Growth and yield of shallots (*Allium ascalonicum* L.)
Lokananta in various doses of nitrogen fertilizers and number of plant per hole in coastal sandy land

Saparso, Kartini and I D Apriliyanto
Agrotechnology Study Program of Agriculture Faculty, Jenderal Soedirman University, Indonesia

Corresponding author: parso.fpunsoed@yahoo.co.id

**Abstract.** This research aimed to determine the effect of N fertilizer dose, number of plant/hole, and their interaction on the growth and yield of shallots. The research used a Randomized Complete Block Design (RCBD) with two factors: various doses of N fertilizer (P) (P1=90, P2=180, and P3=270 N kg/ha) and number of plant/hole (T) (T1=1, T2=2, T3=3, and T4=4). The observed variables were plant height, number of leaves, leaf area, chlorophyll content, stomata opening width, stomata density, weight of fresh and dry leaf, root and tuber, fresh and askip tuber yield, root length, number of roots, number of tubers, and tuber diameter. Obtained data were analyzed using F test then followed by Duncan Multiple Range Test (DMRT) of 5% level if diversity occur. The results showed that N fertilizer of 180 kg/ha produced higher plant height (25.78 cm), density of morning and evening stomata (71.86/mm² 67.03/mm², respectively) with fresh tubers yield of 8.48 t/ha. One plant/hole showed higher yield of tuber diameter (4.68 cm), two plants/hole showed higher height (25.67 cm), and four plants/hole showed higher number of leaves (9.38 strands), roots (73.56 strands), and tubers (4 pieces). There was no interaction between both factors to the observed variables.

1. **Introduction**

Shallot is a plant that has a typical layered tuber that can grow in two seasons on the year. However, most shallot varieties are grown in dry or sunny seasons [1]. Shallot is cultivated seasonally, generally during the dry season, namely April-October. It causes low production of shallots, resulting in scarcity of shallots on a national scale, which can result in high price fluctuations. The need for shallots is quite high because not all countries have a suitable season for growing shallots [2]. The use of seeds or True Seed of Shallot (TSS) can be a promising alternative. The use of TSS as a seed source has several advantages over tubers, including: low seed requirements, low cost of provision, easier storage of seeds, long shelf life of seeds so that they are flexible, can be planted when needed, easy and cheap to distribute, low seed quality variations, and high productivity [3]. In addition, the use of TSS seeds can also increase yields up to two times compared to the use of traditional tubers [4].

Coastal sandy soil is the second problematic land after acid soils, as the marginal land of coastal sand is very potential to be used as productive cultivation land, especially for the cultivation of horticultural crops [5]. Effort to use sand soil as a growing medium for shallot plants is by adding macro nutrients in the form of nitrogen. Nitrogen nutrient is the main element needed by vegetable plants, including onions,
because nitrogen is a component of chlorophyll, enzymes, and amino acids [6]. The number of TSS seedlings planted per hole will determine the number of plants growing in a clump. Many plants in one clump can affect the level of plant population per unit area, while the population level greatly affects the growth and production of plants in a planted area [7]. This study objective to: 1) Determine the effect of various doses of N fertilizer on onion growth and yield, 2) Determine the effect of the number of plants per hole on shallot growth and yield, and 3) Determine the interaction between various doses of N fertilizer and the number of plants per hole on the growth and yield of shallots.

2. Methods
The research was conducted from August to November 2019 in the coastal sand land of Karanganyar Village, Adipala District, Cilacap Regency, Central Java. The experimental design used was a randomized complete block design (RCBD) with two experimental factors. The first factor was various doses of N fertilizer (P), including: P1 = 90 N kg/ha, P2 = 180 N kg/ha, and P3 = 270 N kg/ha. The second factor was the number of plants per hole (T), including: T1 = 1 plant/hole, T2 = 2 plants/hole, T3 = 3 plants/hole, and T4 = 4 plants/hole. The variables observed were plant height, number of leaves, leaf area, chlorophyll content, width of stomatal opening, stomata density, fresh and dry leaf weight, fresh and dry root weight, fresh and dry tuber weight, yield of fresh and ascip tubers, root length, number of roots, number of tubers, and tuber diameter.

The materials used in the study included Lokananta variety (Attachment 1), 5040 seed requirements, planting medium (beach sand land), manure (20 tonnes/ha), SP-36 (200 kg/ha)), KCL (200 kg/ha), phonska fertilizer (200 kg/ha), water, N fertilizers (urea), and ZA. The tools used in this research included diesel engine, bucket, paralon, hose, water reservoir, gembor, treatment label board, ruler, writing tool, observation sheet, calculator, microscope, object glass, clear cutex, tape, digital scale, thermohigrometer, luxmeter Soil Plant Analysis Development (SPAD), camera, oven, and calipers.

