Physiological Aspect of Cauliflower (*Brassica oleracea* var. *Botrytis l.*) as Affected by Nitrogen and Liquid Organic Fertilizer on Coastal Sandy Land

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ABSTRACT

Cauliflower is one of the vegetables that have the ability to adapt to coastal sandy land. Cauliflower production can be increased by extensification efforts using coastal sandy land. The research aimed to determine the type of liquid organic fertilizer, the fertilization interval of liquid organic fertilizer, and the appropriate dose of nitrogen fertilizer for the growth and productivity of cauliflower plant on coastal sandy land. The research was conducted in Jetis sandy beach, Banjarsari Village, Nusawungu Sub-district, Cilacap Regency. The study was conducted from August 2017 to November 2017. The experiment was arranged in a Factorial Randomized Complete Block Design (RCBD). Data were analyzed by F test followed by DMRT 5%. The results showed that (1) type of artificial liquid organic fertilizer gave best result on the dry root weight and chlorophyll b. (2) The 9-day-interval of liquid organic fertilizer application interval gave the best result on the fresh root weight and fresh plant weight, while the 4-day-interval of liquid organic fertilizer application gave the best result on dry flower weight. (3) The doses of N fertilizer significantly affected leaf area, root volume, fresh root weight, fresh leaf weight, dry leaf weight, fresh plant weight, dry plant weight, fresh stem weight, dry stick weight, fresh flower weight, flower weight dry, and flower diameter.

Keywords: Cauliflower, Coastal sandy land, Dose, Interval, Liquid organic fertilizer

ABSTRAK

Kubis bunga merupakan salah satu sayuran mempunyai kemampuan beradaptasi dengan lahan pasir pantai. Produksi kubis bunga dapat ditingkatkan dengan melakukan upaya ekstensifikasi memanfaatkan lahan pasir pantai. Penelitian bertujuan untuk menentukan jenis pupuk organik cair, interval pemupukan pupuk organik cair dan dosis penggunaan pupuk nitrogen yang tepat untuk pertumbuhan dan produktivitas tanaman kubis bunga di lahan pasir pantai. Penelitian dilaksanakan di lahan pasir pantai Jetis, Desa Banjarsari, Kecamatan Nusawungu, Kabupaten Cilacap. Penelitian dilaksanakan Bulan Agustus 2017 sampai dengan Oktober 2017. Penelitian menggunakan Rancangan Acak Kelompok Lengkap (RAKL) faktorial. Data dianalisis dengan uji F dilanjutkan dengan DMRT 5 %. Hasil penelitian menunjukkan bahwa (1) Jenis pupuk organik cair buatan pabrik memberikan hasil yang terbaik terhadap variabel pertumbuhan bobot akar kering dan variabel fisiologis pada klorofil b. (2) Interval pemupukan POC 9 hari memberikan hasil yang terbaik pada variabel pertumbuhan bobot akar segar dan bobot tanaman segar, dan Interval pemupukan POC 4 hari memberikan hasil yang terbaik pada variabel hasil bobot bunga kering. (3) Dosis penggunaan pupuk N berpengaruh terhadap variabel luas daun, volume akar, bobot akar segar, bobot daun segar, bobot daun kering, bobot tanaman segar, bobot tanaman kering, bobot batang segar, bobot batang kering, bobot bunga segar, bobot bunga kering dan diameter bunga.

Kata Kunci: Lahan pasir pantai, Kubis bunga, Pupuk organik cair, Interval, Dosis

INTRODUCTION

Cauliflower, as a horticultural commodity, is adapted to be cultivated in the lowlands (Saparso, 2001). The increasing population will increase the demand for foods, including vegetables. PT. Panah Merah already produced cauliflower cultivar suitable for the lowland called PM126F1, which is expected to be a superior product typical of coastal sandy land.

According to Saparso (2008), coastal sandy soil has very low organic matter content (0.39%), total N (0.014%), and available N (26.79 ppm). Rajiman et al. (2008) state that coastal sandy soil is soil dominated by sand fraction, which is classified in sandy texture class.

