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GROWTH AND YIELD OF SHALLOT UNDER SEVERAL LEVELS OF SOIL WATER TABLE

Susilawati*, **Irmawati**, **Sukarmi Sri**, **Ammar Muhammad**,
Kurnianingsih Astuti, **Yusnita**, **Yayandra**
Department of Agronomy, Faculty of Agriculture, University of Sriwijaya, Indonesia
*E-mail: susilawati@fp.unsri.ac.id

ABSTRACT
The research was aimed to evaluate differences on growth and yield of two shallot varieties under several levels of soil water table. It was conducted in experimental field and plastic house of Agriculture Faculty, Universitas Sriwijaya for three months in 2019. Materials used were shallot bulb from Tajuk and Pancasona varieties and biochar originated from oil palm empty fruit bunch. Factorial Randomized Block Design was used with two treatment factors and three replicates. First treatment was 2 shallot variety consisting Tajuk and Pancasona variety. Second treatment was level of soil water table including T_0= 0 cm below soil surface; T_1= 10 cm below soil surface; T_2= 15 cm below soil surface; and T_3= 20 cm below soil surface. The observed parameters consisted of plant height, leaf number, tiller number, total bulb fresh weight, bulb fresh weight, bulb dry weight, bulb number, bulb diameter, and root length. Results showed that shallot growth of Pancasona and Tajuk variety was highly affected by levels of soil water table. It was then concluded that Pancasona variety showed better growth performance and yield compared to Tajuk variety. The deeper soil water table reaching 20 cm below soil surface can reduce growth and yield of shallot.

KEY WORDS
Non-tidal swamp, shallot variety, water table.

Indonesia is one of seasonal vegetables and fruits producer. Form total 22 types of seasonal vegetables, five main commodities with highest production in 2017 were shallot, cabbage, cayenne pepper, potato, and chili pepper. Shallot production reached 1.47 million tons from total 12.48 million tons or approximately 11.78% (Statistics Indonesia, 2017; Agricultural Statistics, 2018). Therefore, shallot has been an important commodity for national economy development.

Shallot production centre areas in Indonesia include Central Java, East Java, West Java and West Nusa Tenggara. These four provinces have contributed about 85.33% of Indonesian average production. East Java shares the biggest contribution of 40.59% with 432,813 tons of average production. While East Java in the second place with 23.16% and 246,927 tons of average production per year. West Java and West Nusa Tenggara contribute 11.10% and 10.48%, respectively. The rest of 14.67% is from other provinces (Agriculture Data and Information Center, 2016).

Based on General Directorate of Horticulture, the success key of shallot self-sufficiency is on the management and development of production centers that are not solely concentrated in Java. At this moment, shallot cultivation in large scale is not only found in Brebes, Cirebon or Nganjuk, but also has been spread in Solok, Bali, Bima, Sumbawa, Belu, Malaka, Southeast Maluku, Enrekang, Tapin and other areas. West Sumatra province, especially Solok, is shallot production center in Sumatra with total production reaching 955,000 tons in 2017. While shallot domestic demand in West Sumatra is about 2.57 kg/year or about 14,000 tons, the production surplus is then distributed to North Sumatra, South Sumatra, Riau and Jambi (Sudarsono, 2018). Shallot production in South Sumatra in 2015, 2016 and 2017 is around 582.8 tons, 637.6 tons and 1,375.8 tons, respectively (South Sumatra Statistics Center, 2018).

Along with government program of shallot production center development outside Java, South Sumatra is considered to be potential for the option. South Sumatra has the largest coverage areas of non-tidal swamp in Sumatra reaching 2.98 millions ha. From the total, there are about 368,690 ha of non-tidal swamp area cultivated as rice field, consisted of 70,908 ha of shallow swamp, 129,103 ha of middle swamp, and 168,670 ha of deep swamp. While the rest for about 2.60 millions ha are not yet utilized. In 2019, government optimization program of 500,000 ha swamp –both non-tidal and tidal swamp– includes South Sumatra, along with other five provinces which are South Kalimantan, South Sulawesi, Lampung, Jambi and Central Kalimantan. South Sumatra and South Kalimantan are considered as the most ready provinces (Rajagukguk, 2019).

