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Growth and Yield of Shallots at various Plant Spacing in Ultisol Dry Land

Pertumbuhan dan Hasil Bawang Merah pada berbagai Jarak Tanam di Lahan Kering Ultisol

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ABSTRAK

Dalam meningkatan produksi dan produktivitas bawang merah (*Allium ascalonicum* L.) di lahan-lahan suboptimal seperti lahan kering di Jambi, salah satu upaya yang dapat dilakukan adalah dengan meningkatkan populasi tanaman melalui pengaturan jarak tanam. Penelitian ini bertujuan untuk mengkaji pengaruh berbagai jarak tanam terhadap pertumbuhan dan hasil bawang merah serta mendapatkan jarak tanam yang memberikan pertumbuhan dan hasil bawang merah terbaik. Penelitian ini dilaksanakan di *Teaching and Research Farm* Fakultas Pertanian Universitas Jambi. Rancangan yang digunakan yaitu Rancangan Acak Kelompok (RAK) yang terdiri dari empat perlakuan dengan enam ulangan. Jarak tanam yang diperlakukan adalah: 10 cm x 10 cm; 15 cm x 15 cm; 15 cm x 20 cm; dan 20 cm x 20 cm. Berbagai jarak tanam memberikan pengaruh terhadap pertumbuhan dan hasil bawang merah, dan jarak tanam 15 cm x15 cm memberikan pertumbuhan dan hasil yang lebih baik dibandingkan dengan jarak tanam lainnya, dengan jumlah daun per tanaman, bobot umbi per rumpun, dan bobot per umbi berturut-turut sebesar 22,49; 49,84 g, dan 13,94 g.

Kata kunci: *Allium ascalonicum*, produksi, produktivitas, populasi

ABSTRACT

Plant spacing was one method that could be used to boost plant populations. In order to increase shallot (*Allium ascalonicum* L.) production and productivity on less-than-ideal ground, such as dry land in Jambi. This study aimed to examine the effects of various plant spacing on the growth and yield of shallots and to obtain plant spacing that provides the best shallot growth and yield. This research was conducted at the Teaching and Research Farm, Faculty of Agriculture, University of Jambi. The design used a Randomized Block Design (RBD) consisting of four treatments with six replications. The treated plant spacing was:10 cm x 10 cm; 15 cm x 15 cm; 15 cm x 20 cm; and 20 cm x 20 cm. Various plant spacing affected the shallot growth and yield, and a plant spacing of 15 cm x 15 cm provided better growth and yield compared to any other plant spacing, with the number of leaves per plant, the weight of bulbs per clump, and the weight per bulb of 22, 49, 49.84, and 13.94 g successively.

Keywords: *Allium ascalonicum*, production, productivity, population

INTRODUCTION

Shallots were a vegetable horticultural commodity that was needed, both for household consumption and the food industry. Farmers' incomes increased across the country as a result of the processed food industry's necessity and demand for shallots. Although shallot production for three decades has run into positive growth, shallot imports were still being carried out. During the 2014-2017 period, Indonesia ranked third among ASEAN shallot importers, with an average import of 89 thousand tons. (Ministry of Agriculture of the Republic of Indonesia, 2019).

Efforts were being made to increase shallot production and productivity, which was 9.93 tons per hectare in 2019 (BPS and Director General of Horticulture, 2019). This productivity was much lower than the potential for shallot production which could reach 20 tons per hectare. Therefore, increasing production and productivity needs to be conducted in an effort to meet domestic needs and reduce imports. One way of doing it was through the development of planting areas by utilizing dry land whose availability was quite wide and an increase in plant population per unit area of land. Most of the dry land in Jambi was dominated by Ultisol which in addition to its limited water availability and dependency on rainfall, it was also poor in nutrients. Therefore, increasing the production and productivity of shallots in Ultisol drylands by increasing plant populations needs to pay attention to the constraints of limited availability of water and nutrient elements. Plant spacing intends to increase crop production with increasing plant populations; however, increasing plant populations has an impact on increasing competition among plants for water, nutrients, and other growth factors. According to Amare and Gebremedhin (2020), optimal spacing increases better space utilization, high yields, and quality production.

