

Research Article

Growth and Yield of Different Varieties of True Shallot Seed on Highland in West Sumatra, Indonesia

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Cultivation of true shallot seeds has the potential to be developed in Indonesia because apart from being able to reduce the cost of providing seeds, it also has higher productivity than shallot from tubers. This study aims to determine the appearance of true shallot seed varieties that have high yield potential in the highlands of West Sumatra. The study used a randomized complete block design (RCBD) with 4 treatments of true shallot seed varieties, namely, Trisula, Bima, Lokananta, and Sanren, with 6 replications. The results showed that except for the age of harvest and the number of tubers per hill, the treatment of various varieties of true shallot seeds showed a significant effect on all observed variables. Lokananta variety has better growth component, yield component, and yields compared to other varieties (Trisula, Bima, and Sanren). Cultivation of true shallot seeds in the highlands gives lower yields than in the adapted area (lowland), except for the Trisula variety. Lokananta variety is recommended for use in the highlands of West Sumatra.

1. Introduction

Shallots (*Allium ascalonicum* L.) are one of the important food commodities in Indonesia. This commodity is grown in all provinces in Indonesia, except in the Riau Islands Province. West Sumatra Province is one of the centres for shallot production where shallots are cultivated in the highlands, such as Solok Regency (8,879 ha), Agam Regency (661 ha), Solok Selatan Regency (400 ha), Tanah Datar Regency (230 ha), and Lima Puluh Kota Regency (142 ha) [1].

During 2014–2018, the harvested area of shallots had increased by 29.89% in Indonesia and 74.95% in West Sumatra, respectively, from 120,704 ha to 156,799 ha in Indonesia and from 5,941 ha to 10,394 ha in West Sumatra [1]. Meanwhile, according to BPS-Statistics Indonesia 2016 and 2019 report, productivity had decreased by 6.16% in Indonesia, from 10.22 t/ha to 9.59 t/ha. On the other hand, in West Sumatra, there was an increase in the productivity of 6.10% from 10.32 t/ha to 10.95 t/ha [2, 3].

The increase in shallot planting from year to year has increased the need for quality seeds from bulbs. Provision of

quality seeds from bulbs has constraints, such as (1) it requires a large cost of providing seeds from bulbs (around IDR 45 million/ha); (2) it requires a very large number of seeds from bulbs (about 1.5 t/ha); (3) it requires a storage warehouse because of its large number and dormancy period; (4) the usage age of the seed from bulbs is short, and the quality of the seed will decline after 4 months and will be damaged after 6 months; (5) distribution of bulb seeds among farmers/regions requires a large amount of money; and (6) high variation in bulbs seeds' quality and low productivity [4].

The Ministry of Agriculture of the Republic of Indonesia has developed a shallot cultivation technology which sources the seeds from seeds (TSS = true shallot seed). The TSS has advantages, including (1) long storage life (>1 year); (2) higher productivity, up to 20 t/ha; (3) the shape and size of the bulbs produced are relatively more uniform; (4) the cost of buying seeds is relatively cheaper (around IDR 15 million/ha); (5) free of pests and diseases, such as fungi, bacteria, viruses, nematodes, and other insects; and (6) seeds can be planted when needed [5].

The results of the technical and economic feasibility analysis showed that the cultivation of TSS is technically and economically feasible because it can increase the yield of shallot bulbs up to 2 times and the net income in the range of IDR 60–70 million/ha, respectively [6]. Furthermore, this shallot cultivation technology is predicted to improve the bulb yield up to 30 t/ha [7], or even 30–40 t/ha [8]. The varieties of shallot from seeds that have been recently produced include Trisula, Pancasona, Mentas, Maja Cipanas [9], Bima, Sanren, Manjung, Lokananta, Tuktuk, Pikatan, and Tajuk [10]. However, from those varieties, only some varieties are the most circulating ones in the market such as Bima and Trisula (produced by IAARD) and also Lokananta and Sanren (produced by the private sector).