Up until now, non-tidal swamp development is still not optimal due to its flooding problem with various water depths and flooding durations. Flooding have a great impact on environment and yield (Jackson and Ismail, 2015; Malik *et al*., 2015). Main challenge for non-tidal swamp cultivation is how to optimize seasonal water availability. The land can be flooded for several months during rainy season so that it can be utilized for cultivation and also is suffered from drought in dry season (Meihana *et al*., 2019a). Anoxia condition occurs during flooding, while hypoxia occurs when water depth is less than 20 cm (Malik *et al*., 2015; Meihana *et al*., 2019b).

Shallot growth demands a growing media containing crumble soil structure and sufficient organic matter with non-acid soil pH for about 5.6-6.5 (Sumarni and Hidayat, 2005; Kurnianingsih *et al*., 2018a; Kurnianingsih *et al*., 2018b). Generally, shallot will not have optimal growth when being cultivated in rainy season. Main factor for the problem is water availability. Susilawati *et al*. (2018) reported that the combination of 60% of soil and 40% cow manure for growing media resulted in the best shallot growth and yield with average of 84.36 g of dry weight bulb per clump. In contrast, shallot cultivation during dry season will face water shortage problem. However, it is necessary to evaluate how deep soil water table in order to be able to support shallot growth. Research study by Susilawati and Lakitan (2019) resulted that the best performing snap bean growth and yield was obtained in 20 cm of water depth below soil surface. Thus, this research then was conducted to evaluate the difference of growth ability and yield of two shallot varieties under several levels of soil water table cultivated in polybags.

METHODS OF RESEARCH

The research was conducted in experimental farm and in plastic house of Agriculture Faculty, Universitas Sriwijaya Indralaya in Ogan Ilir, South Sumatra. While laboratory works were carried out in Laboratory of Plant Physiology, Agronomy Department, Universitas Sriwijaya Indralaya. The research was conducted for three months in 2019. Materials used consisted of shallot bulbs from Tajuk and Pancasona varieties, biochar from oil palm empty fruit bunch, paper bag and polybag. Research tools consisted of hoe, gauge, plastic buckets, measuring glass, analytical scale and oven. Factorial Randomized Block Design was used with two factors and three replicates. First factor was shallot variety: V_1 = Tajuk variety; and V_2 = Pancasona variety. Second factor was soil water table: T_0 = 0 cm below soil surface; T_1 = 10 cm below soil surface; T_2 = 15 cm below soil surface; and T_3 = 20 cm below soil surface.

Planting media was alluvial top soil cleaned and sieved before putting into the polybags of 10 kg volume. Biochar then was mixed into the media one week before planting with the dosage of 20 tons per ha. Shallot bulbs from Tajuk and Pancasona variety were obtained from Brebes. Before planted, the bulbs were cut in 1/3 from the edge and then planted into the media in 2-3 cm depth. One bulb was planted into each polybag. The polybags containing shallot bulbs then were soaked into plastic bucket filled with water according to the water table treatments and then put in the plastic house.

Water table in the bucket was maintained as the treatments by adding water every evening. Shallot plant treated with water table treatment only survived for 11 days, so the polybags then were taken out of the bucket in the 12th day. After taken out, polybags were still placed in the plastic house until 30 days. Polybags then were placed outside plastic house in 31th day. Parameters observed consisted of plant height, leaf number, and tiller number which were all measured from 3 – 38 days after treatment (DAT) and total plant fresh weight, bulb fresh weight, bulb dry weight, bulb number, bulb diameter, root length and added water volume.

