The Effect of True Shallot Seed (TSS) Varieties and Population on Growth and Bulb Yield

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ABSTRACT

**Background:** The purpose of this research was to evaluate the growth and bulb yield of shallot (*Allium cepa L.*) varieties grown by TSS with different population.

**Methods:** This study was carried out in the low dry land at Laleten Village, Malaka District, NTT Province, Indonesia, from March to August 2018. We investigated different plant populations per planting hole using a split-plot design with two factors and four replications. The main plot was the varieties (Trisula and Bima Brebes) and the subplots were the seedling population (100, 200 and 300 plants/m²).

**Result:** There was no interaction between varieties and population for any of the measured parameters. The population only affected the plant height at the beginning of plant growth. A high plant population (300 plants/m²) gave the highest production of single bulbs but was negatively correlated with the bulb weight. Trisula variety produced significantly more single bulbs than the Bima Brebes one. The establishment of the TSS-adapted varieties could be recommended in this area.

**Key words:** *Allium cepa L.*, Bulb yield, Plant density, TSS.

INTRODUCTION

The use of TSS as a planting material aims to reduce the problem of a limited supply of suitable quality and price bulbs in the peak planting season. In Indonesia, this season generally occurs in February to May and September to December every year (Rosllani et al., 2014). Shifting from bulbs to seed as a planting material makes it easier to transport them to central areas, minimize the transmission of parents viruses, reduce both of high cost production and storage constraints (Prayudi et al., 2014; Darma et al., 2015; Sopha et al., 2014).

At present, TSS has been widely used as planting material for producing consumption tuber because it can double the yield, giving a net income of 22 to 70 million rupiahs per ha, which is higher than the net income for the traditional bulb. In addition, productivity can reach 14.9 t/ha, with R/C and B/C ratios of 3.15 and 2.15, respectively (Basuki 2009; Sumarni et al., 2012; Van Den Brink and Basuki 2012; Rahayu et al., 2019).

Indonesian Government through The Ministry of Agriculture has declared the Export Based Food Storage in the border areas including Malaka district under Nusa Tenggara Timur (NTT) Province that close to The Democratic Republic of Timor-Leste. Government has provided some budget for establishing shallots in Malaka District as a new production centre. Recently, planting area of shallots in NTT is 1,256 hectares with the production of 4.54 tons. Nevertheless, its productivity is still low (about 8 tons/ha). In dry area of Laleten, Malaka District, the estimated productivity of fresh bulbs per hectare for Tuk Tuk, Sanren, Bima Brebes and Trisula varieties of TSS were 5.28, 6.05, 8.41 and 7.97 tons, respectively (Devy et al., 2020). Therefore, implementation of innovation technology such as a superior variety, optimal nutrition, control of pests and diseases optimally and increasing the density of plants are required (Awas et al., 2010; Biru 2015; Shimeles 2014).

Given the influence between the planting density and environmental factors on plant growth and production of shallots, it is necessary to pay particular attention to improve agricultural practices management (Askari-Khorasgani and Pessarakli 2019; Aini et al., 2020). Bosekeng and Coetzter (2015) and Gogoi et al. (2016) reported that increasing planting density treatment significantly affects plant growth, fresh bulb mass, bulb diameter, bulb firmness and production. The purpose of this research was to evaluate the growth and bulb yield of two superior shallots (*Allium cepa L.*) varieties grown by TSS with a different population.

MATERIALS AND METHODS

The research was conducted at Laleten Village, Malaka District, NTT Province, Indonesia, from March to August 2018. This area is located at an altitude of 55 m above sea...
level and has a monthly rainfall of 0 to 1,435 mm, an average temperature of 24-34°C and a dry tropical climate (Devy et al., 2020).

TSS varieties used were Trisula and Bima Brebes. Seeds were sown in beds (1 × 1.5 m) with a height of 30-40 cm. The soil media was processed until loose and then mixed with dolomite lime (150 g/m²), manure (2 kg/m²) and NPK 16-16-16 as a basic fertilizer (50 g/m²). The plot was leveled and kerfs cut (1-2 cm deep) at 10 cm intervals. The selected seedlings were transplanted after four weeks of sowing.

