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Growth and yield of five prospective shallot selected accessions from true seed of shallot in lowland areas

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ABSTRACT

True seed of shallot (TSS) from open pollination crossing are in the heterogenous as a result of the heterozygous parents. This condition gives the opportunity to obtain new selected accession through the genetic variations of their seedlings. Five TSS cultivars of Biru Lancor, Pancasona, Tuk-Tuk, Lokananta, Sanren were used as planting materials to be evaluated the growth and bulb yield performance for the selection of excellent shallot selected accessions in bulb production. The 300 seeds of each cultivar were planted in the field of Faculty of Agriculture, Universitas Gadjah Mada, Banguntapan, Bantul District, Yogyakarta (100 m above sea level). All seedlings were observed for the survival rate, plant growth, and development of bulb. The results showed that the seedlings of Sanren, Lokananta, Pancasona, Tuk-Tuk, and Biru Lancor could germinate with different survival rate of 88%, 87%, 80%, 67.3% and 48%, respectively. There was a significant difference in number of leaves that effected in developing a single bulb and multi-bulb. Prospective selected accessions with high yield in lowland areas was as follows: Biru Lancor 12 plants (4%), Pancasona 20 plants (6.7%), Sanren 146 plants (48.7%), and Lokananta 25 plants (8.3%). All of the selected bulbs will be planted again for further evaluation in excellent trait of bulb aggregation (bulbs multiplication).

INTRODUCTION

Shallot (*Allium cepa* L. Aggregatum group) is an important vegetable commodity having strategic value in Indonesia because it is used as spice in dishes and raw material for food industry such as fried shallot. Shallot is cultivated in 34 provinces in Indonesia with various environmental and agro-climate conditions. This condition affects the national productivity of shallot, reaching 9.67 tons.ha^{-1} in 2018 (Badan Pusat Statistik, 2018). This productivity is low (about 50% decreased) compared to the potential productivity that can reach 20 tons.ha^{-1}. Some technologies, including the application of beneficial microorganisms, were determined to maintain shallot productivity (Darsan et al., 2016; Hidayat et al., 2018). However, the productivity could be improved through the development of new shallot selected accessions with high yield using true seed of shallot (TSS).

In last decade, TSS was used for material of shallot propagation, which showed high productivity of more than 20 tons.ha^{-1} (Basuki, 2009; Brink and Basuki, 2012). TSS produced in Indonesia was commonly developed from open pollination crossing. Because shallot was in heteroygous state, such open pollination crossing provided genetic variation of seedlings (Tashiro et al., 1982; Brink and Basuki, 2012). Brewster (2008) reported that 75–90% of onion seeds were the result of cross-pollination.

Heskiel (2015) reported that there were morphological and genetical variations in Tiron and Tuk-Tuk cultivars when these shallot cultivars planted using TSS. The percentage of genetic variation of Tiron and Tuk-Tuk reached 62.26% and 59.70%, respectively. Observations on morphological characters showed the greatest diversity of morphological characters found in the number of leaves, which reached 60.26% in Tiron. However, Prayudi et al. (2014) revealed a small morphological diversity in the Trisula cultivar from TSS (0.75%), but found variation in the number of bulbs per plant, i.e. 1 to 2 bulbs per plant in first generation. The second generation of Trisula cultivar could have 4 to 10 bulbs per plant. Number of bulbs per plant will determine the potential yield, in which the increase of bulb number would increase the yield.

In Indonesia, the TSS cultivars include Tuk-Tuk, Sanren, and Lokananta produced commercially by East West Company. Meanwhile, other TSS cultivars, such as Biru Lancor and Pancasona, were produced by IVEGRI Lembang (Rosliani et al., 2016). Genetic characters of those parents for TSS cultivars were heterozygous. Therefore, genetical and morphological characters variations in the shallot produced by TSS would be performed. This condition provides the opportunity for breeder to use TSS material for selection of new shallot selected accessions for lowland areas since the cultivation of shallot in Indonesia is expanded to lowland areas. Therefore, this research was conducted to examine growth and yield of five shallot selected accessions from TSS in the lowland area.