Resulted data then were statistically analyzed using analysis of variance (ANOVA) by comparing the resulted F value to F table. When resulted F value less than F table at 5%, it means that the treatment has insignificant effect. While significant effect is obtained if F value is bigger than F table at 5% level. Furthermore, very significant effect is obtained if resulted F value is more than F table at 1% level. Least significant difference test then used to analyze the data that showed significant and very significant effect.

Table 1 – The effect of soil water table on vegetative growth of two shallot varieties

No.	Parameter	F-value			Coefficient of variance (%)
		V	T	VT	
1.	Plant height at treatment or 0 DAT	0.19 ns	2.62 ns	1.99 ns	22.14
2.	Plant height at 3 DAT	2.17 ns	3.14 ns	3.58 *	11.41
3.	Plant height at 10 DAT	1.35 ns	2.35 ns	0.97 ns	13.65
4.	Plant height at 17 DAT	2.73 ns	2.62 ns	2.77 ns	10.20
5.	Plant height at 24 DAT	4.17 ns	4.05 *	3.50 *	10.31
6.	Plant height at 31 DAT	33.79 **	1.62 ns	4.27 *	8.58
7.	Leaf number at treatment or 0 DAT	0.68 ns	1.11 ns	0.05 ns	31.56
8.	Leaf number at 3 DAT	0.31 ns	2.00 ns	0.26 ns	28.01
9.	Leaf number at 10 DAT	1.00 ns	2.36 ns	0.35 ns	27.68
10.	Leaf number at 17 DAT	3.20 ns	2.29 ns	0.30 ns	27.58
11.	Leaf number at 24 DAT	11.25 **	2.34 ns	0.82 ns	28.13
12.	Leaf number at 31 DAT	9.57 **	1.67 ns	0.60 ns	32.40
13.	Tiller number at treatment or 0 DAT	5.22 *	1.06 ns	1.36 ns	22.26
14.	Tiller number at 3 DAT	12.00 **	3.20 ns	7.75 **	14.97
16.	Tiller number at 10 DAT	8.23 *	2.57 ns	3.48 *	17.53
17.	Tiller number at 17 DAT	4.77 *	0.68 ns	3.36 *	20.18
18.	Tiller number at 24 DAT	5.38 *	1.52 ns	2.44 ns	17.35
19.	Tiller number at 31 DAT	1.10 ns	2.41 ns	0.62 ns	26.62
20.	Root length	16.67 **	4.73 *	1.14 ns	21.11
	F table 5 %	4.60	3.34	3.34	
	F table 1 %	8.86	5.56	5.56	

*Note: DAT = day after treatment; ns = not significantly different; * = significantly different at $p < 0.05$; and ** = significantly different at $p < 0.01$.*

RESULTS OF STUDY

Based on analysis of variance, it was resulted that levels of soil water table had significant effect on growth and yield of two shallot varieties as seen in Table 1. Difference on varieties showed very significant effect on plant height at 24 DAT and 31 DAT, tiller number at 0 – 24 DAT, and root length, while soil water table treatment only showed significant effect at 24 DAT. The combination of variety and soil water table treatment had insignificant effect on all observed parameters, except for plant height at 3, 24, and 31 DAT, and also for tiller number at 3 – 17 DAT.

The difference on soil water table showed insignificant effect on growth of two shallot varieties for 11 days after planting, as seen in several parameters such as plant height, leaf number and tiller number at 0 DAT. Based on average data, V_1 (Tajuk) had shorter height compared to V_2 (Pancasona) from 0 to 24 DAT, the difference between these two varieties were significantly showed at 31 DAT. Water table treatment showed insignificant effect on plant height at all plant ages, except at 24 DAT. The difference on leaf number parameter was started to appear from 0 to 17 DAT but was statistically significant at 24 and 31 DAT. Leaf number was not affected by soil water table treatment (Table 2).

Similar with plant height and leaf number, Pancasona also showed better result in tiller number compared to Tajuk variety. Besides, soil water table treatment also did not show any effect on tiller number. However, tiller number of these two varieties statistically showed significant difference started from 0 to 24 DAT, except at 31 DAT. Root length of Tajuk and Pancasona was significantly difference, while soil water table at 0 cm also showed significant difference compared to other depth treatment (Table 3).