One way to overcome the problem of coastal sandy land is by providing organic matter such as liquid organic fertilizer. Suriadikarta et al. (2006) explain that liquid organic fertilizer has benefits for plants, including to fertilize plants, maintain nutrient stability in the soil, reduce the impact of organic waste in the surrounding environment, help revitalize soil productivity, and improve product quality. According to the results of the study of Rafli and Marni (2010), the application of liquid organic fertilizer can increase crop yields, accelerate and multiply the formation of flowers and more plant segments, as well as multiply, extend, and strengthen roots. This liquid organic fertilizer has the advantage of being able to overcome nutrient deficiencies quickly, cope with nutrient leaching problems, and provide nutrients quickly (Taufika, 2011) so that it is very suitable for coastal sandy land. According to Munawar (2011), nitrogen is absorbed by plants from the soil in the form of nitrate ($N0_3^-$) and ammonium (NH_4^+). Nitrate is the most preferred form for plant growth, but it is influenced by environmental factors.

This study aimed to determine the right type of liquid organic fertilizer, the appropriate fertilization intervals of liquid organic fertilizer, and the appropriate dose of nitrogen fertilizer for the growth and productivity of cauliflower plants in coastal sandy land.

MATERIAL AND METHODS

The study was carried out in the Jetis coastal sandy area, Banjarsari Village, Nusawungu District, Cilacap Regency. The study was conducted from August 2017 to November 2017.

Experimental Design

The study was arranged in a Randomized Complete Block Design (RCBD) of 3 factors. The first factor was the type of liquid organic fertilizer

Table 1. ANOVA results on variables of growth, yield components, and physiological characteristics of cauliflower plants as affected by the type of liquid organic fertilizer (P), interval of LOF fertilization (I) dose of N fertilizer (N)

No.	Variables	Treatments		
		P	I	N
Growth Variables				
1	Plant Height (cm/plant)	ns	ns	ns
2	Number of Leaves (strands/plant)	ns	ns	ns
3	Leaf Length (cm/plant)	ns	ns	ns
4	Leaf Area (cm^2/plant)	ns	ns	**
5	Root Length (cm/plant)	ns	ns	ns
6	Root Volume (ml/plant)	ns	ns	*
7	Fresh Root Weight (g/plant)	ns	*	**
8	Dry Root Weight (g/plant)	*	ns	ns
9	Fresh Leaf Weight (g/plant)	ns	ns	**
10	Dry Leaf Weight (g/plant)	ns	ns	**
11	Fresh Plant weight (g/plant)	ns	*	**
12	Dry Plant weight (g/plant)	ns	ns	**
13	Fresh Stem Weight (g/plant)	ns	ns	**
14	Dry Stem Weight (g/plant)	ns	ns	*
Yield Components				
1	Fresh Flower Weight (t/ha)	ns	ns	**
2	Dry Flower Weight (g/plant)	ns	*	*
3	Flower Diameter (cm/plant)	ns	ns	**
Physiological Characteristics				
1	Chlorophyll a	ns	ns	ns
2	Chlorophyll b	*	ns	ns

Remarks: ns = not significantly different according to F test at 5%, * = significantly different according to F test at 5%, ** = highly significantly different according to F test at 5%. P = type of liquid organic fertilizer (LOF), I = Interval of LOF fertilization, N = Dose of N fertilizer.

(LOF)(P), consisting of 3 levels, namely factory production LOF (P1), commercial LOF in the market commonly used by local farmers (P2), and LOF produced by farmers (P3). LOF produced by farmers was made from cow urine fermentation, EM 4, rice bran, and sugar cane drops (molasses). The second factor was the LOF fertilization interval (I), consisting of 3 levels, namely 4-day (I1), 9-day (I2), and 14-day (I3) interval. Meanwhile, the third factor was the dose of N fertilizer (N), consisting of 3 levels, namely 20% (N1, 54 kg N/ha), 60% (N2, 162 Kg N/ha), and 100% (N3, 270 Kg N/ha).

Variables observed biweekly included plant height, the number of leaves, leaf length, leaf area, root length, root volume, fresh and dry weight of roots, fresh and dry weight of leaves, fresh and dry weight of the plant, and fresh and dry weight of stems. Meanwhile, variables observed during harvest included the fresh and dry weight of flower, flower diameter, and chlorophyll a and b measured with spectrophotometric methods.

Data Analysis

The data obtained were tested using analysis of variance (ANOVA) with DSAASTAT software. The observational data were analyzed using the F test at an error level of 5% and continued to DMRT test at the error level of 5% if there were significant differences among treatments.

RESULTS AND DISCUSSION

The results of the analysis were showed in Table 1.

Leaf area (cm^2/plant)

The dose of N fertilizer showed a significant effect on the leaf area. Regression analysis resulted in the equation of $y = -20.78x^2 + 112.22x - 12$ ($R^2 = 0.8193$). The N dose of 100% gave the best results, which was 141.19 cm^2, followed by the dose of 60% and 20%, resulting in a leaf area of 118.72 cm^2 and 90.05 cm^2, respectively.