However, the true shallot seed cultivation technology has not been developed at the farmer level till date in Indonesia, including in West Sumatra. Apart from the fact that the availability of seeds is still difficult to obtain, the availability of information regarding the technology of true shallot seed cultivation which is specific to the highlands of West Sumatra, is also very limited, especially regarding superior varieties that have the potential to be developed in the highlands. The true shallot seed varieties released are generally from lowland adaptation areas.

Research on the use of superior TSS varieties has been previously carried out on upland land in Cianjur, West Java Province (1,000 m asl) with Andisol soil types. The Bima, Sanren, Manjung, BM 8705 (Lokananta), Tuktuk, Pikatan, and Tajuk varieties were compared to the Bima variety from the bulbs. In fact, the bulb yields obtained in the Sanren, Manjung and BM 8705 (Lokananta) varieties were not significantly different from the comparison varieties (Bima from bulbs). Meanwhile, the Pikatan, Tuktuk, and Tajuk varieties gave lower yields and were significantly different from the comparison varieties [10]. Furthermore, research conducted in the lowlands of Cirebon, West Java Province, on the seeds of Maja, Bima, and Tuktuk varieties gave no significant difference in bulb growth and yield [11]. Moreover, research conducted in Sigi District, Central Sulawesi Province, found that the Lokananta and Sanren TSS varieties had different responses to the growth and yield of shallot bulbs [12]. The variety of varietal responses in several regions provides an opportunity to test the yield potential of various TSS varieties at shallot production centres in the highlands of West Sumatra. Therefore, this research was conducted which aims to determine the appearance of growth and yield of various TSS varieties in the highlands of West Sumatra.

2. Materials and Methods

The research was carried out from June to December 2020 at the Sukarami Experimental Garden, West Sumatera Assessment Institute for Agricultural Technology (AIAT), Solok Regency, West Sumatra Province, Indonesia, with an altitude of about 1,000 m above sea level (asl) and Andosol soil type [13]. Soil nutrient content before the experiment (4 weeks before planting) was as follows: pH H₂O (5.73; slightly acidic), C-organic (3.86%; high), N (1.02%; very high), C/N

(3.78; very low), P₂O₅ Bray I (8.58 ppm; very low), and K-dd (0.61 cmol/kg; high) [14].

The research was arranged using a randomized completely block design (RCBD) with 4 treatments and 6 replications so that 24 experimental units were obtained. The four TSS varieties (Trisula, Bima, Lokananta, and Sanren) used as treatment were varieties released from lowland adaptation areas.

Basic fertilizer application in the form of dolomite lime (540 kg/ha), cow manure (20 t/ha), and P fertilizer (150 kg P₂O₅/ha or the equivalent of 417 kg SP36/ha) were applied 3 weeks before planting by spreading it evenly on the experimental plots and then stirred with soil. The size of the plot used was 5 m × 1 m. The plots were closed using silver black plastic mulch (SBPM). Four weeks after the application of basic fertilizers, the soil nutrient content was obtained as follows: pH H₂O (6.12; slightly acidic), C-organic (9.27%; very high), N (1.05%; very high), C/N (8.83; low), P₂O₅ (16.51 ppm; low), and K-dd (1.03 cmol/kg; very high) [14].

The tested seeds of shallot varieties were shown in the nursery for 6 weeks. Seedlings that were transplanting to the planting area were those that already have a height of about 10 cm or more. One week before planting, the seedlings were cut by 1/3 of the leaves so that the leaves became stiff and thick, and then 2 seedlings/planting holes were planted. Three days before planting, SBPM holes were made with a distance of 10 × 10 cm and a hole diameter of 5.5 cm.

