Response of tomato plant on various concentrations and application frequency of gibberellin

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Abstract. This study aimed to determine the production of tomato plants with the application of gibberellin growth regulators. This research was conducted at the Experimental Farm, Faculty of Agriculture, Universitas Hasanuddin from May to September 2017. The study was conducted in the form of an experiment using a Randomized Block Design as an environmental design and repeated three times. The first factor in this study was gibberellin consisted of four levels, namely 0 mg L⁻¹, 15 mg L⁻¹, 30 mg L⁻¹, and 45 mg L⁻¹; the second factor was the frequency of gibberellins application consisted of three levels, namely once, twice, and three times during the growth of the tomato plant. The results showed that the concentration of gibberellin of 45 mg L⁻¹ applied once produced the fastest fruiting age of 48.92 days after planting (DAP), concentration of 45 mg L⁻¹ gibberellin applied three times during growth showed the lowest number of seeds (21.73 seeds), while the concentration of 30 mg L⁻¹ applied three times resulted in earliest fruit ripe (86.17 DAP).

1. Introduction

Tomato is one of the major vegetables in Indonesia and a source of dietary lycopene, an antioxidant that has been known with substantial benefit to human health. In addition to lycopene, tomatoes also contain other carotenoids, including phytoene, phytofluene, z-carotene, g-carotene, b-carotene, eurosporene, and lutein [1]. High demand encourages farmers to cultivate tomatoes but there are still many obstacles encountered in the field such as pests and diseases, the low percentage of fruit set in the lowlands, uncertain climate conditions, and soil fertility. To increase tomato production, sufficient nutrients can be given to plants to ensure optimal growth and production. In addition, it can also use the growth regulator such as gibberellin.

Gibberellin is one of the growth regulators or hormones [2]. Gibberellins have various functions including accelerating growth, stimulating flower formation, stimulating pollen, reducing the number of seeds in the fruit, making the flesh thicker and raising dwarf plants into normal plants [3]. Gibberellins have actually been produced by plants, but to get maximum results, gibberellin stimulation from outside is needed. In the application of gibberellins, optimal concentration is needed according to the variety.
In most plants, auxin and gibberellins work synergistically in regulating fruit growth. In the practice of spraying gibberellins on grapes, the individual grapes grow larger, the internodes are longer so there are more places to grow [4]. According to the research results of Gelmesa et al. [5], the repeated application (every three days after the first application) further stimulated an increase in the gibberellin content so that the ovules could not signal the pollen tube to fertilize while the gibberellins in the ovaries were sufficient to grow into fruit.

2. Methodology
This research was conducted at the Experimental Farm, Faculty of Agriculture, Universitas Hasanuddin from May to September 2017. The study was conducted in the form of an experiment using a 2 factors factorial design with a Randomized Block Design as an environmental design and repeated three times. The first factor in this study was gibberellin consisted of four levels, namely 0 mg L\(^{-1}\), 15 mg L\(^{-1}\), 30 mg L\(^{-1}\), and 45 mg L\(^{-1}\), the second factor was the frequency of gibberellins application consisted of three levels, namely once, twice, and three times during the growth of the tomato plant. This study consisted of 12 combinations of treatments with three replications so that there were 36 experimental units. Each combination of treatments consists of four plants. The materials used in this study were tomato seeds of Permata F1 variety, compost, gibberellin growth regulators, and insecticides (Furadan and Klensect). While the tools used are lawn mowers, machetes, shovels, rope, mica plastic, bamboo, sprayers, hoes, plot boards, scales, and stationery.

3. Results and discussion

3.1. Fruit-bearing age
The result of the variance analysis on the observation data of fruit bearing age of tomato plant shows that the concentration and the application frequency of gibberellins had no significant effect on the parameter. However, interaction between the two treatments had a significant effect on the parameter of fruit-bearing age. Table 1 shows that tomatoes plant applied with gibberellin 45 mg L\(^{-1}\), in one time application resulted in earliest fruiting age of 48.92 days after planting (DAP) and not significantly different from the application of gibberellin in lower concentration but more frequent (15 mg L\(^{-1}\) applied twice and 30 mg L\(^{-1}\) applied three times) during growth. The latest fruiting age is shown in the control treatment (53.92 DAP).

| Concentration of gibberellin | Frequency of gibberellin application | Tukey’s HSD\(_{0.1}\) |
|-----------------------------|-------------------------------------|------------------------|
|                             | Once abc                            |                        |                        |
| 0 mg L\(^{-1}\)             | 51.58 c                             |                        |                        |
| 15 mg L\(^{-1}\)            | 52.42 abc                           | 53.92 a                |                        |
| 30 mg L\(^{-1}\)            | 53.67 ab                            | 49.67 d                | 51.50 c                |
| 45 mg L\(^{-1}\)            | 48.92 d                             | 52.17 abc              | 49.33 d                | 1.78 |

Numbers followed by same letters mean not significantly different at the Tukey’s HSD test level \(\alpha= 0.1\). DAP = days after planting.

