture refers to the practice of cultivating flowers and ornamental plants in manner that promotes environmental, social, and economic sustainability The research aims to determine the growth response, yield, and quality of sunflower plants (*Helianthus annuus* L.) on the application of NPK fertilizer doses and paclobutrazol concentrations. The research was carried out from September 2022 - December 2022 in the experimental garden of the Faculty of Agriculture, Yogyakarta "Veteran" National Development University. The research method is a field experiment arranged in a factorial Complete Randomized Block Design (CRBD) consisting of 2 factors replicated 3 times. The first factor was the doses of NPK fertilizer (9 grams/plant, 10 grams/plant, 11 grams/plant) and the second factor was the concentration of paclobutrazol (10 ppm, 50 ppm, 90 ppm). The data were analyzed using Analysis of Variance followed by Duncan's Multiple Range Test with a level of 5%. The study results showed that there was an interaction between NPK fertilizer and the concentration paclobutrazol on number of flower and size of flower diameter. The best outcomes were observed with NPK fertilizer dose of 9 grams/plant concerning the plant height at 42 DAP. The paclobutrazol concentration of 90 ppm resulted in most favourable outcomes on the parameters of plant height 42 DAP, stem diameter, and vase life.
Keywords: Helianthus annuus, cut flower, plant growth regulator, sustainableagriculture.
Keywords : Crop Production, Tree nurseries, Truf management, Flower gardens, Hidroponic systems.

1 Introduction

Cut flowers are a commodity that is quite attractive to the market because the profits can reach 50% of production costs. One type of flower that has the potential to be used as cut flowers is a sunflower (Helianthus annuus L.). In Indonesia, sunflowers are cut flowers that adorn the interior and exterior of houses, hotels, indoor decorations, and wedding party decorations. Cut flowers that are popular with the public have physical characteristics that

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look fresh, and healthy, the flowers bloom perfectly, and the stems are strong so that they have a relatively long flower shelf life [1].

If the production of sunflower plants switches to the cut flower market, the agronomically desirable characteristics of sunflower plants are still not conducive to cut flowers. The problems that are still found in sunflower cultivation as cut flowers are the small size of the flowers, the flowers wither quickly, and the stems are not sturdy. The low quality of sunflower cultivation is currently unable to meet local market demands. Therefor it is necessary to improve the quality through sunflower cultivation techniques [2].

Cultivation techniques play an important role in increasing the quality and quantity of sunflowers. One effort to encourage good environmental factors is through fertilization. Sunflowers require high levels of nutrients. Relying on nutrients from the soil alone cannot meet plant needs.

Therefore, plants need to be given additional nutrients from the outside in the form of fertilizer. Efforts to increase the efficiency of fertilizer use can be achieved through the right dosage, the right method, the right time of application, and the balance according to plant needs [3].

Providing nutrition through fertilization for plants plays an important role in the vegetative and generative phases of plants because the nutrients provided by the growing media are very limited. Compound fertilizers are more efficient because they contain macronutrients that are needed in the process of plant growth and development, such as nitrogen, phosphorus and potassium nutrients. Mutiara NPK compound fertilizer contains macronutrients, namely N, P, and K. These three elements are essential nutrients that play a very important role and are needed by plants [4]. A dose of 10 grams/plants of NPK fertilizer had the best effect on the growth and yield of sunflower plants. Application of NPK fertilizer 10 grams/plant can increased the average weight of sunflower plants per plot [5]. Mutiara NPK fertilizer with a ratio of 16:16:16 is a soluble compound fertilizer and has a balanced fertilizer composition [6]. The rational and balanced use of fertilizers is one of the key factors to increase plant productivity [7]

Paclobutrazol is a growth regulator that can be given to plants to induce flowering. Paclobutrazol is a retardant that inhibits vegetative growth and focuses on the generative growth of plants and is expected to increase crop yields. Applying paclobutrazol during the vegetative phases before entering the generative phases can be an effective strategy to control plant growth and promote the reproductive development [8]. Paclobutrazol can promote flowering, promote pigment formation, prevent etiolation, and prolong the rooting of cuttings [1]. The application of paclobutrazol in the cut flower production of sunflowers can offer several benefits such as stem length control, increased flower longevity (vase life), enhanced branching, synchronization of flowering, and improved the flower quality. Paclobutrazol can help achieve the characteristics, making the sunflower cut flower more appealing to the consumer [8].

