Planting distance and tuber size affected the productivity of Lansuna local variety of red onion (*Allium ascolonicum* L.)

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Abstract. Shallot Lansuna local variety is trendy among farmers in Minahasa Regency because it is adaptable to all seasons. This study aimed to evaluate planting distance and tuber size on the productivity of local variety onion of Lansuna. It was conducted from April to November 2017 in the Tonsewer Village, Minahasa Regency, using randomized design factorial groups with three replications. The first factor was planting distances of 20 cm x 20 cm and 20 cm x 25 cm, and the second factor was the size of tubers (large, medium, and small). Thus, there were six treatment combinations. The results showed that the planting distances and tuber sizes did not significantly affect the agronomic components (plant height, number of leaves, and number of tubers) and production components (gross weight and net weight). However, the planting distance of 20 cm x 20 cm in combination with larger tuber seeds had the highest yield (26.17 t ha⁻¹) followed by medium tuber seeds (15.79 t ha⁻¹) and small tuber seeds (12.42 t ha⁻¹). The study suggests that Shallot local variety Lansuna should be cultivated using 20 cm x 20 cm spacing distance and larger tuber seeds whenever possible.

1. Introduction

Shallots are some of the leading vegetables that farmers have been working on for a long time. They belong to a group of substitution spices serving as food flavoring seasonings and folk remedies. The quality of tubers becomes a reference for consumers in choosing shallots. It is determined through several criteria, including color, taste density, aroma, and shape [1].

Efforts to increase the production of shallots can be carried out through extensive and intensification of agriculture. Agricultural intensification is an effort to increase agricultural production through the clearing of new farmland. Simultaneously, intensification efforts also increase yields per unit land area with production factors such as soil processing, fertilization, planting distance management, and good maintenance [2]. A cultivation technique that needs to be improved is the setting of planting distance. The density/distance of planting is closely related to the population of plants per unit area, and competition between plants in light, water, nutrients, and space, affecting the growth and yield of tubers [3].

The optimal planting distance for shallot bulbs' production using conventional tuber seeds (4–5 g tubers⁻¹) is 10 x 20 cm or 15 x 20 cm [4]. The recommended planting distances for medium and large seed tubers are 20 x 15 cm and 20 cm x 20 cm. Good seed tubers must be free from disease, not defective, and short.
storage period [5]. Based on its size, shallot seed bulbs can be classified into three seed sizes, i.e., (i) large seed bulbs ($\Omega > 1.8$ cm or >10 g); (ii) medium seed bulbs ($\Omega = 1.5-1.8$ cm or 5-10 g) and (iii) small seed bulbs ($\Omega < 1.5$ cm or <5 g) [6]. Seeds that are too small tend to produce relatively few seeds. In contrast, large seed bulbs can increase production costs because the total weight of the seeds required is higher, even though large tubers have sufficient nutrient reserves to support plants initial growth [7].

Lansuna variety is one of the superior shallots of the region that have been given the protection of crop varieties (PVT) by the central government based on the Decree of the Minister of Agriculture No. 044 /Kpts/SR. 12/D. 2.7/5/2016. Farmers have long utilized this local variety and planted it continuously and traditionally in Tompaso Sub-district (known as Bawang Magelang).

Lansuna red onion variety can adapt to both summer and rain. Thus, the Minahasa government applied for variety protection in 2016. The Lansuna variety has an average plant height of 34.9 cm, leaves numbers of 23.7 per plant, puppies numbers of 6.7 per plant, and weight per tuber of 3.25-15.14 g. Therefore, its yield potential is 13.5 t ha$^{-1}$ tubers. The color of the tubers is bright. Some pests and diseases attacking the local shallots are onion caterpillars (Spodoptera Mauritia, Spodoptera litura, and Spodoptera Exiqua) and withering fusarium caused by Fusarium oxysporum [8].

