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Growth and Yield Response of Sunflower (*Helianthus annuus* L.) Plants to Paclobutrazol Dosage and Application Time

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ABSTRACT

Sunflower (Hellianthus annuus L.) has high economic value due to its great potential in industry. High market demand causes the need for intensification in sunflower cultivation to increase production and seed quality. This study aims to determine the right dosage and time of paclobutrazol application in suppressing growth and increasing the yield of sunflower plants. The research was conducted in Dohoagung Village, Balongpanggang District, Gresik Regency from May to September 2024. This research used a Factorial Completely Randomized Design (CRD) with 2 factors, namely dose and application time. The two treatments resulted in 12 combinations, each of which was repeated three times. The results of the analysis of variance were further tested with the 5% HSD test. The results show that the combination of paclobutrazol dosage of 0.3 g/plant and application time of 4 WAP gives the best results on plant growth (plant height and stem diameter). The single treatment of paclobutrazol dosage of 0.2 g/plant gave the best results on flower diameter, number of seeds, total seed weight and 100 seed weight. A single treatment of paclobutrazol application time at 4 WAP produced the best plant growth and increased flower diameter.

1. INTRODUCTION

Indonesia has a tropical climate that supports the growth and development of various types of flora. Sunflower plants (*Helianthus annuus* L.) belong to the Asteraceae tribe which is easy to grow in various environmental conditions. The harvest of sunflower plants is widely used in various industrial fields, such as: food, beauty, health and floriculture (Farida & Ardiarini, 2019). Widespread cultivation of sunflower plants is still not widely found in Indonesia, because they are only marketed as ornamental plants and cut flowers. Whereas the potential as an industrial raw material is very high, one of which is to produce sunflower seeds and oil (Ardiarini *et al*., 2016). Sunflower oil contains omega 9, omega 6, Vitamin E and polyunsaturated fatty acids, namely monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) which are good for health and beauty (Kulkarni *et al*. 2014).

Indonesia imported 8,008 tons of sunflower seeds in 2021 and increased in 2022 to 11,538 tons (BPS, 2022). This shows that the demand for sunflower seeds has increased. Problems in sunflower cultivation are also caused by low quality and quantity and the absence of reliable continuity of results (Warastuti *et al*., 2017). So it is necessary to intensify efforts in cultivation using the right technology to increase the yield and quality of harvested seeds. Sunflower plants are sensitive to stem breakage or dwarfism, especially when the plants have flowered (Kinasih & Elfarisna, 2020). The size of plant height and diameter is strongly related to plant resistance to fading. Plants that grow tall with a small stem diameter are more susceptible to fading (Ramadhan, 2022). Therefore, efforts to increase stem diameter, shorten plant height and increase sink strength in the flowers are expected to overcome the problem of low production and quality of seed yields. One way is to apply paclobutrazol. Paclobutrazol is a retardant that inhibits the

biosynthesis of the hormone gibberellin so that it can inhibit internode elongation, suppress stem growth and break flower dormancy so that it will spur plant flowering (Suhadi *et al*., 2017).

Application of paclobutrazol at the age of 4 weeks after planting gives the best effect on sunflower plant growth where the resulting stem diameter is thicker and wider, shorter height, and thicker leaves (Marshel *et al*., 2011). Application of paclobutrazol at the age of 4 weeks can produce the shortest plant height and increase the number of peanut pods (Itawari *et al*., 2023). The results of Sarkar (2023) stated that the application of PBZ-250 mg (0.25 g/plant) produced the lowest sunflower plant height, increased flower diameter and 100 seed weight per plant, accelerated flower induction and plant harvest age. In another study, namely Koutrobas *et al*. (2014) it is known that the application of paclobutrazol at high doses can significantly inhibit plant growth until it affects the decrease in achene yield. This research aimed to determine the response of sunflower plant growth and yield to the dose and time of paclobutrazol application. The benefits of this study are to determine the right dosage and time of paclobutrazol application in inhibiting growth and increasing the yield of sunflower plants, so that it is expected to be a reference in further research, as well as contributing to the renewal and development of science.

2. MATERIALS AND METHODS

2.1. Time and Place

The research was conducted from May to September 2024 in Dohoagung Village, Balongpanggang District, Gresik Regency, East Java, Indonesia (-7° 14' 22.20 "N and 112° 25'32.72 "E).