Soil water table treatment showed very significant effect on growth of two shallot varieties as seen in the parameters of plant height at 3, 24 and 31 DAT and tiller number at 3, 10 and 17 DAT. Least significant difference (LSD) test on 5 % level showed on three different plant ages showed that the lowest plant height result was obtained from the same combination treatment which was V_1T_3 with 14.52 cm at 3 DAT, 18.17 cm at 24 and 31 DAT. The same pattern was also resulted in tiller number where the lowest result was on V_1T_1 (Tajuk variety with 10 cm of water table below soil surface) with 2.5 at 3 DAT, 3.0 at 10 DAT and 3.33 at 17 DAT. The lowest result was all obtained from the same variety which was Tajuk variety (Table 4).

Table 2. Plant height of two shallot varieties due to soil water table treatment

Treatment	Plant age (DAT = days after treatment)					
	0	3	10	17	24	31
	Plant height (cm)					
Variety						
V_1	11.18±3.91a	17.28 ±6.85a	20.47±8.90a	23.18±9.94a	24.22±.12.40a	22.26±. 8.54a
V_2	11.63±8.54a	18.51±6.11a	21.84±2.01a	25.51±1.96a	26.40± 1.03a	27.31± 2.67b
LSD						1.86
Soil water table (cm)						
0	9.49±7.39a	18.19±7.18a	23.17±3.18a	26.64±.2.37a	27.10±1.70b	26.01±5.98a
10	12.43±0.00a	17.46±3.71a	20.61±4.49a	24.65±.3.96a	26.10±2.40a	25.04±5.83a
15	13.12±6.15a	19.74±6.75a	21.91±1.73a	24.79±.0.88a	25.83±0.71a	24.77±9.12a
20	10.56±5.06a	16.20±7.14a	18.94±8.59a	22.57±.13.72a	22.19±17.08a	23.33±21.92a
LSD					4.57	
	Leaf number					
V_1	7.42±3.18a	10.44±4.04a	12.46±6.14a	13.00±.6.34a	11.00±.6.54a	11.33±. 5.43a
V_2	8.25±3.38a	11.13±6.76a	13.96±8.45a	15.92± 9.15a	16.25± 9.85a	17.17± 10.78b
					4.74	5.71
Soil water table (cm)						
0	8.58±3.18a	12.75±5.30a	16.08±.8.13a	17.75±9.55 a	17.00±13.44a	17.67±16.26a
10	8.25±1.06a	9.25±1.06a	12.17±.1.41a	13.33±0.71 a	11.83± 2.12a	12.58±4.60a
15	8.25±1.06a	11.75±0.35a	13.83±.0.71a	14.75±7.42 a	13.67±14.85a	14.33±18.38a
20	6.25±1.77a	9.38±0.88a	10.75±.3.89a	12.00±7.07 a	12.00±14.14a	12.42±10.25a

The numbers followed by same letter in the same row means insignificant difference.

Table 3 – Tiller number and root length of two shallot varieties due to soil water table treatment

