Growth and Yield of Shallot (*Allium cepa* L. Aggregatum Group) Affected by Transplanting Age and Varieties of TSS

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Abstract. Shallot (*Allium cepa* L. Aggregatum group) is an important commodity for spices, traditional medicines, and healthy diet components. Growth and yield shallot plants from TSS affected by different transplanting ages were determined in the research in RCBD with two factors and three replications. The first factor was the transplanting time (4, 6, 8, and 10 weeks after sowing/WAS), and the second factor was the TSS varieties (Sanren, Tuk Tuk, and Lokananta). Analysis of variance α of 5% was performed on growth and yield data and continued with Duncan's Multiple Range Test (DMRT). The results showed that transplanting 4 and 6 weeks ages seedlings provided higher plant height, leaf area, root, plant growth rate, and plant yield than those in transplanting 8 and 10 weeks ages seedlings. Seedling at six weeks was the best seedling that provided higher productivity for Tuk Tuk, Lokananta, and Sanren varieties (23.03 tonnes.ha^{-1}), but the result was no significant with seedling transplanted at 4 WAS (20.07 tonnes.ha^{-1}). Seedling transplanted at 8 and 10 WAS decreases the yield by 30% and 39%, respectively. Farmers and seed producers can use and trade Sanren, Tuk Tuk, and Lokananta seedlings at 4–6 weeks after sowing to get the optimum productivity.

Keywords: Seedlings · Transplanting age · True seed of shallot · Varieties

1 Introduction

Shallot (*Allium cepa* L. Aggregatum group) is an important commodity for Indonesian people since it is used for spices, raw materials for consumption, and traditional medicines and diets component [1]. The problem of increasing shallot production was the lack of good quality planting materials [2]. Seed bulbs from the previous harvest were commonly used as planting material. Using seed bulbs continuously from generation to generation will decrease the quality of the bulb. One of the alternative ways to overcome the limitations of planting material and increase production and quality is by developing planting materials of shallot from seeds, known as True Seed of Shallot (TSS) [3]. The use of TSS compared to seed bulbs has several advantages, such as high productivity,

A. G. Abdullah et al. (Eds.): SEAVEG 2021, ABSR 23, pp. 348–356, 2023.
https://doi.org/10.2991/978-94-6463-028-2_37

lower production costs, free from seed born disease infections, easier packaging and distribution, and being stored longer (>two years) [1].

TSS can be cultivated in several ways, i.e., directly planting seeds in the field, transplanting using TSS seedling, and producing mini bulbs (<3 g/bulb) from TSS. The optimum transplanting age of seedlings will affect the success of the planting. Seedlings from TSS (Tuk-Tuk variety) require a time of 6 weeks before transplanting to the field on suboptimal land [4].

Some varieties of TSS are introduced to farmers in Indonesia, such as Sanren, Lokananta, and Tuk-Tuk. According to the variety's description, the three varieties have high production, i.e., 20–30 tonnes.ha^{-1} compared to the plants originating from bulbs of nine tonnes.ha^{-1} [5]. To date, there is less information on whether the three varieties have differences in planting time and how they respond to different seedling ages. Farmers and nurseries need this information in seedling production management and trading. This study aimed to determine the effect of the difference in seedling ages on the growth and yield of shallot plants from seed in Sanren, Lokananta, and Tuk Tuk and obtain the optimum seedling ages for three cultivars.

2 Materials and Methods

This study was conducted from August 2017 to January 2018 on the experimental field of faculty of agriculture UGM, Banguntapan, Bantul with regosol as the type of soil. The research used a randomized, complete block design with two factors. The first factor was the transplanting age of seedlings into the field, consisting of four levels, i.e., four weeks after sowing (WAS), six WAS, eight WAS, and ten WAS. The second factor was three planted shallot varieties, such as Sanren, Lokananta, and Tuk-Tuk. Each treatment had three replications [6].

The stages of this study included germination of TSS to produce seedlings, transplant the seedlings to the field based on transplanting age treatments. The TSS was germinated in a soil block planting medium consisting of a mixture of manure and two seeds per hole. The seedlings were simultaneously transplanted with the treatment. The first transplantation was carried out when the seedlings reached four WAS. The second transplantation was carried out when the seedlings were six WAS; the third and fourth transplantations were sequentially carried out when the seeds were eight WAS and ten WAS. The bulbs were harvested at the age of 60–70 days after being transplanted to the field.