3.2. Number of fruits per plant.
The results of analysis of variance shows that the concentration and the frequency of the application of gibberellin had no significant effect on the number of tomatoes fruit per plant while the interaction between the two treatments had a very significant effect on the parameter. Table 2 shows that highest fruit number per plant was resulted from the gibberellin control treatment (18.75 fruits) and significantly different from other treatments followed by the concentration of 15 mg L\(^{-1}\) applied three times.
times (16.67 fruits). The lowest average fruit number per plant is shown by the concentration of gibberellin of 30 mg L\(^{-1}\) applied one time (7.33 fruits).

**Table 2.** Average number of fruit per plant (fruits) of tomato on different concentration and application frequencies of gibberellin.

| Concentration of gibberellin | Frequency of gibberellin application | Tukey’s HSD \(_{0.1}\) |
|------------------------------|------------------------------------|------------------------|
| 0 mg L\(^{-1}\)             | Once 18.75 a                       | 8.50 i 11.31 f         |
|                              | Twice 13.50 c                       | 9.44 h 16.67 b         |
|                              | Thrice 7.33 j                       | 10.08 g 12.83 d        |
| 15 mg L\(^{-1}\)            | Once 12.25 e                        | 13.58 c 12.92 d        |
|                              | Twice 10.08 g                       |                       |
| 30 mg L\(^{-1}\)            | Once 7.33 j                         |                       |
| 45 mg L\(^{-1}\)            | Once 12.25 e                        |                       |

Numbers followed by same letters mean not significantly different at the Tukey’s HSD test level (\(\alpha=0.1\)).

### 3.3. Fruit fresh weight per plant.

The analysis of variance result shows that the treatment of gibberellin concentration had a very significant effect on the fruit fresh weight per plant while the treatment of the frequency of gibberellin application had no significant effect on the parameter. No significant effect of the interaction between the two treatments. Average of fruit fresh weight per plant in Table 3 shows that the gibberellin control treatment resulted in the highest fruit fresh weight per plant (378.77 g) and significantly different from other treatments. The concentration treatment of 30 mg L\(^{-1}\) had the lowest fruit fresh weight per plant (227.62 g) and was not significantly different from other gibberellin concentration treatment.

**Table 3.** Average fruit fresh weight per plant (g) of tomato on different concentration and application frequencies of gibberellin

| Concentration of gibberellin | Frequency of gibberellin application | Mean | Tukey’s HSD \(_{0.1}\) |
|------------------------------|------------------------------------|------|------------------------|
| 0 mg L\(^{-1}\)             | Once 461.67                        | 387.50 | 378.77 a              |
|                              | Twice 287.14                       | 247.42 | 279.17 b              |
|                              | Thrice 387.50                      | 217.33 | 227.62 b              |
| 15 mg L\(^{-1}\)            | Once 220.67                        | 369.42 | 3.51                  |
|                              | Twice 247.42                       | 217.33 |                       |
| 30 mg L\(^{-1}\)            | Once 294.92                        | 170.61 |                       |
| 45 mg L\(^{-1}\)            | Once 322.83                        | 216.61 |                       |

Numbers followed by same letters mean not significantly different at the Tukey’s HSD test level (\(\alpha=0.1\)).

### 3.4. Fruit diameter

The analysis of variance results shows that both treatment of gibberellin concentration and the frequency of gibberellin application had a very significant effect on the fruit diameter parameter while the interaction between the two treatments had no significant effect on the parameter. Table 4 shows that the treatment of the application frequency of 2 times resulted in the highest average of fruit diameter (3.23 cm) and significantly different from the other application frequency treatments (once and three times) based on Tukey’s HSD test (\(\alpha = 0.1\)). While for the gibberellin concentration treatment, the control treatment resulted in the highest fruit diameter (3.38 cm) and significantly different from the other concentration treatments. The second highest fruit diameter was shown by the

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*Note: The text contains some errors and formatting issues, particularly in the tables and equations.*
gibberellin concentration of 15 mg L\(^{-1}\) and the lowest parameter value was shown by the gibberellin concentration of 30 mg L\(^{-1}\) (G2) has the lowest average fruit diameter (2.99 cm).

