BUKTI KORESPONDENSI RESPONDENSI DAN SUBSTANSI ISI
ARTIKEL JURNAL INTERNASIONAL BEREPUTASI

Judul : Shallot cultivation in tropical climate ecosystems using floating and non-floating systems with different doses of cow manure

Jurnal : Advances in Horticultural Science - (Scopus Q3)

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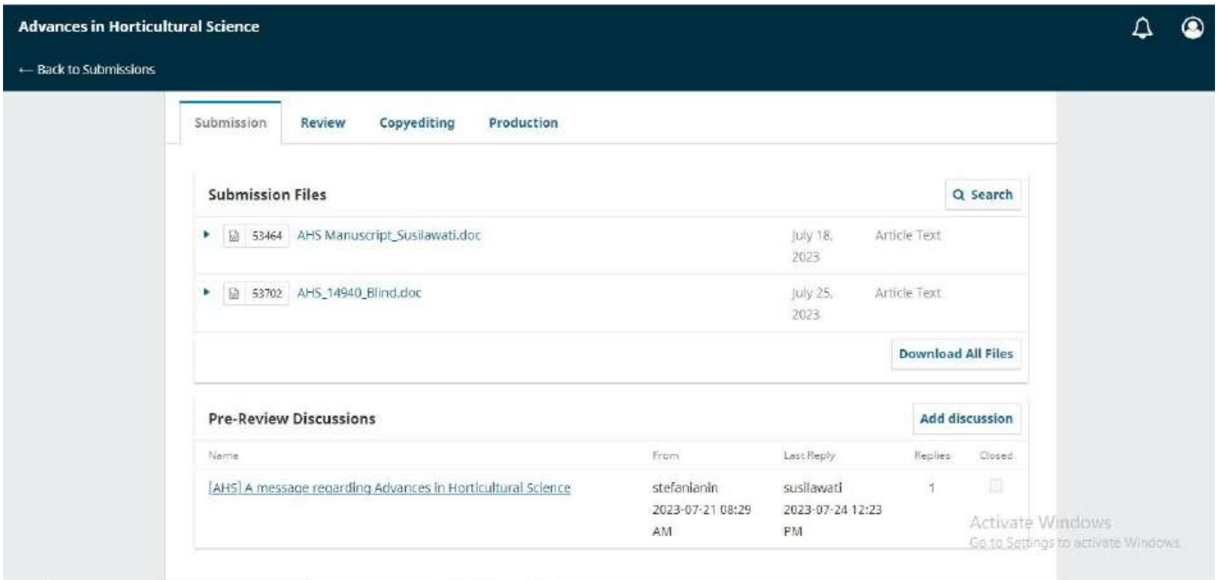
Kontribusi : Penulis Pertama dan Korespondensi

No.	Perihal	Tanggal
1.	Submission	18 Juli 2023
2.	Pre-review	21 Juli 2023
3.	Peer Review round 1	14 September 2023
4.	Peer Review round 2	27 November 2023
5.	Editor decision: accepted	29 November 2023
6.	Proofing	14 Februari 2024
7.	Final Paper	6 Maret 2024

1. Submission

Submission (18 Juli 2023)



Farming Practices and Cow Manure Application on Growth and Yield of Bima Brebes Shallot Variety in Tropical Climate Ecosystem

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Abstract. Compared to other typologies of *lebak* swamp, deep swamp has the longest flooding period which makes it challenging for crops cultivation. However, by adopting floating system, this prolonged duration of flooding can be used for shallot growing. Thus, this study was aimed to ascertain how conventionally and floating grown shallot plants respond to different doses of cow manure in terms of growth and production. The research was located in Experimental Field and Reservoir of Agriculture Faculty, Sriwijaya University (3°13'30.3″S 104°38'55.1"E). Conventional and floating farming practices were utilized with the application of 0, 10, 15, and 20 tons/ha of cow manure. The findings demonstrated that shallot cultivated in floating system had lower number and length of leaf but could produce more bulbs in comparison to the conventional method. The application of 15 tons/ha manure in floating system resulted higher weight of fresh and air-dried bulbs per plant, weighing 74.40 g and 64.82 g, respectively, compared to that in conventional system with only 46.77 g and 37.84 g. In conclusion, Bima Brebes shallot variety can be potentially cultivated in a floating system with the application of 15 tons of cow manure per hectare.