Twenty-four to two m² plots were prepared. The loosened soil was mixed with manure (5 kg/plot) seven days before planting. A basic NPK 16-16-16 fertilizer (25 g/plot) was applied 1-2 days before planting. Watering, weeding and pest and disease control were carried out intensively. Additional a NPK 16-16-16 fertilizer was applied (37.5 g/plot) on day 15 and day 30 and KCl white fertilizer was applied (20.0 g/plot) on day 30 and day 45 after transplanting. Plant spacing used was 10×10 cm so that one plot consisted of 200 planting holes (100 holes/m²).

The experimental design was a split-plot with two factors. The main plot was TSS variety consisting of two levels: (V₁) = Trisula and (V₂) = Bima Brebes. Subplots were the number of seedlings per planting hole or population per m², consisting of three levels: (P₁) = 1 plant/hole or 100 plants/m², P₂ = 2 plants/hole or 200 plants/m² and P₃ = 3 plants/hole or 300 plants/m². Each treatment was arranged with four replications.

Growth parameters of the shallots were measured for ten randomly selected and pre-tagged plants in each plot. The measurement of vegetative phase was done on plant height, leaf number per clump and leaf number per plant; whereas for the generative phase, bulb performance (single, double, multiple), number of bulbs per plot, fresh bulb weight per plot and fresh bulb weight per plant were determined. The data were analyzed using the analysis of variance (ANOVA) and Tukey methods and 95.0% confidence. Pearson Correlation coefficients as well as Coefficient Determination (R²) were also determined for the linked parameters. All data analysis was done with the Minitab 16 software.

RESULTS AND DISCUSSION

Plant height

Plant height at the beginning of growth was only significantly affected by the population treatment. The tallest and shortest plant heights were 16.0 cm for P₃ and 14.0 cm for P₁. Crowded plants resulted in competition for nutrients and sunlight, making the plants grow taller and etiolated to exploit light to the maximum in dense plant populations. Moreover, Irawan et al. (2018) mentioned that the positive effect of population on vegetative growth is related to the capability of the plant to adapt with all growth factors so that it can reach maximal growth.

Number of plants per clump

A shallot plant produces bulbs, each of which grows and has its leaves. It develops as a tiller, which gather in clusters (clump). Number of tillers per clump was only significantly affected by the population. There was a positive correlation (r = 0.904*) between population (X) and tiller number per plot (Y). (Y = 0.659 + 0.818 X; R² = 0.818*). However, if counted per plant, the highest total tiller number was for the P₁ (100 plants/m²) treatment (Table 1).

Leaf number per clump

Total leaf number per clump was only significantly affected by the plant population at two to eight weeks after transplanting. A shallot plant produces bulbs, each of which grows and has its leaves. It develops as a tiller, which gather in clusters (clump). Number of tillers per clump was only significantly affected by the population. There was a positive correlation (r = 0.904*) between population (X) and tiller number per plot (Y). (Y = 0.659 + 0.818 X; R² = 0.818*). However, if counted per plant, the highest total tiller number was for the P₁ (100 plants/m²) treatment (Table 1).

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**Table 1: Effect of varieties and population on tiller number per clump and plant.**

| Treatments   | No. tillers/clump (wat) | No. tillers/plant (wat) |
|--------------|-------------------------|-------------------------|
|              | 2 | 4 | 6 | 8 | 2 | 4 | 6 | 8 |
| **Varieties**|   |   |   |   |   |   |   |   |
| V₁           | 1.97 a | 2.00 a | 1.97 a | 2.23 a | 0.99 a | 1.00 a | 1.07 a | 1.20 a |
| V₂           | 1.96 a | 2.00 a | 2.08 a | 2.36 a | 0.99 a | 1.00 a | 1.02 a | 1.23 a |
| **Population**|   |   |   |   |   |   |   |   |
| P₁           | 1.00 c | 1.00 c | 1.16 c | 1.45 c | 1.00 a | 1.00 a | 1.16 a | 1.45 a |
| P₂           | 1.98 b | 2.10 b | 1.99 b | 2.35 b | 1.00 a | 1.01 a | 1.01 a | 1.20 ab |
| P₃           | 2.92 a | 3.01 a | 2.94 a | 3.09 a | 0.98 a | 1.00 a | 0.99 a | 1.01 b |
| R²           | 0.996 | 0.999 | 0.957 | 0.910 | 0.636 | 0.478 | 0.483 | 0.649 |

Note: V₁: Trisula; V₂: B. Brebes; P₁: 100 plants/m²; P₂: 200 plants/m²; P₃: 300 plants/m².

