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Growth and Yield Responses of Chili (*Capsicum frutescens* L.) to Paclobutrazol Concentrations and P-Fertilizer Doses during the Rainy Season

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***Abstract*— *Field experiment conducted from November 2021 to April 2022 on farmers' fields in Sukamulia, East Lombok, Indonesia, aimed to determine the growth and yield response of chili (Capsicum frutescens L.) to treatment with Paclobutrazol concentrations and phosphorus fertilizer doses during the rainy season. The factorial experiment was arranged in a randomized block design with three blocks and two treatment factors, namely Paclobutrazol concentrations (0, 50, 100 and 150 ppm) and phosphorus fertilizer doses (0, 30, 60 and 90 kg/ha P_2O_5). Data were analyzed using ANOVA and Tukey's HSD at 5% significance level. The results showed that Paclobutrazol concentration significantly decreased growth rates of plant height and the doses of P fertilizer increased the number of productive branches per plant. However, the interaction between the treatment factors had a significant effect on flower initiation and fruit weight per plant, with the highest chili fruit yield, i.e. 549.5 g/plant, was obtained on chili plants receiving treatment combination of 150 ppm Paclobutrazol concentration and P-fertilizer dose of 90 kg/ha P_2O_5. This treatment combination also resulted in the earliest flower initiation (at 42.2 days after planting).*

***Keywords*—Chili, Paclobutrazol, P-fertilizer, flower initiation, rainy season**

I. INTRODUCTION

Small chili (*Capsicum frutescens* L.) can be cultivated from the lowlands to the highlands (1000 m asl) and is the most important horticultural commodity in Indonesia. Chilies have quite high economic value, and high prices can be obtained when chilies are planted in the rainy season. However, the physiological obstacle in increasing chili production in the rainy season is the low percentage of fruit formation, which is mainly due to the fall of flowers, so some efforts must be made to increase chili production [1]. Increasing chili yields can be done by increasing the formation of flowers and fruits, so that the percentage of flower and fruit fall does not affect the yield per unit area. This can be done by using Paclobutrazol (Pbz) as a retardant or with phosphorus fertilizer [2].

Paclobutrazol (Pbz) is a growth regulator that inhibits vegetative growth without changing the pattern of plant development [3], by diverting the results of photosynthesis from vegetative growth to fruit formation [4]. Pbz application can be done by spraying through the leaves and sprinkling it on the ground [5-7]. The function of Pbz is to suppress plant growth resulting in shorter shoots of tomato plants, but better root growth, resulting in plants being more resistant to drought stress or waterlogging [8]. Pbz applied to *Syzygium campanulatum* resulted in shorter plants and decreased leaf area index [9]. The growth of the "Pitanga" ornamental chili can be controlled by treating it with Pbz of 150 ppm, besides being able to induce improvement in fruit characteristics [5, 10]. Pbz concentrations of 10 - 150 ppm significantly reduced the size of Sanseviera plants (Sanseviera trifasciata L.) [6].

Apart from its effect on plant growth, the application of Pbz of 100 -500 ppm can increase flowering, such as in chili plants [7]. An increase in the number of flowers and fruits is associated with a greater amount of chlorophyll even though the leaf area index is reduced [11-12]. In addition to the concentration of Pbz, the timing of its application is also important, because its effects depend on the type of plant, the size of the plant as well as the local climatic conditions. From the results reported by Baloch et al. [13], Pbz applied three times before the formation of flowers on ornamental chilies increased fruit yields and suppressed growth of plant height. In tomato plants, the application of Pbz twice before flowering can reduce plant height and increase fruit yield [14].

In addition to the application of Pbz, flower and fertilization induction can also be carried out by using Phosphorus fertilizer. The application of phosphorus fertilizers to chilies can increase the yield of chilies, which is caused by an increase in the number and length of the fruits [15]. The yield response of chili plants to doses of phosphorus from doses of 0 to 150 kg/ha P occurred in a quadratic manner with the highest yields occurring at a dose of 90 kg/ha [16]. In combination with Nitrogen fertilizers, increased doses of phosphorus fertilizers from 46, 92 and 138 kg/ha, were reported to significantly increase chili fruit yield and number of fruits per plant [17]. Based on those reports, a study has been carried out with the main objective to determine the growth and yield responses of chili (*Capsicum frutescens* L.) to Paclobutrazol concentrations and doses of Phosphorus fertilizer applied during the rainy season.

