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Plant Reproductive Responses of Guava ‘Crystal’ Under Different Paclobutrazol and NPK Fertilizer Doses

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Abstract

A preliminary study of the reproductive responses of crystal guava plants under varying doses of paclobutrazol and NPK fertilizer was conducted. The research took place in a small-scale ‘Crystal’ orchard in Rajabasa 1, East Lampung, from August 2021 to March 2022. The study employed a 3x3 factorial randomized complete block design, examining two factors: paclobutrazol and NPK fertilizer. The first factor, paclobutrazol (P), had three levels: 0 ppm (control), 2000 ppm, and 4000 ppm. The second factor, NPK fertilizer, was tested at three levels: 0 g per plant (control), 250 g per plant, and 500 g per plant. The key variables measured were the number of reproductive shoots, blooming flowers, and fruits, serving as indicators of the ‘Crystal’ guava plant’s reproductive responses. The study findings recommended the application of 2000 ppm paclobutrazol and 500 g per plant of NPK fertilizer due to their significantly positive impact on increasing the number of reproductive shoots, blooming flowers, and fruits. Notably, there was no significant interaction observed between paclobutrazol and NPK treatments in regulating plant reproductive growth.

Keywords: reproductive shoots, guava, nitrogen, potassium, phosphorus.

Introduction

‘Crystal’ guava stands out as a superior fruit in Indonesia, capable of competing with imported fruits in the domestic market. Data from the Indonesia Bureau of Statistics reveals a significant rise in guava production, escalating from 200,487 tons in 2017 to 422,491 tons in 2021. This increase of 222,004 tons over five years underscores the fruit’s growing popularity (BPS 2021). The ‘Crystal’ variety is particularly prized for its crunchy flesh and minimal seeds, constituting less than 3% of the fruit (Widyastuti et al. 2019a).

The significance of ‘Crystal’ guava is further amplified by its rich nutritional content, including essential elements like vitamin C and antioxidants (Jimenez-escrig et al. 2001; Susanto et al. 2019; Guntarti and Hutami 2019; Hartati et al. 2020). Moreover, it is a source of sugar, fiber, protein, and minerals (Adrees et al. 2010). This nutritional profile not only adds to its appeal but also contributes to its perceived health benefits. The rising demand for ‘Crystal’ guava in the market emphasizes the necessity of improving guava fruit production. To cater to this demand, it is important to enhance production methods and maintain the fruit’s superior quality.

Cultural techniques that have been studied to increase production and fruit quality include fruit bagging (Widyastuti et al. 2022a), organic fertilizer application (Trivedi et al. 2012; Goswami et al. 2015), biofertilizer usage (Shukla et al. 2014; Widyastuti et al. 2021), flower bud thinning (Suman and Bhatnagar 2019), strangulation (Widyastuti et al. 2019b), pruning (Bhagawati et al. 2015; Lal et al. 2016; Susanto et al. 2019; Widyastuti et al. 2019c), and the application of growth retardant (Lizawati 2008). Paclobutrazol is a growth retardant that triggers reproductive responses, particularly flowering initiation. Its mechanism involves inhibiting gibberellin biosynthesis, impeding vegetative growth, and prompting flowering, as evidenced in citrus (Darmawan et al. 2014). Soil drenched paclobutrazol at 750 ppm on the 35th day after leaf removal in mango trees led to a substantial increase in the number of flowers, fruits, and fruit weight per tree (96%, 74%, and 73% respectively)

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compared to without paclobutrazol treatment (Yuniastuti et al. 2001).

Apart from growth retardants, optimal fertilization significantly contributes to improved fruit production (Mahendra et al. 2017), especially with macronutrients nitrogen (N), phosphorus (P), and potassium (K). Varied nutrient management, particularly different forms of NPK fertilizers, results in varying harvested fruit weights and fruit quality in 'Crystal' guava (Musyarofah et al. 2020). In this context, the current study aimed to preliminarily assess the reproductive responses of crystal guava plants under varying doses of paclobutrazol and NPK fertilizers.

Material and Methods

The study was conducted from August 2021 to March 2022 in a small-scale Crystal orchard in Rajabasa 1, East Lampung, Indonesia. Two-year-old guava trees were used as the object of study, that were previously selected based on their uniformity in plant height (2 m), canopy size (2-2.5 m), stem diameter (7.5-8 cm). Five-hundred grams of manures was applied to each plant.