Different letters indicate significant differences between means (p ≤ 0.05). wat: weeks after transplanting.
transplanting (Fig 2). The P₃ treatment had the highest leaf number per clump because the plant population per planting hole was the greatest. The total number of leaves was positively correlated (r = 0.93*) with the number of tillers (R² = 0.87*). The higher the number of tillers, the higher the number of leaves produced. However, the highest of leaves number per plant was at P₁ treatment (Table 2).

Vegetative growth performance was generally similar to previous research (Sumarni et al., 2012). In contrast, according to Dawar et al. (2007), the increasing of plant population by 100% would induce their plant height significantly. However, research carried out by Gessesew et al. (2015) stated that N fertilizer and levels of spacing treatments also affected the onion performance. This latter result corresponded with other studies (Kishor et al., 2017; Kahsay et al., 2014; Ngullie and Biswas 2017). The reason for the higher number of leaves and tillers per plant in a less dense population is thought to be due to the lack of competition between plants for the main factors supporting growth.

### Percentage of productive plants

The percentage of plants per plot that grew and produced bulbs was only significantly affected by the plant population treatment (R² = 0.756*), it was about 55 to 75% and (Fig 3). Increasing the population in a planting hole results in competition for water, light and nutrition. Because of a bundle of fibrous roots extending only for a short way into the soil, any factors that cause a sub-optimal environment quickly affect the growth and development of the plants, the formation of bulbs and ultimately the production. Plants in the P₁ treatment performed better than those in the other treatments. This was the outcome of better access to nutrition and lower levels of competition. This implies that a denser population leads to a reduction in the number of plants that grow and produce normally.

#### Table 2: Effect of varieties and plant population on leaf number per plant.

| Treatments | Total of leaves/plant (wat) |
|------------|-----------------------------|
|            | 2  | 4  | 6  | 8  |
| **Varieties** |        |    |    |    |
| V₁         | 2.24a | 4.95a | 5.99a | 7.29a |
| V₂         | 2.22a | 4.36a | 5.75a | 7.64a |
| **Population** |        |    |    |    |
| P₁         | 2.34a | 5.53a | 7.69a | 10.40a |
| P₂         | 2.27ab | 4.13a | 5.31b | 6.68b |
| P₃         | 2.10b | 4.30a | 4.63b | 5.34b |
| R²         | 0.747* | 0.570 | 0.778* | 0.903* |

Note: V₁: Trisula; V₂: B. Brebes; P₁: 100 plants/m²; P₂: 200 plants/m²; P₃: 300 plants/m². Different letters indicate significant differences between means (p ≤ 0.05). wat: weeks after transplanting.

![Fig 2: Leaf number per clump 2 to 8 weeks after transplanting. P₁: 100 plants/m²; P₂: 200 plants/m²; P₃: 300 plants/m².](image2)

![Fig 3: The average percentage of plants which grew and developed normally.](image3)
**Bulb performance**

The percentage of plants that produced single or multiple bulbs was only significantly affected by the variety and population separately, which Trisula and P₃ treatments had significantly more single bulbs than Brebes and other population-treatments, respectively (Table 3; Fig 4).

**Table 3**: Percentage of single and multiple bulbs per plot.

| Treatments | % single and multiple bulbs per plot |
|------------|-------------------------------------|
|            | single | 2  | 3  | 4  |
| **Varieties** |       |    |    |    |
| V₁         | 57.5a  | 40.0b| 2.4b|0.003a|
| V₂         | 29.8b  | 56.5a|13.2a|0.032a|
| **Population** |     |    |    |    |
| P₁         | 23.9b  | 58.9a|16.7a|0.032a|
| P₂         | 47.4a  | 47.7ab|4.7b|0.018a|
| P₃         | 59.7a  | 38.3b|2.0b|0.004a|
| R²         | 0.911* | 0.813*|0.873*|0.402|

Note: V₁: Trisula; V₂: B. Brebes; P₁: 100 plants/m²; P₂: 200 plants/m²; P₃: 300 plants/m². Different letters indicate significant differences between means (p ≤ 0.05).