Keywords: conventional, cow manure, floating**,** shallots

Running title: Shallot Cultivation with Manure Application

INTRODUCTION

As one of strategic commodities widely consumed in Indonesia, shallot (*Allium ascalonicum* L.) is a vegetable crop that significantly contributes to the country's horticultural production and inflation rate. According to the findings of the Socio-Economic Survey from September 2021, Indonesians consume an average of 2.49 kilograms (kg) of shallots per person each month. Shallots are required for the food sector, where they are processed into ready-to-use seasonings, for sprinkling food dishes, as well as for usage in households as a seasoning for cooking (Ministry of Agriculture, 2019; Irjayanti, 2022).

The best height for the growth and development of shallots is between 0 and 450 meters above sea level. Shallot in Indonesia can be grown anywhere from the plains to the highlands at an altitude of up to 1000 m above sea level. Bima Brebes is a shallot variety that is easy to grow and climate-adaptive (Sutrisno, 2015; Anitasari et al., 2019). Since shallot production varies from year to year and there is still a need to cultivate more shallots to meet the population's growing demand, it is still important to maximize shallot farming (Indriyana et al., 2020). In 2021, there will be 1,942,812 tons of shallot produced, with the majority of it coming from Central Java, East Java, East Nusa Tenggara, and West Sumatra. In South Sumatra, shallot production in 2021 was only a total of 1,125 tons (Directorate of Statistical Dissemination, 2022; Central Bureau of Statistics for South Sumatra Province, 2021). The texture and structure of the soil have significant impact on the production and quality of shallots. Applying organic fertilizer will create the fertile, loose soil that shallots need for the development of their bulbs. One of the components that can increase the physical, chemical, and biological qualities of the soil to boost the productivity of shallot plants while reducing the amount of P fertilizers provided to P-deficient soils is organic fertilizer (Susikawati et al., 2018; Noviyanty and Salingkat, 2018; Nguyen et al., 2021). One organic fertilizer that can promote plant development is cow manure (Musdalifah et al., 2021; Atman et al., 2018; Sudarsono et al., 2014).

Swampland limits the growth of shallots in South Sumatra Province. Peatland is potential swamp land for horticulture crops, and it is present in both the 2.62 million hectares of the *lebak* (inland) swamp and the 0.52 million ha of the tidal land, of which 1.20 million ha are in Sumatra (Husen et al., 2015; Susilawati et al., 2022). *Lebak* swamplands have different sensitivity to the risk of waterlogging. Shallow and middle *lebak* swamps are usually cultivated during the dry season; however, the plants are also at risk from drought (Simatupang and Rina, 2019). The productivity of vegetable crops cultivated in *lebak* swamplands may be hampered by drought and flooding. However, deep lebak swamp can be developed depending on the ecological function of the land (Widuri et al., 2016; Suprapto, 2016). The floating farming system is one method for growing plants in deep swamps where the water remains stagnant for longer than six months while the land remains submerged throughout the dry season (low rainfall) (Siaga et al., 2018; Karla et al., 2019; Lakitan, 2021). According to Hasbi et al. (2017), a projected floating farming system for the cultivation of vegetables was created based on the statements of farmers who are interested in using the newly introduced floating farming. Shallots are one of the many crops that may be grown in the floating system. Thus, the aim of this study was to determine the growth response and production of conventional and floating cultivation systems of shallot plants at various doses of cow manure fertilizer.

MATERIALS AND METHODS

Research area

The research was located in the Experimental Field and Reservoir of the Faculty of Agriculture, Sriwijaya University, Indralaya Ogan Ilir (3°13'30.3″S 104°38'55.1"E) where the condition as seen in Figure 1, during dry season in tropical climate ecosystems of South Sumatra, Indonesia, from May to August 2022. Typical agroclimatic conditions at the outdoor research facilities are shown in Figure 2.