The experimental design used in the present study was a completely randomized block design involving two factors of treatment, the doses of paclobutrazol (P) and NPK fertilizer (N). The first factor of paclobutrazol (P) consisted of three levels, i.e., 0 ppm (control), 2000 ppm, and 4000 ppm, prepared from Golstar containing 250 $g.L^{-1}$ active ingredient in form of paclobutrazol. The second factor of NPK fertilizer consists of 0 g per plant (control), 250 g per plant, and 500 g per plant. There were nine combination treatments that were replicated three times so that 27 experimental units were obtained in total. The three main observed variables were the number of reproductive shoots, flowers, and fruits as representative of Crystal guava plant reproductive response. All variables were counted directly in the field by using a hand counter at specific days, i.e., six weeks after treatment (WAT) and 12 WAT for the number of reproductive shoots, 7 WAT for the number of flowers, and 12 WAT and 19 WAT for the number of fruits.

Data of the number of reproductive shoots, number of flowers and number of fruits were subjected to analysis of variance (Anova). Means were separated using Least Significant Difference (LSD) post hoc test at α=0.05. All statistical analysis was performed using Statistix 10.

Results

The results of analysis of variance revealed the insignificant effect of interaction between paclobutrazol and NPK fertilizer dose factors (Table 1). However, a single factor of paclobutrazol or NPK fertilizer significantly affected the reproductive responses of guava, as represented by the number of reproductive shoots, flowers, and fruits (Table 1).

Both paclobutrazol and NPK fertilizer significantly increased the number of reproductive shoots in guava plants at 6 and 12 weeks after treatment (WAT) (Table 2). Paclobutrazol at 2000 ppm proved to be the most efficient treatment, leading to a higher number of reproductive shoots at both 6 WAT and 12 WAT compared to paclobutrazol at 4000 ppm and the control without paclobutrazol. Specifically, it increased the number of reproductive shoots by 58% at 6 WAT and by 53% at 12 WAT compared to the control without paclobutrazol.
Similarly, in the case of NPK fertilizer, the application of 500 g per plant emerged as the most effective treatment, inducing a 58% increase in reproductive shoots at 6 WAT and a 53% increase at 12 WAT compared to the control without NPK (refer to Table 2).

The application of paclobutrazol and NPK fertilizer had a significant impact on the number of flowers (Table 3). Paclobutrazol treatment at concentrations of 2000 ppm or 4000 ppm resulted in a 61% and 42% increase in flower count, respectively, compared to the control group without paclobutrazol. Additionally, the use of NPK fertilizer at a rate of 250 g per plant increased flower numbers by 47%, whereas a dosage of 500 g per plant led to a significant 106% increase, both compared to the absence of NPK fertilizer (Table 3).

Table 1. The result of analysis of variance of 'Crystal' guava reproductive responses to different paclobutrazol and NPK fertilizer doses.

Variables	Paclobutrazol (P)	NPK (N)	Interaction (PxN)
Number of reproductive shoots	*	*	ns
Flower number	*	*	ns
Fruit number	*	*	ns

Note: ns – not significantly different, * significantly different.

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Table 2. The number of reproductive shoots of 'Crystal' guava in response to different paclobutrazol and NPK fertilizer doses.

Treatments	Number of reproductive shoots	
	6 WAT	12 WAT
Without Paclobutrazol	2.97 b	74.33 b
Paclobutrazol 2000 ppm	3.65 a	94.33 a
Paclobutrazol 4000 ppm	3.53 ab	87.22 a
Without NPK	2.60 c	69.00 c
NPK 250 g per plant	3.45 b	81.56 b
NPK 500 g per plant	4.11 a	105.33 a
LSD	0.59	12.10

Note: WAT – Weeks after treatment. Means followed by the same alphabet within the same column are not significantly

Table 3. The number of blooming flowers of 'Crystal' guava in response to different paclobutrazol and NPK fertilizer doses

Treatments	Flower number
Without Paclobutrazol	21.11 b
Paclobutrazol 2000 ppm	33.89 a
Paclobutrazol 4000 ppm	30.00 a
Without NPK	18.78 c
NPK 250 g per plant	27.56 b
NPK 500 g per plant	38.67 a
LSD	8.39

Note: Means followed by the same alphabet in the same column are not significantly different based on the LSD at α=5%.

