Performance of shallot (*Allium cepa* var. ascalonicum) derived from true seed under a dry condition area

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**Abstract.** To reduce the dependence of bulbs as planting material, the innovation technology of shallot (*Allium cepa* var. ascalonicum) cultivation with using true shallot seed (TSS) as planting material was tried. Four cultivars namely Bima Brebes, Trisula, Tuk Tuk, and Sanren were planted at Laleten Village, Malaka District, from April to December 2018. TSS seedlings were raised with a 10x15cm planting spacing or 2,000 plants/30m². The aim of this research was to evaluate the using TSS at the shallot cultivation in the areas where the farmers have never carried out such technology. The vegetative growth of all varieties is not significantly different. The productive plants are range from 70 to 75% of population, which the highest was Trisula. The bulbs number/plant highest in *Bima Brebes*. The number and fresh bulbs weight/bed were 2,293 – 4,601 bulbs and 19.8 – 31.5kgs, respectively. Bulbs weight loss during storage was about 48-65%, which the driest bulbs was Tuk Tuk. The estimated of fresh production was only 5.28 to 8.41 tons/ha. It means that in dry conditions with farmers have not mastered yet on shallot cultivation by using TSS as planting material, the productivity only reaches 20-40% of the production capacity.

**1. Introduction**

In Indonesia, based on its production the shallot (*Allium cepa* var. ascalonicum) is the main vegetable plant besides cabbage, red chili, potatoes, and chili. In the period of 2011-2015, the average growth of harvested area this commodity nationally was 7.16% per year with 122,126 ha and 1.23 million tons of its production [1]. In 2017, the area was 158,172 hectares with production of 1.47 million tons (9.29 tons/ha). Increasing in its production, shallots can be exported around 6.48 thousand tons with a value of 8.81 million US dollars [2]. Besides West Nusa Tenggara Province, the dominance of production center is still on Java, such as Central Java, East Java and West Java with contribution of 77.89%. If the farmers were using bulbs as planting material, at least 150,000 -189,600 tons of them are needed.

The scarcity of high-quality and quantity of bulbs as planting materials needed is a common problem faced by shallot farmers. According to Basuki [3], to get the high-quality harvested bulbs, some of them were using imported one. So that to decrease the costs required for producing shallots, cultivation technology which using botanical seed or true shallot seed (TSS) must be introduced.

TSS as a planting material has not been widely used by farmers because farmers have not mastered in the way of this cultivation technology. Farmers have not yet believed in the magnitude of its added
value if it compared by using bulbs that farmers usually do [3]. But with increasing time, this technology began to be accepted by some of them [4].

Initially, this technology was used only to produce small bulbs derived from seed; and then those bulbs were used by farmers as a planting material on shallot cultivation [5-7]. However, in the following years, many farmers used this seed directly as a bulbs substitute, which was sown and then the seedlings planted to produce commercial bulbs. According to Pangestuti and Sulistyaningsih [8], this seed could use as a potential planting material because farmers have several advantages, including less need (3-7.5 kg/ha), cheaper, more easily on storage management, low variation and high productivity. Although the duration of harvesting time will be 19 - 26 days longer than the traditional one, the weight of bulbs produced is significantly 2 times higher and larger in their size [3]. So that using TSS is considered economically feasible because it can increase net income between 22-70 million rupiahs per hectare compared to the traditional one.

The results of the study on increasing of bulbs production by using TSS technology in Indonesia have also been extensively published. In general, the production is largely determined by the variety, fertilizer application, plants spacing, growth regulator substances and others [9-14]. In a suboptimal area such as on red yellow latosol, this method also can be applied [15]. The purpose of this study was to evaluate the production of shallots by using TSS as the planting material in the dry area of Laleten Village, Malaka District, NTT Province, where farmers have never done this technology.

2. Materials and Methods

2.1. Description of the research area

The research was conducted at a dry Laleten Village, Sub-district Weliman, Malaka District, NTT Province-Indonesia. In the eastern part of the sub-district, there is the Benanain River that uses as a source of water for agriculture in this region. Laleten is located at an altitude of ± 55m above sea level. The site is situated at latitude of -9°37′S and longitude of 124°52′E. In 2013 and 2014, the monthly rainfall was range 0-305 mm/month and 0-1,435mm respectively, while the average temperature was 24 - 34°C with tropical climate. The rainy season extends from January to June with maximum rain received in the months of May to June (2013) (Figure. 1). The main commodities in this area was generally maize, while the shallot is a newly developed one by local government, so the knowledge of its cultivation technology is relatively few.

