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Responses of Solo Garlic Crops Grown at Low Elevation of Tropical Areas to Organic Matter and Paclobutrazol

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ABSTRACT

Solo garlic has been known for its medicinal benefits because of which it is considerably expensive. Nonetheless, no Indonesian farmer produces solo garlic intentionally since no information on how to grow solo garlic in Indonesia is available. Growers, usually harvest 5-10 kg of solo garlic from 1 hectare of garlic crop they grow. A greenhouse experiment was conducted from November 2018 to January 2019 at the Department of Agronomy, Faculty of Agriculture, Bengkulu University, about 10 m above sea level to study the effects of paclobutrazol and organic matter on the growth and yield of solo garlic crop grown at low elevation of Bengkulu. The experiment used completely randomized design arranged in factorial (2 factors; 5 replications). The first factor tested was organic matter levels (0, 2.5, 5.0, 7.5%) and the second factor was paclobutrazol concentrations (0, 500, 1000, 1500 ppm). Solo garlic seeds were planted in the polybag filled with 5 kg of media, a mixed of topsoil and organic matter. The crops were sprayed with paclobutrazol at 21, 35, and 49 days after planting. The results showed that organic matter did not significantly affect crop growth and yield. In contrast, paclobutrazol significantly affected crop growth and yield, with the best yield was found at 1500 ppm paclobutrazol. Furthermore, there was no significant interaction between organic matter and paclobutrazol on the growth and yield of solo garlic grown at low elevation at tropical climate in Indonesia.

INTRODUCTION

Solo garlic, a garlic with single clove, has been known for its medical benefit for years (Mikaili *et al*., 2013), due to its high content of alicin .and organosulphate compounds (Josling, 2001; Mehrbod *et al*., 2009), because of which it is much more expensive than regular garlic. However, no farmers intentionally cultivate the crops in Indonesia due to expensive seeds, agroclimatic problems, and lack of information on how to do so. It is common knowledge that in Indonesia farmers harvest nearly 5-10 kg of solo garlic from 1 hectare of regular garlic crop they grow (BPTP Jateng, personal communication), suggesting that solo garlic could be produced in Indonesia. We just need to figure out what factors promoting solo garlic formation.

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Regular garlic, which has several cloves, is typically produced at high elevation with certain requriment, such as good drainage, rich of organic matter, and rich of nutrient contents (Rahman, 2007; Martin *et al*., 2016). It is not clear whether solo garlic crops need the same growth requirements as regular garlic crops. At this point, many aspects need to be observed to elucidate what factors induce or promote the formation of solo garlic bulb. We assumed that it would include the phycical, biological, and chemical factor of the soil fertility, the presence of competition for growth factors, or the change in endogen balance of plant growth regulator,

Regular garlic has been reported to grow well and produce lots of bulb when grown at the soil ammended with organic matter (OM) (Kumar *et al.*, 2021). However, there is no informasion on the influence of OM on single garlic growth and yield. As a results, an experiment to study the effect of organic matter (OM) on the growth and yield of solo garlic crops needs to be done.

Paclobutrazol has been known to promote potato tuber formation at high temperature (Suharjo *et al*., 2010), as well as low altitude of tropical areas, by inhibiting the biosynthesis of GA_3 endogen (Florez-Lopez *et al*., 2016). In potato crops, GA_3 promote stolon growth and prevent the formation of tubers (Menzel, 1983), by inhibitting starch accumulation at the onset of tuber formation. This GA_3 action was completely inhibited by the presence of paclobutrazol (Menzel, 1983), resulting in the formation of potato tubers (Suharjo *et al*., 2010). At this point, there was no study on the effect of GA_3 and paclobutrazol on solo garlic growth and yield although the effects of paclobutrazol in promoting potato tuber formation has been widely studied.

The objectives of this experiment were to study the effect of OM, paclobutrazol, and their interaction on the growth and yield of solo garlic crops grown at the low elevation of tropical areas.

MATERIALS AND METHODS

A greenhouse experiment was conducted at low elevation (10 m above sea level) of tropical region of Indonesia. The experiment run from November 2018 to January 2019 was taking place at the Deparment of Agronomy Experimental Station, Faculty of Agriculture, Bengkulu University, about 10 m above sea level. We used completely randomized design (CRD) arranged in factorial with 2 factors and 5 replications.

Solo garlic seeds were sown in the polybag filled with 10 kg of media, a mix of top soil and OM. The OM contents were 0, 2.5, 5.0, and 7.5% of the mixture. The crops were sprayed with paclobutrazol (PBZ) (0, 500, 1000, and 1500 ppm) at 21, 35, and 49 days after planting (DAP).

At planting, the crops were fertilized with 100 kg.ha^{-1} N, 100 kg.ha^{-1} P_2O_5 ha.$^{-1}$, and 60 kg ha^{-1} KCl. Another 100 kg.ha^{-1} N was applied when the crops 6 WAE (Hilman *et al*., 1997). The crops were watered every other day.