Table 4. The number of fruits of 'Crystal' guava in response to different paclobutrazol and NPK fertilizer doses

Treatments	Fruit number	
	12 WAT	19 WAT
Without Paclobutrazol	2.54 c	6.22 c
Paclobutrazol 2000 ppm	3.63 a	12.89 a
Paclobutrazol 4000 ppm	3.19 b	9.56 b
Without NPK	2.37 c	5.11 c
NPK 250 g per plant	3.04 b	8.33 b
NPK 500 g per plant	3.96 a	15.22 a
LSD	0.42	3.02

Note: WAT – Weeks after treatment. Means followed by the same alphabet in the same column are not significantly different based on the LSD at α=5%.

Both paclobutrazol and NPK fertilizer significantly increased the number of 'Crystal' guava fruits at 6 and 12 weeks after treatment (WAT) (refer to Table 4). Paclobutrazol at 2000 ppm proved to be the most effective treatment, resulting in a 43% increase in fruit number at 12 WAT and a 107% increase at 19 WAT, surpassing both paclobutrazol at 4000 ppm and the control without paclobutrazol. Similarly, the application of NPK fertilizer at a dose of 500 g per plant led to a 67% increase in fruit number at 12 WAT and a 198% increase at 19 WAT, compared to the control without NPK (Table 4)

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Discussion

The application of paclobutrazol yielded significant improvements in the production of reproductive shoots, with the highest shoot numbers recorded at 2000 ppm paclobutrazol, reaching 3.65 shoots at 6 weeks after treatment (WAT) and 94.33 shoots at 12 WAT. This finding aligns with a previous study by Prawitasari et al. (2005) that paclobutrazol increased the average number of induced, initiated, and differentiated shoots, inhibited vegetative growth, and stimulated the growth of reproductive shoots. The enhanced production of reproductive shoots significantly enhanced flower formation and, subsequently, the harvested fruits.

Similarly, the application of NPK fertilizer demonstrated a significant positive impact on generative shoots. Specifically, applying 500 g per plant of NPK resulted in a higher number of reproductive shoots compared to the 250 g per plant NPK treatment. This finding mirrors the results of prior research by Listari et al. (2004), which also highlighted the positive and significant effect of NPK in increasing the guava reproductive shoot numbers.

Paclobutrazol application increased the number of flowers at 7 WAT, surpassing the control group significantly. This observation aligns with the findings of a previous study by Rai et al. (2004). Similarly, the enhancement of flowering was also evident with NPK fertilizer application. Adequate availability of NPK supports the reproductive growth, evident from the reduction in flower drop. 'Crystal' guava treated with NPK at 500 g per plant exhibited a higher number of flowers compared to those without NPK fertilizer application. The increase in flower numbers on 'Crystal' guava plants is promising, as it directly correlates with the fruit formation.

Under the treatment of 2000 ppm paclobutrazol, a higher number of fruits were formed. Similarly, applying 500 g per plant of NPK also resulted in a higher fruit yield compared to the other two treatments. This increase in fruit production directly correlated with the rise in the number of flowers, consistent with findings from Widyastuti et al. (2019a).

Similar to the impact of strangulation as reported by Widyastuti et al. (2019b), paclobutrazol exhibited significant stimulatory effects on reproductive growth responses. This effect was clearly observed in the sequential processes of flowering, fertilization, and fruit formation. Paclobutrazol not only promote the absorption of minerals, chlorophyll, and carbohydrate content in plant tissues but also heightened the dominance of reproductive growth over vegetative growth. This dominance was closely linked to the C/N ratio in 'Crystal' guava leaves (Widyastuti et al., 2019c). Although the factors influencing this ratio were not measured in the present study, future research that delves into these aspects could prove instrumental in achieving a balanced C/N ratio. Such equilibrium could, in turn, lead to increased photosynthate accumulation and flowering.