![Figure 1. Monthly rainfall of Laleten (2013-2014) and Malaka District (2015-2017) [16-17].](image)

2.2. Land Preparation, Experimental Design and Planting

The research was conducted in the rainy and dry seasons (April-August; August-December) 2018. The field was ploughed and debris removed. Decomposed manure was added into the soil to increase the organic matter before raising the beds. The field was divided into 3 blocks (as replications), and every
block contained beds that having a dimension of 1.0 m x 30m. Beds were separated from each other by
an alley of 0.30m while the blocks were separated from each other by a distance of 0.5m. Two days
before planting, the soil was given fertilizer 0.375kg NPK (16-16-16) per bed and split application with
the same dose was used at the age of 30 and 45 days after transplanting, and white KCl 1.2g per litter.
The experiment is laid out in randomized block design (RBD) with 3 replications. The following TSS
cultivars Bima Brebes, Trisula, Tuk Tuk and Sunren were used as the treatment. Bima Brebes and Trisula
seed were obtained from Indonesian Center for Horticultural Research and Development and the rest
were bought at public market.

Seedlings of all the cultivars were raised in shading bed and transplanted after 30 days into
experimental plots. The seedlings were planted on a bed size of 1.0 x 30.0 m with the plant spacing was
10 x 15cm (2,000 plants per bed). Control of insect pests and diseases were carried out according to the
symptoms and for weed control was done two times; when there was no rain, plants were irrigated
manually. The bulbs were harvested at 12 weeks after planting. Storage of them were done simply by
hanging it in farmers wood-house ceiling, and weighed after 3 months later (December 2018).

2.3. Data Collection

Plant height was measured in centimeter from the soil surface to the tip of matured leaf in the plant using
a ruler. Leaf numbers were obtained by counting their total numbers plant\(^{-1}\). The data were collected
every two weeks starting from 2 to 6 weeks after transplanting. Ten plants per replicate were considered
as representatives to obtain the average data. At harvest, total number of bulbs per bed, bulbs weight in
bed and per plant also bulb performance (mono, multiple) were obtained by counting and manually
weighing with an electronic balance.

2.4. Statistical analysis:

Data was subjected to analysis of variance using Minitab Statistical Software package version 16. Means
that differed significantly was separated using the DMRT test procedure at % level of significance.
Pearson Correlation coefficients were determined for parameters using the same software.

3. Results and Discussion

3.1. Category of Laleten Village area:

According to [18] that suitability class land for shallot was determined by its characteristics and the
requirements for plants growing (Table 1). So that, based on those criteria, Laleten is included at least
in the S2 category (moderately suitable, Table 2).

| Terms of Use/Land Characteristics | Land suitability class |
|----------------------------------|-----------------------|
|                                  | S1        | S2        | S3        | N         |
| Annual Average Temperature (°C)  | 25 - 28   | >28 -31   | >31 - 33  | >33       |
|                                  | 23 - <25  | 21 - <23  | <21       |           |
| Annual Rainfall (mm/year)        | 1,400     | >1,400-1,700 | >1,700-2,500 | >2,500 |
| (<100mm/month)                  | 4-6       | >6        | <4        | <2        |

The limiting factor that affects the productivity of shallots in Laleten is mean temperature, annual
rainfall and duration of dry month (Table 2). In the dry season (August to October 2014) the amount of
rainfall in one planting season is very less for shallots growing, which is 0 mm. Most efforts to
overcome the water deficit are by watering them manually and selecting varieties that are resistant to drought.

| Land characteristic of Laleten (in 2014) | Category |
|----------------------------------------|----------|
| Mean temperature (°C)                  | 24 - 34°C | S2    |
| Annual rainfall (mm/year)              | 900 mm/year | S2    |
| Total rainfall in one season (3 months: May-June) | 364 mm | S1    |
| Duration of the dry month (<100mm/month) | 9 | S2    |

### Table 2. Category of Laleten Village based on its land characteristics.

#### 3.2. Plant height and leaves number

Generally, vegetative growth among four cultivars of TSS plants was not significantly different (p < 0.05). Up to the age of 6 weeks after transplanting, *Bima Brebes* and *Trisula* varieties tend to be slightly higher than *Tuk Tuk* and *Sanren*. In the case of number of leaves, there was no any significantly different between cultivars (Table 3).

| Varieties | Plant Height (cm) | Leaves Number |
|-----------|-------------------|---------------|
|           | 2                | 4             | 6             | 2     | 4     | 6     |
| Bima Brebes | 14.2 ns          | 26.0 ns       | 42.8 ns       | 4.4 ns | 8.2 ns | 10.5 ns |
| Trisula    | 15.4             | 27.1          | 45.5          | 4.2    | 8.8    | 11.2   |
| Tuk Tuk    | 16.8             | 24.7          | 37.5          | 5.4    | 7.9    | 11.2   |
| Sanren     | 16.6             | 25.3          | 38.7          | 5.3    | 8.0    | 11.2   |

ns: not significantly different according to DMRT at 0.05 level

The varieties often make a difference in the ability of plants to grow and develop. According to Saidah *et al.* [19] the height and number of leaves of the *Sanren* and *Lokanata* varieties at Sigi Regency, Central Sulawesi was not significantly different, however the *Sanren* was relatively better. The high and number of its leaves was 44.53 cm and 10.16 while another variety was 43.62 cm and 9.32 respectively. This reflects that each variety is influenced by genetic factors in case of the adaptability to local condition.