Variables observed included plant height, leaf number, bulb number, bulb length, bulb diameter, and bulb fresh weight. Data analysis were done by analysis of variance (ANOVA) followed by mean separation using Duncan's Multiple Range Test (DMRT) at $\alpha = 5\%$

RESULTS AND DISCUSSION

Analysis of Variance

The results of analysis of variance (ANOVA) showed that organic matter did not significantly affect plant growth and bulb yield, paclobutrazol significantly affected bulb attributes (diameter, length, and fresh weight), and their interaction did not significantly affect plant growth and bulb yield (Table 1).

Table 1. Analysis of the effects of organic matter, paclobutrazol, and their interaction on crop growth and bulb yield.

Variable observed	Calculation of F Value		
	Organic Matter	Paclo-butrazol	Inter-action
Leaf number	0.69 ns	0.20 ns	0.73 ns
Harvesting date	0.28 ns	1.30 ns	0.62 ns
Bulb diameter	0.20 ns	3.62 *	0.85 ns
Bulb length	0.02 ns	3.40 *	0.80 ns
Bulb weight	0.37 ns	9.33 *	0.34 ns
F-Table	*2.90*	*2.90*	*2.18*

Note: ns = not significantly different at α=5%, * = significantly different at α=5%

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The Effects of Paclobutrazol

Plant Growth. Application of paclobutrazol reduced plant growth, as indicated by the reduction in plant height (Figure 1) and leaf number (Table 2), suggesting that the chemical used in this experiment was still effective. This result was in line with a previous work reported by Resende and Souza (2002), finding that paclobutrazol application reduced plant height of garlic crops. In fact, paclobutrazol application has been widely known for reducing crop growth (Gautam *et al*., 2014; Resende and Souza, 2002; Tesfahun, 2018), by inhibiting gibberellic acid biosynthesis (Desta and Amare, 2021).

Bulb. Paclobutrazol application did not significantly affect bulb number. All treatments produced only one bulb, showing that the crops grown was solo garlic, expected to produced only single clove of garlic (Syamsiah dan Tajuddin, 2003). However, increasing paclobutrazol concentration increased the diameter of bulb, bulb length, and bulb fresh weight (Table 2; Figure 2.), suggesting the important role of paclobutrazol in bulb formation and growth, as previously reported by Resende and Sauza (2002) on regular garlic. Recent study showed that application of paclobutrazol increased chlorophyl content (Tesfahun, 2018).

Figure 2. Solo garlic bulb produced at 0% OM with different rates of PBZ application (0, 500, 1000, and 1500 ppm)

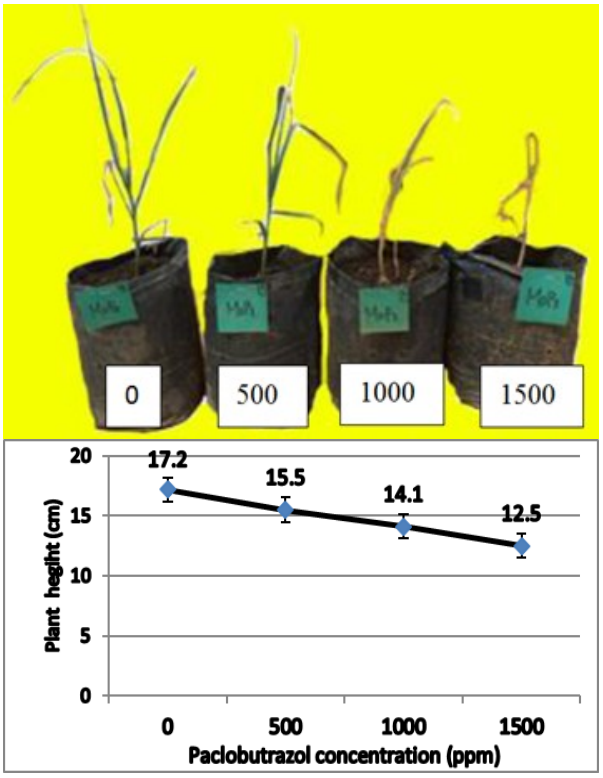

Figure 1. Effects of paclobutrazol concentration (0, 500, 1000, and 1500 ppm) on plant height at 12 weeks after planting.

In short, paclobutrazol minght contribute to the increase in bulb diameter and fresh weight by increasing chlorophyll content, leading to an ↓ GA_3 biosynthesis (Flores-Lopez *et al*., 2016), which resulted in more carbon accumulation. In addition, paclobutrazol has also been reported to promote bulb diameter of shallot (Sari *et al*., 2015).