Sustainable agriculture in floriculture refers to the practice of cultivating flowers and ornamental plants in a manner that promotes environmental, social, and economic sustainability. The goal is to meet the current floral market demands while ensuring the long-term health and productivity of ecosystems and communities involved in the production process [9]. The use of NPK fertilizer and paclobutrazol in sunflower cultivation can potentially enhance the growth and development of sunflower plants, resulting in improved cut flower quality and longer vase life. By providing the necessary nutrients through fertilization, sunflowers can overcome the limitations of nutrient availability in the soil and achieve optimal growth. This can contribute to sustainable agriculture by maximizing the productivity of sunflower plants and meeting market demands for

high-quality cut flowers. Additionally, the use of paclobutrazol as a growth regulator can help optimize the flowering process in sunflowers. By promoting flowering and preventing excessive vegetative growth, paclobutrazol can improve the quality and quantity of flowers produced. This can lead to more efficient use of resources, such as water and energy, in sunflower cultivation, contributing to sustainable agricultural practices [9] [10].

Previous published studies are limited to the combination of NPK fertilizer and paclobutrazol application on sunflower plant as a cut flower. Therefore, this study set out to assess the effect combination of NPK fertilizer and paclobutrazol increasing the quality of sunflower plants as a cut flower such as strong the stem, stem length, flower diameter, the number of flowers, and vase life. The purpose of this study was to examine the interaction between NPK fertilizer doses and paclobutrazol concentrations on growth, yield and quality of sunflower plants, to obtain the best dose of NPK fertilizer, and to obtain the best paclobutrazol concentration on sunflower plants. The hypothesis of this study is suspected that the dose of NPK fertilizer is 10 grams/plants and the concentration paclobutrazol 50 ppm can provide the best results for growth, yield, and quality of sunflower plants

2 Materials and methods

2.1 Experiment location

This study was conducted from September until December 2022 and carried out at the Experimental Garden of the Faculty of Agriculture, Wedomartani, Ngemplak, Sleman Regency, Special Region of Yogyakarta. The research site is located on a medium plain with an altitude of about 191 meters above sea level (asl) with regosol soil type and an average daily temperature of 26OC.

Implementation of this research was started with seed nursery activities. The sunflower seeds a variety “IPB BM1” was sown in germination tub after 3 weeks. Plants were transferred to field open without shade and were sown at 50 cm x 50 cm spacing. The fertilizer goat manure 345 kg was applied as basic fertilizer. Planting was carried out in the afternoon to avoid the dehydration plants.

2.2 Npk fertilizer application

Mutiara NPK fertilizer 16:16:16 application was carried out when the plants were 14 HST and 28 HST. Fertilization is done by sprinkling NPK fertilizer in the root area and then covered with little soil. Plants get a dose of 9 grams/plant, 10 grams/plant, and 11 grams/plant. NPK fertilizer application was carried out in the morning.

2.3 Paclobutrazol application

Paclobutrazol application was carried out by sprinkling it on each planting hole. Each plant was applied with paclobutrazol at concentrations according to treatment, namely 10 ppm, 50 ppm, and 90 ppm. Paclobutrazol application on sunflower plants was carried out at 21 HST, 29 HST, and 35 HST. Paclobutrazol application was carried out in the morning.

2.4 Treatments and experimental design

This study was a field experiment used a factorial Complete Randomized Block Design (CRBD). The treatment consisted of two factors NPK fertilizer dose and paclobutrazol concentration. The doses of NPK fertilizer consist of three levels (9 grams/plant, 10 grams/plant, 11 grams/plant). The concentration of paclobutrazol consists of three levels (10 ppm, 50 ppm, 90 ppm). There are 27 experimental units and each treatment consists of 10 plants with repetition 3 times.

2.5 Observation parameters

2.5.1 Plant Height

Plant height (cm) was measured from the first node to the growing point. This observation was carried out when the plants were 16 DAP, 30 DAP, 42 DAP, and 56 DAP.

2.5.2 Stem Diameter

Stem diameter (cm) was measured using a calliper on the first, second and third segments and then averaged. Observations were made when the plants were 16 DAP, 30 DAP, 42 DAP, and 56 DAP.