On the other hand, the percentage of the cost of shallot seeds against the total cost of production is considerable, about 24.1-51.1% [9,10]. This aspect is in line with the idea that the greater the weight of the planted onion bulbs, the higher production compared to the use of seeds with smaller size weights. Meanwhile, shallot seeds in tubers are still limited due to its low propagation ratio and large seed sizes. When seed prices are high, large seed sizes can increase production costs, as bulb seeds are needed, about 1.3-2.6 t ha$^{-1}$ [6]. This condition is mainly the case in varieties with large tuber sizes. Still, it is well-liked by farmers because it has a good market, and it is an example of local Lansuna varieties grown by farmers in the Minahasa Regency.

Traditionally, the Lansuna local shallot is cultivated using a vast planting distance (20 cm x 40 cm) to facilitate easy weeding and directly impact the broad unity (reduced), waste of land, and total production. The size of tubers of this variety is relatively large (2.25-15.14 g), so the need for seeds per hectare can reach 1.2-1.4 t ha$^{-1}$ [8]. The study aimed to evaluate planting distance and tuber size on the productivity of local onion variety of Lansuna.

2. Materials and methods

The research was conducted in the Tonsewer Village, Minahasa Regency (878 meters above sea level), from April to July 2017. The onion bulbs used are Lansuma local variety. The experiment used a randomized design with a factorial group (RAK) with 3 replications and six combinations (including planting distance and tuber size) (table 1). The tuber size was categorized based on tuber weight because large tubers characterize the Lansuna compared to other varieties. The dimensions of the tubers were large tubers (10-15 g), medium tubers (> 5-9 g), and small tubers (3.25- 4 g).

Soil processing was entirely done using tractors. It was flattened and fitted with plastic mulch. Shallot bulbs were planted on a tile measuring 1 m x 10 m (a total of 18). The planting distance was the treatment. Essential fertilizer in the form of organic fertilizer from chicken manure 5 t ha$^{-1}$, NPK Mutiara 300 kg ha$^{-1}$, Phonska 500 kg ha$^{-1}$, KCl 100 kg ha$^{-1}$, and SP-36 100 kg ha$^{-1}$ were applied 7 days before planting [11]. The rest of the fertilizer was divided into 1/3 part and provided in mixing form when the plant was 15, 30, and 45 days of age after planting with a 5 g liter$^{-1}$ dose.

Before planting, shallot bulbs were given fungicide Mancozeb (10 g) for 10 kg of onions to prevent the seed disease's underside. Watering was done twice a day at the beginning of growth. Watering was reduced to once a day as the plants entered their 5th week to match the field's conditions. Weeding was done when the plant was two weeks old after planting, depending on the area's number of weeds.
Table 1. Treatments in the experiment.

| Spacing planting (cm) | Tuber sizes (g) |
|-----------------------|-----------------|
| 20 x 20               | Large           |
| 20 x 20               | Medium          |
| 20 x 20               | Small           |
| 20 x 25               | Large           |
| 20 x 25               | Medium          |
| 20 x 25               | Small           |

Pest controls were made by applying integrated pest management, where if the attack was above 5%, then spraying was immediately carried out with recommended pesticides [11]. Caterpillar was the most common pest in the onion plant. The pesticide recommended to use was abamectin benzoate at 3 g liter⁻¹ with the application of 3 to 4 times every 4 days, while for Fusarium disease was pyraclostrobin 5% + methiram 55% [11]. Harvesting was done when 80% of the leaves have been limp and fallen on the ground. The wet weight of tubers was observed during harvest, while the dry weight of tubers was observed after tubers were dried for seven days in the sun. The observed changes included plant height, number of leaves, number of tubers, gross weight, and net weight in plots measuring 1 m x 1 m. Observation data were analyzed with the F test, while differences between treatments were tested with the Duncan Multiple Range Test (DMRT) at a rate of 5% [12].

3. Results and discussion

3.1. Plant growth components
Tubers began to sprout at seven days after planting even though the growth was not uniform. Plants grew well, fertile, and healthy from the beginning to the end of the planting period. Caterpillars (Spodoptera exigua) attacked the plant at the age of 2 to 3 weeks after planting. The growth of the Lansuna onion plants is presented in table 2.

