Evaluation of the growth and yield of true shallot seed on the application of two technology packages during two planting seasons in Central Sulawesi

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Abstract. True shallot seed (TSS) considered to be used due to their technical and economical feasibility. The aim of the study was to evaluate the growth and yield productivity of TSS and shallot bulbs generated from TSS. The study was conducted in Kotarindau Village, Dolo District, Sigi Regency, Central Sulawesi. The seeds were planted on dry lowland area. The experiment was arranged using a Randomized Block Design with two treatments, namely the Introduction Technology Package and Farmer Technology Package during two planting seasons. Each treatment was repeated 13 times. Parameter observed were the growth and yield of shallot. The data obtained were analyzed using the T test. The results showed that the Introduction Technology Package had a significant effect on several components of shallot growth and yield compare with the Farmer’s package in the first (using seeds) and the second season (using bulbs). In the second planting season, the number of bulbs was 7-9 times higher than in the first planting season, and the productivity was 2-3 times higher. We can conclude that the shallot bulbs harvested from the seeds have the opportunity to be used as a source of seeds for the next planting season.

1. Introduction
Shallot is one of the leading national vegetable commodities that has been cultivated intensively for a long time. This commodity is included in the non-substituted spice group that functions as a seasoning for cooking. Apart from being the main spice in cooking, shallot is also potential to be used as food industrial raw materials such as fried onions, flour, dry slices, wet slices, oleoresin, oil, pasta and pickles [1-3]. Shallot also important as a sources for biopharmaceuticals industry because they contain flavonoids, quercetin and quercetin glycosides which can be used for the prevention and treatment of various diseases such as diabetes, cancer, coronary heart disease, obesity, hypercholesterolemia, hypertension, cataracts, indigestion and leukemia [4,5]. Due to this high potential of shallot commodity, the demand for shallot will tend to continuously increased. In order to meet the demand, an effort to increase its production should be made.

Based on statistical data, the shallot production in Indonesia in 2016 accounted to 1,446,860 tons and tended to increase in comparison to that in 2015 (1,229,184 tons). However, increasing of shallot production was not accompanied by increasing of its productivity, of which the shallot production in 2016 and 2015 were 9.67 t/ha and 10.06 t/ha, respectively or decreasing by 3.88% [6]. Previously in 2016, productivity of shallot in Central Sulawesi was 5.04 t/ha, indicating a low shallot productivity which far below from the national average [7]. This low productivity can be influenced by many
factors, such as the limitation on the availability of high quality shallot seeds when they are needed by farmers, the high levels of plant pest attack, and fertilization that is not in accordance with the level of soil fertility and plant needs.

The availability of high-quality seeds and their sustainability is one of the determining factors for the success of shallot farming. In general, shallot seeds including shallot can be propagated sexually (seeds) and vegetatively (bulbs). However, many farmers are still using bulbs generated from previous planting as a seed source for the subsequent planting. This method often reduces yield productivity and quality since the quality of the seed could not be guaranteed. Pathogen diseases such as *Fusarium* sp., *Colletotrichum* sp., *Alternaria* sp., or viruses from the previous plantation are often carried by seed bulbs [8].

There are several important criteria for selecting ideal seeds for shallot cultivation, such as reducing the number of seeds per unit area, easier and cheaper transportation and storage, healthier plants, free of pathogen diseases, better quality, and larger bulbs. Various studies have shown that the use of True Seed of Shallot (TSS) can meet these criteria. The number of TSS required is less than using bulbs, which is 4-5 kg/ha. In addition, the use of TSS can also increase the yield up to two times compared to the use of traditional bulbs [9]. Saidah *et al* [10] showed that the use of Trisula variety seeds gave high yields, which ranged from 24.68 to 25.8 t/ha. Thus, using TSS is feasible from a technical and economic perspective [11].