2.2. Tools and Materials

The tools used include polybags measuring 40 cm × 40 cm, seedling polybags, spades, meters, vectors, measuring cups, paddles, hand sprayers, labels, analytical scales, cameras, stationery. The materials used were sunflower seeds of IPB BM 1 variety, soil, manure, husk charcoal, ZPT Paclobutrazol trademark Gobest with 250 g/L active ingredient, Urea, SP-36, and KCl fertilizers, Decis 25EC insecticide, Antracol and Daconil fungicides and water.

2.3. Research method

This study used a factorial completely randomized design (CRD). Factor I was the dose of paclobutrazol (P), including P1: 0.1 g, P2: 0.2 g, and P3: 0.3 g. Factor II is the application time of paclobutrazol including, T1: 4 WAP, T2: 6 WAP, T3: 8 WAP, and T4: 10 WAP. These two factors were combinated to produce 12 treatment combinations, each consisting of 3 replications and 3 samples, so there were 108 plants. Variety analysis was conducted by comparing F_{Count} with F_{Table} at the 5% and 1% test levels. If F_{Count} is greater than F_{Table} 5% but smaller or equal to F_{Table} 1%, it means a real effect (*). If F_{Count} is greater than F_{Table} 5% and F_{Table} 1%, the effect is very significant (**). If F_{Count} is smaller or equal to $F_{(Table)}$ 5%, it means the effect is not significant (tn). If the treatment has a real or very real effect, then the next test is Honestly Significant Difference (HSD).

The implementation of the study began with sowing sunflower seeds using seedling polybags for 14 days. Next, they were transferred to new planting media containing a mixture of manure, soil, and husk charcoal (1:1:1) in polybags measuring 40 cm × 40 cm. Paclobutrazol was applied using the soil drenching method on the planting media with a solution volume of 250 ml/plant. Plants were maintained by watering once a day. Fertilization used urea, KCL and SP-36 fertilizers of 4 g/plant each at planting time and the second fertilization used urea 3 g/plant and KCl 2 g/plant. Meanwhile, control of plant pests and diseases using Decis 25EC insecticide, Antracol and Daconil fungicides was carried out twice a week, while prevention could be done once a month. Growth observations were made at the age of 5, 7, 9 and 11 WAP (weeks after planting). Furthermore, flower harvesting is physiologically characterized by the drying of leaves and petals. Parameters observed included plant height, number of leaves, stem diameter, age of flower appearance, primary flower diameter, number of flowers, harvest age, number of seeds, 100 seed weight and total seed weight.

3. RESULTS AND DISCUSSION

3.1. Plant Height (cm)

The results of the variance analysis showed that the effect of the combination of doses and time of administration of paclobutrazol resulted in a very significant interaction on the height parameters of sunflower plants aged 5, 7 and 9 WAP. Meanwhile, at the age of 11 WAP, the combination of dose and time of paclobutrazol application showed no significant interaction. The single factor of dosage and application time of paclobutrazol had a very significant effect on plant height parameters at the age of 11 weeks of observation. The average plant height due to the interaction of dose and application time of paclobutrazol is presented in Table 1, while the average plant height due to each treatment is presented in Table 2.

Table 1. shows that the combination of paclobutrazol dosage of 0.3 g/plant and application time of 4 WAP produced the lowest sunflower plant height at the observation age of 5, 7 and 9 WAP. The treatment without paclobutrazol (control) produced the highest plants at the observation age of 5, 7 and 9 weeks after planting. The inhibition of sunflower plant height at the age of 9 WAP by the combined effect of paclobutrazol dosage of 0.3 g/plant and application time of 4 weeks after planting amounted to 46.91% compared to the control. It shows the response of shortening plant height by the effect of dose and application time of paclobutrazol, where the higher the dose and the faster the application time of paclobutrazol results in shorter plant height.

Table1. Effect of the combination of dose and time of paclobutrazol application on plant height at the age of 5 - 9 WAP.

Average Plant Height (cm)						
Age (WAP)	**Treatment**		**Application Time (T)**			
	Dose (P)	**Control**	**4 WAP**	**6 WAP**	**8 WAP**	**10 WAP**
5 WAP	0.1 g	37.44 b	28.89 a	37.22 b	37.44 b	37.11 b
	0.2 g		28.67 a	37.11 b	37.00 b	37.00 b
	0.3 g		27.89 a	36.89 b	36.89 b	37.56 b
	HSD 5%		2.33			
7 WAP	0.1 g	70.33 e	45.78 bc	53.00 d	69.11 e	69.11 e
	0.2 g		40.89 ab	50.33 cd	68.33 e	69.00 e
	0.3 g		39.11 a	47.78 c	68.89 e	69.00 e
	HSD 5%		5.21			
9 WAP	0.1 g	102.56 g	70.00 abcd	76.00 bcd	85.44 defg	98.89 efg
	0.2 g		64.89 abc	68.56 abcd	81.78 cdef	101.00 fg
	0.3 g		54.44 a	61.11 ab	78.67 bcde	100.33 fg
	HSD 5%		20.02			

Description: Mean numbers followed by the same letter at the same observation age indicate no significant difference in the 5% HSD test.