Treatment	Plant age (DAT = days after treatment)					
	0	3	10	17	24	31
	Tiller number					
Variety						
V_1	2.88±1.25a	3.17±1.96a	3.46±1.25a	4.00±.1.68 a	4.42±.1.55a	5.50±. 2.04a
V_2	3.54±1.44b	3.92±2.33b	4.25±2.60b	4.79± 2.59 b	5.21± 2.43b	6.17± 4.22a
LSD	0.51	0.37	0.48	0.63	0.59	
Soil water table (cm)						
0	3.50±2.83a	3.92±.4.60a	4.42±4.60 a	4.83±4.24 a	5.33±2.83 a	7.25±3.18 a
10	2.92±2.47a	3.17±.2.83a	3.50±2.12 a	4.25±3.89 a	4.67±4.24 a	5.75±3.18 a
15	3.42±0.35a	3.83±.0.71a	4.00±0.00 a	4.17±0.00 a	4.92±0.35 a	5.25±0.35 a
20	3.00±0.00a	3.25±.0.35a	3.50±0.00 a	4.33±1.41 a	4.33±0.71 a	5.08±1.06 a
	Root length (cm)					
Variety						
V_1	nm	nm	nm	nm	nm	8.73±. 2.15a
V_2	nm	nm	nm	nm	nm	12.46± 10.03b
LSD						1.95
Soil water table (cm)						
0	nm	nm	nm	nm	nm	13.50±16.26 b
10	nm	nm	nm	nm	nm	9.00± 3.54 a
15	nm	nm	nm	nm	nm	9.92± 4.24 a
20	nm	nm	nm	nm	nm	9.96± 7.60 a
LSD						2.39

The numbers followed by same letter in the same row means insignificant difference; nm=not measure.

Shallot variety showed significant effect on yield component as obtained from the parameters of bulb fresh weight, bulb dry weight, bulb diameter and harvest index, while water table treatment had significant effect on total plant fresh weight (shoot + bulb) and bulb fresh weight.

Table 4 – Combinations of variety and soil water table treatment on plant height and tiller number

Treatment	Plant age (DAT = days after treatment)		
	3	24	31
	Plant height		
V_1T_0	19.88±0.12 bc	27.50±2.46 b	24.60±0.44 b
V_1T_1	16.58±1.66 a	25.53±1.50 b	23.67±1.23 b
V_1T_2	18.15±2.24 abc	25.67±2.01 b	22.62±2.76 b
V_1T_3	14.52±1.08 a	18.17±2.10 a	18.17±1.59 a
V_2T_0	16.50±0.66 a	26.70±3.45 b	27.42±3.39 c
V_2T_1	18.33±3.17 abc	26.67±4.69 b	26.42±3.99 c
V_2T_2	21.33±0.52 c	26.00±1.09 b	26.92±2.18 c
V_2T_3	17.88±3.59 abc	26.22±1.36 b	28.50±0.75 d
$LSD_{0.05}$	3.57	4.57	3.72
Treatment	Tiller number		
	3	10	17
V_1T_0	2.83±2.29 ab	3.33±1.04 ab	3.83±1.44 ab
V_1T_1	2.50±0.87 a	3.00±1.32 a	3.33±1.04 a
V_1T_2	4.00±0.87 d	4.00±0.87 c	4.17±1.04 bcd
V_1T_3	3.33±0.58 cd	3.50±0.50 b	4.67±0.58 d
V_2T_0	5.00±0.50 e	5.50±0.50 d	5.83±0.29 e
V_2T_1	3.83±0.29 d	4.00±0.00 c	5.17±1.15 d
V_2T_2	3.67±0.29 d	4.00±0.50 c	4.17±0.58 bcd
V_2T_3	3.17±0.29 bc	3.50±0.50 b	4.00±0.87 bc
$LSD_{0.05}$	0.37	0.48	0.63

The Numbers followed by same letter in the same row means insignificant difference.

Table 5 – The effect of soil water table on yield component of two shallot varieties

No.	Parameter	F-value			Coefficient of variance (%)
		V	T	VT	
1.	Fresh weight of harvested plant (shoot + bulb)	4.07^{ns}	5.24^{*}	0.08^{ns}	42.84
2.	Bulb fresh weight	5.48^{*}	3.92^{*}	0.10^{ns}	47.32
3.	Bulb dry weight	46.42^{**}	1.65^{ns}	0.62^{ns}	51.92
4.	Bulb number	0.73^{ns}	0.79^{ns}	0.66^{ns}	29.40
5.	Bulb diameter	9.54^{*}	1.37^{ns}	0.16^{ns}	33.72
6.	Harvest Index	9.13^{*}	1.73^{ns}	1.24^{ns}	10.68
	F Tabel at 5 %	4.60	3.34	3.34	
	F Tabel at 1 %	8.86	5.56	5.56	

