Growth and production of seed bulbs from true seed shallot planted on dry low land in rainy season

A C Kusumasari 1*, R Pangestuti 1, E Sulistyaningsih 2 and R Rosliani 3

1 Assessment Institute for Agricultural Technology (AIAT) Central Java, Jl. Soekarno Hatta No 10 km 26 Bergas sub-district, Semarang Regency, Central Java, Post Code 50552, Indonesia.
2 Department of Agronomy, Faculty of Agriculture, Gajah Mada University, Jl. Flora No 1 Bulaksumur, Yogyakarta Post Code 55281, Indonesia.
3 Indonesian Vegetables Research Institute, Jl. Tangkuban Perahu 517, Lembang Post Code 4039, Indonesia.

Corresponding author: aryanacitra@yahoo.co.id

Abstract. Bulb propagated from true seed shallot (TSS) has a potency to become a good seed bulb. This study aimed to analyze the growth and production of seed bulbs from TSS planted on dry low land in rainy season. The study was conducted from November to December 2014 in Grobogan Regency, Central Java, Indonesia. A group of G0 bulbs, called Trisula and Tuk Tuk varieties, consisting of small bulbs (Ø 1-1.5 cm, weight 2-5 g) and large bulbs (Ø >1.6 cm, weight >7 g) were planted in a-2 factorial RBD with four replications. Variety and bulb size had a significant effect on all components of growth (plant height, number of tillers) and production (number of bulbs, fresh and dry weight of bulb, bulb diameter, and productivity). The small and large size of G0 Trisula seed bulbs have equal quality as seeds source in the lowland area during rainy season with productivity > 20 tons ha⁻¹ and a small percentage of rejected bulbs (<0.5 % (0.08 tons ha⁻¹). Meanwhile, although having high productivity, Tuk Tuk variety had high percentage of rejected bulbs, 34.22% (9.79 tons ha⁻¹); so it is unsuitable to be used as seed bulb in the rainy season.

1. Introduction
Shallot (Allium cepa L. Aggregatum) is one of the leading vegetable commodities that have long been intensively cultivated in Indonesia which has high economic value and good market prospects. This vegetable commodity belongs to non-substituted spice group which widely consumed and highly demanded as a food seasoning and traditional medicine [1].

Central Java Province of Indonesia is one of the buffers for shallot which contributes 32% of shallot national production. In Central Java, shallot is cultivated continuously throughout the year with support from climatic conditions and farmer’s socio-economic condition [2]. However, in the shallot production, there is a problem in the availability of high-quality shallot seeds which is limited, especially in rainy season [3]. The quality of seeds planted in the rainy season is problematic in term of suitability, resistance of the varieties, and its health. One alternative to ensure the availability of good quality seeds throughout the year is by using seed/True Shallot Seed (TSS) as the material of shallot propagation [4–7].
According to Sumarni and Rosliani [8], shallot cultivation from TSS can be done in several ways: planting TSS directly in the field, seeding TSS to produce seeds, and making seed bulbs (sets), namely mini bulb seeds (<3 g / bulb) from TSS. Planting TSS directly in the field needs more seeds (6–8 g / m²) compared to seeding which is more efficient, stronger, and tougher. Meanwhile, Sopha et al [9] stated that although planting shallots using seed bulbs G0 relatively more expensive, they produce stronger and healthier plants, shorter growing periods, and higher yields. However, the use of seed bulbs G0 from TSS does not significantly change shallot planting system of farmer.

G0 seed bulb is the first derived bulb from TSS propagation products [3,10]. The G0 seed bulb is propagated to produce G1 and then re-planted to produce G3 as extension bulb seed for consumption [3]. Planting propagation Seeding using seed bulbs G0 potentially produces higher production than using ordinary bulbs that commonly used by the farmer, and also healthier as it does not contain accumulation of bulb-borne pathogens like bacteria, fungi, or virus [3,10]. Besides, Tabor [11] stated that the use of shallot bulb is a very effective way to conserve shallot germ plasma.

During this research, there were not many TSS used by farmers, namely Bima, Trisula, and Tuk Tuk varieties. Bima and Trisula are local varieties of Indonesia while of Tuk Tuk is introduced from the Philippines [12]. This study aimed to analyze the growth performance and production of shallots from seed bulbs G0 of Trisula and Tuk Tuk varieties with different bulbs sizes in the lowlands during the rainy season.

