The response of shallot (Allium ascalonicum L.) growth and yield to gibberelline concentration and the interval of NASA liquid organic fertilizer

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Abstract. This study was aimed at determining the effect of gibberellin concentration and the interval of Natural Nusantara (NASA) liquid organic fertilizer, as well as their interactions to influence growth and yield of shallots. This study was conducted from April to July 2019 in Experimental Field and Horticulture Laboratory of the Faculty of Agriculture, Universitas Syiah Kuala. The experiment used a Randomized Block Design with a Factorial pattern of 4x3. Gibberellin concentrations were observed at 4 levels (control, 100, 150, and 200 ppm) and the interval of NASA liquid organic fertilizer was observed at 3 levels (control, every 7, and 14 days DAP). The results showed that the highest shallot plant was found of 14 DAP, and the largest number of bulbs was found at 100 ppm gibberellins concentration. The highest of fresh biomass per clump and the largest bulb diameter were found at 150 ppm gibberellins concentration. The growth and yield of the highest shallots were found at the interval of control treatment of NASA liquid organic fertilizer. The highest number of bulbs was found in the combination of gibberellins control with the interval of NASA liquid organic fertilizer every 14 days.

1. Introduction

Shallots (Allium ascalonicum L.) is a horticultural product that is in great demand by the Indonesian people due to its usefulness in the Indonesian cuisine. The Central Statistics Agency states that the production of shallots in Indonesia is fluctuating. The shallot production from 2010 - 2015 in a row were 1.05 million tons; 0.89 million tons; 0.96 million tons; 1.01 million tons; 1.23 million tons and 1.22 million tons [1]. The reduction of shallot production may be caused by factors such as lack of soil fertility, limited water, the use of low quality seeds and farmers' knowledge of shallot cultivation technology that is still low and improper fertilization techniques [2].

One of the factors that can help the growth and development of shallots is a plant growth regulator (PGR). PGR has an important role in regulating biological processes in plant tissues [3], regulating the acceleration of growth of tissues and integrating them into all parts of plants [4]. One of the PGR that plays a role in accelerating the growth and development of plants was gibberellins.

Gibberellin influence seed dormancy and germination, juvenile and adult growth phases, acts the metabolism of plant life to promote the growth of most organs through increased cell division and cell
elaboration, and also to support the developmental phases, vegetative and reproductive growth phases [5]. The concentration of gibberellins at 50 ppm could improve the yield and quality of shallot bulbs with an average bulb weight production of 5.61 kg plot⁻¹ or equal to 10.19 t ha⁻¹ [6]. Another study stated that the plant’s height and number of leaf of each shallot plant increased significantly when soaked in gibberellins with a concentration of 100 ppm for 30 minutes [7].

In addition to providing growth regulators, fertilizer is also important since it enrich nutrients in the soil. One of the fertilizers that can be used to support plant growth and development is NASA's liquid organic fertilizer (LOF). NASA’s LOF is a natural organic fertilizer made from the extracts of organic material produced by livestock waste and some plants that are processed based on environmentally friendly technology [8]. NASA’s LOF can help to accelerate the growth of plants, maintain the balance of nutrients in the soil, reduce the level of pest attacks and have no side effects on the environment [9].

NASA’s LOF interval needs to be considered to match to plants need. The interval of NASA’s LOF of 10 ml L⁻¹ every 1 week given the height of shallot plants better than the interval of every 2 weeks, with a ratio of height 45.33 cm and 41.50 cm [10]. Another study stated that the interval of the application of liquid organic fertilizer Crocober every week produced more bulbs at 13.83 t ha⁻¹ compared to the interval of every 2 weeks at 9.47 t ha⁻¹ [11].

Based on the discussion above, a study will be conducted to find out the right combination of gibberellin’s concentration and liquid organic fertilizer intervals to increase yields and shallot production. The aim of this study were to determine the concentration of gibberellins and the interval of NASA liquid organic fertilizer and their interaction to influence growth and yield of shallot.

2. Material and Method

2.1. Experimental Site

This study was conducted from April to July 2019 in Experimental Field and Horticulture Laboratory of the Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh, Indonesia.