Table 2. Effects of planting spacing and size of tubers on plant height, number of leaves, and number of tubers at 56 days after planting.

| Space planting and tuber size | Plant height (cm) | Number of tubers (clos) | Number of leaves (strands) |
|-------------------------------|-------------------|-------------------------|----------------------------|
| 20 cm x 20 cm + Large (> 10-15 g) | 50.833            | 5.667                   | 32.100                     |
| 20 cm x 20 cm + Medium (> 5-9 g) | 49.800            | 3.867                   | 22.800                     |
| 20 cm x 20 cm + Small (3.25- 4 g) | 45.467            | 3.200                   | 20.567                     |
| 20 cm x 25 cm + Large (> 10-15 g) | 44.833            | 5.000                   | 26.167                     |
| 20 cm x 25 cm + Medium (>5-9 g) | 44.433            | 3.367                   | 18.867                     |
| 20 cm x 25 cm + Small (3.25-4 g) | 41.300            | 2.767                   | 14.800                     |

Source: Primary data, 2017 processed.

The treatment of planting distance and tubers' size did not significantly affect the plant height, the number of leaves, and the number of tubers (table 2). The interaction between the two factors was not significant (table 2). However, the planting distance treatment of 20 cm x 20 cm combined with different
tuber sizes resulted in a better vegetative growth (plant height, number of leaves, and number of tubers) compared to the planting distance treatment of 20 cm x 25 cm. This result is in line with the statement according to which plants' density has an inseparable relationship with the amount of yield obtained from a piece of land [13]. Furthermore, each unit of the high land area's production can be achieved with a high population due to maximum light use at the beginning of growth [14]. Meanwhile, planting distance usually depends on the type and size of onions and can change based on the soil [15].

The tuber size had a noticeable effect on plant height, where large and medium-size tubers had higher average plant height compared to small-size tuber treatment. The large tuber also affected the number of leaves compared to medium and small tubers. In terms of the number of tubers, the size treatment had a noticeable influence on the number of tubers produced.

**Table 3.** The significant effects of shallot tuber size on agronomic characteristics.

| Tuber sizes | Plant height (cm) | Number of leaves (strands) | Number of tubers (seeds) |
|-------------|-------------------|----------------------------|--------------------------|
| Large (> 10-15 g) | 47.83<sup>b</sup> | 9:13<sup>b</sup> | 5.33<sup>c</sup> |
| Medium (> 5-9 g) | 47.11<sup>ab</sup> | 8:83<sup>a</sup> | 3.61<sup>b</sup> |
| Small (3.25- 4 g) | 43.38<sup>a</sup> | 5:68<sup>a</sup> | 2.98<sup>a</sup> |

Source: Primary data, 2017, processed.
Note: <sup>a,b,c</sup> in a column followed by the same later means there is no significant difference at the 5% level using DMRT.

Large tubers provided the highest number of bulbs compared to medium and small tubers (table 3). This result is in line with research according to which the interaction between tuber size and planting distance does not affect all observed mods. However, large tubers at a planting distance of 30 cm x 30 cm provided higher yields in all tubers and per clump [16]. The large tubers had relatively larger tuber layers with a broader cross-section of roots to increase water and nutrients' absorption ability for plant growth [17]. The large seeds had relatively more nutrient reserves useful as energy formation materials for plant growth [18]. The bulb with large seeds grew better and produced longer leaves. Also, they had a larger area of the leaves, resulting in a high number of tubers per plant total yield [5].

Nevertheless, large seed bulbs are closely related to the total weight of the seeds required. Thus, the cost of production become higher. The weight of planted tubers could provide higher production than seeds with smaller size weights. Meanwhile, the constraints of delivering shallot seeds in large tubers still exist due to the low propagation [6].

### 3.2. Planted components

Lansuna local varieties of shallots, grown by farmers in Minahasa Regency, has a relatively short harvest life compared to other varieties. The harvest age is between 56 and 60 days after planting. Meanwhile, this variety of shelf life is 3-4 months [19]. Harvesting to produce tuber seeds takes longer than harvesting for tuber consumption. Harvesting is carried out on plants whose stem base is already limp, and most of the leaves have been limp and dry with tubers popping upwards.