The use of TSS among farmers has not yet been developed. Farmers think that shallot cultivation using TSS will take a longer period to harvest than using bulbs since it has to go through the nursery stage. Hence, maintenance is also more difficult. However, it is less known that this cultivation system did not necessarily go through the nursery. The Previous study [8,12] shows that planting shallot from TSS can be done in three ways, by direct planting in the field (direct seedling), seedling, and planting mini bulbs (shallot set) obtained from planting seeds. On this basis, farmers' habits need to be overcome by producing seed bulbs from planting seeds.

Many researches related to TSS production have been conducted, however, there has not been much further research on the potential for seed tuber production. The use of TSS in shallot cultivation will produce tuber with a larger size than using tuber seeds. Previous research [12] reported that the seed tuber from seed was larger if planted in Andisol soil. The objective of this research was to evaluate the growth and yield productivity of shallot using TSS by using two technology packages, Introduction and Farmer's Technology Package.

2. Materials and methods

2.1 Study area
The study was conducted from April to December 2019 on dryland in Kotarindau Village, Dolo Subdistrict, Sigi Regency, Central Sulawesi Province. The materials used were TSS seeds, organic and inorganic fertilizers, lime, pesticides, bio-pesticides, and herbicides. The tools that used were a hoe, measuring devices, and other supporting tools.

2.2 Methodology
The methodology used a Randomized Block Design with two treatments, namely the Introduction Technology Package (ITP) and Farmer Technology Package (FTP). The Introduction technology package is a technology package that was the result of an assessment in the previous year (2018), while the Farmer technology package is a package of existing technology or farmer habits. Treatment details were described as follows.
Table 1. The components of technology package of shallot multiple production technology 2019 used in the present study.

| Technology Components | Farmer technology package | Introduction technology package |
|-----------------------|---------------------------|--------------------------------|
| Tillage               | Intensive                 | Intensive                      |
| Variety               | Trisula                   | Trisula                        |
| Plant spacing         | 15cm x 15cm               | 8cm x 10cm                     |
| Manure                | 1 t/ha                    | 3 t/ha                         |
| Basic fertilizer      | 250 Kg/ha Phonska + 50 Kg/ha | 400 Kg/ha Phonska + 150 Kg/ha |
| Supplementary fertilizer | 1: 3 weeks after planting | 1: 3 weeks after planting |
| Lime                  | -                         | 1.0 t/ha                       |
| Pest Control          | Pesticide                 | Integrated pest control (+)    |

In this research, each treatment was repeated 13 times. The parameters observed are plant height, number of leaves, number of bulbs per clump, tuber weight per clump and the productivity (t/ha of dried bulbs). Beside the growth and yield parameters, observation also conducted to notes the percentage/intensity of pest and disease attacks as well as the dynamics of pests and diseases. Ten (10) samples were taken from each treatment and each replication. This study was conducted in two seasonal planting (MT). The first MT (MT I) was completed in August 2019, while the second MT (MT II) started at the end of October 2019 and harvested at the end of December 2019. The first MT planted shallot using TSS seeds. The shallot yield produces in MT I were then stored for ± 2 month and later used as source of bulbs for MT II. The selected bulbs used weigh between 3-5 g per tuber. Data obtained were then tabulated and analyzed using T test with SPSS version 23.

3. Result and discussion

3.1 Shallot growth performance in two planting seasons

The T test showed that the treatment of the Introduction Technology Package and the Farmer's Package had a significant effect on the growth of shallot plants derived from TSS during the two seasons of planting. The average plant height and number of leaves are presented in Table 2.

Table 2. Mean values of vegetative component resulted form first and second planting seasons in 2019.

| Treatment                       | Plant Height(cm) | Number of Leaves |
|---------------------------------|------------------|------------------|
| **First Planting Season**       |                  |                  |
| Introduction Technology Package | 32,26 b          | 5,46 b           |
| Farmer Technology Package       | 29,12 a          | 4,80 a           |
| **Second Planting Season**      |                  |                  |
| Introduction Technology Package | 30,85 b          | 31,38 b          |
| Farmer Technology Package       | 21,87 a          | 20,80 a          |

Description: The number followed by the same letter in the same column is not significantly different according to T test at 95%.