Similar research results were shown by Rombon *et al*. (2018), that the higher the dose of paclobutrazol applied to plants and the earlier the application time of paclobutrazol, the greater the effect on plant height inhibition. The treatment produced plants with the lowest height. Paclobutrazol can work effectively and is able to suppress plant height growth.

The dose treatment of 0.3 g/plant produced the lowest sunflower plant height, while the highest plant was the control (Table 2). There is an inhibition of sunflower plant height by the effect of paclobutrazol dosage of 0.3 g/plant by 34.98% compared to the control. This is in line with the results of research Marshel *et al.* (2015) which explains that the higher the dose of paclobutrazol applied, the lower the plant height produced. Paclobutrazol application affects the endogenous gibberellin content. Paclobutrazol-applied plants are thought to be lower in endogenous gibberellin content than those untreated without paclobutrazol. Paclobutrazol inhibits gibberellin production resulting in a reduction in cell division rate and a decrease in vegetative growth.

Table 2. Effect of Dosage and Application Time of Paclobutrazol on plant height at the age of 11 WAP

Treatment	Average Plant Height
Control	132.56 c
Paclobutrazol Dosage	
P1 (0.1 g)	101.53 b
P2 (0.2 g)	94.53 ab
P3 (0.3 g)	86.19 a
HSD 5%	12.08
Paclobutrazol Application Time	
T1 (4 WAP)	93.39 a
T2 (6 WAP)	96.08 ab
T3 (8 WAP)	103.69 b
T4 (10 WAP)	121.64 c
HSD 5%	12.08

Description: Mean numbers followed by the same letter in the same treatment indicate no significant difference in the 5% HSD test.

Table 2 also shows that the application time of paclobutrazol 4 WAP produces the lowest plant height which is significantly different from the control and other application times, except for the 6 WAP application time treatment. There is a difference in sunflower plant height by the effect of paclobutrazol application time 4 WAP by 29.54% compared to the control. This shows that the earlier the application of paclobutrazol is done, the shorter the plant height produced. These results are in line with the research of Itawari *et al.* (2023) which showed that the application of paclobutrazol at the age of 4 weeks after planting gave the best effect. The treatment produced the lowest plant height, the highest number of pods per sample, and the highest number of filled pods per sample which were significantly different from the other treatments. The earlier paclobutrazol is given, the greater its inhibitory properties on plant height will be.

3.2. Rod Diameter

The results of the analysis of variance of the effect of the combined treatment of dose and time of paclobutrazol application on stem diameter showed that there was a very significant interaction at the age of 5 and 7 weeks after planting. The single factor of dose and time of paclobutrazol application each gave a very significant effect on stem diameter at the age of 9 and 11 weeks after planting. The average plant stem diameter due to the interaction of dose and time of paclobutrazol application is presented in Table 3, while the average plant height due to each treatment is presented in Table 4.

Table 3. Effect of the combination of dose and time of paclobutrazol application on stem diameter at the age of 5 and 7 WAP

Average Stem Diameter (mm)						
Age (WAP)	**Treatment**		**Paclobutrazol Application Time (T)**			
	Dose (P)	**Control**	**4 WAP**	**6 WAP**	**8 WAP**	**10 WAP**
5 WAP	0.1 g		9.20 b	8.49 a	8.40 a	8.46 a
	0.2 g	8.44 a	9.46 bc	8.46 a	8.47 a	8.47 a
	0.3 g		10.19 c	8.44 a	8.43 a	8.48 a
	HSD 5%		0.62			
7 WAP	0.1 g		11.37 abc	11.22 abc	10.71 ab	10.49 a
	0.2 g	10.52 a	13.06 bcd	12.32 abcd	10.91 abc	10.84 abc
	0.3 g		14.70 d	13.20 cd	10.41 a	10.86 abc
	HSD 5%		2.45			

Description: Mean numbers followed by the same letter at the same observation age indicate no significant difference in the 5% HSD test.