2.5.3 Time Appearance of Flower Bud

Time appearance of flower buds Appear (days) observation was carried out by counting the days when the first flower bud appears on the main stem, starting from the first day of transplanting. The criteria for the buds that appear are that they look like stars and are green in colour. The time of flower bud emergence was calculated when the flower bud appeared at 50% of the number of plants per experimental plot.

2.5.4 Number of Flower

The number of flowers was observed at harvest and the number of flowers that appear per plant was calculated. The number of flowers was observed starting from the age of 70 DAP.

2.5.5 Size of Flower Diameter

Size of flower diameter was measured at harvest time and was observed from 70 DAP.

2.5.6 Vase Life

Vase life (days) was observed at harvest time. After were harvested the flower stems were cut 50 cm long and the leaves were crushed. Flowers were stored indoors or under the shade and placed in a container filled with water. Then count the number of days from when the flowers are harvested until the flowers wither. The criteria for wilting sunflowers are that the flowers are brown in colour, the stems are softened, and the flower heads are starting to droop.

2.5.7 Quality of Sunflower

The quality of sunflower was observed at the postharvest time.

2.6 Observation parameters

The data were statistically analysed by analysis of variance to find the effect of treatment on the parameters of the experiment and to compare the difference between means were tested with DMRT at the 5% level of significance.

3 Result and discussion

3.1 Plant height

Table 1. The average plant height (cm) in various treatment combinations between doses of NPK fertilizer and paclobutrazol concentrations at 16 DAP, 30 DAP, and 42 DAP

Treatment		**Observation**	
	16 DAP	30 DAP	42 DAP
NPK Fertilizer Doses			
9 grams/plant (N1)	5,41 a	10,22 ab	64,53 b
10 grams/plant (N2)	5,65 a	9,73 b	73,00 a
11 grams/plant (N3)	5,95 a	11,59 a	70,72 a
Paclobutrazol concentration			
10 ppm (P1)	5,94 p	10,01 p	71,43 p
50 ppm (P2)	5,38 p	10,27 p	73,70 p
90 ppm (P3)	5,64 p	11,26 p	63,13 q
Interaction	(-)	(-)	(-)

Note: The average followed by the same letter shows no significant difference based on the DMRT test at 5% level. The sign (-) there is no interaction.

Table 2. Average plant height (cm) per plant at various doses of NPK fertilizer and Paclobutrazol concentrations at 56 DAP observations

NPK Fertilizer Doses	**Paclobutrazol concentration**			
	10 ppm (P1)	50 ppm (P2)	90 ppm (P3)	**Average**
9 grams/plant (N1)	136,75 b	125,33 c	115,08 d	125,72
10 grams/plant (N2)	145,00 a	143,67 a	136,08 b	141,58

11 grams/plant (N3)	133,50 b	144,58 a	118,68 d	132,26
Average	138,42	137,86	123,28	
Interaction				(+)

Note: The average followed by the same letter shows no significant difference based on the DMRT test at 5% level. The sign (+) there is an interaction.

In table 1, showed the plant height at 16 DAP between treatments of NPK fertilizer doses did not show a different effect. At 30 DAP, the dose of 11 gram/plant NPK fertilizer was significantly higher than the 10 gram/plant NPK fertilizer dose, but had no different effect than the 9 gram/plant NPK fertilizer dose. At the age of 42 DAP, the NPK fertilizer dose of 10 grams/plant and 11 grams/plant was significantly higher than the NPK fertilizer dose treatment of 9 grams/plant. Giving the smallest dose of NPK fertilizer has the effect of shortening plant growth, meaning that the higher the NPK dose can improve the plant height. This is in line with Sugiharto et al.,[7] that the nutrient nitrogen (N) has a major role for plants to stimulate overall growth, including increasing plant height and forming branching. Accordance with Setiadi et al., [11] Plant height is affected by active cell division, especially in meristem tissue, thereby affecting plant height. The nutrient that plays a role in cell division is element K. The provision of element K from NPK can meet the needs of the nutrient potassium in plants so that cell division is active which affects plant height. At the age of 16 DAP and 30 DAP between paclobutrazol concentration treatments showed no significant difference. At the age of 42 DAP, treatment with paclobutrazol concentrations of 10 ppm (P1) and 50 ppm (P2) was significantly higher compared to paclobutrazol concentrations of 90 ppm (P3). The paclobutrazol is one of the retardant ZPT that is capable of inhibiting stem elongation so that it can suppress plant growth. This is in line with the theory of Rugayah et al., [12] that paclobutrazol inhibits cell elongation and stem segment elongation which can stop vegetative growth.