Follow-up fertilizers in the form of N fertilizer at a dose of 200 kg N/ha derived from 65% urea (130 kg N/ha or equivalent to 283 kg urea/ha) and 35% ZA (Ammonium sulfate) (70 kg N/ha or equivalent to 333 kg Ammonium sulfate/ha) were applied with fertilizer K (150 kg K₂O/ha or the equivalent of 250 kg KCl/ha). Follow-up fertilizers were applied when the plants were 15 days after planting (DAP) and 30 DAP, each 1/2 part of the dose by burying around the plant and covered with soil.

Weeding was done manually at the age of 15, 30, and 45 DAP. Pests and disease were controlled using 3% carbofuran insecticide at the time of planting which was given in the planting hole. Further control was done using recommended pesticides at intervals of 1 × 1 week to 2 × 1 weeks, depending on the level of pest and disease attacks. Additionally, harvesting was done when the green shallot leaves reached 80% yellow, and most of the bulbs were protruding above the soil surface. The formation of a distinctive red pigment and dark red or purplish-red color on the bulbs also occurred. Furthermore, harvesting was done by pulling the plants carefully, then collecting, and drying (using indirect sunlight).

The variables observed included the following: (a) plant height, (b) leaf number per clump, (c) leaf number per bulb, (d) harvest age, (e) bulb number per clump, (f) bulb weight per clump, (g) weight per bulb, (h) bulb height, (i) bulb diameter, (j) wet biomass yield, (k) dry biomass yield, (l) shrinkage of biomass (wet biomass yield–dry biomass yield), (m) shrinkage bulb (wet biomass yield–dry bulb yield), and (n) dry bulb yield. The observed data were tabulated and analyzed for variance (F test), and if a significant difference was found, DMRT (Duncan Multiple Range Test) is at 5% level and correlation analysis was performed [15].

3. Results and Discussion

3.1. The Effect of Various Varieties on Growth, Yield Components, and Yield. Varieties had a very significant effect on plant height, leaf number per clump, bulb weight per clump, weight per bulb, bulb height, bulb diameter, dry biomass yield, shrinkage bulb, and dry bulb yield. Variety had a significant effect on the leaf number per bulb, wet biomass yield, and shrinkage of biomass. Meanwhile, on the harvest age and bulb number per clump, the variety had no significant effect (Table 1).

3.2. Growth Component. The results of statistical analysis on plant height showed that varieties had a significant effect on plant height. Plant height ranges from 60.22 to 70.33 cm. The tallest plants were found in the Lokananta variety (70.33 mm) and the shortest was in the Bima variety (60.22 cm). Varieties also had a significant effect on the leaf number per clump and leaf number per bulb. The leaf number per clump ranged from 14.94 to 17.65 sheets, and the leaf number per bulb ranged from 7.26 to 8.47 sheets. The highest leaf number per clump was in the Sanren variety (17.65 sheets), and the lowest was in the Lokananta variety (14.94 sheets). The similarity was also seen in the leaf number per bulb. On the other hand, the varieties had no significant effect on harvest age (Table 2).

3.3. Yield Component. Statistical analysis on the bulb number per clump showed that the variety had no significant effect on the bulb number per clump. On the other hand, variety significantly affected the bulb weight per clump. The bulb weight per clump ranged from 8.11 to 16.56 g. The greatest bulb weight per clump was found in the Lokananta variety (16.56 g), and the lowest was in the Sanren variety (8.11 g). Variety also affected the weight per bulb, bulb height, and bulb diameter. The weight per bulb ranged from 3.88–8.08 g, bulb height ranged from 20.0–25.5 mm, and bulb diameter ranged from 24.3–31.6 mm. The greatest weight per bulb was in Lokananta variety (8.08 g), and the lowest was in Sanren variety (3.88 g). The same results were seen in bulb height. The highest bulb diameter was also found in Lokananta variety (31.6 mm) and the lowest in Bima and Sanren varieties, 24.3 mm each (Table 3).