### Table 4. Average fruit diameter (cm) of tomato on different concentration and application frequencies of gibberellin

| Concentration of gibberellin | Frequency of gibberellin application | Mean   | Tukey’s HSD\(_{0.1}\) |
|-----------------------------|-------------------------------------|--------|------------------------|
| 0 mg L\(^{-1}\)            | Once 3.32, Twice 3.31, Thrice 3.52 | 3.38 a |                        |
| 15 mg L\(^{-1}\)           | Once 3.19, Twice 3.28, Thrice 2.96 | 3.14 ab| 0.29                   |
| 30 mg L\(^{-1}\)           | Once 3.14, Twice 3.10, Thrice 2.73 | 2.99 b |                        |
| 45 mg L\(^{-1}\)           | Once 3.20, Twice 3.21, Thrice 2.81 | 3.08 b |                        |
| Mean                        | Once 3.21 xy, Twice 3.23 x, Thrice 3.00 y |        |                        |
| Tukey’s HSD\(_{0.1,\text{freq}}\) |                        | 0.23   |                        |

Numbers followed by same letters in the same row (x, y) and column (a, b, c) mean not significantly different at the Tukey’s HSD test level of \(\alpha=0.1\).

#### 3.5. Number of seeds per fruit

The analysis of variance shows that the gibberellin concentrations had a very significant effect on the number of seeds per fruit while the frequency of the application of gibberellins and the interaction between the two treatments had no significant effect on the parameter. Observation of the number of seeds showed that tomatoes with a control treatment had the highest average number of seeds (48.89 seeds), significantly different from other treatments. The concentration of gibberellin 45 mg L\(^{-1}\) applied three times had the lowest average number of seeds (21.73 seeds) and not significantly different from the treatment of concentration of 30 mg L\(^{-1}\) but significantly different from the treatment of concentration of 15 mg L\(^{-1}\).

### Table 5. Average number of seeds per fruit (seeds) of tomato on different concentration and application frequencies of gibberellin.

| Concentration of gibberellin | Frequency of gibberellin application | Mean   | Tukey’s HSD\(_{0.1}\) |
|-----------------------------|-------------------------------------|--------|------------------------|
| 0 mg L\(^{-1}\)            | Once 48.89, Twice 45.04, Thrice 47.27 | 47.07 a |                        |
| 15 mg L\(^{-1}\)           | Once 35.33, Twice 35.77, Thrice 34.15 | 35.08 b |                        |
| 30 mg L\(^{-1}\)           | Once 33.06, Twice 35.44, Thrice 22.30 | 30.27 c | 4.62                   |
| 45 mg L\(^{-1}\)           | Once 34.18, Twice 31.03, Thrice 21.73 | 28.98 c |                        |

Numbers followed by same letters mean not significantly different at the Tukey’s HSD test level of \(\alpha=0.1\).

#### 3.6. Fruit flesh thickness

The analysis of variance results shows that both treatment of gibberellin concentration and the frequency of gibberellin application had a very significant effect on the fruit flesh thickness parameter while the interaction between the two treatments had no significant effect on the parameter. Table 6 shows that the treatment of the application of gibberellin three times resulted in the highest average of
fruit flesh thickness (7.06 mm) and significantly different from other treatments. Application of gibberellins twice during the growth of tomato plant resulted in the lowest fruit flesh thickness (5.76 mm). Table 6 also shows that the highest fruit flesh thickness (6.92 mm) was obtained by the use of gibberellin concentration of 45 mg L$^{-1}$ and significantly different from the control treatment, 15 and 30 mg L$^{-1}$ treatments. The control treatment had the lowest average fruit flesh thickness of 5.19 mm.

**Table 6.** Average fruit flesh thickness (mm) of tomato on different concentration and application frequencies of gibberellin.

| Concentration of gibberellin | Frequency of gibberellin application | Mean | Tukey’s HSD$_{0.1}$ |
|-----------------------------|-------------------------------------|------|---------------------|
|                             | Once      | Twice | Thrice |                  |
| 0 mg L$^{-1}$               | 4.87      | 5.38  | 5.30   | 5.19  b           |
| 15 mg L$^{-1}$              | 5.91      | 6.02  | 6.72   | 6.21  ab          |
| 30 mg L$^{-1}$              | 5.93      | 5.76  | 8.10   | 6.60  ab          |
| 45 mg L$^{-1}$              | 6.75      | 5.87  | 8.14   | 6.92  a           |
| Mean                        | 5.86      | 5.76  | 7.06   | x                 |

Numbers followed by same letters in the same row (x, y) and column (a, b, c) mean not significantly different at the Tukey’s HSD test level of $\alpha=0.1$.

4. Discussion
In this study, gibberellin and its frequency of application significantly affected some of generative parameters such as the time of fruit initiation and ripening, the number of fruit per plant, total number of fruits and number of seeds per fruit. This results confirm the ability of gibberellin in affecting the generative characters of the plants. Tomatoes treated with gibberellins showed earlier fruit development than control plants. Application of gibberellins can effect stem lengthening, flowering and fertilization [6]. Gibberellin functions to increase the flower and stimulate fruit formation including the time of fruit ripening as shown in this study. Previous study also found that application of gibberellin to fruit helps accelerate fruit ripening [7].