2. Materials and methods
The research was conducted in a rain fed land from November to December 2014 during the rainy season in Brabo Village, Grobogan Regency, Central Java Province, Indonesia. The location altitude is 50 meters above sea level with a slope of 00 - 80. The experimental design used was a two-factor Randomized Group Design (RGD) with 4 replications. The first factor was Trisula and Tuk-tuk varieties, the second factor was bulbs size consisted of small bulbs size (Ø 1-1.5 cm and weight 2-5 g) and large bulbs size (Ø> 1.6 cm and weight >7 g).

The integrated planting system was applied by controlling pests using biological agents, sex pheromones (Feromon Exi, CV Nusagri, Indonesia), yellow traps, mature organic fertilizers, seed treatment using fungicide 2 g kg⁻¹ (mancozeb 80%, PT Dow Agroscience, Indonesia), and precision fertilization. The variables observed were growth (plant height, number of leaves, and number of tillers at the age of 2, 4, and 6 WAP) and production (number of bulbs/clump, bulb fresh weight/clump, bulbs size, eskip dry weight, and productivity). Data were analyzed statistically using variance (Anova), and if there was a significant difference between treatments, Duncan Multiple Range Test (DMRT) was applied at 5%.

3. Results and discussion
Growth is morphological adaptability of plants to the environment that will affect the growth and yield of a plant [13]. In addition, Ayu et al [13] stated that the different plant varieties have different responses even though they are planted in the same environmental conditions because every variety has different genetic potential. The variance analyses resulted that the varieties treatment of bulbs size had a significant effect on all components of both growth and yield. The growth components consisted of plant height, number of leaves, and number of tillers at the age of 2, 4, 6 WAP, while yield components included number of bulbs, bulbs dry weight, longitudinal and transverse bulbs diameter, and productivity.

3.1. Components of growth

3.1.1. Plant height. The result of DMRT of plant height is presented in Table 1. The results showed that the mean of the plants height aged 2, 4, and 6 WAP was significantly different. In the beginning of the growth (2 WAP), the plant height of shallot from all bulbs sizes of Trisula variety was higher than that of Tuk-tuk variety. The plant height of small bulbs size of both varieties was higher than that of the
large size. However, at the age of 4 and 6 WAP, the growth of Tuk-tuk shallot variety of all bulbs sizes was higher than that of Trisula shallot variety. At the age of 6 WAP, the plant height of Trisula shallot variety from small and large bulbs was 39.80 cm and 35.85 cm, respectively, while Tuk Tuk shallot variety from small and large bulbs was 46.85 cm and 50.91 cm, respectively. The description of the plant height of Tuk Tuk shallot variety, which is ± 50 cm [12], is higher than that of Trisula shallot variety, which is 39.92 cm [14]. Therefore, it could be concluded that the difference in plant height between the 2 varieties was due to genetic factors.

Table 1. Plants height of trisula and tuk-tuk shallot varieties from seed g0 bulb in 2, 4, 6 WAP

| Parameters       | Varieties     | Small Bulb | Large Bulb |
|------------------|---------------|------------|------------|
| Plant Height 2 WAP | Trisula       | 20.93 aA   | 18.44 aA   |
|                  | Tuk-tuk       | 17.42 bA   | 15.00 bA   |
| Plant Height 4 WAP | Trisula       | 35.90 yX   | 33.35 yX   |
|                  | Tuk-tuk       | 41.21 xX   | 43.80 xX   |
| Plant Height 6 WAP | Trisula       | 39.80 vW   | 46.85 wV   |
|                  | Tuk-tuk       | 35.85 wW   | 50.91 vV   |

Note: Numbers followed by the same capital letter on the same row and the same lowercase letters in the same column show an effect which is not significantly different based on the DMRT test with a confidence level of 5%. WAP = week after planting

3.1.2. Number of leaves. The result of DMRT on the number of leaves is presented in Table 2. It shows that the mean of the number of leaves aged 2, 4, and 6 WAP was significantly different. The number of leaves from large bulb Tuk-Tuk was higher than another treatment at 2, 4 dan 6 WAP. At the age of 6 WAP, the number of leaves on the Trisula shallot variety from small and large bulbs was 19.80 and 19.20 respectively, while that on the small and large bulbs of Tuk Tuk varieties were 18.50 and 29.20, respectively.