2.2. Planting Materials

The tools used were meters, hoes, rakes, raffia, rags, buckets, measuring cups, drop pipettes, calipers, digital scales, ovens, label boards, and stationery. The materials used in this study were 3 kg of shallot bulbs of Bima Brebes variety, 103.68 kg of manure, rice husk, 0.9 kg of Urea fertilizer, 0.8 kg of SP-36 fertilizer, 0.6 kg of KCl fertilizer, 5 g of gibberellins and NASA LOF of 1.5 L in a dosage of 5 ml L⁻¹ according to the recommendation shown at the packaging.

2.3. Field Culture, Planting and Harvesting

The land was plowed, harrowed and ridges. Plant plots were prepared each width of 120 cm and length of 120 cm as much as 36 plots with the planting distance of 20 cm x 20 cm and the distance between each plot were 40 cm. Manure was applied at 20 t ha⁻¹ (2.88 kg plot⁻¹). The selected bulbs used were healthy bulbs, which characterized by the physical appearance of the skin that is not injured and free from disease. One third of the upper part of bulb was cut and then soaked in gibberellin’s solution according to the concentration of each treatment. Gibberellins were obtained in the form of tablets of 5 g and were diluted to be a concentrated solution by dissolving it into 100 ml of water. Furthermore, the concentrated solution was dissolved into water according to the concentration of the treatment as follows: Gibberellins concentrated solutions were diluted into 1 L water, each of 0.1 ml to get 100 ppm, 0.15 ml to get 150 ppm, and 0.2 ml to get 200 ppm. For the control treatment, bulbs were only soaked in plain water. Bulbs were soaked for 30 minutes then planted one bulb per planting hole. Half-dose of urea fertilizer of 180 kg ha⁻¹ (15 g plot⁻¹), SP-36 153 kg ha⁻¹ (22 g plot⁻¹) and KCl 120 kg ha⁻¹ (17.3 g plot⁻¹) were given when bulbs were planted, and the remaining half dose of urea is given at 14 DAP. NASA's LOF was applied in accordance with the treatment (control, 7 days and 14 days) by spraying it to the plants. Before being applied, NASA’s LOF was first diluted into water according to the recommended dosage as on the package, that was 5 ml L⁻¹. NASA’s LOF was applied according to the
treatment in the afternoon. Maintenance of shallots consists of watering, replanting, weeding, and controlling pests and diseases. Harvesting was done at 70 DAP.

2.4. Experimental Design, Data Collection, and Analysis

The design of the study used was a Factorial pattern (4 x 3), Randomized Completely Block Design with three replications. Each experimental unit consisted of 5 sample plants. The first factor consisted of four level of gibberellin’s concentration (control, 100, 150 and 200 ppm) and the second factor consisted three level of interval NASA liquid organic fertilizer (control, every 7 and 14 days).

Observed parameters were plant’s height at the age of 14, 21, 28, 35 and 42 DAP, the number of bulbs, fresh biomass weight per clump, dry biomass weight per clump, bulb diameter, fresh bulb weight, dry bulb weight, and yield potential.

The data was then analyzed statistically with the analysis of variance (ANOVA). Data were analyzed using SPSS (Statistical Package for the Social Sciences) version 22.0 to determine the effect of treatment. If the treatment had a significant effect, then further analysis was done using Duncan New Multiple Range Test (DNMRT) at the 5% significant level.

3. Results and Discussion

3.1. The Effect of Gibberellin’s Concentration on Growth and Yield of Shallot Plants

The results showed that the concentration of gibberellins had a very significant effect on the height of shallot plants at the age of 21 DAP, the number of bulbs per clump, fresh biomass weight per clump and bulb diameter and significantly affected the height of shallot plants at the age of 14 DAP, but had no significant effect on height of shallot plants at the age of 28, 35 and 42 DAP, dry biomass weight per clump, fresh bulb weight, dry bulb weight and yield potential. The average growth and yield of shallots due to the concentration of gibberellins can be seen in Table 1. Figure 1, 2 and 3 show the different treatment of gibberellin’s concentration in each treatment of NASA liquid organic fertilizer.