Based on the field observations, the interaction between planting distance and tuber size did not significantly influence gross weight and net weight proxy components (table 4). The interaction between large tuber sizes in two different planting distances had a higher tendency to value than medium and small tuber sizes (table 4). Meanwhile, the large tuber size significantly influenced the average gross weight and net weight compared to medium and small tubers (table 5).
Table 4. Effects of planting distance and shallot tuber size on gross weight at 56 days after planting and net weight at 70 days after planting.

| Planting distance and tuber size | Gross weight (t ha\(^{-1}\)) | Net weight (t ha\(^{-1}\)) |
|---------------------------------|-------------------------------|-----------------------------|
| 20 cm x 20 cm + Large (> 10-15 g) | 38.473                        | 30.913                      |
| 20 cm x 20 cm + Medium (> 5-9 g) | 27.453                        | 19.807                      |
| 20 cm x 20 cm + Small (3.25-4 g) | 20.933                        | 15.473                      |
| 20 cm x 25 cm + Large (> 10-15 g) | 32.677                        | 21.440                      |
| 20 cm x 25 cm + Medium (> 5-9 g) | 17.445                        | 11.781                      |
| 20 cm x 25 cm + Small (3.25-4 g) | 14.224                        | 9.376                       |

Source: Primary data, 2017, processed.

Table 5. The significance of the effect of shallot tuber size on production components.

| Tuber Sizes  | Gross weight (t ha\(^{-1}\)) | Agronomic Characteristics | Net weight (t ha\(^{-1}\)) |
|--------------|-------------------------------|---------------------------|-----------------------------|
| Large (> 10-15 g) | 35.37\(\text{b}\)       | Gross weight              | 26.17\(\text{b}\)       |
| Medium (> 5-9 g) | 10.44\(\text{a}\)     | Agronomic Characteristics | 15.79\(\text{a}\)     |
| Small (3.25-4 g) | 5.57\(\text{a}\)      | Net weight                | 12.42\(\text{a}\)      |

Source: Primary data, 2017, processed.
Note: \(\text{a, b, c}\), in a column followed by the same later means that there are no significant differences at the 5% level by DMRT.

Large size of tuber had the best growth and production [20]. The growth of onion plants deriving from large tubers will provide better growth than seeds with relatively smaller physical size [21]. Other opinions suggested that large physical sizes have excellent growth potential [22]. Thus, the number of leaves to be formed will increase compared to small seedlings [23]. The increasing number of leaves will, in turn, increase the rate of photosynthesis, thereby affecting the growth and production of plants [24].

The production of shallots is influenced by varieties [25]. Each type has different potential results and characters [26]. Lansuna shallots, derived from the introduction of the Philippine, bear a resemblance to the Sembrani varieties reviewed in Tompaso Sub-District in 2017. Lansuna variety have the advantage of growth components and yields over other types. The study results using mixed tubers, Lansuna production can reach 22 t ha\(^{-1}\) while Sembrani 20 t ha\(^{-1}\) [19,27]. Although the results of these two varieties are not much different, Lansuna gaze is still preferred by consumers because it is spicier, smells more intense with a brighter color than Sembrani (less bright color).

High yields were observed in all components of large seed tubers' results, meaning that the quality of good seedlings much determined the plant's production. As mentioned in previous research, large seed bulbs produced good growth of all observed components, highly determined by the seed quality. High plant growth and production will not be achieved even if the production facilities were used the maximum with planting material in the form of low-quality seedlings.

4. Conclusions
The interaction between planting space and tuber size did not significantly influence all observed variables. The large tuber size significantly affected all observed variables, namely plant height, number of leaves, number of tubers, gross weight, and net weight. Although there was no significant difference between planting space and the size of tubers, the use of large tubers at a planting space of 20 cm x 20 cm had the
highest trend value of some combination of treatment of all observed variables. The highest net weight obtained from treatment using large tubers was 26.17 t ha\(^{-1}\), followed by medium tubers 15.79 t ha\(^{-1}\) and small tuber 12.42 t ha\(^{-1}\).

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