Furthermore, the application of NPK fertilizer played an important role in supplying essential nutrients to plants, promoted flowering and fruit formation (Waskito et al., 2018). Despite its efficacy, the use of paclobutrazol for regulating guava flowering and fruiting demands careful consideration due to its potential adverse effects. While paclobutrazol has a low likelihood of contaminating surface water and groundwater, there is a significant risk associated with its accumulation in aquatic life. This accumulation poses a notable concern when aquatic organisms are consumed by humans, given the genotoxic and carcinogenic risks involved (Kishore et al., 2015).

Conclusion

The application of 2000 ppm paclobutrazol significantly increased the number of reproductive shoots, flowers, and fruits in 'Crystal' guava. Concurrently, applying 500 g of NPK fertilizer per plant yielded the best results in increasing the quantity of reproductive shoots, flowers, and fruits. There was no significant interaction between the paclobutrazol and NPK treatments in regulating the reproductive growth of 'Crystal' guava.

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References

Adrees, M., Younis, M., Farooq, U., and Hussain, K. (2010). Nutritional quality evaluation of different guava varieties. *Pakistan Journal of Agricultural Research* **47**, 1-4.

Bhagawati, R., Bhagawati, K., Choudhary, V.K., Rajkhowa, D.J., and Sharma, R.J. (2015). Effect of pruning intensities on the performance of fruit plants under mid-hill condition of eastern Himalayas, case study on guava. *International*

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Letters of Natural Science **46**, 46-51. DOI: 10.18052/www.scipress.com/ILNS.46.46.

[BPS] Badan Pusat Statistik. 2021. Produksi Tanaman Buah-buahan. [https://www.bps.go.id/indicator/55/62/3/produksi-tanaman-buah-buahan.html]. July 1, 2023

Darmawan, M., Poerwarto, R., and Susanto, S. (2014). Aplikasi prohexadionca, paclobutrazol, dan strangulasi untuk induksi pembungaan di luar musim pada tanaman jeruk keprok (*Citrus reticulata*). *Jurnal Hortikultura* **24**, 133-140.

Goswami, A.K., Shant, I., Madhubala, T., Pratibha, Mishra, D.S., and Rajesh, K. (2015). Studies on integrated nutrient management on yield and quality of guava cv. Pant Prabhat. *Indian Journal of Horticulture* **72**, 139-142. DOI: 10.5958/0974-0112.2015.00026.2.

Guntarti, A., and Hutami, E.N. (2019). Validation and vitamin C testing in crystal guava (*Psidium guajava* L.) with variations of origin with the HPLC method. *International Journal of Chemistry* **11**, 52-29. DOI: 10.5539/ijc.v11n1p52

Hartati, R., Nadifan, H.I., and Fidrianny, I. (2020). Crystal guava (*Psidium guajava* L. 'Crystal'): evaluation of in vitro antioxidant capacities and phytochemical content. *Science World Journal* DOI: 10.1155/2020/9413727.

Jiménez-Escrig, A., Rincón, M., Pulido, R., and Saura-Calixto, D. (2001). Guava fruit (*Psidium guajava* L.) as a new source of antioxidant dietary fiber. *Journal of Agriculture and Food Chemistry* **49**, 5489-5493. DOI: 10.1021/jf010147p.

Kishore, K., Singh, S. and Kurian, R.M. (2015). Paclobutrazol use in perennial fruit crops and its residual effects: A review. *Indian Journal of Agricultural Sciences*, **85**, 863–72.

Lal, D., Meena, M.L., and Nayyer, M.A. (2016). Effect of pruning levels and spraying some chemical substances on quality characteristics of guava (*Psidium guajava* L.). *Research of Environment Life Science* **9**, 1062-1064.

Listari, A., Supanjani, S. Sumardi, S., Widodo, W and Djamilah, D. (2004). Pengaruh dosis pupuk kandang kambing dan NPK 16:16:16 terhadap pertumbuhan dan kualitas jumlah biji kristral (*Psidium guajava* L.) pada musim penghujan. *Jurnal Ilmu-Ilmu Pertanian Indonesia* **21**, 44-48.

Lizawati, (2008). Induksi pembungaan dan pembuahan tanaman buah dengan penggunaan retardant. *Jurnal Agronomi* **12**, 18-22

Mahendra, I. G. J., Rai, I. N., and Wiraatmaja, I. W. (2017). Upaya meningkatkan produksi dan kualitas buah jambu biji kristal (*Psidium guajava* L. cv. Kristal) melalui pemupukan. *Agrotrop* **7**, 60-68.