MATERIALS AND METHODS

True seed of shallot of five cultivars of Pancasona, Biru Lancor, Tuk-Tuk, Sanren, and Lokananta were used in the research. TSS of Biru Lancor and Pancasona cultivars were produced from TSS production project using insect pollinator (honey bees) applications in IVEGRI Lembang (Rosliani et al., 2016). The TSS of Tuk-Tuk, Sanren, and Lokananta cultivars were collected from commercial seeds production by East West Company. The research was conducted at lowland experimental field of Faculty of Agriculture, Universitas Gadjah Mada, Banguntapan District, Yogyakarta (100 m above sea level) from May to September 2017. The research was arranged in a randomized complete block design (RCBD) with treatment of TSS of Pancasona, Biru Lancor, Tuk-Tuk, Sanren, and Lokananta cultivars. Each cultivar consisted of 100 seedling (from 100 seeds) per block, and there were three blocks as replications. Planting was conducted using transplanting system into the polybag with sandy soil media in the screen house.

Plant materials and seedling preparation

TSS seeds were treated with fungicide (mancozeb) before sown into the soil blocks with 2 × 2 × 2.5 cm dimension. Soil blocks were made from cocopeat mixture, compost, manure, natural phosphate, and dolomite with a ratio of 2 : 2 : 2 : 1 : 1 (v/v/v/v/v). Watering was manually applied everyday. Fungicide (mancozeb and mefenoksan) at 2 g.L^{-1} was applied at 10 days after sowing to control the pathogen. Leaf was cut and left for 8 cm long at 26 days after sowing. KNO_3 fertilizer at 1 g.L^{-1} and an NPK compound fertilizer (16–16–16) at 5 g per tray were applied at 28 days-age. The seedlings were transplanted at 40 days-age into polybags at 35 × 35 × 17.5 cm dimension with media containing sand : goat manure at a ratio of 2 : 1 (v/v). Each polybag was planted with two seedlings. Fertilizers were applied to the seedlings three times at 40, 50, and 65 days after sowing at a dose of 180 kg N, 90 kg P_2O_5 and 120 kg K_2O as recommended by Brink and Basuki (2012). The plants from all population were selected and marked in two groups at 80 days-age, which were plants with a single bulb and those with double/ multiple bulbs. The trait of single bulb and double/ multiple bulbs was determined as important trait related to shallot production. The bulbs were harvested at 110 days-age.

Selection new selected accession of shallot

New selected accessions of shallot were selected based on the plant growth and bulb development. Variables of survived plants, number of plants forming bulbs, number of plants forming bulbs aggregation, plant height, number of leaves, and leaf area were observed at 80 days after sowing with 10 plants observed each block. The harvested bulbs were cured for a week then selected and measured for the weight and diameter.

Data Analysis

Data of survived plants, the number of plants forming bulbs, and the number of plants forming aggregation bulbs were tabulated and analyzed in percentage. The average value of plant height, the number of leaves, bulb weight and bulbs diameter were compared between the plants with a single bulb and double/multiple bulbs. The difference between the two groups of plants was calculated and analyzed to determine the potential increase in yield by increasing the number of the bulb in plants. Estimated yield per ha was calculated with the assumption that the planting space was 10 cm × 7.5 cm.

RESULTS AND DISCUSSIONS

Three out of five TSS cultivars showed germination and survival rate of more than 80%, which were Sanren (88%), Lokananta (87%), and Pancasona (81%) (Table 1). Seedlings of TSS cultivar Tuk-Tuk and Biru Lancor showed low survival rate of 67.3 % and 48%, respectively. Five cultivars of shallot plants showed variations in bulb aggregation, which were plants with multiple bulbs and plants with single bulb. Sanren cultivar had the highest number of plants with multiple bulbs (61.6%), followed by Lokananta (10.2%), Biru Lancor (9.52%), Pancasona (9.26%) and Tuk-Tuk (1.2%). The cultivars that had genetic ability to produce multiple bulbs, namely Sanren, Lokananta, Biru Lancor, and Pancasona could be selected as new selected accessions of shallot for further evaluation in stability of bulb aggregation. According to Putrasamedja (2012), shallot clones derived from TSS could produce high number of tillers. Tiller might be related to the development of bulb aggregation that would contribute to the increase in bulb yield.

Characters of plant height (Figure 1), number of leaves (Figure 2) and leaf area (Figure 3) were also identified to evaluate the differences between plants forming single bulb and those forming multiple bulbs. There were no significant differences in plant height between plants with single bulb and those with multiple bulbs observed in Lokananta, Sanren, Pancasona and Biru Lancor cultivars. However, Tuk-Tuk cultivar with multiple bulbs had higher plant height compared to those forming single bulb.

Table 1. Survival plants and number plant formed bulb on five shallot cultivars planting by seeds in the low land area.