This finding presumably occurred because the large bulb of Tuk Tuk variety had a lot of food reserves that causing more formation of leaves. [15,16] proposed that an increase in the number of leaves will affect the ability of plants to produce plant biomass that affects the yield.

Table 2. Average number of shallots leaves of trisula and tuk-tuk varieties from seed bulbs G0 aged 2, 4, and 6 WAP

| Parameters       | Varieties     | Small Bulb | Large Bulb |
|------------------|---------------|------------|------------|
| Number of Leaves 2 WAP | Trisula       | 7.30 aA   | 7.15 bB    |
|                  | Tuk-tuk       | 7.00 aA   | 14.70 aA   |
| Number of Leaves 4 WAP | Trisula       | 14.65 xX  | 14.10 yX   |
|                  | Tuk-tuk       | 13.55 xY  | 27.30 xX   |
| Number of Leaves 6 WAP | Trisula       | 19.80 vW  | 19.20 wV   |
|                  | Tuk-tuk       | 18.50 vW  | 29.20 vV   |

Note: Numbers followed by the same capital letter on the same row and the same lowercase letters in the same column show an effect which is not significantly different based on the DMRT test with a confidence level of 5%. WAP = week after planting

3.1.3. Number of tillers. The result of DMRT of the number of tillers is presented in Table 3. The result showed that the mean of number of tillers on shallot aged 2, 4 and 6 WAP was significantly different. At all ages, the Trisula shallots variety derived from G0 seed bulbs, either small or large, had the same number of tillers, while the Tuk Tuk shallot variety from G0 seed bulbs, either small or large, had different number of tillers depending on the sizes of the bulbs. The number of tillers of the Trisula variety from large and small bulbs sizes was not significantly different from that of Tuk Tuk from large bulb size. The large bulb size of Tuk Tuk variety produced a larger number of tillers, which was in line
with the finding of [17] that the larger the seed bulb size used is, the greater the number of tillers will be. The size of the bulbs that produced a normal number of tillers according to the genetic characteristics of the parent that was ≥ 3 grams.

### Table 3. Average number of shallot tillers of Trisula and Tuk-Tuk varieties from seed bulbs G0 aged 2, 4, and 6 WAP

| Parameters               | Varieties | Small Bulb | Large Bulb |
|--------------------------|-----------|------------|------------|
| Number of Tillers 2 WAP  | Trisula   | 1.00 aA    | 1.00 bB    |
|                         | Tuk-tuk   | 1.00 aB    | 1.50 aA    |
| Number of Tillers 4 WAP  | Trisula   | 2.90 xX    | 2.60 xyX   |
|                         | Tuk-tuk   | 1.57 xY    | 3.95 xX    |
| Number of Tillers 6 WAP  | Trisula   | 3.05 vV    | 2.75 vwV   |
|                         | Tuk-tuk   | 1.90 wW    | 3.10 vV    |

Note: Numbers followed by the same capital letter on the same row and the same lowercase letters in the same column show an effect which is not significantly different based on the DMRT test with a confidence level of 5%. WAP = week after planting

#### 3.2. Components of production and productivity

The results of DMRT showed that the different treatments on varieties and bulb sizes significantly affected all yield components (number of bulbs/clump, fresh weight/clump, bulb dry weight, and bulb size). The result of the analysis of yield components is presented in Table 4. In the Trisula shallot variety, the differences in seed bulbs sizes (both small and large) were not significantly different in all yield component parameters. On the contrary, on the Tuk Tuk shallot variety, the bulbs sizes were very influential to all production components except the transverse diameter and the escape dry weight.

##### 3.2.1. Number of bulbs. The use of small seed bulbs of the Trisula variety resulted in a higher number of bulbs per clump compared to that of the Tuk-tuk variety. The number of small and large bulbs of Trisula variety produced 3.98 bulbs and 3.54 bulbs, respectively, while that of the Tuk Tuk variety produced 2.03 bulbs and 3.73 bulbs, respectively. This showed that a single bulb of G0 split into an aggregate in G1 was higher in Trisula variety than in Tuk-Tuk variety. Shallot with large bulb characteristic potentially has a small number of tillers [18]. It is described that Tuk Tuk variety has a potential number of tillers reaching 1-2 large size bulbs [12]. In fact, this research found that the Tuk Tuk variety was able to exceed its genetic potential, one of which was influenced by the size of the bulb. The large bulb can provide sufficient food value to support growth and development in the field [18].