Figure 1. Conventional (A) and floating (B) farming practices of shallot cultivation

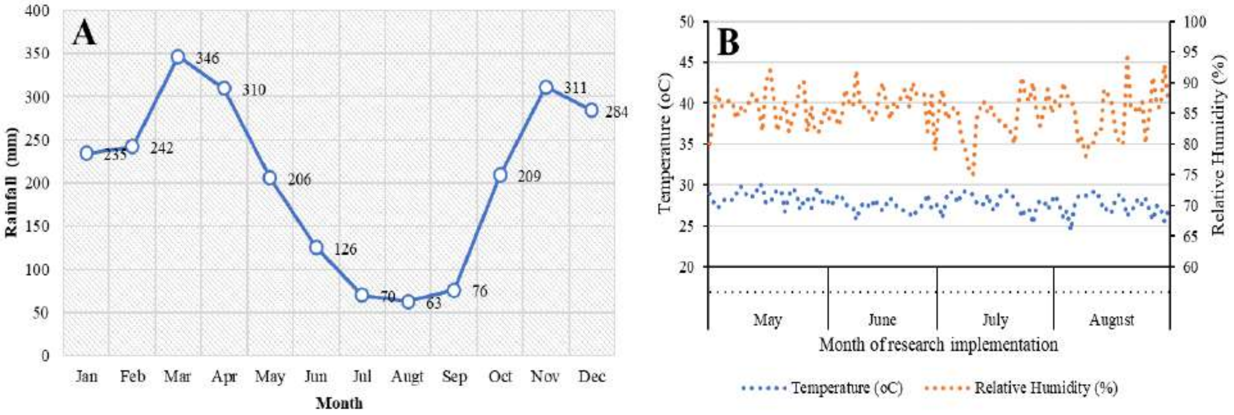

Figure 2. Typical agroclimatic conditions: Rainfall (A), Temperature and Relative Humidity (B) at the outdoor research facilities. Source: https://www.bmkg.go.id

Procedures

The planting materials were cow manure, alluvial soil, bamboo raft, and other supporting materials. The shallot bulbs used were of the Bima Brebes variety originated from the shallot seed farmers in Brebes, Central Java. The experiment was arranged using a factorial randomized block design with two factors and three replicates. The treatments consisted of farming practices (the conventional and floating systems) and dosages of cow manure (0, 10, 15, and 20 tons/ha).

For all farming practice treatments, the planting media were prepared in the same method: after been completely mixed, it was placed into 35 cm x 30 cm polybags. The planting media were a mixture of alluvial topsoil combined with cow manure according to the treatments. In conventional farming technique, the area was prepared by clearing the surrounding weeds and unwanted plants to make a space for placing the polybags filled with the media. In floating cultivation, the polybags were put on a 2 m x 1 m of bamboo raft. Each replicate was put in one bamboo raft. The planting media were sprayed with Bio Soil Grow Booster at a concentration of 4 ml/liter of water one week before planting. Inorganic fertilizers were also used with dosages of TSP (150 kg/ha), urea (100 kg/ha), and KCl (100 kg/ha). TSP fertilizer was applied 7 days before planting, whereas urea and KCl were applied twice, at 7 and 25 days after planting (DAP), each time in half the prescribed amount. Before being planted, bulbs were first cut off by a third of the top end and then placed into the planting hole at a depth of 2–3 cm.

Data analysis

The variables were growth characteristics such leaf length, leaf number and leaf color as well as shallot production variables such as bulb number, bulb diameter, fresh weight, dry weight, and shrinkage percentage, as well as estimated production per hectare. The calculated F-value generated from the analysis of variance (ANOVA) was compared to values of F-table at $p \leq 0.05$ and $p \leq 0.01$ for justifying significant effects of the treatments. Furthermore, if the treatment effect was significant on any measured traits, the least significant difference (LSD) test was conducted for determining significant differences among treatment levels on each of specified traits.

RESULTS AND DISCUSSION

Leaf length (cm) and leaf number of Shallots

Shallot plants grown in tropical climate ecosystems with two farming practices as in conventional (Figure 1A) and floating (Figure 1B) systems at various doses of cow manure showed differences in growth and yield. Rainfall continued to decline from May to August 2022, when the study was conducted. Rainfall reduced from 206 mm in May to 63 mm in August (Figure 2A). High rainfall levels at the start of the study provided a favorable environment for shallot growth in conventional cultivation system (polybags stacked on dry soil). On the other hand, shallots grown in wetlands using floating system (polybags placed on rafts) did not favor heavy rainfall. From May to August 2022, the temperature and humidity remained relatively stable. The range of the temperature and humidity was 27.47–27.92 ºC and 84.51–86.36 %, respectively (Figure 2B).