The variables included seedling growth while transplanted, plant growth 85 days after planting, and yield components. Observation of plant growth included variables of plant height, leaf number, leaf area, root length, number of roots, root surface area, crop growth rate, plant dry weight, and yield components. Yield components included productivity, fresh bulb weight per plant, harvest weight of sun-dried, number of bulbs, and bulb diameter. The data were analyzed using analysis of variance. Duncan's Multiple Range Test (DMRT) was used at a significance level of $p < 0.05$ when there were any significant differences in ANOVA.

3 Results and Discussion

3.1 Seedlings Growth at Transplanting Time

There was no interaction between transplanting age and varieties on seedling growth variables as shown in Table 1. The difference in seedling age affects the TSS seedling growth variables. The older the seedling age, the higher the plant height, leaf area, number of roots, and root length. However, the number of leaves and root area were not significantly different. The differences in TSS varieties did not cause differences in seedling growth variables.

The total dry weight of seedlings while transplanting was presented in Table 2. There was an interaction between the transplanting age treatments and varieties on the dry weight of seedlings. In Sanren and Lokananta varieties, older seedling age will increase the dry weight of seedlings. However, in Tuk-Tuk variety, there was no significant effect on seedling age to dry seedling weight.

3.2 Shallot Grow After Transplanting

There was no interaction between transplanting age and varieties on plant growth variables after transplanting, as shown in Table 3. Seedling ages 4 and 6 WAS had higher leaf area, root length and crop growth rate (CGR) than those of 8 and 10 seedling ages. Seedling ages 4 and 6 WAS had higher leaf area, root length, and CGR than 8 and 10

Table 1. Characteristics of seedlings in height, number of leaves, leaf area, number of roots, root length and root area with different transplanting age (four, six, eight and ten weeks after sowing)

Treatment	Height (cm)	Number of leaves	Leaf area (cm^2)	Number of roots	Root length (cm)	Root area (cm^2)
Transplanting age						
Four weeks	13,86 c	5,11 a	7,86 b	25,56 b	9,77 b	0,72 a
Six weeks	17,20 ab	6,00 a	9,74 b	28,33 a	10,01 b	0,69 a
Eight weeks	16,75 b	6,67 a	9,18 b	28,44 a	10,67 b	0,75 a
Ten weeks	18,52 a	6,89 a	12,16 a	30,44 a	13,49 a	0,82 a
Varieties						
Sanren	15,57 q	6,08 p	9,16 p	27,00 p	10,61 p	0,74 p
Lokananta	17,59 p	6,16 p	9,59 p	28,25 p	10,69 p	0,70 p
Tuk-tuk	16,57 pq	6,25 p	10,45 p	29,41 p	11,66 p	0,78 p
Average	16,57	6,16	9,73	28,22	10,98	0,74
Interaction	–	–	–	–	–	–
CVV (%)	8,1	22,55	4,54	9,12	14,12	18,64

Notes: Numbers in the same column followed by the same letters were not significantly different from the DMRT test at the 5% level; (–) no interaction of varieties and transplanting age.

Table 2. Seedlings dry weight before transplanted (MG)

Transplanting age	Varieties			Average
	Sanren	Lokananta	Tuk-tuk	
Four weeks	2,33 c	3,33 bc	5,0 ab	3,55
Six weeks	3,6 bc	4,3 abc	4,3 abc	4,11
Eight weeks	3,6 bc	4,3 abc	5,0 ab	4,33
Ten weeks	6,3 a	6,0 a	4,33 abc	5,55
Average	4	4,5	4,6	+
Coefficient of variance				28,38%

Notes: Numbers in the same column and row followed by the same letters were not significantly different from the DMRT at the 5% level; (+) an interaction of varieties and transplanting age.