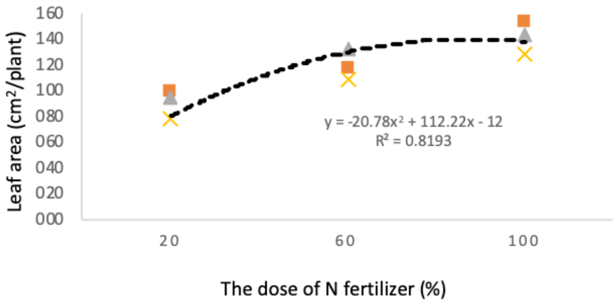

Figure 1. Leaf area of cauliflower plants as affected by various doses of N fertilizer

Figure 1 shows the leaf area of the cauliflower at various doses of N fertilizer. According to Hanum (2008), nitrogen is a constituent component of many essential compounds for plants. The nitrogen element is a nutrient that is needed by plants to form vegetative parts of plants such as leaves, stems, and roots.

Root Volume (ml)

The dose of N fertilizer had a significant effect on the root volume. Regression analysis resulted in the equation of $y = -0.7645x^2 + 3.6688x + 2$ (R^2=0.958). The N dose of 100% gave the best results, which was 6.17 ml, not significantly different from the dose of 60% resulting in 6.15 ml. Both treatments gave significantly different effects compared to the dose of 20%, which resulted in the root volume of 5.03 ml. Hanum (2008) states that nitrogen is used in regulating overall plant growth. With the improved root structure, the process of nutrient absorption will run more optimally.

Fresh Root Weight (g/plant)

The dose of N fertilizer and LOF fertilization interval significantly affected the fresh root weight. Regression analysis resulted in the equation of $y = -1.2717x^2 + 5.884x$ (R^2=0.9794). The application of N fertilizer at doses of 60% and 100% gave the best results, which were 6.55 g and 6.25 g, respectively. Both treatments gave significantly higher fresh root weight compared to the treatment of 20% N fertilizer that produced a fresh root weight of 4.75 g. According to Jumin (2002), the root is the main vegetative organ that supplies water, minerals, and materials that are essential for plant growth and development.

The 9-day-interval of LOF fertilization gave the best results on the fresh root weight of 6.84 g, followed by a 4-day-interval of LOF fertilization and the 14-day-interval of LOF fertilization, resulting in the fresh root weight of 5.38 g and 5.32 g, respectively. Regression analysis resulted in the equation of $y = -1.7383x^2 + 6.972x$ ($R^2 = 0.9694$). According to Rosmarkam and Yuwono (2002), the administration of nitrogen under optimal dose causes an increase in ammonia assimilation and protein content in leaves, and high N administration is thought to cause plants to fall easily because the root system is relatively narrow or undeveloped.

Dry Root Weight (g/plant)

The type of liquid organic fertilizer significantly affected the dry root weight. The LOF produced by the factory gave the best results on the dry root weight, which was 3.95 g, followed by the LOF produced by farmers and the commercial LOF in the market, resulting in the dry root weight of 2.73 g and 2.43 g, respectively.

The type of liquid organic fertilizer produced by the factory gave the best results on the dry root weight because, in addition to containing nutrients, it is also equipped with hormones or growth regulators of gibberellins, cytokinin, and auxins. Meanwhile, commercial liquid organic fertilizer only contains auxin growth regulators. In general, the types of hormones or growth regulators are auxin, cytokinin, and gibberellin. Auxin can be arranged in meristem tissue in the ends of plants such as shoots, flower buds, leaf buds, and others (Dwijoseputro, 2004).

Fresh Leaf Weight (g/plant)

The dose of N fertilizer significantly affected the fresh leaf weight. Regression analysis resulted in the equation of $y = -8.5272x^2 + 62.365x$ ($R^2 = 0.9328$). The application of N fertilizer at a dose of 100% gave the best results (112.55 g), followed by that at 60% and 20% resulting in the fresh leaf weight of 84.04 g and 60.42 g, respectively. According to Gardner and Mitchell (1991), nitrogen fertilization has a significant effect on leaf expansion. The increase in the leaf area will be followed by the increase in the fresh leaf weight.