Musyarofah, N., Susanto, S., Aziz, S.A., Suketi, K. and Dadang, (2020). The diversity of 'Kristal' guava (*Psidium guajava*) fruit quality in response to different altitudes and cultural practices. *Biodiversitas* **21**, 3310-3316. DOI: 10.13057/biodiv/d210755

Prawitasari, T., Dorly, D., and Wahyuni, S. (2005). Induksi pembungaan rambutan dengan aplikasi paklobutrazol. *Biota: Jurnal Ilmiah Ilmu-Ilmu Hayati* **98**,108.

Rai, I.N., Poerwanto, R., Darusman, L.K., and Purwoko, B.S. (2004). Pengaturan pembungaan tanaman manggis (*Garcinia mangostana* L.) di luar musim dengan strangulasi, serta aplikasi paklobutrazol dan etepon. *Jurnal Agronomi Indonesia* **32**, 12-20.

Shukla, S.K., Adak,T., Singha, A., Kumar, K., Singh, V.K., and Singh, A. (2014). Response of guava trees (*Psidium guajava*) to soil applications of mineral and organic fertilisers and biofertilisers under conditions of low fertile soil. *Journal of Horticultural Research* **22**, 105-114.

Suman, M., and Bhatnagar, P. (2019). A review on techniques for crop regulation in guava. *Indian Journal of Pure Applied Bioscience* **7**, 504-510. DOI: 10.18782/2320- 7051.7756.

Susanto, S., Melati, M., and Aziz, S.A. (2019). Pruning to improve flowering and fruiting of 'Crystal' guava. *AGRIVITA Journal of Agricultural Science*. **4**, 48-54. DOI: 10.17503/agrivita.v41i1.1954.

Trivedi, Y.V., Patel, N.L., Ahlawat, T.R., Gaikwad, S.S. and Bhalerao, P.P. (2012). Impact of organic manures and inorganic fertilizers on growth, yield, nutrient uptake and soil nutrient status in guava. *Indian Journal of Horticulture* **69**, 501-506.

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https://doi.org/10.29244/jtcs.10.03.238-243

Waskito, H., Nuraini, A., and Rostini, N. (2018). Respon pertumbuhan dan hasil cabai keriting (*Capsicum annuum* L.) CK5 akibat perlakuan pupuk NPK dan pupuk hayati. *Kultivasi* **17**, 676-681.

Widyastuti, R.A.D., Susanto, S., Melati, M., and Kurniawati, A. (2019a). Studies on flowering and fruiting rhythms of 'Crystal' guava (*Psidium guajava* L.) at three different locations, Indonesia. *Ecology of Environment Conservation* **25**, 1505-1509.

Widyastuti, R.A.D., Susanto, S., Melati, M., and Kurniawati, A. (2019b) Flowering arrangement of guava (*Psidium guajava* L.) plants 'crystals' through different strangulation times. *Journal of Agriculture Technology Development* **22**, 243-250.

Widyastuti, R.A.D., Susanto, S., Melati, M., and Kurniawati, A (2019c). Effect of pruning time on flower regulation of guava (*Psidium guajava*). *Journal of Physics Conference Series* **1155**, 1-6. DOI: 10.1088/1742-6596/1155/1/012013.

Widyastuti, R.A.D., Hendarto, K., Yanfika, H., Listiana, I., Mutolib, A. and Rahmat, A. (2021). Effect of local microorganisms (LOM) and growing media on growth of guava (*Psidium guajava* L.) at nursery stage. *Journal of Physics Conference Series* **1796**, 012091.

Widyastuti, R.A.D., Budiarto, R., Hendarto, K., Warganegara, H.A., Listiana, I., Haryanto, Y., and Yanfika, H. (2022a). Fruit quality of guava (*Psidium guajava* 'Kristal') under different fruit bagging treatments and altitudes of growing location. *Journal of Tropical Crop Sciences* **9**, 8-14

Yuniastuti, S., Purbiati, T., Santoso, P., and Srihastuti, E. (2001). Pengaruh pemangkasan cabang dan aplikasi paclobutrazol terhadap hasil dan pendapatan usaha tani mangga. *Jurnal Hortikultura* **11**, 223-231.