Table 3 shows that the combination of paclobutrazol dose of 0.3 g/plant and application time of 4 WAP produced the highest stem diameter of sunflower plants at the observation age of 5 and 7 WAP. The lowest plant stem diameter was produced by the control plants. There was an increase in stem diameter at the age of 7 weeks after planting by the effect of the combined treatment of paclobutrazol dosage of 0.3 g/plant and application time of 4 weeks after planting by 39.73% compared to the control. This shows that the higher the dose and the earlier the application time of paclobutrazol, the higher the response to the increase in stem thickness.

According to Desta & Amare (2021), paclobutrazol is a group of triazoles that play a role in regulating plant growth. This property is influenced by changes in plant hormone levels, including abscisic acid, gibberellin, and cytokinin in plants. Paclobutrazol is able to inhibit the performance of gibberellins so that it affects the suppression of plant height or length, increasing stem diameter due to the absence of cell elongation but the number of cells still increases, thus triggering enlargement in cambium and parenchyma tissues.

Table 4. Effect of dose and time of paclobutrazol application on stem diameter at the age of 9 and 11 WAP

Average Stem Diameter (mm)		
Treatment	**Age (WAP)**	
	9 WAP	**11 WAP**
Control	14.47 a	19.06 a
Paclobutrazol Dosage		
P1 (0.1 g)	15.14 ab	19.93 ab
P2 (0.2 g)	16.56 bc	21.32 bc
P3 (0.3 g)	17.49 c	22.79 c
HSD 5%	1.91	2.20
Paclobutrazol Application Time		
T1 (4 WAP)	17.87 b	23.65 b
T2 (6 WAP)	15.82 a	20.47 a
T3 (8 WAP)	15.29 a	19.78 a
T4 (10 WAP)	14.67 a	19.19 a
HSD 5%	1.91	2.20

Description: Mean numbers followed by the same letter at the same observation age indicate no significant difference in the 5% HSD test.

Table 4. the results showed that a dose of 0.3 g/plant produced the widest stem diameter, significantly different from the control and the dose of 0.1 g/plant. There was an increase in stem diameter due to the application of a dose of 0.3 g/plant of 19.56% compared to the control. These results indicate an effect on increasing the size of the stem diameter along with an increase in the dose of paclobutrazol given. Suhadi *et al.* (2017) explained that stem thickening due to paclobutrazol treatment occurs because the volume of parenchyma cells in the cortex tissue and cell production in the cambium tissue increases.

Table 4 also shows that the application time of paclobutrazol 4 WAP produces the highest plant stem diameter which is significantly different from the control and other application times. There was an increase in the stem diameter of sunflower plants by the effect of paclobutrazol application time 4 WAP by 24.08% compared to the control. This shows that there is a response to thickening the diameter of the plant stem by the effect of paclobutrazol application time, where the faster the paclobutrazol application time, the thicker and wider the resulting plant stem. This is in line with the research of Marshel *et al.* (2015) where the application of paclobutrazol at the age of 4 WAP showed the highest average diameter. The application of pacloburazol is able to affect the anatomy of plant stems due to an increase in cell volume in the cortex and cambium. So that the stems that are formed become thicker.

3.3. Number of Leaves

The results of the analysis of variance on the effect of the combination of dose and time of paclobutrazol application on the number of leaves of sunflower plants showed no significant interaction. The single factor of paclobutrazol

dosage has a significant effect on the number of leaves at the age of 9-11 MS. The single factor of application time had no significant effect from the observation age of 5 to 11 MS. The average number of leaves in each treatment is shown in Table 5.

Table 5 shows that the dose of 0.3 g/plant produces the lowest number of leaves and was significantly different from other treatments and the control. The decrease in the number of leaves due to the effect of the application dose of paclobutrazol 0.3 g/plant at the observation age of 11 WAP was 4.66% compared to the control. Harpitaningrum *et al.* (2014) stated that the application of paclobutrazol at high doses significantly reduced the number of plant leaves which was thought to be due to the inhibition of vegetative growth in plants. Table 5 shows that the application time treatment had no significant effect on the average number of leaves of sunflower plants aged 5-11 weeks after planting.

Table 5. Effect of dose and time of paclobutrazol application on the number of leaves at the age of 5 - 11 WAP

Average Number of Leaves (Helai)				
Treatment	**Age (WAP)**			
	5 WAP	**7 WAP**	**9 WAP**	**11 WAP**
Control	13.78	22.11	37.00 b	56.00 b
Palobutrazol dosage (P)				
0.1 g	14.14	22.06	37.33 b	56.06 b
0.2 g	14.03	22.14	37.28 b	55.94 b
0.3 g	14.03	22.08	35.69 a	53.39 a
HSD 5%	ns	ns	1.21	1.36
Paclobutrazol Application Time (T)				
4 WAP	13.81	22.04	36.89	54.83
6 WAP	14.11	21.97	36.28	55.28
8 WAP	14.03	22.19	36.89	55.78
10 WAP	14.06	22.17	37.25	55.50
HSD 5%	ns	ns	ns	ns

Notes: Mean numbers followed by the same letter at the same observation age indicate no significant difference in the 5% HSD test; ns = not significantly different.