Dry Leaf Weight (g/tanaman)

Regression analysis resulted in the equation of $y = -1.0553x^2 + 6.4249x$ ($R^2 = 0.8513$). The application of N fertilizer at a dose of 100% produced the highest dry leaf weight (10.02 g), followed by that at 60% and 20%, resulting in the dry leaf weight of 7.89 g and 6.11 g, respectively. According to Harjadi (2002), the leaves become greener when enough nitrogen is available, and the process of photosynthesis rate is higher, producing more photosynthates, thereby increasing the dry weight of the shoot.

Fresh Plant weight (g/plant)

Regression analysis resulted in the equation of $y = -40.18x^2 + 163.72x + 20$ ($R^2 = 0.695$) (Figure 2). The 9-day-interval of LOF fertilization produced the highest fresh plant weight of 178.50 g, followed by the 14-day-interval and 4-day-interval of LOF fertilization, resulting in the fresh plant weight of 152.28 g and 151.76 g, respectively. According to

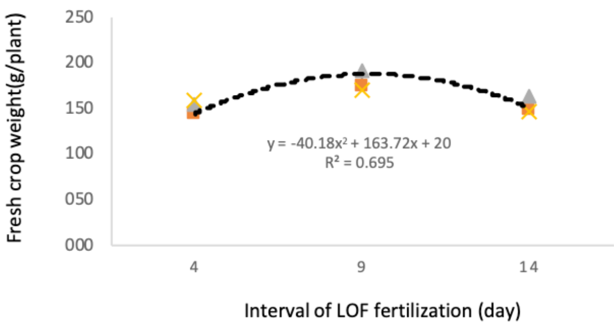

Figure 2. Fresh plant weight of cauliflower plants as affected by intervals of LOF fertilization

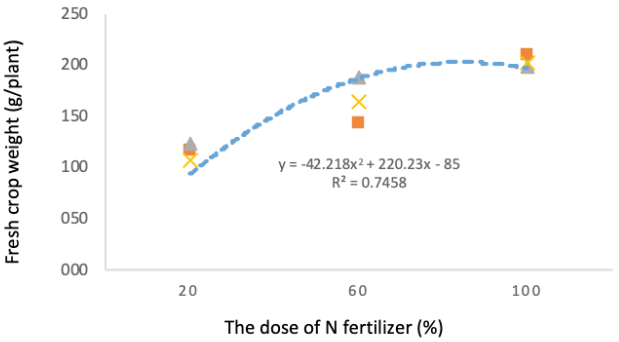

Figure 3. Fresh plant weight of cauliflower plants as affected by various doses of N fertilizer

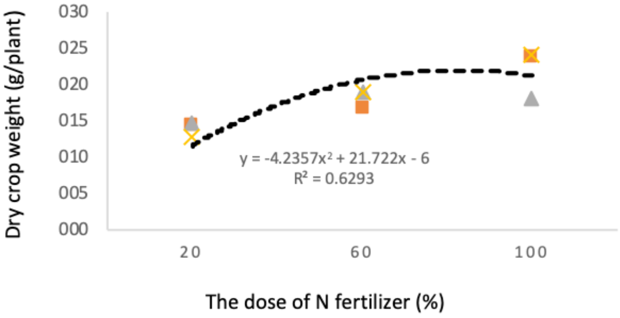

Figure 4. Dry plant weight of cauliflower plants as affected by various doses of N fertilizer

Saragih et al. (2013), an interval in the application of urea fertilizer can optimize the availability of the applied nutrients to plants, thereby fulfilling the needs of the N elements for plants.

The effect of the dose of N fertilizer on fresh plant weight is presented in Figure 3. Regression analysis resulted in the equation of $y = -42.218x^2 + 220.23x - 85$ ($R^2 = 0.7458$). The application of N fertilizer at a dose of 100% gave the best results, which was 202.95 g, followed by that at 60% and 20%, resulting in the fresh plant weight of 7.89 g and 6.11 g, respectively. This result is because N fertilizer applied at a dose of 100% can be absorbed effectively by plants. According to Dwidjoseputro (2004), the photosynthesis process is going well with sufficient N nutrients. Photosynthesis, with the help of sunlight and leaf chlorophyll, can convert inorganic substances into organic substances, which is very influential on the total fresh weight and dry weight per plant.

Dry Plant weight (g/plant)

Regression analysis resulted in the equation of $y = -4.2357x^2 + 21.722x - 6$ ($R^2 = 0.6293$). The application of N fertilizer at a dose of 100% produced the highest dry weight of the plant, which was 21.84 g, followed by that at 60% and 20%, resulting in the dry plant weight of 18.14 g and 13.85 g, respectively. The higher provision of N influences the dry weight due to the adequacy of nutrients absorbed by plants (Suwardi and Roy, 2009) (Figure 4).