3.4. Yield. The results of statistical analysis on the wet biomass yield indicated that the variety had a significant effect on the wet biomass yield. The wet biomass yield ranged from 19,115 to 32,102 kg/ha. The highest wet biomass yield was found in Lokananta variety (32,102 kg/ha), and the lowest was in Bima variety (19,115 kg/ha). Variety also has a significant effect on the dry biomass yield and dry bulb yield. The highest dry biomass yield was found in Lokananta variety (20,632 kg/ha), and the lowest was in Bima variety (13,440 kg/ha). Similar results were seen in the dry bulb yield. The shrinkage of biomass and bulb was also affected by variety. The shrinkage of biomass ranged from 29.5 to 36.0%, and shrinkage bulb ranged from 66.1 to 75.9%. The highest

shrinkage of biomass was found in Trisula variety (36.0%), and the lowest was in Bima (29.5%); while the highest shrinkage bulb was found in Sanren variety (75.9%), and the lowest was in Trisula variety (66.1%) (Table 4).

The appearance of growth components, yield components, and yield of TSS was influenced by the genetic characteristics of the variety and the growing environment. The Lokananta variety had the highest plant height which was not significantly different from the Sanren variety. The result was similar to previous studies [10, 12, 16]. Otherwise, the Lokananta variety had the lowest leaf number per clump and the lowest leaf number per bulb in the Sanren variety similar to that obtained from previous studies [10]. Plant growth is an interaction between genetic traits and environmental factors [17–19]. The difference in the appearance of plants under the same environmental conditions is caused by the genotypic traits of population members [20].

Compared to the descriptions of each variety, it appeared that all varieties tested had higher plant heights. In the description, the plant heights of Trisula, Bima, Lokananta, and Sanren varieties were 39.92 cm, 25–44 cm, 49.08–57.40 cm, and 49.08–57.40 cm, respectively. Meanwhile, the leaf number per tuber of the Bima, Lokananta, and Sanren varieties was in accordance with the description. However, the Trisula variety has a number of leaves per bulb that exceeds its description (4–5 pieces). Furthermore, the leaf number per clump of all tested varieties was still below the description. This is probably because the dense spacing (10 × 10 cm and 2 seeds/planting hole) will increase the plant population more than 2 times, resulting in competition in utilizing sunlight which causes the plants to become taller. In plants with high density, there will be a lack of light so that the number of leaves becomes small due to the reduced photosynthesis process. In addition, there is also an etiolation process (plant growth acceleration) so that plants become taller [21–23].

Furthermore, the harvest age of all tested varieties was longer than the description, ranging from 21–33 days. In the description, the average harvesting age of the Trisula, Bima, Lokananta, and Sanren varieties of bulbs was 53, 60, 65, and 63 DAP, while the results of the research were 86 DAP, 85 DAP, 86 DAP, and 86 DAP. In the Tuktuk TSS variety, the harvesting age was 19–26 days longer than in traditional seeds (bulb origin). This occurs due to broken roots caused by uprooting in the nursery and stagnation in growth and environmental stress at the beginning of growth in the field [8]. In addition, it is also due to the time interval required, starting from the mini bulbs when transplanted in the original seed planting system with bulb size of the seed from the bulb planting system.

Another reason is that all tested varieties were released into lowland adaptation areas so that planting in the highlands led to an extension of the harvest age. The seed yield of Bima variety is 21 days longer in the highlands (1,000 m asl) than in the lowlands (100 m asl) [24], while the harvest age of bulbs in the lowlands is 40 days faster than in the highlands [25]. This is because temperature greatly affects the harvest age [26]. Plants grown at low temperatures (highlands) take a longer time to initiate reproductive

TABLE 1: Summary of variance analysis (*F* test) of the effect of various varieties on growth components, yield components, and yield of true shallot seed (TSS).