The Interaction Effects of OM and Paclobutrazol

The interaction of organic matter and paclobutrazol did not significantly affect leaf number and bulb number (Table 3). However, it affected harvesting date showing that at 0% of organic material level, increasing PBZ concentration delayed harverting date. Likewise, at higher (2.5, 5.0 and 7.5%) proportion of organic materials. These findings

Table 2. The effects of paclobutrazol application on plant growth and bulb yield

Paclobutrazol (ppm)	Leaf number	Harvesting date (DAP)	Bulb number	Bulb diameter (mm)	Bulb length (cm)	Bulb fresh weight (g)
0	4.06 a	54.25 a	1.0 a	1.22 c	3.17 b	2.52 c
500	4.06 a	50.75 a	1.0 a	1.55 b	3.38 ab	3.50 bc
1000	3.56 ab	54.25 a	1.0 a	1.61 b	3.77 a	4.35 b
1500	2.25 b	59.50 a	1.0 a	3.95 a	3.56 ab	6.17 a

Note: the number at the same column followed by the same letter was not significantly different

Table 3. The interaction effect of OM and PBZ on leaf number, harvesting date, and bulb number

Organic Matter	PBZ	Leaf number		Harvesting Date (DAP)		Bulb number
0%	0 ppm	3.66	a	56.01	ab	1.0 a
	500 ppm	2.01	a	56.02	ab	1.0 a
	1000 ppm	3.33	a	49.01	b	1.0 a
	1500 ppm	2.66	a	63.14	a	1.0 a
2.5%	0 ppm	1.89	a	49.12	b	1.0 a
	500 ppm	3.01	a	49.01	b	1.0 a
	1000 ppm	2.66	a	56.22	ab	1.0 a
	1500 ppm	2.33	a	56.24	ab	1.0 a
5.0 %	0 ppm	2.00	a	63.12	a	1.0 a
	500 ppm	3.00	a	49.11	b	1.0 a
	1000 ppm	2.00	a	56.14	ab	1.0 a
	1500 ppm	2.33	a	56.15	ab	1.0 a
7.5 %	0 ppm	2.00	a	49.01	b	1.0 a
	500 ppm	2.66	a	49.01	b	1.0 a
	1000 ppm	2.33	a	56.03	ab	1.0 a
	1500 ppm	2.66	a	63.14	a	1.0 a

Note: the number at the same column followed by the same letter was not significantly different

suggested that increasing organic matterial promoted crop growth, leading to delay in harvesting solo garlic bulb.

The interaction between organic matter and paclobutrazol did not signigicantly affect leaf number and bulb number. In general, at any rate of organic matter, increasing paclobutrazol significantly delayed the harvesting date, except for 5.0% OM+ 0 ppm PBZ (Table 3).

Application of paclobutrazol promoted tuber size across the organic matter levels. However, the highest tuber diameter was found when solo garlic crops were grown at 7.5% of organic matter and sprayed with 1500 ppm Paclobutrazol (Figure 3).

Paclobutrazol also increased bulb fresh weight, regardless of the level of OM ammended into the media. The highest bulb fresh weight was found at 2.5% OM + 1500 ppm PBZ (Figure 4.) Increasing tuber size and weight had been also reported previously by Resende et al. (2002) when spraying garlic crop with paclobutrazol (from 0 to 500, 1000, dan 1500 ppm). Similar results were reported by Kristina et al. (2024) on garlic and Salta et al., (2023) on shallot. Kristina et al. (2024) explained that the increase in bulb size and weight were attributed to the increase in assimilate accumulation, as a result of reducing shoot growth.

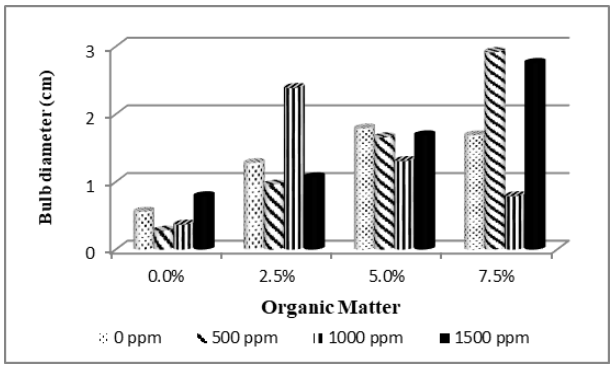

Figure 3. The interaction effect of OM and paclobutrazol (ppm) on bulb diameter (mm).

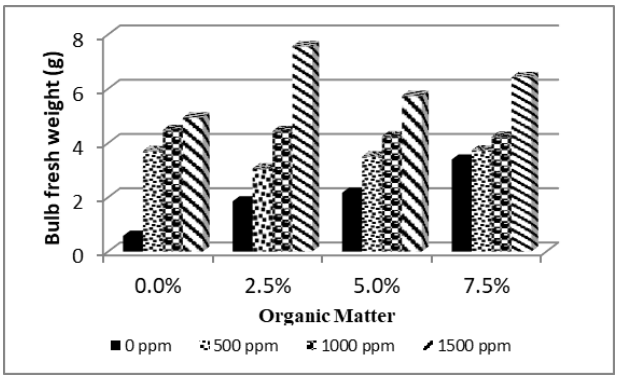

Figure 4. Effect of the interaction between organic matter (0, 2.5, 5.0, and 7.5%) and paclobutrazol (0, 500, 1000, and 1500 ppm) on bulb fresh weight (g).

CONCLUSION

Organic matter may not be needed in the media for growing solo garlic in a green house at low elevation in tropical climate. The best paclobutrazol concentration to promote the formation of solo garlic was 1500 ppm. Organic matter and paclobutrazol acted independently in influencing the growth and yield of solo garlic crops.

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