Table 3. Plant growth after transplantation

Treatment	Leaf area (cm^2)	Number of roots	Root length (cm)	CGR ($g.cm^2.week^{-1}).10^{-2}$	Harvest time* (DAS)
Seedling ages					
Four weeks	379.82 a	51.39 a	59.20 a	5,9 a	99
Six weeks	322.07 a	43.19 ab	58.74 a	6,0 a	113
Eight weeks	214.76 b	37.28 ab	45.39 b	3,2 b	130
Ten weeks	159.04 b	23.63 ab	45.78 b	3,6 b	141
Varieties					
Sanren	260.78 p	43.54 p	46.88 p	4,1 p	195
Lokananta	314.34 p	36.98 p	50.60 p	5,5 p	197
Tuk-tuk	231.64 p	36.10 p	59.06 p	4,5 p	121
Interaction	–	–	–	–	
CV (%)	18.66%	22.56%	13.78%	23,08%	

Notes: Value with the same letters is not significantly different based on the DMRT test at the 5% level; numbers followed by the letters are the same in the treatment averages; (–) no interaction of varieties and transplanting age.

seedling ages to produce more assimilate for the plant. The assimilate then translocate to the bulb, resulting in a higher bulb and increased yield and plant productivity. Furthermore, the older the seedling age, the shorter the age of the plant in the field so that the plant growth process was also limited.

The root area of TSS had a lower value but was not significantly different from the root of the bulb plants (Table 4). There was an interaction between the treatment of transplanting age and varieties to the variable of root area after transplanting. Sanren had

Table 4. Root area after transplantation

Transplanting age	Varieties			Average
	Sanren	Lokananta	Tuk-Tuk	
Four weeks	14,1 bcde	20,0 a	19,4 a	17,88
Six weeks	17,5 ab	18,3 ab	6,17 de	14,03
Eight weeks	10,7 bcde	15,90 abc	10,5 bcde	12,38
Ten weeks	9,21 cde	4,14 e	6,85 de	6,73
Average	12,9	14,62	10,75	+
Coefficient of variance				24,89%

Notes: Value with the same letters is not significantly different based on the DMRT test at the 5% level; Numbers followed by the letters are the same in the treatment, (+) a significant interaction of varieties and transplanting age.

the highest root area when transplanted at six WAS and was significantly different from the plant at ten weeks old seedlings. Lokananta root area in plants with transplanting ages of four, six, and eight WAS was better and significantly different from plants transplanted at ten WAS. Shallots from Tuk-Tuk variety had the largest root area transplanted at four-week-old seedlings and were significantly different from the treatment of other transplanting ages.

There was no interaction between the transplanting age and shallot varieties on dry weights of shoot (leaves and bulbs), root, and total dry weight of plant at harvest (Table 6). Shallots from TSS were significantly different from bulbs on the dry weights of shoot, root, and total plant variables. Plants from bulbs had a more significant number of bulbs, causing the total dry weight of plants than TSS, which could only form 2–4 bulbs per plant (Table 5). Plants transplanted at a younger age had dry shoot weight and total dry weight significantly different from those transplanted at an older age. However, the differences in the transplanting age did not produce a different dry weight of roots. The treatment of varieties did not show significant differences in the root dry weight and total plant dry weight variable at harvest. However, it produced significant differences in shoot dry weight. Lokananta variety had the highest shoot dry weight compared to that of Sanren and Tuk-Tuk.

There was no interaction between the transplanting age and shallot varieties on productivity, fresh harvest weight, dry weight of the sun-dried per plant, number of bulbs, and diameter of the bulb (Table 6). The productivity of shallots from TSS was not significantly different from those that had been planted from bulbs. Plants transplanted at six WAS had productivity that was significantly different from those transplanted at an older age. However, The treatment among the three cultivated varieties did not show significant differences in production. The fresh harvest weight and dry weight of sun-dried per plant after harvest resulted significantly between shallot from TSS and shallot from seed bulbs. The TSS dry weight per plant had a lower value and was significantly different from seed bulbs because it was influenced by the number of bulbs formed.