Desta & amare (2021) in the leaf organ paclobutrazol does not affect the amount, but it also forms thicker leaves. Paclobutrazol treatment showed that the sponge tissue and palisade mesophyll differentiated where the cells in the tissue became longer. Paclobutrazol was also shown to be able to increase the amount of chlorophyll, increased chlorophyll content is associated with increased cytokinin content in plants. Cytokinins can stimulate chlorophyll biosynthesis and reduce chlorophyll catabolism.

3.4. Age at Flower Appearance

The results of the analysis of variance showed that the combination of dose and time of application of paclobutrazol had a significant interaction with the age of flower emergence in sunflower plants. Table 6. indicate that the combination of the dose treatment of 0.2 g/plant and the application time at 4 weeks of planting gave the best effect in accelerating the age of flower emergence which was significantly different from the control and other combination treatments except the combination with the application time of 6 and 8 weeks of planting. The longest average age of flower emergence was the control plant. The combination of the dose of 0.2 g/plant and the application time of 4 weeks after planting can accelerate the age of flower appearance by 10.25% compared to the control.

The application of paclobutrazol at a younger age will encourage faster flowering induction due to the suppression of vegetative growth in plants. According to Nawahepta *et al.* (2022), paclobutrazol application can result in faster flowering. Research by Sakanti *et al*. (2024) also showed that administering the correct dosage of paclobutrazol to plants has a positive effect, and paclobutrazol has been shown to shorten flowering time in cherry tomatoes.

Table 6. Effect of combined dose and time of paclobutrazol application on age at emergence

Average Age at Flower Appearance (DAP)				
Treatment	**Paclobutrazol Application Time (T)**			
Paclobutrazol dosage (P)	**4 WAP**	**6 WAP**	**8 WAP**	**10 WAP**
Control	78.00 d			
0.1 g	77.44 de	72.78 abc	71.33 ab	77.11 de
0.2 g	70.00 a	71.89 ab	72.00 ab	74.89 bcde
0.3 g	74.56 bcde	73.33 abcd	73.33 abcd	76.89 cde
HSD 5%	4.12			

Description: Mean numbers followed by the same letter indicate no significant difference in the 5% HSD test.

this compound inhibits the performance of gibberellin which causes a decrease in the rate of cell division, rate thus inhibiting vegetative growth and will indirectly divert photosynthate to reproductive growth to form flowers and fruit. The same thing is also stated that paklobutrazol is anti-gibberellin so that it can inhibit plant vegetative growth and then break flower dormancy. This will spur the flowering of plants (Nuriah *et al.*, 2018).

3.5. Harvest Age

The results of the analysis of variance of the effect of dose treatment and application time of paclobutrazol indicated that the combination of the two treatments interacted very significantly with the harvest age of sunflower plants. The average value of harvest age due to the combination of dose treatment and application time of paclobutrazol is presented in Table 7. The results showed that the combination of a dose of 0.3 g/plant and an application time of 6 WAP resulted in the fastest harvest age of sunflower plants, the value was significantly different from the control and the combination treatment of a dose of 0.1 g/plant and an application time of 4 WAP, a dose of 0.1 g/plant and an application time of 6 WAP, and a combination of all doses and an application time of 10 WAP. The longest harvest age was found in the control plants. The combination of treatment dose of 0.3 g/plant and application time of 6 weeks after planting can accelerate the harvest age by 5.57% compared to the control.

Table 7. Effect of the combination of dose and time of paclobutrazol application on the age of harvesting

	Average Harvest Age (DAP)			
Treatment	**Paclobutrazol Application Time (T)**			
Paclobutrazol dosage (P)	**4 WAP**	**6 WAP**	**8 WAP**	**10 WAP**
Control	111.67 de			
0.1 g	113.44 e	109.44 bcde	106.33 ab	109.56 bcde
0.2 g	107.67 abc	109.22 abcd	108.78 abcd	110.00 bcde
0.3 g	108.11 abcd	105.44 a	106.33 ab	111.11 cde
HSD 5%	3.89			

Notes: Mean numbers followed by the same letter indicate no significant difference in the 5% HSD test.

