The effect of Gibberellin (GA₃) and Paclobutrazol on growth and production on Tomato (*Lycopersicum esculentum* Mill.)

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Abstract. Tomato (*Lycopersicum esculentum* Mill.) is a horticultural crop with a high demand for daily consumption and industrial purpose. Growth and development of a plant is influenced by internal, such as seed, and external factors. The use of growth hormones such as Gibberellin and Paclobutrazol is expected to increase growth and production of tomato. This research aimed to evaluate the effects of Gibberellin and Paclobutrazol on growth and production of tomato. This research was conducted in a gauze house of Faculty of Agriculture, Universitas Sumatera Utara, Medan. This research used randomized complete block design with two factors and three replications. The first factor was Gibberellin (G₁ = 0 ppm, G₂ = 5 ppm, G₃ = 10 ppm, G₄ = 15 ppm) and the second was Paclobutrazol (P₀ = 0 ppm, P₁ = 250 ppm, P₂ = 500 ppm, P₃ = 750 ppm). The media used for nursery, i.e. a mixture of peat soil (with a depth of 20 cm) and compost with a ratio of 1:1, was put in a plastic tray. The result showed that Gibberellin had a significant effect on increasing flowering time and fruit production per sample. Paclobutrazol had a remarkable role on decreasing plant height and increasing flowering. Interaction of Gibberellin and Paclobutrazol showed no significant effect on all observed parameters.

1. Introduction
Tomato is a vegetable fruit with a high market demand. Indonesian tomato production has steadily been approaching a million tons since 2012 [1].

Gibberellins (GA₃) can accelerate seed germination, shoot growth, stem elongation, leaf growth, and triggers flowering and fruit development, while affects root growth and differentiation. GA₃ is able to influence genetic traits and physiological processes found in plants, such as flowering, parthenocarpy and mobilization of carbohydrates during germination period [2]. Novita [3] reported that increasing concentration of gibberellin from 0, 5, 10 to 15 ppm can accelerate flowering age and improves fruit production. Gibberellin is one of growth regulators (ZPT) and encourages seed development and leaf growth, in addition to promoting flowering and fruit development. The appearance of flowers is the beginning of fruit formation. The faster the occurrence of flowering, the faster the formation of fruit. Consequently, this would increase economic values of tomato as it produces tomatoes in a short time [4].

Paclobutrazol is one of retardants to inhibit cell elongation in sub apical meristem; hence, it reduces the rate of stem elongation without affecting leaf growth and development. It is necessary to give Paclobutrazol to tomato plants to limit plant height; photosynthate produced is, therefore, more optimally allocated to formation and development of flowers and fruit. Apart from Paclobutrazol, another compound that can assist in flowering process in tomato is growth regulators, especially gibberellins [5]. Paclobutrazol must be properly used in terms of amount and application [6].

Growth regulators are organic compounds that are exogenously administered for plants to activate and modify physiological processes without acting as plant growth regulators. They are grouped into growth stimulators and growth inhibitors. Growth regulators capable to inhibit growth can be used to increase tomato production; these include Paclobutrazol. The aim of this research was to evaluate the
effects of Gibberellin (GA$_3$) and Paclobutrazol on growth and production of tomato (*Lycopersicium esculentum*).

2. Materials and methods
This research was conducted at the screen house of the Faculty of Agriculture, Universitas Sumatera Utara, Medan. The study was conducted using a factorial randomized complete block design with two factors. The first factor was GA$_3$ (G) concentrations: G$_1$: 0 ppm, G$_2$: 5 ppm, G$_3$: 10 ppm, G$_4$: 15 ppm. The second factor was Paclobutrazol with four levels P$_0$: 0 ppm, P$_1$: 250 ppm, P$_2$: 500 ppm, P$_3$: 750 ppm. Both were then combined to obtain 16 treatments and replicated three 3 times. Therefore, there were 48 experimental units.

The media used for the nursery was a mixture of sapric peat (taken from a depth of 20 cm) and compost with a ratio of 1:1. Tomato seeds were seeded for 4 weeks and transplanted into polybags. GA$_3$ application was carried out in the first week after transplanting according to their respective concentration levels. Paclobutrazol was applied in the second week after transplanting according to their respective concentration levels by direct spraying.