It seems that variety has genetically response to environment as well as cultural practices. Ramanjaneyulu et al. (2017) reported that the difference of genotypes is mostly due to their growth, expression, root characters, photosynthetic efficiency and tolerance to moisture stress as well. Physiological processes such as growth and development, are principally impacted by the environmental conditions, such as photoperiod, temperature, the wavelength of light, density, water stress, nutrients and growth hormones. However, the plant’s genetic character is also a factor. In shallot, the AcFT1 and AcFT4 genes promote and inhibit bulb formation, respectively (Khokhar 2014; Shimeles 2014; Abdissa et al. 2011). According to Masuzaki et al. (2007), a gene or genes that could inhibit the bulb formation and stimulate side shoot formation in the shallot plant may be located on chromosome 2A.

The size of the bulb produced was only affected by the population (Table 4). There was a negative correlation (r = -0.882*) between bulb weight and population. A greater plant population decreased the bulb size (R² = 0.788*). We also observed that the percentage of multiple bulbs (Y) was positively correlated (r = 0.704*) with bulb size (X) (Y = -2.6 + 4.75 X; R² = 0.495*). This indicated that reducing the population (Pᵢ), would trigger the formation of multiple bulbs in response to the environment.

**Yields: the weight and total number of marketable bulbs per plot**

The weight and number of marketable bulbs per plot were only significantly affected by the population. We found positive correlations between the total number of marketable bulbs with population number (r = 0.85*) and the weight of bulbs per plot with population number (r = 0.48*) (Table 5). The Pᵢ treatment yielded both the highest number of bulbs (356 bulbs) and the highest total mass of bulbs (3,306g per plot). In terms of variety, bulb weight of 2,840g and 2,726g and total marketable bulbs per plot of 256 and 231 were found for Trisula and Bima Brebes, respectively.

**Table 4**: Average bulb size.

| Treatments | Size/bulb (g) |
|------------|--------------|
| **Varieties** |       |    |
| V₁         | 12.06 a     |   |
| V₂         | 12.76 a     |   |
| **Population** |     |    |
| P₁         | 16.52 a     |   |
| P₂         | 11.40 b     |   |
| P₃         | 9.31 c      |   |
| R²         | 0.788*      |   |

Note: V₁: Trisula; V₂: B. Brebes; P₁: 100 plants/m²; P₂: 200 plants/m²; P₃: 300 plants/m². Different letters indicate significant differences between means (p ≤ 0.05).

**Table 5**: Correlation between yield and growth parameters.

| Parameters          | Total numbers of marketable bulbs/plot | Weight of bulbs/plot |
|---------------------|----------------------------------------|----------------------|
|                     | Pearson correlation (r) | P-value | Pearson correlation (r) | P-value |
| Number of tillers   | 0.795*                     | 0.00    | 0.440*                 | 0.031   |
| Number of leaves    | 0.748*                     | 0.00    | 0.459*                 | 0.024   |
| Population          | 0.845*                     | 0.00    | 0.480*                 | 0.018   |
| Average bulb weight | -0.735*                    | 0.00    | -0.219                 | 0.303   |

**Fig 4**: Single and multiple bulbs of Trisula and Bima Brebes.
Derived TSS-shallot yield was significantly and positively correlated with the number of tillers, the number of leaves and the population and negatively correlated with the average bulb weight (Table 5). Increasing the population per plot would increase in the number of tillers and leaves as a source of photosynthesis, enhance their productivity and increase the yield per hectare. For Bima and Trisula, the estimated production of bulbs was 7.45 t/ha and 7.03 t/ha, respectively. However, the size of the bulbs was negatively correlated ($r = -0.735^*$) with the total number of bulbs. Thus, smaller individual bulb size is essential in maximizing the total number of productive shallots per unit area (Fig 5). These findings were in line of other studies (Maintang et al., 2019).

CONCLUSION

Shallot varieties treatments only affected on bulb production. In terms of population, on the vegetative phase, it affected significantly on the number of tillers and the total number leaves per clump. In the generative one, this treatment was negatively correlated with the percentage of productive plants per plot and the bulb size produced. The application of shallot cultivation using the TSS superior varieties could be recommended in this area.

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