It is also stated by Prihantari *et al*. (2022), that paclobutrazol can accelerate the flowering process because there is an inhibition of gibberellin biosynthesis which is able to inhibit cell division and accelerate the vegetative phase, thus triggering flower induction and accelerating the harvest age of plants. The results of research by Syaputra *et al*. (2017) stated that plants applied with paclobutrazol had a faster harvest age compared to the control. Harvest age is related to the age of flower emergence, the sooner the age of flower emergence, the faster the fruit formation will be as well as the harvest age which becomes faster. The same thing was also stated by Sarkar (2023) who explained that sunflower plants applied with paclobutrazol were able to reach flower maturity faster at the age of 73 days compared to the control which reached maturity at the age of 106 days. Inhibition of stem growth and better development of the root system due to paclobutrazol application causes the distribution of biomass towards the filling of sunflower seeds and results in a higher 100 seed weight and seed yield.

3.6. Crop Yield

The results of the analysis of variance showed that the combination of dose treatment and application time of paclobutrazol interacted not significantly with the yield parameters of sunflower plants. The single factor of paclobutrazol dosage had a very significant effect on the average plant yield parameters including flower diameter, number of seeds, total seed weight and 100 seed weight of sunflower plants. The single factor of paclobutrazol application time significantly affects the flower diameter of sunflower plants. The average yield parameters of sunflower plants due to each treatment are presented in Table 8.

Table 8. Effect of dose and time of paclobutrazol application on the average yield of plants

Treatment	Flower Diameter	Number of Seeds	Total Seed Weight	100 Seed Weight
Control	10.11 a	640.44 b	18.92 b	2.94 b
Paclobutrazol Dosage				
P1 (0.1 g)	10.83 b	647.89 bc	21.06 bc	3.35 bc
P2 (0.2 g)	11.04 b	664.56 c	23.59 c	3.58 c
P3 (0.3 g)	9.82 a	611.42 a	12.54 a	1.99 a
HSD 5%	0.66	20.77	2.41	0.37
Paclobutrazol Application Time				
T1 (4 WAP)	10.89 b	649.92	19.83	3.04
T2 (6 WAP)	10.49 ab	633.67	18.81	2.93
T3 (8 WAP)	10.31 ab	637.25	18.94	3.00
T4 (10 WAP)	10.13 a	643.47	18.54	2.88
HSD 5%	0.66	ns	ns	ns

Notes: Numbers followed by the same letter in the same treatment indicate no significant difference in the 5% HSD test; ns = not significantly different.

Table 8 shows that the treatment dosage of 0.2 g/plant gave the highest results which were significantly different from the treatment dosage of 0.3 g/plant and the control. The treatment of paclobutrazol application dosage of 0.2 g/plant gave the best results in increasing flower diameter, number of seeds, 100 seed weight and total seed weight. The increase in the number of seeds, 100 seed weight and total seed weight due to the effect of the dose treatment of 0.2 g/plant amounted to 3.76%, 21.76% and 24.68% respectively. The dosage of 0.2 g/plant was able to suppress plant vegetative growth and accelerate flower induction, resulting in the transfer of plant assimilates to the formation of flowers and seeds. This is in line with the results of research by Sarkar (2023) that sunflower plants applied paclobutrazol at a dose of 2.5 g/plant produced a significant increase in the weight of 100 seeds and the number of seeds per plant compared to control plants.

Paclobutrazol stops plant growth so that carbohydrate reserves can increase and allow plants to flower soon and bear more fruit. Paklobutrazol can increase the production of the number and weight of seeds in sunflower plants, but the application of large doses of paclobutrazol can reduce the production of sunflower plants (Kinasih & Elfarisna, 2020). Therefore, the right application dose must be used to avoid a decrease in plant yield. The dose of 0.2 g/plant gives the highest yield, this is due to the long duration of flower and seed development. This can be seen from the time difference between the age of flower emergence and the age of plant harvest. The duration of flower development at a dose of 0.2 g/plant is longer than other treatments and the control. So that the longer the duration, the higher the yield obtained. According to Febrianto & Islam (2019) the flower freshness period is the period achieved by the flower from blooming to wilting which is related to the aging process.

The treatment of application time 4 WAP produced the widest flower diameter with a percentage increase in size of 7.71% compared to the control. This shows that there is a response the earlier the paclobutrazol application time is carried out, the higher the effect in increasing the diameter of the flowers of sunflower plants. The increase in flower diameter occurs because the suppression of vegetative growth of plants is able to encourage generative growth and trigger earlier flower induction, thus affecting the use of assimilate in the flowering phase to form flowers and seeds.