Cultivar	Number of plants planted	Survived plants	Percentage of survived plants	Plants formed bulb	Plant formed single bulb		Plant formed multi-bulbs	
					Number	%	Number	%
Tuk-Tuk	300	202	67.33	171	169	98.83	2	1.17
Lokananta	300	260	86.67	245	220	89.80	25	10.20
Sanren	300	264	88.00	237	220	89.80	146	61.60
Pancasona	300	242	80.67	216	114	90.48	12	9.52
Biru lancor	300	144	48.00	126	196	90.74	20	9.26

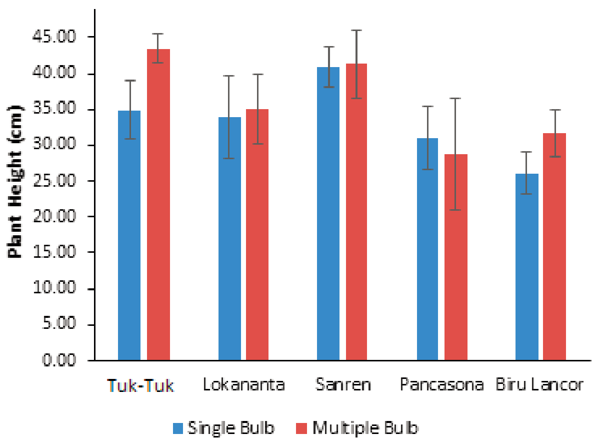

Figure 1. Plant height of five shallot cultivars planted from TSS at 80 days after sowing

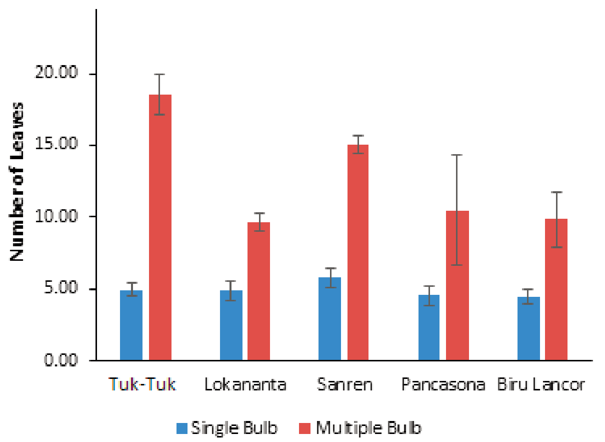

Figure 2. Number of leaves of five shallot cultivars planted from TSS at 80 days after sowing

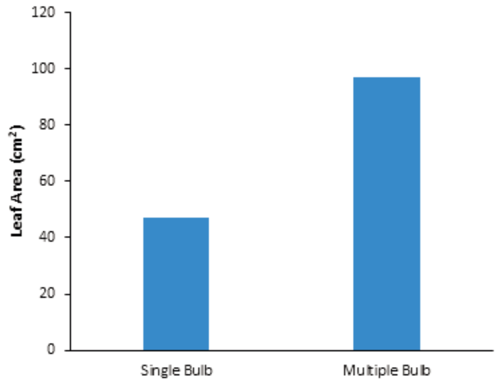

Figure 3. Leaf area of Sanren cultivar planted from TSS at 80 days after sowing

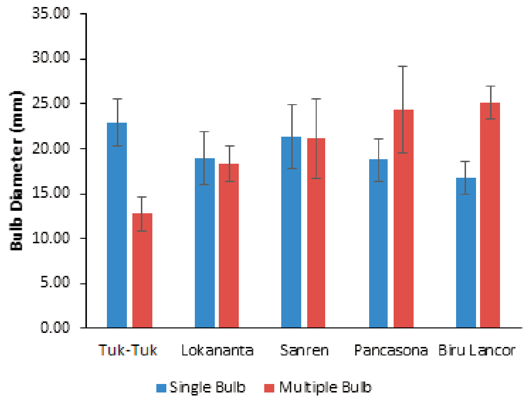

Figure 4. Bulb diameter of five shallot cultivars planted from True Seed of Shallot

Meanwhile, Sanren and Tuk-Tuk had higher plant than the others cultivars, and Pancasona and Biru Lancor had the lower ones.