In Table 2, observations at 56 DAP showed that there was an interaction in the combination of NPK fertilizer doses and paclobutrazol concentrations. The combination of NPK fertilizer dose of 9 grams/plant and paclobutrazol concentration of 90 ppm (N1P3) showed the shortest plant height but no has a significant difference with the combination of NPK fertilizer dose of 11 grams/plant and paclobutrazol concentration of 90 ppm (N3P3). The combination of the highest paclobutrazol concentrations resulted in shorter plants. Paclobutrazol is a plant inhibiting substance that relaxes plant growth points so that plant heights with high concentrations have shorter plant heights. This is in accordance with Zulfaniah et al., [13] that paclobutrazol is a growth inhibitory substance that functions to inhibit gibberellin synthesis which stimulates cell division in the growth phase so that the presence of paclobutrazol will rest the growing point of the plant.

3.2 Stem diameter

Table 3. The average stem diameter (cm) per plant at various doses of NPK fertilizer and Paclobutrazol concentrations at 16 DAP, 30 DAP, 42 DAP, and 56 DAP

		Observation		
Treatment	16 DAP	30 DAP	42 DAP	56 DAP
NPK Fertilizer Doses				

9 grams/plant (N1)	0,34 b	0,88 a	1,75 a	2,90 a
10 grams/plant (N2)	0,33 b	0,74 b	1,54 b	2,88 a
11 grams/plant (N3)	0,39 a	0,92 a	1,76 a	2,91 a
Paclobutrazol concentration				
10 ppm (P1)	0,35 q	0,81 q	1,67 q	2,88 q
50 ppm (P2)	0,33 q	0,78 q	1,57 q	2,89 q
90 ppm (P3)	0,38 p	0,95 p	1,81 p	2,93 p
Interaction	(-)	(-)	(-)	(-)

Note: The average followed by the same letter shows no significant difference based on the DMRT test at 5% level. The sign (-) there is no interaction.

Table 3, showed that the stem diameter parameter showed no interaction between doses of NPK fertilizer and the concentration of paclobutrazol. At the age of 16 DAP with NPK fertilizer doses of 11 grams/plant showed the widest stems compared to NPK fertilizer doses of 9 grams/plant and 10 grams/plant. At the age of 30 DAP and 42 DAP, the NPK fertilizer dose of 11 grams/plant and the NPK fertilizer dose of 9 grams/plant were significantly wider than the NPK fertilizer dose of 10 grams/plant. Whereas at the age of 56 DAP the dose of NPK fertilizer between treatments showed no significant difference. The N nutrient contained in NPK fertilizer is needed for the formation or growth of vegetative parts of plants such as leaves, stems and roots. According to Ayu and Sulhaswardi, [14] cell division and elongation in plants is influenced by the availability of the P element. The P element is an element that forms enzymes and energy for plant metabolism. Phosphorus from NPK fertilizer plays a role in compiling the plant body.

At the four observation times, namely 16 DAP, 30 DAP, 42 DAP, and 56 DAP, application of 90 ppm paclobutrazol showed the widest stem compared to other paclobutrazol concentrations. This is in line with the theory of Zulfaniah et al., [13] that the enlargement that occurs in plant stems as a result of paclobutrazol application is caused by stunted plant height growth which makes the plants relatively short and causes the accumulation of phosphosynthesis results and forms food reserves in the stem area.

3.3 Time appearance of flower bud

Table 4. The average time appearance of flower buds (days) per plant at various doses of NPK fertilizer and Paclobutrazol concentrations

NPK Fertilizer Doses	**Paclobutrazol concentration**			
	10 ppm (P1)	50 ppm (P2)	90 ppm (P3)	**Average**
9 grams/plant (N1)	64,67 d	62,33 bc	58,67 a	61,89
10 grams/plant (N2)	60,67 ab	64,67 d	64,00 cd	63,11
11 grams/plant (N3)	61,00 b	62,33 bc	58,67 a	60,67
Average	62,11	63,11	60,44	
Interaction				(+)

Note: The average followed by the same letter shows no significant difference based on the DMRT test at 5% level. The sign (+) there is an interaction.