II. MATERIALS AND METHODS

The method used in this study was an experimental method by conducting a field experiment from November 2021 to March 2022, in Padamara Village, Sukamulia District, East Lombok Regency, Indonesia. The materials used in the experiment were chili seeds of the Ori 212 variety, Mutiara NPK fertilizer, Paclobutrazol (Cultar 250 SC) and SP36 fertilizer. The experiment was arranged in a randomized block design with three replications and two factorial treatment factors, namely Paclobutrazol (Pbz) concentrations (0, 50, 100 and 150 ppm) and P-fertilizer doses (0, 30, 60 and 90 kg/ha P_2O_5).

Observation variables included average growth rate (AGR) of plant height, number of productive branches, flower initiation age, number of flowers and fruit weight per plant. Data were analyzed using the Analysis of Variance (Anova) and the Honest Significant Difference Test (Tukey's HSD) at the 5% level of significance.

III. RESULTS AND DISCUSSION

Rainfall data during implementation of the experiment from November 2021 to March 2022, obtained from the Power Data Access Viewer, were 331.61; 277.78; 342.32; 207.67; and 191.42 mm/month, respectively, so that during the experiment, the climatic conditions of the location were in the wet months. High rainfall can affect the initiation of flowers and the number of fruits formed. The results of the analysis of variance (ANOVA) for the observation data are presented in Table 1.

Table 1. Summary of ANOVA results for all observation variables

Variables	Pbz conc.	P doses	Pbz*P
AGR of plant height	s	ns	ns
Productive branches	ns	s	ns
Flower Initiation age	s	s	s
Fruit yield per plant	s	ns	s

Remaks: s= significant; ns= non-significant

The interaction between Pbz concentration and Phosphorus fertilizer dosage had a significant effect on the age of flower initiation and fruit weight per plant, but had no significant effect on plant height and number of productive branches (Table 1). The application of Pbz can inhibit the formation of GA, resulting in stunted shoot growth, so that photosynthate is diverted to flower initiation, coupled with the function of P which can induce fertilization. Inhibiting plant vegetative growth as well as inducing flowering, by suppressing the formation of Gibberellins, photosynthate is more directed to fertilization than vegetative growth. Application of P fertilizer can also induce better flowering. This is in accordance with the statements of Desta & Amare [4] and Jayanti et al. [18] that the application of Paclobutrazol and Phosphorus increased the percentage of the number of flowers and fruits of chilies.

As a single factor, the application of Pbz significantly affected the growth rate of plant height (Table 1), which suppressed the growth rate of plant height (Table 4), while the dose of Phosphorus only had an effect on the number of productive branches, namely increasing the number of productive branches (Table 4). Pbz increases the chlorophyll content of leaves so that photosynthetic activity can run better, but photosynthate is used more for fruit formation. These are in accordance with the statement of Harpitaningrum et al. [19] that the yield of cucumber plants increased in line with increasing concentrations of Pbz. Emongor and Mabe [15] also reported that phosphorus affects fruit yield in ornamental chilies.

3.1. Interaction effects on flower initiation and fruit yield

The earliest flowering date was found in the Pbz3P3 treatment combination, namely 42.2 days after transplanting (Table 2). This is presumably because Pbz suppresses vegetative growth of plants, resulting in faster flowering accompanied by the effect of P which accelerates flowering due to a larger dose of Phosphorus fertilizer. Adilah et al. [20] and Syahputra et al. [21] stated that application of 250 ppm Paclobutrazol could inhibit vegetative growth and increase fruit yields. This is because the applied Paclobutrazol is able to stimulate the formation of flowers in tomato plants [13, 22]. Phosphate has several functions including accelerating the process of flowering and fertilization, strengthening plant organs (leaves, flowers and fruit) so they don't fall off easily, producing enzymes that play a role in photosynthesis and translocation of photosynthesis results in the form of assimilates to the reproductive organs of plants [23], so that flowering dates become earlier.