*Note: ns = not significantly different; * = significantly different at $p < 0.05$; and ** = significantly different at $p < 0.01$.*

The difference on shallot variety gave significant effect on yield component since planting for 11 days. Total plant (shoot + bulb) fresh weight of Pancasona was higher than Tajuk in all water table treatments. The lowest weight was obtained from 20 cm of water table below soil surface treatment. Control treatment (without water table treatment) of two varieties had higher weight compared to other treatments with 18.17 g and 21.83 g for Pancasona and Tajuk variety (Figure 1).

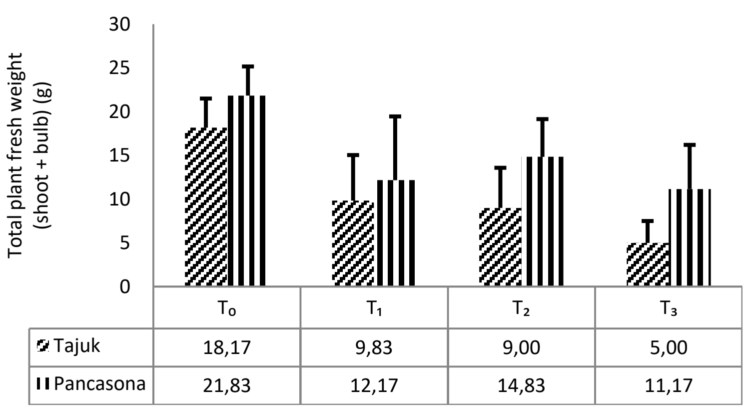

Figure 1 – Total plant fresh weight (shoot + bulb) of two shallot varieties

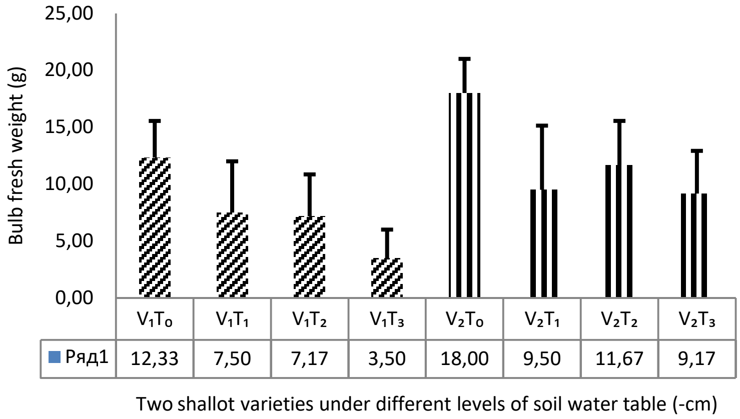

Figure 2 – Bulb fresh weight of two shallot varieties under different levels of soil water table

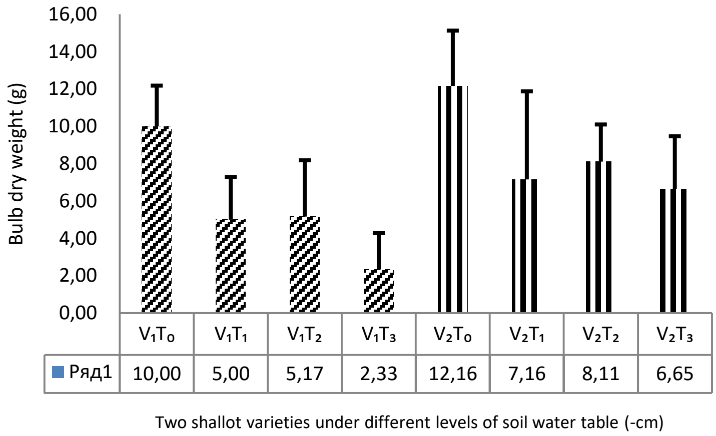

Figure 3 – Bulb dry weight of two shallot varieties under different levels of soil water table

Similar to total plant fresh weight, bulb fresh and dry weight both had the same pattern where the combination treatments of Tajuk showed a lower result compared to Pancasona. The highest weights from both varieties were obtained from control (without water table treatment) with 12.33 g and 18.00 g of bulb fresh weight and 10.00 g and 12.66 of dry weight for Tajuk and Pancasona, respectively (Figure 2 and 3).