| Parameter                                  | Concentration of Gibberellin (ppm) |
|--------------------------------------------|------------------------------------|
|                                            | 0    | 100  | 150  | 200  |
| Plant Height (cm)                          |      |      |      |      |
| 14 DAP                                     | 6.82 | 7.67 | 7.40 | 8.77 |
| 21 DAP                                     | 14.34| 14.48| 15.00| 18.38|
| 28 DAP                                     | 21.09| 21.60| 19.73| 21.59|
| 35 DAP                                     | 24.63| 24.17| 23.49| 22.03|
| 42 DAP                                     | 26.89| 27.84| 28.04| 25.57|
| Number of Bulb                             |      |      |      |      |
|                                            | 6.89 | 8.18 | 6.20 | 6.24 |
| Fresh Biomass Weight per Clump (g)         |      |      |      |      |
|                                            | 22.28| 23.13| 32.08| 24.96|
| Dry Biomass Weight per Clump (g)           |      |      |      |      |
|                                            | 14.08| 14.39| 14.64| 15.70|
| Bulb Diameter (mm)                         |      |      |      |      |
|                                            | 19.88| 23.03| 26.10| 20.59|
| Fresh Bulb Weight (g)                      |      |      |      |      |
|                                            | 14.98| 15.70| 15.71| 16.60|
| Dry Bulb Weight (g)                        |      |      |      |      |
|                                            | 13.55| 13.88| 14.12| 15.09|
| Yield Potential (t ha⁻¹)                   |      |      |      |      |
|                                            | 4.51 | 3.94 | 4.64 | 4.55 |

Notes: Numbers followed by the same letter in the same row are not significantly different at the 0.05 DMR test level.

The results also showed that the height of shallot plants at the age of 14 DAP and the highest number of bulbs were found at 100 ppm gibberellin’s concentration. This may be due to the immersion of bulb in a 100 ppm gibberellin’s solution which had been able to stimulate cell elongation, and thereby increasing plant height and being able to accelerate the production of the new bulb. Gibberellin concentration of 100 ppm produced the best shallot plant’s height at age 15 and 52 DAP, number of
leave, fresh bulb weight, dry bulb weight and number of bulbs [7]. The height of shallot plants at the age of 60 DAP, number of leaves, number of bulbs, bulb length, fresh bulb weight, and the highest dry bulb weight were found in the treatment of 100 ppm gibberellin concentration [12][13].

Furthermore, the results showed that the highest fresh biomass weight per clump and the highest bulb diameter were found at 150 ppm gibberellins concentration. This may be due to the immersion of bulb in a 150 ppm gibberellins solution which caused the formation of amylase enzymes that convert starch to sugar faster and the process of cell elongation runs faster as well, resulting in the enlargement of the bulb diameter. Gibberellins were able to increase cell size and the amount of cells that cause cell division, increased the size and amount of cells which eventually increase the weight of the biomass [14]. Moreover, gibberellin have stimulated cell growth because this hormone serves to increase the hydrolysis of starch, fructant, and sucrose into glucose and fructose molecules. The best concentration of gibberellins for the percentage of pith bulb, number of seeds per clump, fresh biomass weights per clump, seed weight per plot of shallot plant and bulb diameter were found at 150 ppm gibberellin concentration compared to control and lower than concentrations of 150 ppm [15].

**Figure 1.** Comparison of Gibberellin’s concentrations (G<sub>0</sub>= control; G<sub>1</sub>= 100 ppm; G<sub>2</sub>= 150 ppm; G<sub>3</sub>= 200 ppm) with NASA intervals of control treatments

**Figure 2.** Comparison of Gibberellin's concentration (G<sub>0</sub>= control; G<sub>1</sub>= 100 ppm; G<sub>2</sub>= 150 ppm; G<sub>3</sub>= 200 ppm) with NASA interval once every 7 days