The variance analysis revealed that the variations in farming practices had a significant impact. The results of the least significant difference (LSD) test on leaf length parameter demonstrated that two farming practices differed significantly. In conventional cultivation, the maximum leaf length was 40.43±1.25 cm at 5 weeks after planting (WAP), whereas in floating system, it was only 30.47±0.47 cm at 4 WAP. In floating agriculture system, water is continuously supplied via the soil pores by capillary force, causing slower oxygen diffusion. Additionally, when it rains heavily, the media becomes more water-saturated, which lowers the amount of accessible oxygen. Oxygen is needed by the roots for respiration and for maintaining healthy cell function (Neira et al., 2015; Ernest, 2018; Jaya et al., 2021; Kartika et al., 2021). The damage on root will eventually affect the upper plant parts growth as seen from the agronomical features. Research by Susilawati et al. (2012) on red pepper plants showed that all cultivars experienced varying degrees of root damage as a result of flooding stress. The amount of oxygen that is present in the growing media is significantly influenced by the height of the water table. Research on bean plants had shown that the roots, particularly the process of root respiration, were significantly impacted by water levels that were 10 cm below the planting media surface. Although organic fertilizer applied to red chilies in a floating system had not affected growth, proper water level and the application of organic matter to shallot plants considerably stimulated growth (Susilawati et al., 2019a; Susilawati et al., 2019b; Susilawati et al., 2022). On leaf length parameter, the application of cow manure showed insignificant result in the first week and significant in the second to eighth weeks. The longest leaves were obtained at a dose of 20 tons per hectare (P_3 treatment) with 40.19±2.96 cm, not significantly different from a dose of 15 tons per hectare (P_2) of 40.06±1.69 cm. The combination of farming practices and cow manure treatments had a significant effect on leaf length only in 6 and 8 WAP in the conventional P_3 treatment with 44.74±1.10 cm and 44.92±1.36 cm, respectively.

On the leaf number parameter, the difference in farming practices only had a significant effect in the first to third weeks. The average number of leaves was mostly higher in the conventional system, except in the fourth week when the leaf number in the floating system was higher at 24.33 ± 1.92 compared to 23.39 ± 1.33 in the conventional system. The research on eggplant showed that increasing the water content of the substrate from 1 to 3 cm would increase the growth of vegetative organs (Jaya et al., 2019). The difference in cow manure doses affected the number of leaves, where the highest leaf number was obtained in P_2 treatment with 31.78 ± 2.65 in 7 WAP (Table 1). Similarly, research by Feriatin et al. (2021) also showed that the use of cow manure would affect leaf number of the Lokananta shallot variety. The P_3 treatment for conventional cultivation and the P_2 treatment for floating cultivation produced the highest average of leaf length and leaf number when cow manure was applied. In the conventional P_3 treatment, the maximum leaf length was 37.45 cm with a 21.33 average leaf number, while in the floating P_2 treatment, the highest leaf length was 29.80 cm with 23.14 leaves. Cow manure is an organic fertilizer that can alter the structure and texture of the soil, making the media crumblier, which explains the difference in the dosage of cow manure between the two cultivation systems (Figure 3). Meanwhile, as a result of the relatively high moisture of the planting media in floating culture, cow manure already affects the texture and structure of the media at lower doses (Gudugi, 2013; Elisabeth et al., 2013; Ekwealor et al., 2020; Wisdom et al., 2021).