##### 3.2.2. Fresh weight of bulbs. The fresh weight of bulbs produced by Trisula and Tuk Tuk varieties both planted using large and small bulbs was 52.07, 57.47, 67.65, and 91.02 grams, respectively. The fresh weight of the bulb was closely related to the number of leaves. According to [15], leaves have a significant role in plant growth and determine plant biomass. The result of fresh bulb weight has same pattern with the result of the leaves number.

##### 3.2.3. Dry Weight of bulbs. The dry weight of bulbs produced by Trisula and Tuk Tuk varieties planted using large and small bulbs were 28.55, 29.40, 32.70, and 43.75 grams, respectively. Although the fresh weight of Tuk Tuk shallot variety from large bulb was higher than other treatments, its escape dry weight was not significantly different from the Tuk Tuk variety from small bulb size and Trisula variety from large bulb. According to [19], highly fresh weight with low escape dry weight indicates that the water content is higher than the photosynthetic content.

##### 3.2.4. Bulbs size (bulbs’ height and diameter). The height and diameter of bulbs produced by small and large seed bulbs of Tuk Tuk shallot variety were wider than of Trisula shallot variety. Genetically, Tuk Tuk shallot variety is characterized by its large bulbs with height around 35-50 mm and diameter
about 19-42 mm [12] while Trisula variety is characterized by its small bulbs, about 20-30 mm in height and 10-25 mm in diameter [14].

The result of this experiment showed that the Tuk Tuk variety from either small or large bulbs produced bulbs measuring 34.46 mm and 30.18 mm in height and 36.18 mm and 34.41 mm in diameter, respectively. In fact, the size of bulbs affects growth and yield of shallot [20]. Besides, large bulbs will produce large bulb diameter and the bulbs produced are predominantly round and large [18,16]. Thus, the larger the bulb size will produce greater number of leaves, tillers, and production.

The finding also showed that bulb size produced by Trisula variety could exceed its genetic potential, either small or large bulb seed, by 26.63 mm and 28.97 mm in height and 29.36 and 34.41 mm in diameter. This suggested that Trisula variety using G0 seed bulb planted in the rainy season still produce good yields and it might exceed its potential.

| Table 4. Production components of Trisula and Tuk-Tuk shallot varieties from G0 bulb seed |
|--------------------------------|-----------------|-----------------|-----------------|
| Parameters                     | Varieties       | Small Bulb      | Large Bulb      |
|--------------------------------|-----------------|-----------------|-----------------|
| Number Tiller/Clump (Tiller)   | Trisula         | 3.98 a X        | 3.54 ab X       |
|                                | Tuk-tuk         | 2.03 b Y        | 3.73 a X        |
| Fresh Weight of Bulb/Clump (gr)| Trisula         | 52.07 a X       | 57.47 b X       |
|                                | Tuk-tuk         | 67.65 a Y       | 91.02 a X       |
| Dry weight of Bulb (gr)        | Trisula         | 26.63 b X       | 28.97 ab X      |
|                                | Tuk-tuk         | 34.46 b X       | 36.18 a X       |
| Bulb Height (mm)               | Trisula         | 20.04 a Y       | 21.73 a X       |
|                                | Tuk-tuk         | 22.34 a X       | 23.14 a X       |
| Diameter (mm)                  | Trisula         | 99.64           | 100.00          |
|                                | Tuk-tuk         | 82.48           | 65.78           |

Note: Numbers followed by the same capital letter on the same row and the same lowercase letters in the same column show an effect which is not significantly different based on the DMRT test with a confidence level of 5%.

3.2.5. Productivity. The productivity of Tuk Tuk shallot variety from large bulbs was 28.61 tons ha\(^{-1}\), followed by Trisula small bulbs, Trisula large bulbs, and Tuk Tuk small bulbs with 22.34, 21.73, and 20.04 tons ha\(^{-1}\), respectively. Meanwhile, according to the variety description of Trisula, the potential yield of Trisula variety is 6.5 – 23.1 tons ha\(^{-1}\) and Tuk Tuk variety is up to 32 tons ha\(^{-1}\) (Decree of the Minister of Agriculture Number: 361/Kpts/SR.120/5/2006)[12].