#### 3.3. Percentage of productive plants:

Not all plants would develop optimally and have bulbs that can be harvested at that location. Productive plants only range from 71 to 75%, with cultivar *Trisula* relatively better than others (Figure. 2).

Unproductive plants which do not produce bulbs are due to their genetic traits that affect morphological characters. The suboptimal environmental condition and agronomic practices such as fertilization and irrigation can also have a significant impact on biomass, leaf area index, cell turgor and chlorophyll concentration [9, 20]. The attack of pests, diseases and their inability to compete with weeds encourages the crop damage. This is due to the character of its slow growth, shallow’s roots, and thin-cylindrical upright leaves that is unable to suppress weed growth by its shading.

#### 3.4. Bulb characters

**3.4.1. Color.** The fresh harvest bulbs of shallot produced from the TSS plants were varied in color and size; *Trisula* cultivar color was redder than others, while most of *Tuk Tuk* has a smaller size due to single bulb character (Figure. 3).
Genetic factors affect the diversity of plant and shallot bulbs performance, the need for day length, harvest age, physiological changes during storage, size, shape and color of bulbs produced [20]. According to Irianto et al. [21] three varieties of shallot namely Bima Brebes, Bauji, and Bangkok which are cultivated in Ultisol have different physiological characteristic such as Net Assimilation Rate (NAR), Specific Leaf Weight (SLW), Leaf Area Index (LAI), Crop Growth Rate (CGR), and Leaf Area Ratio (LAR) that can make the difference in their response into phosphate fertilizer. While the physico-chemical parameters, such as diameter, length, weight, fat total, carbohydrate, crude fiber, starch content, antioxidant capacity and quercetin also different significantly on the ten selected cultivars that have released as the Indonesia New Superior Varieties [22]. According to Solanki et al. [23], from all its characters, the one that greatly influences the preferences of customers in choosing cultivars in the market are bulbs shape and color.

3.4.2. Mono and multiple bulbs. Among four varieties grown, Tuk Tuk produced almost mono bulbs, while Bima Brebes and Sanren have also multiple ones that consisted of two to four bulbs (Figure. 4). The differences in ability between varieties in producing a single bulb or more due to their genetic character [24-25].

3.5. Bulbs yield
Total number and bulbs weight. The total number of bulbs per plant was significantly different ($p <0.05$) between Bima Brebes and Tuk Tuk. Based on its weight, the largest and smallest bulb sizes were Trisula and Sanren, respectively. However, both of fresh weight per bulb and bulb per bed are not significantly different among four varieties (Table 4).
Figure 4. Percentage of single and multiple bulbs on four TSS cultivars.

The bulbs size is negatively correlated \((r = -0.433)\) with their total number per plant \((Y = -11.0 - 1.36 X; R^2 = 0.188)\); the greater the number of bulbs per plant, the smaller of one bulb size it produces. The bulbs weight of cv. Brebes and cv. Tuk Tuk in the rainy season reached 18.3 and 15.8g per plant respectively [9], however in this experiment were 21.4 and 13.5 g per plant. This due to the difference of environment conditions. Bulbs shallot produced from plants that are cultivated in areas with low moisture regime soil, generally have smaller size compared with that is done at the optimal condition [20].

Table 4. The average number of total bulbs/plant, fresh weight/bulb, number of bulbs/bed, and bulbs fresh weight/bed

| Cultivars     | Total of bulbs number/plant | Fresh weight/bulb (g) | Total number of bulbs/bed | Bulbs fresh weight/bed (kg) |
|---------------|------------------------------|------------------------|---------------------------|-----------------------------|
| Bima Brebes   | 3.1a*                        | 6.8a                   | 4.601a                    | 31.5 a                      |
| Trisula       | 2.3ab                        | 9.4a                   | 3.372ab                   | 29.9 a                      |
| Tuk Tuk       | 1.6b                         | 8.7a                   | 2.293b                    | 19.8a                       |
| Sanren        | 2.4ab                        | 6.2a                   | 3.547ab                   | 22.7a                       |

*In the column with the same letter are not significantly different according to DMRT at 0.05 level.

