Vol. 12, No. 2 (2023) : 268 - 276
DOI : http://dx.doi.org/10.23960/jtep-l.v12i2.268-276

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Response of Growth and Production of Shallot (*Allium ascalonicum* L.) to Liquid Fertilizer and Cattle Manure

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Article History :

Received : 14 August 2022
Received in revised form : 10 January 2023
Accepted : 17 January 2023

Keywords :

Plant height,
Shallot,
Soil Fertility,
Tuber weight,
Tuber size.

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ABSTRACT

The purpose of this research is to improve the physical properties and fertility of soil to improve production of shallot. The research method used is a randomized block factorial design with 3 replication. The first factor was application of liquid fertilizer (N) consisting of 3 levels (N0: 0 cm^3/L water; N1: 1.5 cm^3/L water; N2: 3 cm^3/L water). Second factor was cattle manure (A) consisting of 4 levels, namely: A0: 0 g; A1: 40 g cattle manure; A2: 80 g cattle manure; and A3: 120 g cattle manure. The results shown treatment with liquid fertilizer has a significant effect on plant height at weeks after planting (WAP). The study showed that treatment with liquid fertilizer has a significant effect on plant height, tuber weight per clump, and tuber weight per plot, but didn't not have a significant effect on number of leaves and number of samplings of the shallot plants. Treatment with cattle manure has a significant effect on plant height, tuber weight per clump, tuber weight per plot, and tuber diameter, but does not have a significant effect on number of leaves and number of saplings of the shallot plants. It can be concluded that the higher the application of liquid fertilizer, up to 3 cm^3/L , the higher the growth and production of shallot plants, and the higher the application of cattle manure, up to 120 g/plot the higher the growth and production of shallot plants.

1. INTRODUCTION

Shallots (*Allium ascalonicum* L.) are a widely cultivated commodity in Indonesia and have been grown intensively by farmers for a long period of time as a primary vegetable commodity. Therefore, shallots have a high economic value and their cultivation can provide both a source of income and work opportunities for the community. Although farmers have a fairly strong interest in growing shallots, a number of obstacles —both technical and economic— are still encountered in the cultivation process (Sumarni *et al*., 2005). Shallots contain protein, fat, carbohydrate, vitamins and minerals, and anti-mutagenic and anti-carcinogenic compounds. In every 100 grams of shallot tuber, the water content is 80-85 g, protein 1.5 g, fat 0.3 g, and carbohydrate 9.3 g (Tarmizi, 2010).

Some characteristics on its production in Indonesia are 1) planted in lowland and restricted area; 2) low technology application; 3) overused of pesticide; 4) low quality of cultivated seed. These factors lead to crucial problem on shallot annual production (Gunawan *et al*., 2021).

Shallot production in the province of North Sumatra, according to the Department of Agriculture, cited from BPS (2022), was 53.962 tons in 2021, and 29.222 tons in 2020, while the demand for shallots was 66,420 tons. These data show that shallot production in North Sumatra is still far below the amount required. In the national level, shallot production is the top eight highest in 2019 to supply 18,072t to total national production (BPS, 2020). Nutrient retention and availability as well as pH and cation exchange capacity (CEC) are a profound factor that lead to limitation of shallot growth.

There are a number of points that need attention in order to achieve the desired level of shallot production. One of these is the cultivation system. Shallots cannot withstand drought due to their short roots. Throughout the growth and development of the tuber, a fairly large amount of water is required. However, shallot crops cannot survive in waterlogged conditions (Telaumbanua, 2019). One cultivation technique that can be implemented to increase shallot production is fertilization, which aims to improve soil productivity by providing nutrition for the plant. Fertilizer can be applied through the leaves and the roots of the plant. Fertilizer applied through the leaves is called liquid fertilizer or leaf fertilizer and fertilizer applied through the roots is known as root fertilizer.

The application of animal manure aims to improve the physical properties of the soil, add soil nutrients, and increase the activity of microorganisms in the soil. The use of animal manure on dry land in particular aims to improve the physical properties of the soil, which in turn enhances the soil's water binding ability and improves aeration and drainage (Rahayu & Nur, 2007). Mineral fertilizer and animal manure increase the C and N content of soil, clay and silt to be proper fraction (Loss *et al*., 2019).