3. Results and discussion
Analysis of variance, as in Table 1, showed that the dose of N fertilizer (P) had a significant effect on plant height, morning stomata density, and late evening stomata density. The number of seeds per planting hole significantly affected plant height, number of leaves, number of roots, number of tubers per clump, and tuber diameter. Neither the dose of fertilizer nor the number of seeds per planting hole had an effect on the yield of fresh tubers and yield of ascip tubers. It is suspected that this occurs because the plant leaf area index is still low so that the utilization of light and nutrients for plants is not optimal. According the optimum ILD is 3 to produce the maximum primary product.

Based on the research, there was no interaction between the dose of N fertilizer and the number of plants per hole on plant height, number of leaves, leaf area, chlorophyll content, root length, number of roots, morning stomata opening width, afternoon stomata opening width, stomatal opening width. afternoon, morning stomata density, afternoon stomata density, morning stomata density, fresh leaf weight, dry leaf weight, fresh root weight, and dry root weight. This shows that the interaction between the N fertilizer dose and the number of plants per hole had the same effect on these variables. According to [8], if the two treatment factors have an influential result but there is no interaction between the two, it is estimated that the functions of the two factors are the same so that the best recommendation is to choose one because the results will not be better if applied together. There were any constrain in driving force on growth of the shallot either capture the light and absorb the available nutrient.

3.1. Shallot growth in the treatment of N fertilizer dose
The fertilizer dosage of 180 kg N/ha produced the highest plant height as shown in the Figure 1, namely 25.78 cm. The relationship between the two is shown in Figure 1 which produces the equation \( y = -0.0001x^2 + 0.0508x + 21.0583 \) \( (R^2 = 0.5132) \), showing that the dose of N fertilizer has a significant effect in increasing plant height. This is consistent with the statement of [9], the highest N supply will accelerate the conversion of carbohydrates into protein and will be used for the preparation of cell walls,
but if the N supply is too large, an increase in cell size and cell wall thickening can cause plant leaves and stems to become succulent and less hard and growth will be stunted.

**Table 1. Growth and yield of shallots in various doses of nitrogen fertilizers and number of plant per hole**

| Variables | Treatment | P | T | P x T |
|-----------|-----------|---|---|-------|
| A. The Growth | | | | |
| 1. Plant Height (cm) | sn | sn | tn |
| 2. Number of leaves (leaf) | tn | sn | tn |
| 3. Wide of leaves (cm/plant) | tn | tn | tn |
| 4. Greening of leaf (unit) | tn | tn | tn |
| 5. Root length (cm) | tn | tn | tn |
| 6. Root number (root) | tn | n | tn |
| 7. Morning stomatal closure (μm) | tn | tn | tn |
| 8. Afternoon stomatal closure (μm) | tn | tn | tn |
| 9. Evening stomatal closure (μm) | tn | tn | tn |
| 10. Morning stomatal density (stomata/mm²) | n | tn | tn |
| 11. Afternoon stomatal density (stomata/mm²) | n | tn | tn |
| 12. Evening stomatal density (μm²) | tn | tn | tn |
| 13. Leaves fresh weigh (g) | tn | tn | tn |
| 14. Leaves dry weigh (g) | tn | tn | tn |
| 15. Root fresh weigh (g) | | | |
| | | | |
| B. The Yield | | | |
| 1. Bulb fresh weigh (g) | tn | tn | tn |
| 2. Bulb dry weigh (g) | tn | tn | tn |
| 3. Number of bulb per plant (buah) | tn | sn | tn |
| 4. Bulb diameter (cm) | tn | sn | tn |
| 5. Yield of fresh bulb (t/ha) | tn | tn | tn |
| 6. Yield of dry bulb (t/ha) | tn | tn | tn |

Note: P = Dose of N, T = Number of seed per plant, P x T = Interaction of N x P, tn = not significant different, n = significant different, sn = very significantly different.

Figure 2 shows that the fertilizer dosage of 180 kg N/ha produced the highest average stomata density in the morning, namely 71.86/mm². The relationship between the two is shown in Figure 2 which results in the equation y = -0.0007x² + 0.2532x + 48.806 (R² = 0.6851), showing that the dose of N fertilizer has a significant effect in increasing the density of stomata in the morning. This is in accordance with the opinion of Rhodes and Samaras [10] stated that the application of N fertilizers played an important role in increasing the number of stomata in leaves.

The fertilizer dosage of 180 kg N/ha produced the highest average density of stomata in the afternoon, namely 67.03/mm² (Figure 3). The relationship between the two is shown in Figure 3 which produces the equation y = -0.0004x² + 0.1042x + 60.067 (R² = 0.6275), showing that the dose of N fertilizer has a significant effect in increasing the stomata density in the afternoon. Based on the stomata density graph in the morning and evening, it shows that the fertilizer dose of 180 kg N/ha affects the density of stomata more than fertilizer dose of 90 kg N/ha and 270 kg N/ha. This is also in accordance with the opinion of Kartasapoetra [11] which states that one of the factors that affect the density and number of stomata in
leaves is the role of nitrogen in helping the formation or growth of vegetative parts of plants, such as stomata on leaves, the more the number of stomata the greater the level of stomata density.