Variable	<i>F</i> -test values
Plant height	10.23**
Leaf number per clump	5.58**
Leaf number per bulb	3.43*
Harvest age	1.00 ^{ns}
Bulb number per clump	2.41 ^{ns}
Bulb weight per clump	30.12**
Weight per bulb	39.55**
Bulb height	11.49**
Bulb diameter	13.77**
Wet biomass yield	25.41*
Dry biomass yield	37.09**
Shrinkage of biomass (wet biomass yield–dry biomass yield)	3.34*
Shrinkage bulb (wet biomass yield–dry bulb yield)	7.52**
Dry bulb yield	15.47**

Note: ^{ns} not significantly different, *significantly different at 5% level, **significantly different at 1% level.

TABLE 2: Plant height, leaf number per clump, leaf number per bulb, and harvest age of various TSS varieties.

Variety	Plant height (cm)	Leaf number per clump (sheet)	Leaf number per bulb (sheet)	Harvest age (day)
Trisula	61.87 b	15.05 b	8.15 ab	86 a
Bima	60.22 b	16.29 ab	7.61 ab	85 a
Lokananta	70.33 a	14.94 b	7.26 b	86 a
Sanren	68.07 a	17.65 a	8.47 a	86 a
CV (%)	5.70	8.27	9.29	0.24

The numbers in each column followed by the same lowercase letter are not significantly different at 5% DMRT level.

TABLE 3: Bulb weight per clump, weight per bulb, bulb height, bulb diameter, and bulb number per clump of various TSS varieties.

Variety	Bulb weight per clump (g)	Weight per bulb (g)	Bulb height (mm)	Bulb diameter (mm)	Bulbs number per clump (piece)
Trisula	11.05 b	5.93 b	21.7 b	26.4 b	1.86 a
Bima	11.30 b	5.27 b	20.6 b	24.3 b	2.15 a
Lokananta	16.56 a	8.08 a	25.5 a	31.6 a	2.07 a
Sanren	8.11 c	3.88 c	20.0 b	24.3 b	2.08 a
CV (%)	13.16	12.20	8.09	8.53	9.76

The numbers in each column followed by the same lowercase letter are not significantly different at the 5% DMRT level.

TABLE 4: Wet biomass yield, dry biomass yield, shrinkage of biomass, dry bulb yield, and shrinkage bulb of various TSS varieties.

Variety	Wet biomass yield (kg/ha)	Dry biomass yield (kg/ha)	Shrinkage of biomass (%)	Dry bulb yield (kg/ha)	Shrinkage bulb (%)
Trisula	26,192 b	16,738 c	36.0 a	8,870 b	66.1 b
Bima	19,115 c	13,440 d	29.5 b	6,324 c	66.5 b
Lokananta	32,102 a	20,632 a	35.5 a	10,469 a	67.3 b
Sanren	28,217 b	18,803 b	33.0 ab	6,714 c	75.9 a
CV (%)	10.02	7.13	11.92	14.92	6.02

The numbers in each column followed by the same lowercase letter are not significantly different at the 5% DMRT level.

development than at high temperatures (lowlands) [27]. At low temperatures, the plant growth rate is slower due to the slow process of photosynthesis, thus extending the harvest age [21, 28].

Lokananta variety also has the best bulb weight per clump, weight per bulb, bulb height, and bulb diameter compared to other varieties. This is due to the variety response which is closely related to the plant height. It is suspected that higher plants have wider leaves, which will produce more photosynthate. Previous studies have found a

very significant correlation between plant height and bulb height, bulb diameter, wet biomass yield, and dry biomass yield and not significantly different from the number of bulbs per clump [10]. The same condition was also found in this study (Table 5). However, the value of the yield component is still low in comparison with the description. Highland's low-temperature factor is predicted to be the cause of the low yield component value of the varieties released to the lowlands with high temperatures. Research on rice plants found that low temperatures can reduce the

TABLE 5: Matrix correlation between yield, yield component, and growth component.