3.6. Total bulbs, weight per bed and estimated yield per hectare

Generally, bulbs production of all cultivars is not different significantly. In this area, the estimated of fresh weight bulbs production/ha reached only 5.28 and 6.05 tons for Tuk Tuk and Sanren, while the rest were 8.41 and 7.97 tons for Bima Brebes and Trisula respectively (Table 5).

This yield is still very low compare with their production capacity. From the description, all planted cultivars have well adaptability character on the low land, with their fresh weight production range would be between 6-30 tons/ha (Table 6).
Table 5. The average number of bulbs/bed, fresh weight/bed and estimated bulbs fresh weight/ha

| Cultivars     | Total number of bulbs/bed | Bulbs fresh weight/bed (kg) | Estimated bulbs fresh weight/ha (ton) ** |
|---------------|---------------------------|-----------------------------|---------------------------------------|
| Bima Brebes   | 4.601 a*                  | 31.5 a                      | 8.41 a                                |
| Trisula       | 3.372 ab                   | 29.9 a                      | 7.98 a                                |
| Tuk Tuk       | 2.293 b                    | 22.6 a                      | 5.28 a                                |
| Sanren        | 3.547 ab                   | 30.8 a                      | 6.05 a                                |

* in the column with the same letter are not significantly different according to DMRT at 0.05 level
**ha with 70% beds and 30% ditches.

Table 6. Description of four shallots cultivars [27-30].

| Cultivars     | Adaptability (m asl) | Harvest age (dat) | Weight/bulb (g) | Lost weight during storage (%) | Fresh Production/ha (ton) |
|---------------|----------------------|-------------------|-----------------|-------------------------------|--------------------------|
| Bima Brebes   | -                    | 60                | -               | 21.5                          | 9.9*                     |
| Trisula       | 6-85                 | 50-55             | 10-25           | 38.04                         | 6.5-23.2                 |
| Tuk Tuk       | Low-high             | 70-85             | 15              | -                             | 20-30                    |
| Sanren        | -                    | 62-64             | 17.0-19.4       | 36.7                          | 23.2-28.1                |

as: above the sea level; dat: days after transplanting; *dry weight; --: no data

Bulbs production is a very complex trait influenced by several genetic factors that interact with the environment and its farming practices [31]. According to research done by Sumarni et al. [9], the production of Bima Brebes and Tuk Tuk cultivars in the rainy season was 4.9-5.6 and 3.6-4.1 tons per hectare respectively, while in the dry season in the lowlands, fresh weight of Tuk Tuk and Sanren can reach 30.9-37.5 and 39.7-42.5 tons per hectare [32]. This describes that production will be lower in less favorable environmental conditions. Other researches have also concluded that the differences in varieties and populations influenced the adaptability of plants to their environment so that it will affect their production ability [20, 32, 33-36]. In dry areas, increasing shallot production can be done by adding organic matter that will increase the soil fertility by enhancement of C-organic level [31, 37].

3.7. Dry weight after 3-month storage
Most of bulbs produced are sold by farmers in fresh conditions and the rest is stored for use as planting materials. After three months of storage, cultivar that have the lowest dry weight/plant is Tuk Tuk (Table 7).

Table 7. The average of dry weight/plant and percentage of bulbs loss weight

| Cultivars     | Dry weight plant⁻¹ (g) | loss weight during 3 months storage (%) |
|---------------|------------------------|----------------------------------------|
| Bima Brebes   | 11.0a*                 | 48.4a                                  |
| Trisula       | 8.6a                   | 57.1ab                                 |
| Tuk Tuk       | 4.6b                   | 65.3b                                  |
| Sanren        | 7.7a                   | 48.5a                                  |

* in the column with the same letter are not significantly different according to DMRT at 0.05 level

According to Sekara et al. [20], the shelf-life of shallot bulbs depends on its genetic trait and other external factors, such as their size, dry matter content, degree of maturity at harvest time, and conditions during storage. Bulbs produced in areas that has a low moisture regime soil are usually smaller; during storage, it sensitive into attack of neck or early bulb rot disease [38]. On the other
hand, bulbs yielded in the rainy season that had sufficient humidity would lose their weight during storage was less than dry one [9].

In onion, the deterioration during storage is caused by several biochemical processes [39]. After 2 months at 25 °C storage, peroxidase activity decreased progressively, fructose and glucose concentration continuously reduced, while sucrose increased consistently; until six months, the enzymatic activity of Q4'G glucosidase and Q4'glucosyltransferase increased progressively, after that farmers started to decrease.

4. Conclusion
TSS as planting material for shallot cultivation can be used in dry area Laleten with a production of around 5 to 8.5 ton/ha. The productivity of this plant only reaches 20-40% of optimal production capacity.

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