When compared, the results of this study showed that the productivity of Trisula variety equals with its potential yields, while that of Tuk-Tuk variety is still below its potential yield. It was presumably caused by rainy season which unsuitable time for Tuk-Tuk variety to be planted. Further analysis of the average productivity of shallot G0 seed bulbs from TSS is presented in Table 5.

| Table 5. Yield quality of G1 seed bulbs propagated by G0 seed bulb from True Shallot Seed (TSS) |
|--------------------------------|-----------------|-----------------|-----------------|
| Parameters                     | Varieties       | Small Bulb      | Large Bulb      |
|--------------------------------|-----------------|-----------------|-----------------|
| Total Production (ton ha\(^{-1}\)) | Trisula         | 22.34 a X       | 21.73 b X       |
|                                | Tuk-tuk         | 20.04 a Y       | 28.61 a X       |
| Fresh Production for Seed Bulb (ton ha\(^{-1}\)) | Trisula         | 22.26 a X       | 21.73 a X       |
|                                | Tuk-tuk         | 16.53 b X       | 18.82 ab X      |
| Percentage of bulb for Seed Bulb (%) | Trisula         | 99.64           | 100.00          |
|                                | Tuk-tuk         | 82.48           | 65.78           |
| Rejected Bulb (rotten bulb) (ton ha\(^{-1}\)) | Trisula         | 0.08            | 0               |
|                                | Tuk-tuk         | 3.51            | 9.79            |

Note: Numbers followed by the same capital letter on the same row and the same lowercase letters in the same column show an effect which is not significantly different based on the DMRT test with a confidence level of 5%. 


Based on Table 5, the productivity of Tuk Tuk variety was higher than that of Trisula variety. The yield that could be used for seed bulb of Tuk Tuk variety was 65.78% for large bulbs and 82.48% for small bulbs. The bulbs used for consumption was as many as 3.51 tones ha\(^{-1}\) of small bulbs and 9.79 tones ha\(^{-1}\) of large bulbs.

The Tuk-tuk variety had a weakness that it was vulnerable if planted in the rainy season due to diseases; therefore, the percentage of shallot bulb that could not be used as seeds was higher than that of Trisula variety. In the rainy season, shallots are susceptible to Fusarium and Alternaria sp. which can decrease the yield [2], and Fusarium disease in shallots is one of the most significant production constraints [21].

The percentage of Trisula shallot seed bulb propagation from small and large sizes that could be used as the next generation seeds was 99.64% and 100%, respectively; thus, the rejected bulbs were only 0.08% and 0%, respectively. Trisula have better seed bulb quality because more tolerant to disease in the rainy season. In fact, the difference in sizes of the seed bulbs in the Trisula variety did not significantly affect productivity. It proves that the use of small-sized Trisula G0 seed bulbs had the same yield potential as the use of large bulbs when propagated for the next generation.

These findings suggested that small-sized G0 seed bulbs of Trisula variety were recommended as seed bulb in lowlands during the rainy season. The result confirmed the findings from [18,22,23,24] that stated seed efficiency needs to be strived in both reducing the weight and size of the seeds without reducing cropping population with the expected optimum production. Furthermore, [25] argued that large bulb size will result in larger sizes and number of leaves, resulting in a higher number of bulbs per plant. However, the use of large seed bulb requires considerations of seed requirements, as they will affect the production costs.

4. Conclusion
Based on the results and discussion, it can be concluded that treatment on varieties and bulb sizes had a significant effect on all components of growth and production of shallots from G0 seed bulbs. The different size of the seed bulb in Trisula variety did not have a significant effect on the growth and production variables, while large bulbs of Tuk-Tuk variety significantly increased the value of the variable of the growth and production. The small and large size of G0 Trisula seed bulbs had equal quality as a source of seeds in the lowlands area during the rainy season with productivity > 20 tons ha\(^{-1}\) and a small percentage of rejected bulbs (<0.5% (0.08 tones ha\(^{-1}\)). The small and large size of G0 Tuk Tuk variety had high productivity (>20 tons ha\(^{-1}\)) but also had high percentage of rejected bulbs of 34.22% (9.79 tones ha\(^{-1}\)), so it is unsuitable to be used as seed bulb in the rainy season.

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