**Figure 3.** Comparison of Gibberellin's concentration (G<sub>0</sub>= control; G<sub>1</sub>= 100 ppm; G<sub>2</sub>= 150 ppm; G<sub>3</sub>= 200 ppm) with NASA interval once every 14 days
3.2. The Effect of Interval of NASA Organic Liquid Fertilizer on Growth and Yield of Shallots

The results showed that NASA’s LOF interval had a very significant effect on the height of shallot plants at the age of 14 DAP, and significantly affected the height of shallot plants at 21 and 42 DAP, but had no significant effect on plant’s height at age 28 and 35 DAP, the number of bulbs per clump, fresh biomass weight per clump, dry biomass weight per clump, bulb diameter, fresh bulb weight, dry bulb weight and yield potential. The average growth and yield of shallots due to the interval of NASA liquid organic fertilizer can be seen in Table 2. Figure 4, 5, 6 and 7 show the different treatment of NASA liquid organic fertilizer on each gibberellin’s concentration.

Table 2. The average growth and yield of shallots due to the interval of NASA liquid organic fertilizer

| Parameter                  | NASA Liquid Organic Fertilizer Interval (days) |
|----------------------------|-----------------------------------------------|
|                            | 0        | 7        | 14       |
| Plant Height (cm)          |          |          |          |
| 14 DAP                     | 8.48 b   | 7.68 ab  | 6.84 a   |
| 21 DAP                     | 16.49 b  | 15.71 ab | 14.45 a  |
| 28 DAP                     | 22.43    | 20.80    | 19.78    |
| 35 DAP                     | 24.16    | 24.31    | 22.27    |
| 42 DAP                     | 27.38 ab | 28.30 b  | 25.58 a  |
| Number of Bulb             |          |          |          |
| Dry Biomass Weight per Clump (g) |          |          |          |
| 14.74                      |          | 14.88    | 14.49    |
| Bulb Diameter (mm)         |          |          |          |
| 22.27                      |          | 22.87    | 22.06    |
| Fresh Bulb Weight (g)      |          |          |          |
| 15.82                      |          | 16.09    | 15.35    |
| Dry Bulb Weight (g)        |          |          |          |
| 14.21                      |          | 14.30    | 13.94    |
| Yield Potential (t ha⁻¹)   |          |          |          |
| 4.32                       |          | 4.37     | 4.54     |

Notes: Numbers followed by the same letter in the same raw are not significantly different at the 0.05 DMRT test level.

The results showed that the best growth and yield of shallots were found in control treatment that was not significantly different at NASA’s LOF interval of once every 7 days. This is presumably caused by nutrient content, especially N in the soil which has been fulfilled due to the history of the land used that previously had been treated with Paclobutrazol, Rizobacteri and other organic matters. The application of organic fertilizers that meet the needs of plants will provide the better results in growth and yield. Nutrients contained in organic fertilizers have the function of forming meristem tissue in the growth of shallots [18].

The concentration of LOF of 5 ml L⁻¹ once every 7 days to increase the height of shallot plants but did not significantly affect the number of leaves and age of harvest [17]. Application of liquid fertilizer at 3 L plot⁻¹ with mulch in the shallot plant increased organic matter content and microorganism populations in the soil and resulting highest bulb weight [18]. Nevertheless the results of the study showed that the interval of NASA’s LOF had no significant effect on the height of the shallot plants at the age of 28 and 35 DAP, the number of bulbs per clump, fresh biomass weight per clump, dry biomass weight per clump, bulb diameter, fresh bulb weight, dry bulb weight and yield potential. This is presumably caused by NASA recommended concentrations do not match the needs of the shallot plants. NASA’s LOF contents is N 0.12%, P₂O₅ 0.03%, K₂O 0.31%, S 0.12%, Na 0.15%, Cl 0.29%, and several other microelements. Based on the Minister of Agriculture Regulation (Permentan) number 70 of 2011 related to nutrient content that must exist in liquid organic fertilizer products are N at 3-6%, P₂O₅ at 3-6%, and K₂O at 3-6%. So, the NASA’s LOF did not meet the recommended nutrient content standards.