Table 5. Plant dry weight at harvest

Treatment	Shoot Dry Weight (g)	Root Dry Weight (g)	Total Dry Weight (g)
Transplanting age			
Four weeks	7,61 a	0,45 a	8,05 a
Six weeks	6,82 b	0,43 a	7,26 b
Eight weeks	5,82 c	0,35 a	6,09 c
Ten weeks	5,03 d	0,27 a	5,39 c
Varieties			
Sanren	6,01 b	0,43 p	6,43 p
Lokananta	6,67 a	0,42 p	7,09 p
Tuk-tuk	6,29 ab	0,29 p	6,58 p
Interaction	–	–	–
Coefficient of variance	4,28%	22,84%	5,3%

Notes: Value with the same letters is not significantly different based on the DMRT test at the 5% level; Numbers followed by the letters are the same in the treatment averages, and the control is not significantly different from the test of the contrast level of 5%; (−) no interaction of varieties and transplanting age.

The plants from TSS and control plants (bulbs) showed significant differences in the number of bulbs formed at harvest. Tuk-Tuk bulb yields had a large diameter but could only form two bulbs per plant. This result was in line with the research conducted by Buda et al. [7], stating that Tuk-Tuk had the highest weight adapted in Kintamani. There was an increase in bulb diameter and fresh weight of fresh weight 31.03% and 48.57% with the addition of N elements, respectively. According to Basuki [8], the characteristics of shallots favored by farmers are round and have large bulbs with a diameter of more than two cm and dark red color.

The number of bulbs and diameters obtained from the observations followed the variety's description. Sanren, Lokananta, and Tuk-Tuk varieties might have adapted well in environmental conditions. Genetic factors were more dominant factors than seedlings' age. According to Poespodarsono [9], there are two causes for a variety to adapt well, i.e., varieties consisting of one type genotype to control adaptation in the environment condition, and varieties consisting of several different genotypes, each of them can adapt to the environment.

In Table 6 we know that productivity was decreased as the effect of longer transplanting age. Table 7 shows in percentage the effect seedling ages to decrease shallot yields. Productivity value was compared with the seedling result six weeks after sowing, which had the highest productivity. Seedlings were aged four weeks after sowing led to a decrease in yield by thirteen 13%, while seedlings aged 8 and 10 weeks after sowing caused a decrease of thirty % and thirty-nine%, respectively. This result in line with Pangestuti et al. [10] stated that seeding is the most crucial step in TSS cultivation.

Table 6. Components of shallot yields

Treatment	Productivity (ton.ha^{-1})	Harvest fresh weight per plant (g)	The dry weight of sun-dried per plant (g)	Number of bulbs formed	Bulb diameter (cm)
Transplanting age					
Four weeks	20,07 ab	50,69 a	26,38 a	2,95 ab	2,71 a
Six weeks	23,03 a	58,15 a	32,29 a	3,40 a	2,66 a
Eight weeks	16,19 ab	24,53 b	12,96 b	2,64 b	2,13 b
Ten weeks	14,51 b	21,98 b	11,46 b	2,56 b	1,4 c
Varieties					
Sanren	17,39 p	37,50 p	20,47 p	4,07 p	1,95 r
Lokananta	16,75 p	35,28 p	17,74 p	2,57 q	2,23 p
Tuk-tuk	21,20 p	43,74 p	24,11 p	2,02 r	2,50 q
Interaction	–	–	–	–	–
Coefficient of variance	14,74%	17,75%	18,37%	17,4%	9,08%

Notes: Value with the same letters is not significantly different based on the DMRT test at the 5% level; Numbers followed by the letters are the same in the treatment averages, and the control is not significantly different from the test of the contrast level of 5%; (–) no interaction of varieties and transplanting age.

Table 7. Effect seedling ages to decrease of shallot productivity

Seedling ages	Yield Decrease	
	(ton. ha^{-1})	Percentage (%)
Six weeks*	0	0
Four weeks	3	13
Eight weeks	7	30
Ten weeks	9	39

*Seedling with higher yield.

Optimum transplanting age may affect seedling quality and increase the planting success rate in the field and enhance the plant's productivity [11, 12].

4 Conclusions

- Seedling at six weeks was the best seedling that provided higher productivity for Tuk Tuk, Lokananta, and Sanren varieties (23.03 tonnes.ha^{-1}), but the result was no significant with seedling transplanted at 4 WAS (20.07 tonnes.ha^{-1}).

- Seedling transplanted at 8 and 10 weeks after sowing decreases the yield by 30%, and 39%, respectively.

Acknowledgment. The authors would like to thank ACIAR and Rekognisi Tugas Akhir (RTA)" program 2019 for supporting this research.

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