Variables	TT	JR	JU	UP	JB	BB	BU	DU	TU	BH	BG	SB	SU	HU
TT	1.000													
JR	-0.091	1.000												
JU	-0.123	0.564**	1.000											
UP	-0.155	0.040	0.100	1.000										
JB	0.012	0.442*	-0.484*	-0.058	1.000									
BB	0.358	-0.439*	-0.580**	-0.121	0.184	1.000								
BU	0.363	-0.606**	-0.415*	-0.091	-0.179	0.931**	1.000							
DU	0.509**	-0.534*	-0.540**	-0.269	0.024	0.757**	0.754**	1.000						
TU	0.420*	-0.474*	-0.577**	-0.355	0.144	0.711**	0.652**	0.909**	1.000					
BH	0.686**	-0.270	-0.118	-0.182	-0.181	0.411*	0.484*	0.634**	0.503*	1.000				
BG	0.761**	-0.198	-0.143	-0.167	-0.079	0.401	0.441*	0.646**	0.514*	0.969**	1.000			
SB	0.179	-0.352	0.053	-0.169	-0.440*	0.243	0.386	0.311	0.258	0.662**	0.464*	1.000		
SU	0.332	0.526**	0.378	-0.175	0.107	-0.313	-0.342	-0.127	-0.195	0.318	0.364	0.074	1.000	
HU	0.398	-0.675**	-0.426*	-0.075	-0.239	0.648**	0.735**	0.724**	0.663**	0.670**	0.612**	0.545**	-0.474*	1.000

Note: TT = plant height, JR = leaf number per clump, JU = leaf number per bulb, UP = harvest age, JB = bulb number per clump, BB = bulb weight per clump, BU = weight per bulb, DU = bulb diameter, TU = bulb height, BH = wet biomass yield, BG = dry biomass yield, SB = shrinkage of biomass (wet-dry), SU = shrinkage bulb (wet biomass yield-dry bulb yield), HU = dry bulb yield, ** = significantly different at the level of 5%, * = significantly different at the level of 1%.

value of yield and yield components, depending on the variety planted [29].

Wet biomass yield, dry biomass yield, and dry bulb yield were also found in Lokananta varieties which were significantly different from other varieties. However, the yield of this dry bulb was still below the description, except for the Trisula variety. Overall, this is controlled by genetic traits [30]. However, differences in the final appearance of plants were also determined by differences in environmental conditions [20]. Varieties that have high yield potential at one location are not necessarily high yield potentials at other locations [31]. Bima variety of shallot is very sensitive to environmental changes, while the varieties of Probolinggo, Tiron-sawah, and Biru-pasir are well adapted to all environments [32].

The increase in dry bulb yield was closely related to the growth component and yield component [10]. This study found of dry bulb yield had a very significant positive correlation with bulb weight per clump, weight per bulb, bulb diameter, bulb height, wet biomass weight, dry biomass weight, and shrinkage of biomass. On the other hand, the leaf number per clump was significantly negatively correlated, while the leaf number per bulb and shrinkage bulb had a significant negative correlation (Table 5). Therefore, the higher values of bulb weight per clump, weight per bulb, bulb diameter, and bulb height resulted in increased dry bulb yield of the Lokananta variety. The negative correlation between the dry bulb and leaf number (per clump and per tuber) indicates that the dry bulb yield decreases with more leaves. This may be due to the distribution of assimilates for vegetative growth more than for shallot bulb growth [33].

4. Conclusions

Lokananta variety provided the best growth components (leaf number per clump and leaf number per bulb) and yield component (bulb weight per clump, weight per bulb, bulb height, and bulb diameter) so that it gave the largest dry bulb

yield compared to other varieties (Trisula, Bima, and Sanren). This study recommends using Lokananta variety of shallots whose seeds come from true shallot seeds to produce the largest dry bulbs in the highlands of West Sumatra.

Data Availability

All data described in the Results and Discussion section are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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