The study results conducted by Bernhard and Below (2020) on corn show that increasing plant populations by reducing the rows between plants escalates plant biomass, but root biomass does not change. Narrower row spacing helps plants overcome density stress in high populations by changing the plant phenotype to obtain high yields. According to El-Ezz and Haffez (2019), plant density higher than optimal levels results in severe competition among the plants for above-ground light or for underground nutrition, causing plant development to slow down and seed yields to decline. El Sherif and Ismail (2017) discovered in their turmeric plant study that plant spacing of 20 cm x 20 cm produces higher turmeric growth and yield compared to the plant spacing of 40 cm x 40 cm. In contrast, Fatchullah study (2016) on potato plants showed that an increase in plant populations by shortening the plant spacing provides lower potato yields compared to the wider plant spacing.

Plant spacing was one of the factors that determine the efficiency of the use of soil, light, water, and nutrients by plants (Modupeola & Olaniyi, 2015). The results of the study conducted by Deviana et al. (2014) in the Bima variety of shallot plant show that a plant spacing of 10 cm x 15 cm could produce a higher weight of dry bulbs per plot compared to the planting distances of 15 cm x 15 cm and 20 cm x 15 cm. The use of 10 cm x 20 cm plant spacing of Thailand shallot variety grown on clay produces saplings the most and the wet weight of the bulb was the heaviest compared to the plant spacing of 10 cm x 15 cm, and 10 cm x 25 cm (Setiawan & Suparno, 2018). The previous research findings show that the optimal plant spacing for a plant was heavily influenced by the type of plant and its growing environment. Therefore, this study aimed to examine the effects of plant spacing on shallot growth and yield in Ultisol dry land, and to obtain optimal plant spacing able to provide maximum growth and yield.

MATERIALS AND METHODS

The research was carried out at the Teaching and Research Farm, Faculty of Agriculture, Jambi University, with a height of 35 m above sea level. The study used a Randomized Block Design (RBD) with one factor, namely plant spacing with six replications. The trial plant spacing comprised: 10 cm x 10 cm; 15 cm x 15 cm; 15 cm x 20 cm; and 20 cm x 20 cm.

The material used in this study was shallot seedlings of the Bima Brebes variety, with a diameter of a medium-sized bulb of 1.5-1.8 cm, brightly colored seedlings with a shelf life of approximately three months. Planting was carried out by dibbling a depth of ± 5 cm. Before planting, the outer peel of the dried seedling bulbs was cleaned first, and cut off the ends of the bulbs were approximately 1/4 part of the entire bulb.

Before planting, the land was fed with cow manure of 15 ton/ha and 250 kg/ha SP-36. Basic fertilizers were applied by evenly spreading and stirring with the soil conducted one week before planting. Follow-up fertilizers in the form of Urea and KCL were applied twice, namely 2 weeks after planting (WAP) and 4 WAP. The Urea and KCl fertilizers were applied as much as 1/3 dose (first administration), and 2/3 dose (second administration). The provision of dose of Urea and KCl was 200 kg/ha. The fertilizers were applied between the rows of plants. The maintenance of other plants followed the standards of shallot keeping in general.

Observations of plant height and number of leaves per clump were carried out at the age of 6 WAP, while the number of bulbs per clump, the weight of bulbs per clump, and the weight per bulb were carried out at the time of harvest. The data were analyzed using variance analysis and continued with the BNT follow-up test at the level of $\alpha = 5\%$. Pearson's simple correlation analysis used SPPS 16.0.