There were significant differences in number of leaves between plants with single bulb and those with multiple bulbs observed in all cultivars (Figure 2). Plants with multiple bulbs had higher number of leaves than the plant with single bulb. Plants with single bulb were supported by five leaves in average, and plant with multiple bulbs were supported by 10–15 leaves. The number of leaves can be a specific morphological trait to identify the plants with multiple bulbs earlier before the appearance of bulbs aggregation in the field. According to Abbey et al. (1998), shallot bulb number is positively correlated to the number of leaves. Shallot plants with higher number of leaves would produce high photosynthetic for bulb development.

Leaf area of Sanren cultivar with multiple bulbs and single bulb was 96.90 cm^2 and 47.08 cm^2, respectively (Figure 3). This result indicated that plants with higher number of leaves and higher value of leaf area had higher capacity of photosynthesis supporting photo-synthate accumulation as energy for bulb development.

The process of bulb formation and the ability to develop aggregation in shallot bulbs from seeds were influenced by the ability of plants to produce photosynthate accumulated in the bulbs. Photo-synthate accumulation would be used in another growth metabolism in the plant as indicated by an increase in the number of leaves, which would affect the sufficiency of the photosynthate to support the development of bulb. According to Masuzaki et al. (2007), the formation and aggregation of bulb in shallot were influenced by the lateral growth of bulb, but the ability to form aggregations would be optimal if this process was supported by genes that regulate sucrose transport to storage organs/bulbs.

The bulb diameter and bulb weight indicate the amount of photosynthate translocated to the bulb. There were no significant differences in bulb diameter between the plants with single bulb and those with multiple bulbs in Tuk-Tuk, Lokananta, and Sanren

Table 2. Bulb weight (g), number of bulb and percentage of increased yield on bulb with aggregation (multiple bulbs)

Cultivar	Bulb weight (g)		Number of Bulb with aggregation	Increased weight on multiple bulbs	
	Single Bulb	Multiple Bulbs		(g)	%
Tuk-Tuk	6.99 ± 1.36	25.64 ± 4.47	2	18.65	266.63
Lokananta	4.51 ± 0.75	11.64 ± 4.51	2–3	7.13	157.90
Sanren	5.73 ± 1.82	13.30 ± 5.44	2–4	7.57	132.17
Pancasona	3.68 ± 0.93	7.78 ± 2.29	2–3	4.10	111.22
Biru lancor	2.47 ± 0.34	6.68 ± 1.56	2–3	4.21	170.88

cultivars (Figure 4). In Pancasona and Biru Lancor cultivars, the plants with multiple bulbs had higher value of bulb diameter compared to those with a single bulb.

The plants with multiple bulbs had higher bulbs weight than those with single bulb in all cultivars. The average number of bulbs in the plants with aggregation was 2–3 bulbs. With additional 2–3 bulbs in each plant, the increase in bulbs weight attained to more than 100% in all cultivars (Table 2). This result was confirmed by Putrasamedja (2012), reporting that the important variable that an increase yield of shallot from TSS is bulb aggregation.

Plants of each cultivar showing aggregation produced multiple bulbs varying from 2 to 4 bulbs. Those plants had higher number of leaves compared to normal plants (plant forming single bulb). The yield of the plants with multiple bulbs (2–3 bulbs) would increase up to 100% compared to the yield of those with a single bulb. Rabinowitch and Kamenetsky (2002) explained that shallot had ability to produce lateral shoots, in which more lateral shoot would initiate and develop new leaves in plant. These new leaves would become source in photosynthesis and increase the photosynthetic rate, thereby increasing photosynthate accumulation in plant. The increase in the accumulation of photosynthate would support the genetic potential of plants to develop bulb aggregation. This process was reported by Damte et al. (2017) as the stage in which the bulbs began to "push each other apart".

With the performance of multiple bulbs, there was high possibility to select new shallot selected accessions that have high productivity in the lowland areas from the TSS of Sanren, Lokananta, Biru Lancor and Pancasona cultivars. Prospective selected accessions with high yield in lowland areas were Sanren (146 plants), Lokananta (25 plants), Pancasona (25 plants), and Biru Lancor (12 plants) (Table 1). The multiple bulbs from the first generation would be selected and used to the next selection phase to evaluate the stability in bulb aggregation. Our report on the growth and bulb yield of shallot selected accessions using true seed of shallot in the lowland areas was one step towards to improve shallot productivity in the future.

CONCLUSIONS

Prospective shallots selected accessions showing characteristics of multiple bulbs and high yield in lowland areas, which could be selected were the cultivars of Biru Lancor (12 plants or 4%), Pancasona (20 plants or 6.7%), Sanren (146 plants or 48.7%) and Lokananta (25 plants or 8.3%).

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