Cattle manure has the ability to improve the physical, biological, and chemical properties of the soil. The decomposition of this organic matter releases nutrients and produces humus, thus increasing the cation exchange capacity of the soil and reducing the leaching of cations Ca_2^+, Mg_2^+, K^+, and NH_4^+ (Adugna, 2008). Organic matter in cattle manure is higher than in other types of animal manure, and has a sufficiently high N content, namely 2.6%, with 2.9% (P), and 3,4% (K), and a C/N ratio of 8.3 (Zhang *et al*., 2016). The use of 30 ton t/ha of cattle manure can produce a shallot crop dry weight of 15.37 g/plot and a wet tuber weight of 5.01 g/plot in shallot crops. Biological entity contained in chicken manure could also improve the soil sterility as it consisted antibiotic such as amoxicillin, kanamycin, gentamicin, and cephalexin with prevalence of 20.91%–65.9% for ARB (antibiotic-resistant bacteria) (Yang *et al*., 2014).

However, it is not yet known the best dose of fertilizer required for optimal shallot growth and yield. Therefore, research is needed to discover the response of growth and yield of shallots to liquid fertilizer and cattle manure. The hypothesis of the research is that the of application of liquid fertilizer and cattle manure does have an effect on the growth and yield of shallots, and that there is an interaction between the effects of liquid fertilizer and cattle manure application on the growth and yield of shallots. It is expected that the research will provide information for readers and farmers, in particular shallot farmers, about the response of growth and yield of shallots to the application of liquid fertilizer and cattle manure.

2. RESEARCH METHOD

2.1. Place and Time of Research

The research was conducted in the Experimental Garden belonging to the Faculty of Agriculture in Universitas Pembangunan Masyarakat Indonesia. The research was carried out from February to May 2019.

2.2. Materials and Tools

The materials used in the research were: shallot tubers of the Brebes variety, cattle manure, Nasa liquid fertilizer (containing N 0.12%, P_2O_5 0.03%, K 0.31%, Ca 60.4 ppm, Mn 2.46 ppm, Fe 12.89 ppm, Cu 0.03 ppm), insecticide, and fungicide.

The tools used in the research were a hoe, a cleaver, a measuring tape, a watering can, an analytical balance, Vernier calipers, a plank, and other writing tools needed to support the research.

2.3. Research Method

The research used completely randomized factorial design with 2 factors. First factor was application of liquid fertilizer (N) consisting of 3 levels (N0: 0 cm^3/L water; N1: 1.5 cm^3/L water; N2: 3 cm^3/L water). Second factor was cattle manure (A) consisting of 4 levels, namely: A_0: 0 ton/ha; A_1: 40 g cattle manure (equal to 10 ton/ha); A_2: 80 g cattle manure (equal to 20 ton/ha); A_3: 120 g cattle manure (equal to 30 ton/ha). Three repetitions were performed for each treatment. The study was carried out in the field using media with above-mentioned arrangement.

2.4. Observation and Measurements

The variables observed were:

1) Plant height (cm). Observation was made using a ruler. Measurement was made using a stake to mark the soil surface at the time of planting. Measurement was taken at 2, 3, 4, and 5 WAP (week after planting), at intervals one week.
2) Tuber weight per clump (g). Tubers were weighed after the entire crop had been harvested, by collecting and weighing every plant in every sample plot using a balance. Tuber weight was measured after cleaning any remaining soil from the tubers and separating the tubers from the roots and stems of the plants.
3) Tuber weight per plot (g). Tubers were weighed similarly as before.
4) Tuber diameter (mm). The size of tubers were measured using vernier calipers (mm). Measurement was taken of all the plants used in the sample after the entire crop had been harvested. Tuber diameter was calculated by adding the diameters of all tubers and dividing the sum by the number of tubers in every plant sample .

2.5. Data Analysis

The data analysis was carried out with variance, using the following linear model:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \qquad (1)$$

where i = 1, 2, 3 (liquid fertilizer), j = 1, 2, 3, 4 (cattle manure), k = 1, 2, 3 (number of replications), μ = the overall mean effects, α = the effects liquid fertilizer, β = the effects of cattle manure, ε_{ijk} = the random error compared for the whole factor. Next, an average difference test was carried out on the factors that showed a significant effect in the variance test, using the Duncan range test at a level of 5%.

3. RESULTS AND DISCUSSION

From the different variables observed, the following results were obtained:

3.1. Plant Height (cm).

Data about shallot plant height at ages 2, 3, 4, and 5 weeks after planting (WAP) as presented in Table 1. From the results of the variance analysis, it can be seen that liquid fertilizer treatment does not have a significant effect at ages 2 and 3 WAP, and effectively improved in aged 4 and 5 WAP. Treatment with cattle manure does not have a significant effect at ages 2, 3, and 4 WAP, but does have a significant effect at age 5 WAP. Interaction between the two treatments does not have a significant effect on plant height at any of the ages of observation.