3. Results and discussion
Results suggested that Paclobutrazol had a significant effect on plant height; meanwhile, gibberellin behaved otherwise. There was no interaction between Paclobutrazol and gibberellins on tomato plant height (Table 1). Paclobutrazol at low concentrations can inhibit plant height, but with an increasing concentration, it will further suppress plant height. This is because Paclobutrazol inhibits synthesis of gibberellins in plants, causing plants to become short. Poerwanto et al. [7] stated that Paclobutrazol is a plant growth hormone hampering gibberellin biosynthesis, so that applying this substance causes inhibition of stem elongation and stimulates flower induction. Suppression of vegetative growth occurs due to Paclobutrazol inhibiting the production of endogenous gibberellins and reducing the rate of cell elongation resulting in reduced plant height.

Table 1. The effect of Paclobutrazol on plant height of tomato

| Paclobutrazol Treatment (ppm) | Plant Height (cm) |
|------------------------------|-------------------|
| P0 (0)                       | 100.16a           |
| P1 (250)                     | 83.50b            |
| P2 (500)                     | 74.17c            |
| P3 (750)                     | 66.14d            |

Note: numbers accompanied by the same letter are not significantly different based on the 5% BNT test.

Results showed that Paclobutrazol had a significant effect on flowering time of tomato (Table 2), similar to Gibberellins (Table 3); however, there was no interaction between gibberellins and Paclobutrazol on flowering time.

Treatment of Paclobutrazol can speed up flowering time in tomato, inhibiting the growth of shoots and causing the flower buds to decrease. Karaguzel et al. [8] argued that administering Paclobutrazol with a high concentration (2,500 mg/plant) on Lupinus varius produced fewer flowers than the one without Paclobutrazol.

Table 2. Effect of Paclobutrazol on flowering time on tomato

| Paclobutrazol Treatment (ppm) | Flowering Time (days after planting) |
|------------------------------|--------------------------------------|
| P0 (0)                       | 60.27a                               |
| P1 (5)                       | 57.15b                               |
| P2 (10)                      | 54.70c                               |
| P3 (15)                      | 51.50d                               |

Note: numbers accompanied by the same letter are not significantly different based on the 5% BNT test.
Gibberellin which was applied at the beginning of flowering plays a role in helping flowering process and reducing flower and fruit abscission. Safitri and Aini [9] suggested that applying GA3 at the beginning of fruiting phase was able to increase the number of formed fruits.

Table 3. Effect of Gibberellin on flowering time

| Gibberellin Treatment (ppm) | Flowering Time (days after planting) |
|----------------------------|-------------------------------------|
| G0 (0)                     | 53.56d                              |
| G1 (5)                     | 55.15c                              |
| G2 (10)                    | 56.70b                              |
| G3 (15)                    | 58.00a                              |

Note: numbers accompanied by the same letter are not significantly different based on the 5% BNT test

The research suggested that gibberellins influenced the increase of fruit production per sample (Table 4). This indicated that GA3 can stimulate plant growth, leading to a rise in crop production. Winten et al. [10] reported that Gibberellins quickly stimulated the release of flowers and increased quality and quantity of fruit. Moreover, Wijayanto et al. [11] showed that administering concentrations of GA3 led a very significant effect on fresh weight, diameter of fruit flesh and the number of watermelon seeds.

Table 4. Effect of Gibberellin on fruit production

| Gibberellin Treatment (ppm) | Fruit Production Per Sample (g) |
|----------------------------|---------------------------------|
| G0 (0)                     | 2382d                           |
| G1 (5)                     | 2650c                           |
| G2 (10)                    | 2814b                           |
| G3 (15)                    | 2977a                           |

Note: numbers accompanied by the same letter are not significantly different based on the 5% BNT test

4. Conclusion
Gibberellin had a significant ramification on increasing flowering time and fruit production per sample. Meanwhile, Paclobutrazol had a pronounced outcome on decreasing plant height and increasing flowering time.

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