Table 1. Leaf length (cm) and leaf number of shallot with the application of cow manure (ton/ha) on different farming practices

Treatment	Week after planting (WAP)							
	1	2	3	4	5	6	7	8
Farming practices								
Leaf length (cm)								
Conventional	11.67 ± 0.66 a	26.60 ± 0.79 a	36.43 ± 1.03 a	40.32 ± 1.45 a	40.43 ± 1.69 a	38.39 ± 1.71 a	38.39 ± 1.66 a	36.09 ± 1.95 a
Floating	8.28 ± 0.32 b	20.04 ± 0.56 b	27.58 ± 1.09 b	30.47 ± 1.43 b	29.45 ± 1.90 b	26.66 ± 2.08 b	25.66 ± 1.82 b	24.88 ± 1.76 b
Significance	**	**	**	**	**	**	**	**
LSD0.05	1.516	1.375	2.209	1.961	1.992	2.208	2.536	4.549
Leaf number								
Conventional	7.83 ± 0.39 a	12.38 ± 0.43 a	17.78 ± 0.69 a	22.13 ± 0.93	23.39 ± 1.33	25.69 ± 1.50	26.00 ± 1.43	23.64 ± 1.21
Floating	5.88 ± 0.21 b	10.38 ± 0.47 b	15.66 ± 0.61 b	20.94 ± 1.25	24.33 ± 1.92	25.25 ± 2.15	23.61 ± 2.06	20.03 ± 1.91
Significance	**	**	*	ns	ns	ns	ns	ns
LSD0.05	0.777	1.303	1.548	2.479	2.929	3.831	4.679	4.567
Cow manure (ton/ha)								
Leaf length (cm)								
P_0 (0)	9.31 ± 0.90	21.37 ± 1.74 b	27.53 ± 2.37 b	29.07 ± 2.54 b	26.80 ± 2.99 c	24.83 ± 3.09 c	25.61 ± 3.07 c	25.24 ± 2.96 b
P_1 (10)	10.19 ± 1.23	22.09 ± 1.24 b	30.71 ± 1.86 a	33.59 ± 2.21 b	32.72 ± 2.64 b	29.26 ± 3.12 b	29.86 ± 3.00 b	30.29 ± 2.58 b
P_2 (15)	9.54 ± 0.87	25.30 ± 1.58 a	35.52 ± 1.81 a	39.69 ± 1.74 a	40.06 ± 1.69 a	38.93 ± 1.33 a	37.84 ± 1.34 a	37.16 ± 1.80 a
P_3 (20)	10.86 ± 1.12	24.52 ± 1.89 a	34.26 ± 2.31 a	39.23 ± 2.82 a	40.19 ± 2.96 a	37.10 ± 3.46 a	34.76 ± 4.63 a	29.27 ± 4.69 b
Significance	ns	**	**	**	**	**	**	*
LSD0.05	2.144	1.945	2.189	2.773	2.817	3.122	3.587	6.434
Leaf number								
P_0 (0)	6.00 ± 0.40 b	10.33 ± 0.31	14.33 ± 0.41 b	17.55 ± 0.62 b	17.72 ± 0.88 c	19.50 ± 1.64 c	20.50 ± 2.11 b	19.39 ± 2.28
P_1 (10)	6.94 ± 0.59 ab	11.33 ± 1.06	16.78 ± 1.11 a	20.39 ± 1.12 b	22.50 ± 1.32 b	25.99 ± 1.47 b	26.28 ± 2.09 ab	23.11 ± 2.04
P_2 (15)	6.72 ± 0.58 ab	11.39 ± 0.76	17.22 ± 0.99 a	24.00 ± 1.59 a	29.05 ± 2.38 a	31.78 ± 2.65 a	29.67 ± 2.39 b	25.94 ± 1.88
P_3 (20)	7.78 ± 0.68 a	12.50 ± 0.55	18.55 ± 0.59 a	24.22 ± 0.80 a	26.16 ± 1.32 ab	24.61 ± 1.78 bc	22.78 ± 2.14 b	18.89 ± 2.36
Significance	*	ns	**	**	**	**	*	ns
LSD0.05	1.099	1.842	2.189	3.506	4.144	5.418	6.618	6.459