The other effect from the application of gibberellin causes a decrease in the number of seeds in the tomatoes. The decrease in the number of seeds in the fruit is assumed to make the fruit development faster and make the flesh thicker so that the seeds in the fruit are less. This is in line with the research Adnyesuari et al. [8] that observed a reduction in the number of seeds per fruit with the increasing frequency of spraying GA3 compared to controls on Intan and Gamato varieties. The difference in the number of seeds formed can affect the characteristics of the fruit even though the appearance is the same, such as size small fruit compared to seed or fruit in the control treatment.

The gibberellin treatment had a very significant effect on the parameters of fresh weight per fruit, fruit diameter, number of seeds, and thickness of fruit flesh. Decrease in fruit weight is assumed because the fruit formed is not formed naturally but results from the application of the plant hormone gibberellin so that the fruit does not fully develop. Setiawan et al. [9] stated that tomatoes from gibberellin induction had smaller fruit sizes than tomato control treatments. This is because the GA induced fruit has fewer cell counts than the natural fruit, although the cell size results from GA treatment are greater. Fewer cell counts resulted in smaller fruit diameters and smaller fruit yields, but the volume of pericarp was greater than the control fruit.

The gibberellin treatment reduces the number of seeds in tomatoes. The higher the concentration of gibberellins given, the lesser the seeds formed in tomatoes. Spraying the gibberellins from the outside
(exogenously) makes the seeds no longer develop because the growth or enlargement of the fruit is supported from the outside. This is in line with the opinion of Adnyesuari et al. [8] that spraying GA3 on flower buds increases the content of auxin and endogenous gibberellins in pollen and ovaries. However, on flowers induced by GA3, the effect of increasing gibberellins and auxin on pollen will directly affect the increase in the synthesis of gibberellins and auxin in the ovaries, thereby stimulating cell division and enlargement. So the ovary will enlarge without stimulation of the ovules and cause no seeds to form. The concentration of gibberellins and auxin in the new ovary will increase after 28 hours since the application is carried out (application is done once before the flowers bloom on tomato buds) [10]. Spraying GA3 three times reduces the number of seeds to be less than the control. Most of the gibberellins produced by plants are inactive forms that will require precursors to become active forms. Acetyl co-A serves as a precursor to the synthesis of gibberellin [11]. The ability of gibberellins to increase growth in plants is stronger than the effects caused by auxin if given singly. However, auxin in very small quantities is still needed so that the gibberellin can provide maximum effect.

Giving gibberellin to tomatoes showed an increase in the thickness of fruit flesh. According to the results of the study, the application of gibberellin concentrations of 45 mg L\(^{-1}\) had an average flesh thickness of 6.92 mm and was significantly different from the control with an average thickness of 5.19 mm. Gibberellins can make fruit bigger than pollinated fruit. In tomatoes the growth regulator of gibberellins makes the flesh thicker because the cells in the fruit get stimulation from the gibberellins. This is in line with the opinion of Setiawan et al. [9] stating that the fruit yields of GA3 induction were thicker than pollinated fruits.

The treatment of the application frequency of the hormone of gibberellin showed significant effect on the observation parameters, namely fresh weight per fruit and fruit diameter and had a very significant effect on the parameters of fruit flesh thickness and number of seeds. A decrease in fresh weight per fruit and fruit diameter observed in this study in the treatment of gibberellins with lesser frequency of spraying can be related to lesser amount of this hormones received by the plant, hence resulted in fruit development that lower than the fruit formed from natural pollination which was heavier and larger in diameter. According to Adnyesuari [8] increasing the frequency of gibberellin spraying tends to cause a decrease in weight per fruit. Decrease in weight occurs because the smaller diameter and frequency of once spraying is followed by a reduction in fruit length compared to control. This is related to the influence of gibberellins on cell division and enlargement in the ovary. Increasing the thickness of fruit flesh on gibberellin-induced fruit is directly proportional to the reduction in the number of seeds. Reduced fruit seeds provide room for fruit flesh to develop. Cells in fruit are larger than pericarp cells of control plants. This causes the thickness of fruit flesh to increase.

5. Conclusions

Based on the results of the research that has been obtained, it can be concluded that:

a) There is an interaction between concentration and frequency of the application of gibberellin. Gibberellin concentration 45 mg L\(^{-1}\) and the frequency of administration of gibberellin once during the growth resulted in fastest fruiting age, concentration of 45 mg L\(^{-1}\) applied three times showed the lowest number of seeds and concentrations of 30 mg L\(^{-1}\) applied three times during growth showed the fastest fruit ripe age.

b) The gibberellin concentration of 45 mg L\(^{-1}\) showed higher number of seeds and the thickness of fruit flesh.

c) The frequency of administration of gibberellin of three times gave the best results on the parameters of the number of seeds and the thickness of fruit flesh.

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