RESULTS

Plant spacing had an effect on shallot growth in terms of plant height and the number of leaves per clump. The height of the plant and the number of leaves per clump of shallots (Table 1). Table 1 showed that narrow spacing with increasingly dense plant populations results in greater plant heights than wider spacing. The plant height at a row spacing of 10 cm x 10 cm was higher and differed significantly from any other planting distances. This condition did not occur in the number of shallots, the narrow planting distance produced the same number of leaves as the wide planting distance. Row spacing 15 cm x 15 cm yielded the amount of more numerous and significantly different leaves with the row spacing of 10 cm x 10 cm, 15 x 20 cm, and 20 cm x 20 cm. Meanwhile, among various planting distances, the number of leaves was not different, except with a planting distance of 15 cm x 15 cm. The shallot crops in the form of the number of bulbs and the weight of bulbs per clump and the quality of the yield in the form of weights per bulb were significantly influenced by the various trial planting distances (Table 2). Increasing the plant population by narrowing the distance between plants and the distance between rows of plants to 10 cm x 10 cm raised the number of bulbs per clump of shallots. However, this increase in the number of bulbs was not followed by an increase in weight per bulb and the weight of bulbs per clump. The narrower plant spacing resulted in the lower weight of the bulb, in other words, the produced bulbs became small that it could not increase the weight of bulbs per clump. Conversely, too wide planting distances (20 cm x 20 cm) reduced the number of bulbs per clump, the weight per bulb, and the weight of bulbs per clump (Table 2).

Table 1. Plant height and number of leaves per clump of shallots at various plant spacing aged 6 WAP

Spacing	Plant Height (cm)	Number of Leaves per Clump
10 cm x 10 cm	32.07 c	21.05 a
15 cm x 15 cm	31.27 b	22.49 b
15 cm x 20 cm	30.73 ab	20.91 a
20 cm x 20 cm	30.28 a	20.68 a

Note: The numbers followed by the same letter were not significantly different according to the BNT test α = 5%

Table 2. The number of bulbs, the weight of bulbs, and the weight per bulb of shallot at different plant spacing

Spacing	Number of Bulbs per Clump	Weight of Bulbs per Clump (g)	Weight per Bulb (g)
10 cm x 10 cm	4.67 c	44.75 a	12.02 a
15 cm x 15 cm	4.58 bc	49.84 b	13.94 b
15 cm x 20 cm	4.08 ab	50.29 b	12.44 a
20 cm x 20 cm	3.99 a	45.21 a	11.77 a

Note: The numbers followed by the same letter were not significantly different according to the BNT test α = 5%

The results of the correlation analysis showed that the observed variables did not showed a significant correlation, except between the number and weight of bulbs with r = 0.035. However, the plant height was more closely correlated with the number of leaves, compared to the number of the bulbs and the weight of bulbs (r = 0.318; 0.449 and 0.381), meanwhile, the number of leaves correlated more closely with the weight of bulbs compared to the number of bulbs (r = 0.470; 0.696) with the result that the number of leaves largely determined the success of planting shallots with a high bulb weight.

DISCUSSION

The study results showed that the treatment of various plant spacing influenced the growth and yield of shallots. A narrow planting distance of 10 cm x 10 cm resulted in a taller plant height compared to the wider planting distance. These results are in line with the study conducted by Lea et al. (2018) on shallot plants planted during the rainy season, where the use of tighter planting distances also provides taller plant height, as well as the results of Mubarok and Dewi's study (2019) on soybean crops. Tight planting distances (25 cm x 20 cm) on turmeric plants result in higher plant heights compared to the rather wide planting distances (25 cm x 30 cm). This is due to the higher population with tighter planting distances causing competition among the plants and plant parts in obtaining sunlight resulting in etiolation in plants that they tend to grow elongated. Meanwhile, the plant population is much fewer or wider spacing causing each plant to perform at its maximum capacity (Modupeola & Olaniyi, 2015).

The height of the plant is getting higher because the tighter planting distance (10 cm x 10 cm) is not followed by a greater number of leaves. The results of the study conducted by Saidah et al. (2019) on shallot plants planted from the seed origin show that tighter planting distances cause higher plant heights but with fewer leaves. This increase in plant height causes plants to reduce photosynthetic partitions to form a greater number of plant leaves. Dhaliwal and Williams II (2020) state that plant density affects plant architecture, changes growth and development patterns and affects photosynthetic production and partitioning. The plant spacing providing the highest number of leaves to shallots in this study was 15 cm x 15 cm, while the planting distances of 15 cm x 20 cm and 20 cm x 20 cm produced a number of leaves that were no different from the planting distances of 10 cm x 10 cm.