In Table 4, the combination of NPK fertilizer doses and paclobutrazol concentrations showed significant differences in the time of flower bud emergence. The best combination

of treatments for flower bud emergence parameters was the combination of NPK fertilizer dose of 9 grams/plant and 90 ppm paclobutrazol concentration (N1P3) and the combination of NPK fertilizer dose treatment of 11 grams/plant and 90 ppm paclobutrazol concentration (N3P3) but did not show a significant difference with a combination treatment of NPK fertilizer dose of 10 grams/plant and paclobutrazol concentration of 10 ppm (N2P1).

The time when flower buds appear is also related to the element P which has the function of being a source and transfer of energy in plants. ADP and ATP are high-energy phosphate compounds that control many reactions in plants such as photosynthesis, respiration, protein, and amino acid synthesis. In line with Elbohy [15] that the availability of sufficient nutrients during the vegetative phase by NPK fertilizer so that it reaches the maximum vegetative phase faster and enters the generative phase earlier. In addition, another theory Suhadi et al., [16] states that paclobutrazol ZPT functions to increase RNA, protein, sucrose, starch and chlorophyll. These substances can support flowering. A balanced nutrient supply including phosporus and potassium is crucial promoting flowering and reproductive development. The combination of NPK Fertilizer and paclobutrazol might influence the timing and abundance of flower production.

3.4 Time appearance of flower bud

Table 5. The average number of flowers (buds) at various doses of NPK fertilizer and paclobutrazol concentrations

NPK Fertilizer Doses	**Paclobutrazol concentration**			
	10 ppm (P1)	50 ppm (P2)	90 ppm (P3)	**Average**
9 grams/plant (N1)	13.00 d	14,67 c	17,00 a	14,89
10 grams/plant (N2)	12,00 f	12.67 d	14,00 d	12,89
11 grams/plant (N3)	12.67 d	11,33 g	16,00 b	15,67
Average	12,56	12,89	15,67	
Interaction				(+)

Note: The average followed by the same letter shows no significant difference based on the DMRT test at 5% level. The sign (+) there is an interaction.

In Table 5, the combination of NPK fertilizer doses and paclobutrazol concentrations showed significant differences in the number of flowers. The combination of NPK fertilizer doses of 9 grams/plant and a concentration of 90 ppm (N1P3) showed the highest number of flowers compared to other treatment combinations. According to Sugiharto et al., [7] if the need for the element P is met, the flowering and fertilization processes will go well. The presence of K from NPK fertilizer plays a role in transporting the results of photosynthesis from the leaves through the phloem tissue to the reproductive organs to increase the number of flowers. The research results of Wardani et al., [17] showed that paclobutrazol could produce a greater number of flowers compared to other PGR applications because paclobutrazol succeeded in inhibiting vegetative growth and diverting photosynthate for generative development by forming flowers.

3.5 Size of flower diameter

Table 6. The average size of flower diameter (cm) in various combinations of NPK fertilizer treatments and Paclobutrazol concentrations

NPK Fertilizer Doses	Paclobutrazol concentration			
	10 ppm (P1)	50 ppm (P2)	90 ppm (P3)	**Average**
9 grams/plant (N1)	19,67 b	17,00 d	21,67 a	19,44
10 grams/plant (N2)	17,00 d	17,67 cd	17,33 cd	17,33
11 grams/plant (N3)	19,00 bc	17,33 cd	19,00 bc	18,44
Average	18,56	17,33	19,33	
Interaction				(+)

Note: The average followed by the same letter shows no significant difference based on the DMRT test at 5% level. The sign (+) there is an interaction.

Table 6, shows that the size of the flower diameter parameter that there is an interaction. The combination of NPK fertilizer doses and paclobutrazol concentrations had a significant effect on flower diameter. The combination of NPK fertilizer doses of 9 grams/plant and paclobutrazol concentration of 90 ppm (N1P3) showed the widest flower diameter compared to the other treatment combinations. The diameter of the flower is affected by the diameter of the stem. N nutrients received by plants in the flowering phase also affect the flower diameter. In addition, the available P element plays a very important role in the formation and maturation of flowers. Giving paclobutrazol can affect the flower diameter. In line with research by Rugayah et al., [12] stated that paclobutrazol can inhibit vegetative growth of plants so that the height growth of stems and flower stalks becomes stunted and tends to be thicker. The increase in flower stalk diameter is due to an increase in pseudo stem circumference.