Fresh Stem Weight (g/plant)

Regression analysis resulted in the equation of $y = -4.5396x^2 + 26.877x$ ($R^2 = 0.9727$). The application of N fertilizer at a dose of 100% produced the highest fresh stem weight of 40.22 g, followed by the N application at 60% and 20%, resulting in the fresh stem weight of 34.25 g and 23.68 g, respectively. According to Lingga (1998), the main role of the nitrogen element is to stimulate overall plant growth, especially stems, leaves, and the formation of chlorophyll that play a role in photosynthesis as a protein-forming material.

Dry Stem Weight (g/plant)

Regression analysis resulted in the equation of $y = -0.6835x^2 + 3,5114x$ ($R^2 = 0.8872$). The application of N fertilizer at a dose of 100% produced the highest dry stem weight, which was 4.46 g, followed by the N application at 60% and 20%, resulting in the dry stem weight of 4.05 g and 3.06 g, respectively. According to Harjadi (2002), plant growth is indicated by the addition of a measure of dry weight that reflects the increase in protoplasm due to the increase in the size and number of cells.

Fresh Flower Weight (t/ha)

Regression analysis resulted in the equation of $y = -0.6224x^2 + 3.2922x - 1$ ($R^2 = 0.6496$) (Figure 5). The N application at a dose of 100% produced the best result on the fresh flower weight, which was 3.4 t/ha, followed by the N application at 60% and 20%, resulting in the fresh flower weight of

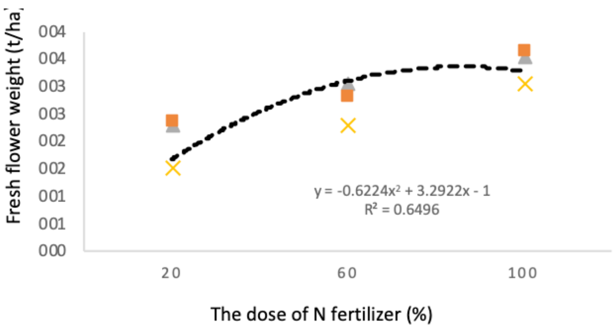

Figure 5. Fresh flower weight of cauliflower plants as affected by various doses of N fertilizer

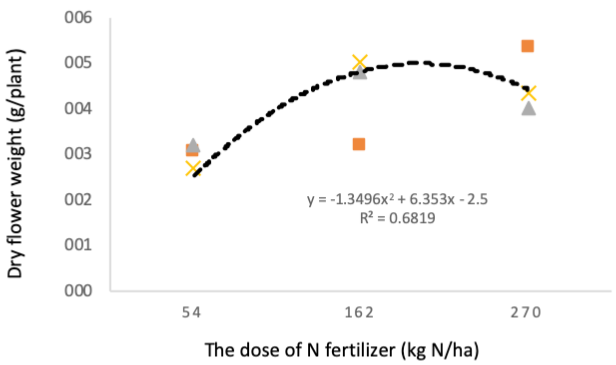

Figure 6. Dry flower weight of cauliflower plants as affected by various doses of N fertilizer

2.71 t/ha and 2.06 t/ha. According to Goldsworthy and Fisher (2000), nitrogen supply has a major influence on flowering and, subsequently, on yield.

Dry Flower Weight (g/plant)

Regression analysis resulted in the equation of $y = -1,3496x^2 + 6,353x - 2.5$ ($R^2 = 0.6819$). The N application at a dose of 100%and 60% produced the highest dry flower weight, which was 4.57 g and 4.34 g, respectively. Meanwhile, the lowest dry flower weight (2.98 g) was observed in the N application at 20% (Figure 6).

The application of 100% and 60% N fertilizer gave the best results on the dry flower weight due to the availability of nutrients, especially N, which is sufficient for plants so that the photosynthesis rate increase. The value of dry flower weight is directly proportional to the value of fresh flower weight.

Regression analysis resulted in the equation of $y = 1.469x^2 - 6.4396x + 10$ ($R^2 = 0.974$). The 4-day-interval of LOF fertilization produced the highest dry flower weight, which was 4.89 g, followed by the 14-day-interval and 9-day-interval of LOF fertilization, resulting in the dry flower weight of 3.86 g and 3.14 g, respectively. The availability of sufficient nitrogen causes a balanced ratio between leaves and roots, thereby supporting vegetative growth. These conditions will induce the plant to enter its generative phase (Ramadhani et al., 2016).