The spacing of 10 cm x 10 cm did not only result in a smaller number of leaves but also results in a lower weight of bulbs per clump compared to any other planting distances. In this case, the leaves as an organ of photosynthesis affected the ability of plants to produce carbohydrates thus affecting the weight of bulbs per clump. Too tight planting distances result in competition between plants not only for sunlight but also for water and nutrients (Diana et al., 2022).

This condition got more and more exacerbated by the dry land type of Ultisol, where water availability was limited and poor in nutrients. According to Welde and Gebremariam (2016), although the regulation of planting distance by narrowing the planting distance aimed to increase the ability of plants to compete with weeds because there is an obstacle to the interception of sunlight due to the plant canopies covering the surface of the field which inhibits the weed growth and suppresses the rate of evapotranspiration, too narrow planting distance increases competition among plants.

This affected the weight per bulb and the number of bulbs produced (Table 2). Setting the planting distance by widening the plant spacing to 20 cm x 20 cm; in this study, actually reduced the growth and yield of shallots. A planting distance of 20 cm x 20 cm provided the plant height, leaf size, bulb weight, and the number of bulbs per clump, as well as the lowest weight per bulb compared to any other planting distances (Tables 1 & 2). The study results are in line with that of Ichwan et al. (2021) on edamame plants, where the wider the planting distance decreases the yield of edamame. Wider spacing aimed to increase plant growth and yield due to the availability of more water, nutrients, and other growth factors. However, if the planting distance is too wide and does not match the morphology and architecture of the plant, it will reduce plant growth and yield. Spacing that is too wide is also not good because this will provide opportunities for weeds to thrive, causing a decrease in plant production and can also reduce the effectiveness of land use. (Probowati et al., 2014). The study results of Nugraha et al. (2021) on shallot plants show that wider planting distances on shallots increase weed growth by increasing their dry weight compared to narrower planting distances. The wide planting distance (1 m x 1.5 m) on watermelon plants resulted in a higher weed cover value (6.66) compared to the narrow planting distance (1m x 0.5 m) with a value of 4.00. This is followed by the wet weight of weeds and higher weed density at wider planting distances. In addition, the weight of the fruit and the diameter of the watermelon producing at a wider planting distance (10.83 kg/ha and 10.18 cm) are much lower compared to the narrower planting distances (23.02 kg/ha and 10.79 cm) (Adenubi & Sanni, 2020).

The results of this study showed that the ideal planting distance for shallots planted on Ultisol dry land was 15 cm x 15 cm and 15 cm x 20 cm, as it provided a different number of bulbs and the weight of bulbs per clump. However, viewed from the weight per bulb produced, the planting distance of 15 cm x 15 cm provided a higher weight per bulb and it was different from the planting distance of 15 cm x 20 cm; in other words, the quality of the bulbs produced with a planting distance of 15 cm x 15 cm was better. The planting distance aimed to provide opportunities for plants to grow well without undergoing much competition in terms of water absorption, nutrients, and sunlight. The use of proper spacing will optimize the utilization of sunlight for the process of photosynthesis by plants and the availability of balanced growing space (Wahyudin et al., 2017).

The productivity of shallots obtained from this study using a planting distance of 15 cm x 15 cm (444,444 plants per hectare) was 22.15 ton/ha. If the land use efficiency was 60%, then the obtained productivity was still quite good, which was 13.29 ton/ha, 1.34 times higher than the national shallot productivity which was only 9.93 ton/ha.

CONCLUSION

The growth and yield of shallot crops are affected by plant spacing. Furthermore, a planting distance of 15 cm x 15 cm can produce better growth, yield, and quality of shallot yields than any other plant, with 22.49 leaves per plant, 49.84 g of bulbs per clump, and 13.94 g of weight per bulb, respectively. Finally, the number of shallots determines the success of shallot planting with a high bulb weight.

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