Table 2. The interaction effect of the treatment factors on flower initiation age (days after transplanting)

Treatments	P0	P1	P2	P3
Pbz0	45.5 a	43.3 ab	44.8 a	45.0 a
Pbz1	42.6 b	43.0 ab	45.2 a	44.4 a
Pbz2	42.5 b	43.4 b	44.8 a	44.3 a
Pbz3	42.7 b	42.5 a	42.3 b	42.2 b
HSD	0.83			

Remarks: The mean values followed by the same letters indicate non-significantly different both vertically and horizontally

The interaction between Paclobutrazol concentration and Phosphorus dosage increased the percentage of flowering shoots. The results of previous studies showed that the Phosphorus and Paclobutrazol treatments increased the C/N ratio in the leaves during the flower bud differentiation period which in turn helped increase the initiation of flowering [10]. From Table 3, it can be seen that there was a significant interaction effect between Paclobutrazol concentrations and P fertilizer doses, where at each level of P fertilizer dose, an increase in Paclobutrazol concentration significantly increased fruit weight per plant. Pulungan et al. [24] also stated that the proper use of Paclobutrazol will have a significant effect on flower initiation and fruit formation. The inhibition of flowering time can be caused by the inappropriate concentration of Paclobutrazol applied because each plant has a different sensitivity to growth inhibitory substances [16, 20].

Table 3. The interaction effect of the treatment factors on the chili fruit yield (gram/plant)

Treatments	P0	P1	P2	P3
Pbz0	201.4 c	201.9 b	478.6 a	464.5 a
Pbz1	208.6 bc	215.7 ab	508.6 b	516.4 b
Pbz2	224.7 ab	224.5 ab	513.0 b	540.4 c
Pbz3	242.7 a	235.5 a	524.6 b	549.5 c
HSD	23.2			

Remarks: The mean values followed by the same letters indicate non-significantly different both vertically and horizontally

3.2. AGR of plant height and productive branch number

The application of Paclobutrazol at various concentrations had a significant effect on the growth rate of plant height, while the P doses only had a significant effect on the number of productive branches per chili plant (Table 1). This is because the effect of Paclobutrazol applied to plants functions as an inhibitor of plant height growth, so that an increase in Pbz concentration can inhibit the growth rate of plant height, as shown in Table 4.

Table 4. The main effect of the treatment factors on AGR of plant height (cm per 2 weeks) and number of productive branches per chili plant

Treatments	AGR of plant height (cm per 2 weeks)	Productive branch number per plant
Pbz0	10.88 a	17.79
Pbz1	10.06 b	18.12
Pbz2	9.87 b	19.77
Pbz3	9.17 b	20.24
HSD 5%	1.23	ns
P0	10.05	20.42 a
P1	9.8	23.65 b
P2	9.57	23.08 b
P3	9.58	23.92 b
HSD 5%	ns	1.90

Remarks: Mean values followed by the same letters are not significantly different between levels of a treatment factor

Based on Table 4, the results of Paclobutrazol application at various concentrations on plant height showed that the Paclobutrazol concentrations had a significant effect on the growth rates of chili plant height. The highest growth rate was in the Pbz0 treatment (Control) with an average growth rate of 10.88 cm per 2 weeks, followed by the Pbz1 treatment (50 ppm) and the Pbz2 treatment (100 ppm), while under the Pbz3 treatment (150 ppm), the AGR of plant height was the lowest with an average of 9.17 cm per 2 weeks. The results of this study indicate that the application of Paclobutrazol at the concentrations ranged from 0 to 150 ppm can suppress the growth rate of plant height.

The growth rate (AGR) of plant height in the Paclobutrazol Pbz0 (Control) treatment was significantly different from that in Pbz1 (50 ppm), Pbz2 (100 ppm), and Pbz3 (150 ppm) treatments. This is in line with the statement of Moko et al. [25] as well as Guniarti & Suhardjono [26] that the absence of Paclobutrazol allows plant growth to proceed normally or without suppression of plant height and the treatment with 0 ppm produced the highest plant height. Based on the results of research by Syaputra et al. [21] and Dwi & Koesriharti [27], application of high concentrations of Paclobutrazol greatly reduced tomato plant height compared to low concentrations.

In contrast, the doses of P fertilizer had no effect on the growth rate of plant height (Table 4). This is because at the beginning of plant growth, P fertilizer plays a very important role in the tissues which actively divides parts of the plant tissue, because the more the plant height is suppressed, the more branching will be produced, which has the potential to produce a large number of branches [15, 28], as shown in Table 4, that P doses have more effect on the number of branches compared to the growth rates of plant height.

IV. CONCLUSION

Based on the research results, it can be concluded that the treatment combination of 150 ppm Paclobutrazol and P fertilizer dose of 90 kg/ha P_2O_5 accelerated flower initiation which resulted in the earliest flower initiation, i.e. at 42.2 days after planting, and produced the highest average of chili fruit yield of 549.5 g/plant.

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