DISCUSSION OF RESULTS

Based on the research, it was resulted that two observed shallot varieties still could tolerate water table condition until 20 cm below soil surface as seen from their growth for 11 days started from planting (Table 1). Table 2 also indicates that there was no significant difference of growth parameters under different levels of soil water table. Along with this result, Susila *et al*. (2013) reported that Bima Brebes shallot variety still could increase its yield even with 25 cm of water table below soil surface.

Tajuk variety generally had lower growth ability compared to Pancasona as seen in all growth parameters. Based on variety description, Tajuk is shallot variety introduced from Thailand that suited to be cultivated in lowland area in Nganjuk Regency. While Pancasona is a shallot variety bred by Vegetable Research Center that can well adapt in lowland area with 6-85 m above sea level. A relatively high ability of growth component was plant height which was only effective at the end of growth phase compared to leave number affected by 24 DAT to 31 DAT, moreover tiller number affected since 0 DAT to 31 DAT.

Generally, results showed that shallot could grow and have better yield under normal water condition (control treatment) as can be seen in vegetative phase shown by Table 2-3 where the plant height, leaf number, and tiller number had some decreases under soil water table treatment especially in 20 cm of water table below soil surface. This showed that the water table until 20 cm below soil surface did not support shallot growth. Based on a research by Susilawati et al. (2019) about the use of biochar at different levels of soil water table towards shallot, there was a contradictive result where shallot still could grow well at the water depth until 20 cm below soil surface when provided with biochar treatment. This was assumed that the addition of biochar had improved water binding capacity of the planting media, so there was adequate water supply for the plant. Dou *et al*. (2014) stated that the addition of biochar affected soil physical characteristics which could increase water absorption capacity thus could directly affect wider root development zone resulted in the plant's amenity to get water and nutrition need for its growth. The other research result showed that the use of biochar sized less than 1 mm had better effect than biochar sized 1 or more than 1 mm on rice growth (Kartika *et al*., 2018; Kartika *et al*., 2019). The condition of 20 cm water level below media surface had better probability for the root to grow and develop as there was soil pore filled with oxygen due to the addition of biochar. A research result by Lakitan *et al*. (2018) stated that bean's root could not survive in a water saturated condition.

In accordance with the vegetative phase, yield components result had rather similar pattern in which the highest total plant weight (shoot and bulb) and bulb fresh weight and bulb dry weight was obtained in Pancasona variety compared to Tajuk variety. Likewise, at the treatment of water table, the yield was decreasing with the depth until 20 cm below soil surface (Figure 1-3). However, this condition is also contradictive when biochar was added to the planting media. This was due to biochar originated from oil palm empty fruit bunch was composed by 25.6% of C-organic and 19.4 of C/N ratio which could improve soil physical characteristics (Santi dan Goenadi, 2012). This condition resulted in better plant growth and development for both shoots and bulbs. The use of biochar was considered would be very helpful in improving soil under less optimum conditions as in this research where water availability was limited. Another research mentioned that there was a huge biomass increase if the biochar was given to the soil without fertilizer (infertile soil) compared to the soil with fertilizer (Haefele *et al*. 2011; Carter *et al*. 2013).

CONCLUSION

Based on the results, it was concluded that Pancasona variety had better growth compared to Tajuk variety under several levels of soil water table. Soil water table of 20 cm below soil surface could decrease the growth and yield of shallot for both Pancasona and Tajuk variety.

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