For the comparison, the treatment of the application of the liquid organic fertilizer using raw materials from palm fruit fiber waste which were fermented at 20 ml L⁻¹ provided the increase on growth
in palm oil parameters such as plant height at the age 1, 2, 3 and 4 month after planting (MAP), stem diameter 3 and 4 MAP, fresh shoot weight and root fresh weight [19].

Figure 4. Comparison of NASA interval (N₀= control; N₁= every 7 days; N₂= every 14 days) with gibberellin’s concentrations of control treatments

Figure 5. Comparison of NASA interval (N₀= control; N₁= every 7 days; N₂= every 14 days) with 100 ppm gibberellin’s concentrations

Figure 6. Comparison of NASA interval (N₀= control; N₁= every 7 days; N₂= every 14 days) with 150 ppm gibberellin’s concentrations

Figure 7. Comparison of NASA interval (N₀= control; N₁= every 7 days; N₂= every 14 days) with 200 ppm gibberellin’s concentrations
3.3. The Effect of Interaction between Gibberellin’s Concentration and NASA’s Liquid Organic Fertilizer Intervals on Growth and Yield of Shallots

The results showed that there were significant interactions between gibberellin concentration and NASA’s LOF intervals on the number of bulbs per clump, but did not significantly affect plant’s height at the age of 14, 21, 28, 35 and 42 DAP, fresh biomass weight per clump, dry biomass weight per clump, bulb diameter, fresh bulb weight, dry bulb weight and yield potential. The average number of bulbs due to the interaction between gibberellin concentration treatments and NASA’s LOF intervals can be seen in Table 3 and Figure 8.

The highest number of bulbs was found in the combination of the control gibberellin treatment with NASA’s LOF interval every 14 days which gave an average yield of 8.27 bulbs. The interval of NASA’s LOF once every 14 days without gibberellin was able to produce the largest number of bulbs.

Table 3. Interaction between gibberellin’s concentration and NASA’s LOF intervals on number of bulbs

| Concentration of Gibberellin (ppm) | NASA Liquid Organic Fertilizer Interval (days) |
|----------------------------------|---------------------------------------------|
|                                  | 0                                          | 7  | 14   |
| 0                                | 5.27 Aa                                     | 7.13 Ab | 8.27 Bb |
| 100                              | 8.13 Ba                                     | 7.93 Ab | 8.00 Ba |
| 150                              | 5.53 Aa                                     | 7.87 Ab | 5.20 Aa |
| 200                              | 6.27 Aa                                     | 6.67 Aa | 5.80 Aa |

Notes: Numbers followed by the same letter in (capital letters viewed by row and lower case letters viewed by column) are not significantly different at the 0.05 DMRT test level.

Figure 8. The relationship between gibberellin’s concentration and NASA’s LOF interval on number of bulbs shallot

The application of liquid organic fertilizer once every 14 days in accordance with the needs of plants helps the formation of new bulbs. Gibberellin control treatment gives the best results because N in the soil has been fulfilled so that the influence of gibberellins is not so visible. In addition, it is suspected that gibberellins will be more visibly affected if applied in a single treatment. The application of liquid organic fertilizer with the concentrations of 0, 25% and 50% every 14 days showed that the results did not significantly affect the number of leaves, fresh biomass weight per clump, dry biomass weight per clump, but significantly affected the number of bulbs [20] [21].

In addition, it is suspected that gibberellins will be more visibly effective if applied in a single treatment. The height of hemp plants at age of 6, 8, 10 and 12 WAP, fresh weight of stems per clump, dry plant weight, fresh biomass weight, stem diameter and the highest number of saplings of hemp plant were found in control treatment of gibberellin and liquid organic fertilizer of 40 ml L⁻¹ [22].
4. Conclusions
The results showed that the highest of shallot plants was found at 14 DAP and the largest number of bulbs was found at 100 ppm of gibberellins concentration. The fresh biomass weight per clump and the largest bulb diameter were found at 150 ppm of gibberellins concentration. The growth and yield of the highest shallot were found at the interval of NASA’s LOF of control treatment that was not significantly different from every 7 days. The highest number of bulbs was found in the combination of the control gibberellins treatment with NA’s LOF interval every 14 days.

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