Table 2 showed that the plant height and number of shallot leaves was significantly higher (95% significant level) for Introduction Technology Package than those in the Farmer Technology Package for both planting seasons. Plant growth in the Introduction Package has tighter spacing resulting in the higher competition against light, known as etiolation effect. Less light will drive leaves to elongate faster [13]. The denser the spacing, the lesser light receive by each plant. Plant height is an important component to indicate plant growth and also to determine plant respond of growing environment or
treatment given [14]. Increasing plant density can cause plant stems to become smaller and often taller [15].

The Introduction Package also gives more basic fertilizer than the Farmer Technology Package, resulted in better growth performance. In this methods, nutrient addition was provided since the early growth, 3-5 weeks after planting, by application of NPK fertilizer. Root crops [16] as well as vegetative growth such as roots, stem or leaves elongation [17] will require large amount of nutrient to simulate plant growth and development.

Leaves as photosynthetic organ, playing an important role for plant growth. Leaf formation is influenced by plant genetic traits, but a good environment can accelerate this formation [18]. Yudianto et al. [19] explained that the number of leaves in a plant will affect the growth and development of plants, where plants with more leaves will have more energy available for photosynthesis compared to those with fewer leaves.

### 3.2 Yield productivity of shallot in two planting seasons

In this research, yield productivity parameter counted is bulbs or tuber development. Bulbs are formed from rhizomes that penetrate the soil and gradually swell and become a fleshy organ (tuber). Bulbs has a function to store photosynthetic results in the form of carbohydrates [20]. Stem and prospective bulbs will initially forms straight vertical shape and later swell proportionally. Bulbs can be harvested after reaches maximum size.

Results of the T test showed that the treatment of the Introduction Package and the Farmer's Package had a significant effect on the yield of shallot during the two growing seasons, except for the number of bulbs per clump and tuber diameter. Although not significantly different at the 95% level, treatment in the Introduction Package has larger number of bulbs per clumps than in the Farmer Technology Package (Table 3).

| Technology Package Treatment | Number of Bulbs per Clump | Tuber Diameter (mm) | Weight of Tuber per Clump (g) | Productivity (t/ha) |
|------------------------------|---------------------------|---------------------|-----------------------------|---------------------|
| **The First Planting Season (MT I)** | | | | |
| Introduction technology package | 1.55 a | 30.45 a | 17.91 b | 18.18 b |
| Farmer technology package | 1.38 a | 28.86 a | 13.79 a | 7.67 a |
| **The Second Planting Season (MT II)** | | | | |
| Introduction technology package | 10.31 a | 20.25 a | 43.66 b | 40.87 b |
| Farmer technology package | 9.22 a | 19.79 b | 29.15 a | 26.90 a |

Description: The mean number followed by the same letter in the same column is non significantly different according to the T test at the 95% level

Number of bulbs per clump, diameter, fresh weight of tuber and tuber productivity were significantly different between the treatments in the first planting season (MT I) and the second planting season (MT II). MT I produces smaller average number of bulbs (1.38-1.55), but larger tuber (28.86-30.45 mm) than MT II. This result is similar with the previous results that original TSS produces larger bulbs and may yield double productivity compared to using bulbs. The fresh weight of bulbs per clump depends on the number of bulbs per clumps [8-10]. The higher number of bulbs produced; the higher fresh weight of bulb clumps obtained.