Flower Diameter (cm)

Regression analysis resulted in the equation of $y = -0.274x2 + 1.6496x + 4.5$ ($R^2 = 0.6613$). The N application at a dose of 100% gave the best result on flower diameter, which was 7.07 cm, followed by the N application at 60% and 20%, resulting in the flower diameter of 6.43 cm and 6.14 cm, respectively. According to Marvelia et al. (2006), N plays a role in flowering. In plants whose growth in the vegetative phase is more dominant than the generative phase, then carbohydrate use is more dominant than its storage (Figure 7).

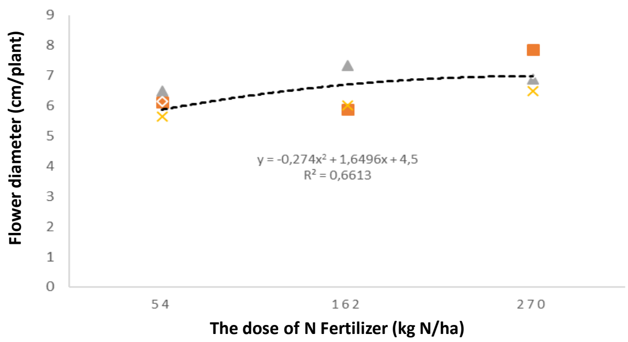

Figure 7. Flower diameter of cauliflower plants as affected by various doses of N fertilizer

Chlorophyll b (mg/l)

The type of liquid organic fertilizer produced by the factory produced the highest content of chlorophyll b, which was 29.81 mg/l, followed by the commercial liquid organic fertilizer in the market and that produced by farmers, resulting in the chlorophyll b content of 21.47 mg/l and 20.02 mg/l, respectively.

Light energy will be converted into chemical energy in the reaction center, which can then be used for the reduction process in photosynthesis. Chlorophyll b functions as an antenna, collecting light to be transferred to the reaction center. The reaction center is composed of chlorophyll a (Taiz and Zeiger, 1991) (Figure 8).

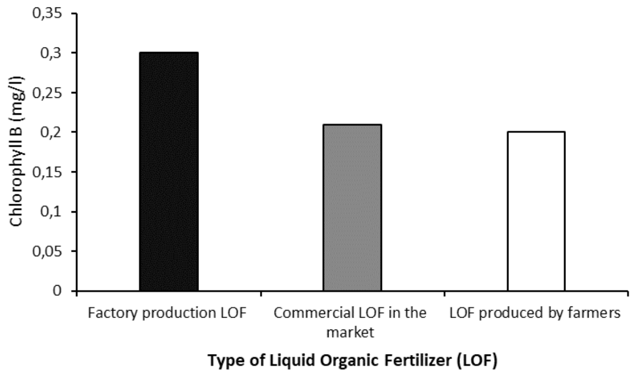

Figure 8. Chlorophyll b of cauliflower plants as affected by the types of liquid organic fertilizer

CONCLUSION

1. The factory-made liquid organic fertilizer gave the best results on the growth of cauliflower plants, which was the dry root weight of 3.95 g/plant and on the physiological characteristic, which was chlorophyll b content of 29.81 mg / l. The type of liquid organic fertilizer did not significantly affect the yield of fresh flower weight, meaning that the types of liquid organic fertilizer used in this study produced relatively the same fresh flower weight.
2. The 9-day-interval of LOF fertilization gave the best results on the growth variable of fresh root weight and fresh plant weight, while the 4-day-interval of LOF fertilization gave the best results on the dry flower weight. LOF fertilization interval had no significant effect on the fresh flower weight, meaning that the LOF fertilization interval tested in this study resulted in relatively the same fresh flower weight.
3. The application of N fertilizer at a dose of 100% gave the best results on the growth variables of leaf area (141.19 cm^2/plant), root volume (6.17 ml/plant), fresh leaf weight (112.55 g/plant or 5.6275 t / ha), dry leaf weight (10.02 g/plant or 0.501 t / ha), fresh plant weight (202.95 g/ plant or 10.1475 t/ha), dry plant weight (21.84 g/plant or 1.092 t/ha), fresh stem weight (40.22 g/plant or 2,011 t/ha), and dry stem weight (4.46 g/plant or (0.223 t/ha), as well as on the variables of yield components, including fresh flower weight (3.4 t/ha), dry flower weight (4.57 g/plant or 0.2285 t/ha), and flower diameter (7.07 cm/plant).

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