Table 1. Effect of treatments on shallot plant height (cm) at ages 2, 3, 4, and 5 WAP

Treatment	Plant Age			
	2 WAP	2 WAP	2 WAP	2 WAP
Liquid Fertilizer				
N0	16.51 a	18.85 a	23.32 a	25.70 a
N1	17.05 a	19.70 a	24.77 b	27.43 b
N2	17.14 a	19.91 a	25.20 b	27.97 b
Cattle Manure				
A0	16.79 a	19.16 a	23.68 a	25.85 a
A1	16.92 a	19.33 a	23.93 a	26.13 a
A2	16.85 a	19.62 a	24.91 a	27.93 b
A3	17.04 a	19.83 a	25.18 a	28.22 b

Note: Figures followed by the same letter in the same column show an insignificant difference at a level α = 0.05 based on the Duncan Range Multiple Test

From Table 1 it can be seen that at age 5 WAP, the liquid fertilizer treatment which produces the application of liquid fertilizer 1.5 cm^3/L of water (N1) and 3 cm^3/L of water (N2) can increase plant height. There is no significant difference between N2 and N1. It can also be seen that A3 produced the highest plant height because it was not significantly different from A2. A1 had no significant effect on plant height and A2 and A3 have an effect on increasing plant height. Thus, the application of nutrients through the leaves is more effective than application through the soil because it bypasses a number of negative reactions in the soil.

The increase in shallot growth and production is due to the fact that the liquid fertilizer contains macro and micro nutrients, vitamins, minerals, and organic acids, as well as auxin, gibberellin, and cytokinine growth regulators which are vital in plant growth. Nitrogen plays an important role in the formation of amino acids, amides, and adenine. Adenine is a constituent of nucleotides and nucleoproteins such as DNA and RNA. Amino acids, amides, and amines are building blocks of proteins and nucleic acids. Nitrogen is a constituent of peptide bonds that serve to bind protein-forming amino acids (Sutriyono *et al*., 2020).

3.2. Tuber Weight Per Clump

From the results of the variance analysis, it was found that treatment with liquid fertilizer and cattle manure has a significant effect. The average tuber weight per clump of shallots treated with liquid fertilizer and cattle manure is presented in Table 2.

Table 2. Effect of treatments on the shallot tuber weight (g) per clump

Cattle Manure	Liquid Fertilizer			
	N0	N1	N2	Average
A0	24.33	26.04	27.43	25.93 A
A1	24.23	26.93	27.58	26.24 AB
A2	26.54	28.14	28.55	27.74 AB
A3	27.13	28.40	28.37	27.97 B
Average	25.56 a	27.38 b	27.98 b	

Note: Figures followed by the same lowercases in the same row or capital letters in the same column show an insignificant difference at a level α = 0.05 based on the Duncan Range Multiple Test

Table 2 represents Treatments N1 and N2 can increase tuber weight per clump.Treatment A3 increased tuber weight per hill, but treatments A1 and A2 did not increase tuber weight per clump. Phorphorus plays important role on cellular level such as maintaining membrane structures, biomolecule synthesis and enzyme activation. Furthermore. Phosphorus is a constituent of ATP, which is an energy source, and also a constituent of DNA and RNA, which are nucleic acid compounds. ATP is needed as an energy source for the activities of cell division and cell elongation (Malhota *et al*., 2018). An increase in cell division due to the availability of phosphorous has a positive effect on the growth of canopy organs because the plant canopy and root are mutually dependent. The root absorbs nutrients from inside the soil and transports them to the plant canopy. In the canopy, these nutrients are processed to become growth compounds which are stored in the stem as food reserves in the form of fiber thereby increasing the number of leaves (Rachman *et al*., 2008).

3.3. Tuber Weight Per Plot

From the results of the variance analysis, it was found that treatment with liquid fertilizer and cattle manure has a significant effect, but interaction between the two treatments does not have a significant effect on tuber weight per plot. The average tuber weight per plot of the shallot plants treated with liquid fertilizer and cattle manure is presented in Table 3.

Table 3 presents the application of liquid fertilizer 1.5 cm^3/L of water (N1) and 3 cm^3/L of water (N2) can increase tuber diameter. There is no significant difference between N2 and N1. It was also found that treatment with liquid fertilizer has a significant effect on plant height, tuber weight per clump, and tuber weight per plot, but does not have a significant effect on the number of leaves and number of saplings of shallot plants. In comparison, the liquid fertilizer could improve the productivity of shallot 1.5 times compare to previous research using biochar and NPK (Yoanma et al., 2022).