Sakanti *et al.* (2019) stated that paclobutrazol suppresses growth in the vegetative phase and pushes plants towards the generative phase. In the sub apical meristem, paclobutrazol compounds inhibit gibberellin biosynthesis which results in a decreased cell division rate, so that growth in the vegetative phase is inhibited and then there is a transfer of photosynthate to the reproductive phase by forming flowers and fruit. Therefore, the flowers produced can be larger. Research by Rugayah *et al*. (2020), paclobutrazol application resulted in a longer flower blooming period of 7.22 days compared to the control. This is because plants treated with paclobutrazol have larger stems so that they can store more food reserves and cause flowers to last longer. The results of research by Lienargo *et al*. (2014) also stated that the earlier application time of paclobutrazol on vegetative growth had a greater effect on suppressing growth and increasing the yield of yellow Manado variety corn plants.

The treatment of dose and time of paclobutrazol application did not give a real effect because the number of flowers is more influenced by the genetics of the plant itself. Flowers will appear on plant branches starting from the top branch and gradually appear on the branches below. This is in accordance with the results of research Tustiyani *et al*. (2020) that the application of various doses of paclobutrazol has no significant effect on the number of flowers because these characters are more influenced by genetic factors.

4. CONCLUSION

The combination of treatment dose of 0.3 g/plant and application time of 4 weeks after planting gave the best effect on growth (plant height and stem diameter). The dose treatment of 0.2 g/plant gives the finest effect on the parameters of the age of flower appearance and the yield of sunflower plants (flower diameter, number of seeds, total seed weight and 100 seed weight). The treatment of paclobutrazol application time 4 WAP produces the best effect on vegetative growth and sunflower yield (increasing flower diameter).

REFERENCES

Ardiarini, N.R., Waluyo, B., & Kuswanto. (2016). Variability and genetic distance of potential sunflower (*Helianthus annuus* L.) genotypes from Indonesia for industrial purpose. *Transactions of Persatuan Genetik Malaysia*, ***3***, 69-75.

BPS. (2022). *Statistik Perdagangan Luar Negeri Indonesia: Impor 2022*. Badan Pusat Statistik, Jakarta.

Desta, B., & Amare, G. (2021). Paclobutrazol as a plant growth regulator. *Chemical and Biological Technologies in Agriculture*, ***8***(1), 1–15. https://doi.org/10.1186/s40538-020-00199-z

Farida, D.G., & Ardiarini, N.R. (2019). Fenologi dan karakterisasi morfo-agronomi tanaman bunga matahari (*Helianthus annuus* L.) pada kawasan tropis. *Jurnal Produksi Tanaman*, ***7***(5), 792–800.

Febrianto, R.A., & Islam, T. (2019). Pengaruh konsentrasi paclobutrazol terhadap pertumbuhan dan hasil tiga varietas tanaman krisan (*Chrysanthemum* spp.). *Jurnal Produksi Tanaman*, ***7***(8), 1427–1434.

Harpitaningrum, P., Sungkawa, I., & Wahyuni, S. (2014). Pengaruh konsentrasi paclobutrazol terhadap pertumbuhan dan hasil tanaman mentimun (*Cucumis sativus* L.) kultivar Venus. *Agrijati Jurnal Ilmiah Ilmu-Ilmu Pertanian*, ***25***(1), 1–17.

Itawari, K., Rosa, E., & Savitri, S. (2023). Pengaruh waktu pemberian zpt paclobutrazol 250 gi dan konsentrasi pupuk hayati bioboost terhadap pertumbuhan dan hasil tanaman kacang tanah (*Arachis hypogea* L.). *Jurnal Agriflora*, ***7***(2), 32-38.

Kinasih, L.A., & Elfarisna, E. (2020). Pengaruh dosis paklobutrazol terhadap pertumbuhan dan produksi bunga matahari (*Helianthus annuus* L.). *Jurnal Agrosains Dan Teknologi*, ***5***(1), 27-35.

Koutroubas, S.D., Vassiliou, G., & Damalas, C.A. (2014). Sunflower morphology and yield as affected by foliar applications of plant growth regulators. *International Journal of Plant Production*, ***8***(2), 215–230. https://doi.org/10.22069/ijpp.2014.1525

Kulkarni, S. S., Bhalke, R, D., Pande, V. V., Kendre, P.N. (2014). Herbal plants in photo protection and sun screening action: An overview. *Indo American Journal of Pharmaceutical Research*, ***4***(2), 1104–1113.