**Figure 1.** High of plants in the treatment of N fertilizer dose

**Figure 2.** Graph of morning stomata density at the dose of N fertilizer treatment

**Figure 3.** Density graph of late afternoon stomata on N fertilizer dosage treatment
3.2. Shallot growth on the treatment of the number of plants per hole

The number of 2 plants per hole resulted in the highest average plant height of 25.67 cm (Figure 4). The relationship between the two is shown in Figure 4, which produces the equation \( y = -0.3222x^2 + 0.1311x + 24.994 \) \((R^2 = 0.5925)\), showing that the number of plants per hole has a significant effect in increasing plant height. According to Salisbury and Ross [12], plants with a larger population will compete for light by growing sideways. Plants in a population rarely receive optimal light or sunlight, so that plants can grow taller between plants. This is also explained by Lakitan [13], that plants that grow in suboptimal light intensity conditions due to denser populations will cause etiolation.

Figure 5 shows that the number of 4 plants per hole produced the highest average number of leaves, namely 9.38. The relationship between the two is shown in Figure 5 which produces the equation \( y = -0.1x^2 + 1.4022x + 5.4444 \) \((R^2 = 0.5502)\), showing that the number of plants per hole has a significant effect in increasing the number of leaves. According to Yanti [14], the use of a relatively large number of seed tubers means that the number of tillers that are formed will be higher, thus the number of leaves produced will also increase. Using a lot of seed tubers in one hole will result in a large number of tillers in one clump.

The number of 4 plants per hole produced the highest average number of roots, namely 73.56 strands as shown in the Figure 6. The relationship between the two is shown in Figure 6 which results in the equation \( y = -1.5278x^2 + 17.317x + 28.417 \) \((R^2 = 0.5677)\), showing that the number of plants per hole has a significant effect in increasing the number of roots. According to Dwidjoseputro [15], a plant will thrive if the elements needed are sufficiently available and these elements have a form suitable for plant absorption.
3.3. Yield of Shallot in the treatment of dose of N fertilizer and the number of plants per hole

Based on the research that has been done, the N fertilizer dosage had no significant effect on fresh tuber weight, dry tuber weight, number of tubers, tuber diameter, yield of fresh tubers, and yield of ascip tubers. This shows that the response of the plants is the same to the dose of N fertilizer. The doses of N fertilizer has not been able to increase the yield of shallot plants. According to Lan and Liang [16], fertilization in sand soil has a low level of efficiency, because about 40-70% of nitrogen given from fertilization is lost due to washing, evaporation and immobilization of microbes in the soil.

The number of one plant per hole resulted in the highest average tuber diameter of 4.68 cm. The both relationship according to equation \( y = 0.3039x^2 - 2.1123x + 6.4833 \) \((R^2 = 0.9685)\), showing that the number of plants per hole has a significant effect in increasing tuber diameter. According to Wiguna et al [17], a small number of plants provides the opportunity for plants to absorb more water so as to increase tuber size. Similarly to Basuki [4], the number of tillers is related to the size of the tubers, where large tubers have a smaller number of tillers.

The number of 4 plants per hole resulted in the highest average tuber diameter of 4. The relationship between the two produces the equation \( y = -0.1111x^2 + 0.2222x + 1.3333 \) \((R^2 = 0.992)\), showing that the number of plants per hole has a significant effect in increasing the number of tubers. According to [17], a high number of tillers can produce a high number of tubers as well. This is because each tiller can produce tubers. According to Zulhendi [18], where the greater the number of seedlings per plant hole, the more tillers will be produced.

4. Conclusions and suggestions

4.1. Conclusion

Giving N fertilizer doses up to 180 kg N/ha showed higher growth in plant height and morning and evening stomatal density, with plant height growth of 25.78 cm, morning stomata density 71.86/mm², and density evening stomata 67.03/mm². The effect of N fertilizer dosage on the yield of fresh tubers was 8.48 t/ha.

The number of plants/hole showed different growth and yield. The number of 1 plant/hole showed a higher yield for tuber diameter of 4.68 cm, the number of 2 plants/hole showed a higher growth for plant height by 25.67 cm, and the number of 4 plants/hole showed higher growth for the number of leaves of 9.38 and the root number of 73.56, and the number of tubers. The effect of the number of plants/hole on the yield of fresh tubers was 8.48 t/ha.

The interaction between N fertilizer dosage and the number of plants/hole did not show the real growth and yield of shallot plants.
4.2. Suggestions
It is necessary to carry out further research on shallot plants in coastal sandy land with the same or more varied dosage of N fertilizer with different numbers of plants per hole and added plant distance.

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