Chromosomes are made up of DNA, RNA, and protein. Chromosomes are constituents of the cell nucleus and play a role in cell division. The greater the number of chromosome building blocks, the more active the process of cell division and cell elongation. Potassium is essential for the formation of carbohydrates and the translocation of sugar as well as assisting with the formation of protein. It also plays an

Table 3. Effect of treatments on the shallot tuber weight (g) per plot

Cattle Manure	Liquid Fertilizer			
	N0	N1	N2	Average
A0	183.37	196.20	208.33	195.97 A
A1	184.33	202.67	206.73	197.91 A
A2	199.20	212.27	216.33	209.27 B
A3	204.97	213.70	215.03	211.23 B
Average	192.97 a	206.21 b	211.61 b	

Note: Figures followed by the same lowercases in the same row or capital letters in the same column show an insignificant difference at a level α = 0.05 based on the Duncan Range Multiple Test

important role as a catalyst of various biochemical reactions. Potassium increases antioxidant defence in plant and therefore protect them from oxidative stress (Hasanuzzaman *et al*., 2018).

Plant production depends strongly on the vegetative growth of the plant. A high amount of photosynthesis could produce during the generative phase as the manifestation of plant production. This increase in the products of photosynthesis (assimilates) is closely related to the role of liquid fertilizer which provides nutrition for the plant. The organic matter present in cattle manure can improve the physical, chemical, and biological properties of the soil.

3.4. Tuber Diameter

From the results of the variance analysis, it was found that the treatment of liquid fertilizer and cattle manure has a significant effect but the interaction between the two treatments does not have a significant effect on tuber diameter. The average diameter of shallot tubers after treatment with liquid fertilizer and cattle manure is presented in Table 4.

Table 4. Effect of treatments on the shallot tuber diameter (cm) per plot

Cattle Manure	Liquid Fertilizer			
	N0	N1	N2	Average
A0	2.93	3.08	3.18	3.06 a
A1	2.93	3.17	3.21	3.10 a
A2	3.16	3.30	3.33	3.26 b
A3	3.19	3.33	3.30	3.27 b
Average	3.05 a	3.22 b	3.25 b	

Note: Figures followed by the same letter in the same column show an insignificant difference at a level α = 0.05 based on the Duncan Range Multiple Test

From table 4 it can be seen that the liquid fertilizer treatment which produces the largest tuber diameter is N2, but not significantly different from N1. Table 4 also shows that the cattle manure treatment which produces the largest tuber diameter is A3, significantly different from A0 and A1, but not significantly different from A2. The higher the application of cattle manure, up to 120 g/plot, the higher the growth and production of shallot plants.

Organic matter is an important component in the soil system. The primary role of organic matter is as a conditioner for critical soils, to improve the physical and biological properties of the soil, and to add nutrients. Therefore, the application of cattle manure can provide nutrients needed by the plant so that the shallot plants can grow better and lead to a higher yield. Cattle manure has a significant effect on shallot growth and production because the application of cattle manure increases the fertility of the soil. The biological properties of the soil are improved by the presence of organic matter, and the organic matter in cattle manure encourages the life of microorganisms in the soil. Physical analysis of the association of organic matter content and spectral reflectance revealed a negative correlation. Less reflectance is associated with lower organic matter which correlates to low soil fertility (Guo *et al*., 2017).

The role of microorganisms is vital in the breakdown process of organic matter, specifically ammonification and nitrification. Microorganisms contained in chicken manure will help in facilitating composting process, reducing NH4+ content during the cooling stage. Additionally, NO_3^- increased after the first pile turning on day 10, continuing until the end of thermophilic stage. Microorganism is also helpful Improvements across transformation of nitrogen, humification levels and composting (Wan *et al*., 2020). This entity also sustains the soil productivity and enhances plant resistance toward phytopathogen.

The addition of cattle manure can also supply the soil with a number of nutrients suc6h as nitrogen, phosphorous, potassium, and other elements, although the amount is relatively small. The nutrients resulting from the decomposition of the organic matter quickly change into a form that becomes available for the plant, because the decomposition process can take place in conditions that are suitable for plant growth (Font-Palma, 2019). The result of the decomposition of the organic compost by cellulose-degrading bacteria can increase plant nutrients and organic C/N in the soil, providing the energy needed for growth activities (Fan *et al*., 2019). Leaf growth will become increasingly active with the availability of energy, which is distributed in the reproductive stage, leading to an acceleration in tuber development and better tuber initiation, thus producing a heavier shallot production (Rana, 2017).

4. CONCLUSIONS

From the results of the research, the following conclusions can be drawn:

1. Treatment with liquid fertilizer has a significant effect on plant height, tuber weight per clump, and tuber weight per plot. The higher the application of liquid fertilizer, up to 3 cm^3/L water, the higher the growth and production of the shallot plants.
2. Treatment with cattle manure has a significant effect on plant height, tuber weight per clump, tuber weight per plot, and tuber size. The higher the application of cattle manure, up to 120 g/plot, the higher the growth and production of the shallot bulb.

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