Table 3 shows that overall yield components in the Introduction Technology Package are better than the Farmer’s Package. This means that the treatment of the Introduction Technology Package (Table 1) especially the differences in plant spacing and amount of fertilizer, can increase the yield of individual plant. Tuber production per hectare can be influenced by the number of bulbs and bulb weight when planted. Previous research showed that basically the use of tight spacing has an aims to increase yields, because it can avoid other limiting factors [21]. If plant density is accompanied by the
addition of N, P, K fertilizers, it will be able to increase weight of bulbs per plant, so that tuber production per hectare will also increase [22]. This is because adequate supply of K in the soil is very important to increase the growth of shallot plants [23,24]. Beside the NPK fertilizer, the Introduction Technology Package also uses KCl and dolomite lime which will meet the needs of the shallot plant during its growth. The function of potassium (K) is directly involved in regulating the biochemical and physiological processes of plant growth, although it is not part of the chemical structure of plants. Potassium also plays an important role in translocation of photosynthetic results in the form of carbohydrates and water to the bulbs and as a catalyst for nutrient absorption by plants, so that it will affect the enlargement process and tuber yield [25-27]. If the plant is deficient in potassium, the photosynthesis and respiration processes will be inhibited [28]. Potassium also makes plants less prone to collapse, is more resistant to disease and environmental stress [29]. Application of lime and dolomite is assumed to give effect on the growth and yield of shallot bulbs, by increasing soil pH and provide nutrients such as K, Ca, and Mg elements needed. Dolomite contains nutrients, including Calcium and Magnesium [30]. These two elements are essential nutrients needed by plants in metabolic processes, including in the formation of bulbs. Purwono and Purnamawati [31] stated that for shallot plants, sufficient calcium nutrients are required for tuber formation. The number of bulbs was 7-9 times higher in the second planting season and the productivity was also 2-3 times higher.

3.3 Dynamics of pest and disease attack
Research results shows that pest and disease attack vary each growing season. In the first planting season (MT I), 62% of shallot in Introducing Package were attack by caterpillar, while only 11% in the Farmer Technology Package, Spodoptera exigua also found attaching to plants (Figure 1). Less caterpillar attack in the Farmer Technology Package is because in this package, farmer is using pesticide for pest prevention. Meanwhile, in the Introduction Package, the pest control was conducted based on the level of pest attack observed and the use of pesticides is become the last alternative. The caterpillar attack begins 35 days after planting, while in the MT II This caterpillars attack at the age of 21 days after planting. This pest actually can be controlled by trapping yellow binder, a sex pheromone combined with pesticides. However, exi pheromones have no effect on reducing the attack rate. The number of adult insects caught is very small (2-5 per jar). This is presumably because the effect of exi pheromone has decreased because it has been stored for a long time (>6 months).

![Figure 1. Condition of shallot with Spodoptera exigua attack](image)

Intensive pest attack was suspected to be caused by uncertain climate change and high rainfall. During the first planting season, the amount of rainfall was relatively small, ranging from 94-120 mm/month. This dry season is the season where caterpillars Spodoptera can thrive faster than in the rainy season. In the rainy season, Spodoptera eggs will be carried by rainwater and will decompose so that they cannot hatch. In the dry season, temperature and low humidity is is favorable for the eggs to develop into larvae. Climate change was reported to give a negative impact on the diversity and
abundance of insect pests and thus, resulting in crop damage and finally affected agricultural production [32-33]. Previous research stated that an increase in temperature will cause almost all insects/pests to become more abundant [34]. Temperature is an important factor for insect life [35] by affectings the development, reproduction and dynamics of pest populations. It can also affects the physiology, abundance, phenology, distribution and dimensions of insects. Daily temperatures between 28-30 °C as we measured in the study location, and slightly low temperature at night are the most suitable for the emergence of a number of adult insects in the field [36].

The disease that attacks shallot plants in the first growing season is fusarium wilt. The attack begins 35 days after planting with a percentage of 1%. In the second season, there is no disease found. The Fusarium wilt disease can be overcome and plant can be recovered after giving its biological agent, Trichoderma sp. This is in line with the research of [37], that the provision of Trichoderma sp. can inhibit the growth and development of Fusarium wilt disease because of their antagonistic properties. Ramadhina et al. [38] also showed that the growth and yield of shallot were higher when treated by Trichoderma sp compared to control.

4. Conclusion
The Introduction Technology Package had a significant effect on several components of shallot growth and yield compare with the Farmer’s package in the first (using seeds) and the second season (using bulbs). The use of seed bulbs harvested from TSS has good prospects in anticipating limited seed supplies. Based on the research results it is recommended for planting shallot using different spacing (crop density) for TSS and bulbs. Wider space between individual plant is recommended for planting using bulbs to produce more bulbs.

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