Lienargo, B.R., Runtunuwu, S.D., Rogi, J.E., & Tumewu, P. (2014). Pengaruh waktu penyemprotan dan konsentrasi Paclobutrazol (pbz) terhadap pertumbuhan dan produksi tanaman jagung (zea mays l.) Varietas manado kuning. *Cocos*, ***4***(1), 1-9.

Marshel, E., Bangun, M.K., & Putri, L.A.P. (2015). Pengaruh waktu dan konsentrasi paclobutrazol terhadap pertumbuhan bunga matahari (*Helianthus annuus* L.). *Jurnal Online Agroekoteknologi*, ***3***(3), 929–937.

Nawahepta, D.A., Kusumaningrum, N.A., & Sutini, S. (2022). Pengaruh bahan tanam dan pemberian paclobutrazol terhadap

pertumbuhan dan pembungaan tanaman hortensia (*Hydrangea macrophylla*). *Plumula: Berkala Ilmiah Agroteknologi*, ***10***(2), 123-130.

Nuriah, E., Marveldani, M., & Shintarika, F. (2018, Oktober 8). Pengaruh aplikasi paclobutrazol dan KNO_3 terhadap pertumbuhan dan pembungaan anggrek tebu (*Grammatophyllum speciosum* Blume). In *Prosiding Seminar Nasional Pengembangan Teknologi Pertanian* (pp 176–181). Politeknik Negeri Lampung.

Prihantari, E.T., Hardiyati, T., & Samiyarsih, S. (2022). Kualitas biji dan karakter agronomi padi hitam (*Oryza sativa* L.) lokal pekalongan dengan penambahan paklobutrazol dan giberelin. *BioEksakta : Jurnal Ilmiah Biologi Unsoed*, ***3***(2), 88. https://doi.org/10.20884/1.bioe.2021.3.2.4240

Ramadhan, N., Martinsyah, R.H., & Jamsari, J. (2022). Pertumbuhan dan hasil 6 varietas bunga matahari (*Helianthus annus* L.) pada lahan bukaan baru di dataran tinggi alahan panjang. *Jurnal Galung Tropika*, ***11***(1), 45-52. https://doi.org/10.31850/jgt.v11i1.870

Rombon, D., Najoan, J., & Runtunuwu, S.D. (2018). Pengaruh interaksi konsentrasi dan waktu aplikasi paclobutrazol terhadap pertumbuhan dan hasil tanaman padi sawah (*Oryza sativa* L.) varietas serayu. *COCOS*, ***10***(5), 1-6.

Rugayah, R., Hendarto, K., Ginting, Y.C., & Ristiani, R. (2020). Pengaruh konsentrasi paclobutrazol pada pertumbuhan dan penampilan tanaman sedap malam (*Polyanthes tuberosa* L.) dalam pot. *Jurnal Agrotropika*, ***19***(1), 27-34.

Sakanti, P.D., Karno, K., & Rosyida, R. (2024). Efek konsentrasi paklobutrazol dan pemangkasan pada petumbuhan dan hasil tanaman tomat ceri (*Lycopersicum esculentum* var. Cerasiforme). *J-Plantasimbiosa*, *6*(1), 74-90.

Sarkar, J. (2023). Effect of paclobutrazol on physiology, growth and yield of sunflower (*Helianthus annuus* L.). *Plant Physiology Reports*, ***28***(2), 231–237. https://doi.org/10.1007/s40502-023-00729-5

Suhadi, I., Nurhidayati, N., & Sharon, B.A. (2017). Efektifitas retardan sintetik terhadap pertumbuhan dan masa pajang bunga matahari (*Hellianthus annus* L.). *Jurnal AGRIFOR*, ***16***(2), 219–228.

Syaputra, E., Nurbaiti, N., & Yoseva, S. (2017). Pengaruh pemberian paclobutrazol terhadap pertumbuhan dan produksi tanaman tomat (*Lycopersicum esculentum* Mill.) dengan pemangkasan satu cabang utama. *Jom Faperta*, ***4***(1), 1-11.

Tustiyani, I., Nurhayati, T., & Mutakin, J. (2020). Pengaruh konsentrasi paclobutrazol terhadap pertumbuhan bunga matahari (*Helianthus annuus* L.). *Lumbung*, ***19***(2), 112–119. https://doi.org/10.32530/lumbung.v19i2.240

Warastuti, I.D.P., Sugiharto A.N., dan Ardiarini N.R. (2017). Evaluasi keseragaman dalam aksesi bunga matahari (*Helianthus annuus* L.) berdasarkan karakter generatif. *Jurnal Produksi Tanaman*, ***5***(7), 1062-1069.