3.6 Vase life

Table 7. The average length of blooming time (days) in various combinations of NPK fertilizer treatments and Paclobutrazol concentrations

NPK Fertilizer Doses	Paclobutrazol concentration			
	10 ppm (P1)	50 ppm (P2)	90 ppm (P3)	**Average**
9 grams/plant (N1)	8,67	8,00	9,00	8,56 a
10 grams/plant (N2)	8,00	8,00	8,67	8,22 b
11 grams/plant (N3)	8,67	8,33	8,67	8,56 a
Average	8,44 q	8,11 q	8,78 p	
Interaction				(-)

Note: The average followed by the same letter shows no significant difference based on DMRT test at 5% level. The sign (-) there is no interaction.

In Table 7, the parameters for the length of time the flowers bloom (vase life) showed that the combination treatment of NPK fertilizer doses and paclobutrazol concentrations had no interaction. The NPK fertilizer dose treatment of 11 grams/plant showed a longer blooming time. In the treatment of paclobutrazol concentration of 90 ppm (N3P1) the flowers bloom longer than other concentrations. A Wider stem diameter indicates the plant absorbs more water so that flower resistance (vase life) is longer. According to Yusdian et al., [18] the potassium nutrient contained in NPK fertilizer helps the formation of proteins and carbohydrates which play a role in enzyme activators so that they can strengthen leaves, flowers, and fruit on plants so they do not fall easily.

The paclobutrazol concentration of 90 ppm (P3) showed longer blooming than the paclobutrazol concentrations of 10 ppm (P1) and 50 ppm (P2). According to Sugiharto et al., [7] the time for the flowers to bloom becomes longer after the application of paclobutrazol. This is consistent with the theory that paclobutrazol, which belongs to the retardant class, can extend the harvest life of fresh materials such as flowers, fruit and vegetables.

3.7 The quality of sunflower

Table 8. Sunflower Main Flower Grading Standards at Florists

No	Test Type	Unit	Quality Class	
			A	B
1.	Minimum stalk length	cm	20-30	Origin
2.	Flower Diameter	cm	15-20	Origin
3.	Flower Freshness		Fresh	Origin
4.	The state of the flower stalk		Strong, straight	Origin
5.	Stem diameter	cm	1-1,3	Origin

Table 9. Sunflower Branch Flower Grading Standards at Florists

No	Test Type	Unit	Quality Class	
			A	B
1.	Minimum stalk length	cm	30-40	Origin
2.	Flower diameter	cm	8-12	Origin
3.	Flower freshness		Segar	Origin
4.	The state of the flower stalk		Strong, straight	Origin
5.	Stem diameter	cm	0,3-0,7	Origin

Sunflowers as quality cut flowers have uniform maturity, are free from defects, have straight stems, and have good quality leaves. Sunflower of the IPB BM1 variety belongs to the top branching flower so that it produces one main flower and the other is a branching flower. Both types of flowers produced can meet the quality grading which exists in the florist. Therefor the sunflower variety is easily accepted by the florist. These two types have different selling points when marketed in the florist, for the main interest pegged at a price of around Rp. 5000 – Rp. 7000 each flower and for branch flowers around Rp. 2000 – IDR 4,000 each flower.

4 Conclusion

There was an interaction between the combination treatment of NPK fertilizer doses and paclobutrazol concentrations. The best results were at 9 gram/plant NPK fertilizer dose and 90 ppm paclobutrazol concentration on the parameters of flower number and size of flower diameter. The best outcomes were observed with the NPK fertilizer dose of 9 grams/plant concerning the plant height at 42 DAP. The paclobutrazol concentration of 90 ppm resulted in most favourable outcomes on the parameters of plant height 42 DAP, stem diameter, and vase life.

Based on the conclusions of this study, it can be suggested that further research is needed by application NPK fertilizer doses that are lower than 9 grams/plant with a minimum of 2.5 grams/plant and paclobutrazol concentrations higher than 90 ppm with a maximum of 150 ppm to obtain the results of sunflower plants as the most optimal cut flowers.

The application of NPK fertilizer and paclobutrazol in sunflower cultivation can support sustainable agriculture by improving crop productivity, enhancing flower quality, and optimizing resource utilization.

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