Note: Data represent mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05

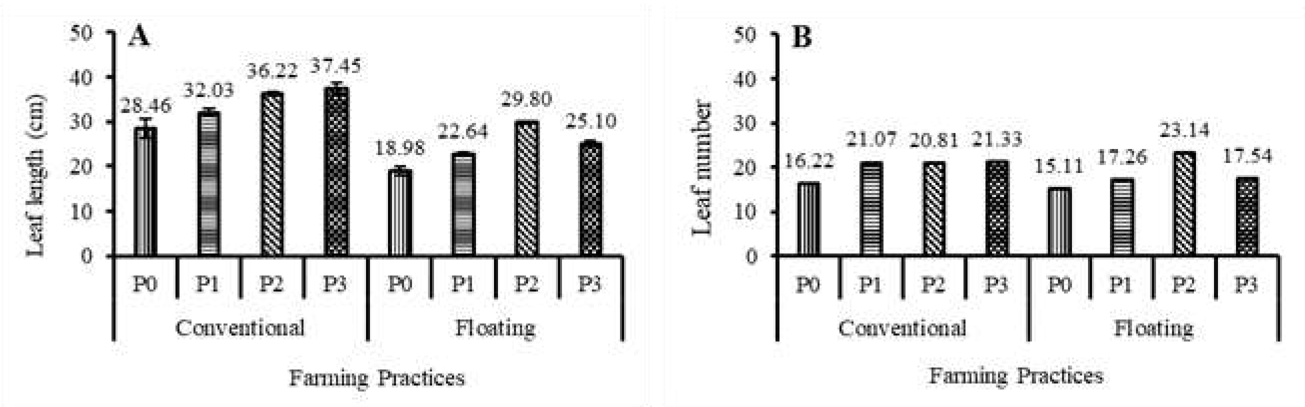

Figure 3. The application of cow manure on the parameters of leaf length (A) and leaf number (B) in different farming practices

SPAD value

In this study, the parameter of leaf greenness—which serves as an indicator for chlorophyll content—was quantified using the SPAD tool without damaging the leaves measured from the second to the eighth week. In the fourth and sixth weeks, the culture technique treatment significantly affected the SPAD value, while had no significant effect in 2 and 8 WAP. Shallots cultivated in floating system was recorded to have higher values in 2, 4 and 6 WAP with 77.69±2.69, 64.10±4.41, and 48.18±1.25, respectively, as compared to that in conventional system with 74.68±3.08, 48.18±1.25, and 48.79±1.43. However, in the eighth week, SPAD value in conventional system was higher than in floating system with 44.78±1.33 and 43.22±4.48, respectively. The SPAD values of the two cultivation techniques was at the highest at 2 WAP, and then continued to decrease until 8 WAP. In comparison to other models, the polynomial model's regression analysis of the SPAD value in the shallot cultivation resulted in the largest determination coefficient (R^2) that is close to 1, with 0.9123 for the conventional system and 0.9618 for the floating system. The magnitude of the R^2 value indicates that the SPAD value is affected by the cultivation technique in a quadratic manner, increasing until it reaches the peak before starting to decline (Table 3). A study on corn resulted in a similar result, where the SPAD values would decrease after reaching their peak which mostly affected by the environment (Ghozali, 2016; Kandel, 2020; Szulc et al., 2021).

This study also found that the increase in cow manure dosage would also increase the SPAD value where the highest SPAD value was obtained in the P_3 treatment at 82.54 and the lowest in the P_0 treatment at 31.21. The SPAD value has been widely used to estimate the chlorophyll content of other crops, such as tomatoes (Jiang et al., 2017). Furthermore, the application of cow manure could also increase leaf chlorophyll, as indicated by the SPAD value in wheat and rice plants (Shah et al., 2017; Atman et al., 2018). The combination of cultivation techniques and cow manure treatments resulted in no significant effect in 2 and 8 WAP, a significant effect in 4 WAP, and a highly significant effect in 6 WAP. The highest SPAD value was obtained in floating cultivation and cow manure at a dose of 20 tons/ha at 77.01±5.35 in 4 WAP and 75.11±3.96 in 6 WAP (Table 2).

Table 2. SPAD value of shallot on different farming practices with the application of cow manure

Treatment	Weeks after planting (WAP)			
	2	4	6	8
	Farming practices			
Conventional	74.68 ± 3.08	48.18 ± 1.25 b	48.79 ± 1.43 b	44.78 ± 1.33
Floating	77.69 ± 2.88	64.10 ± 4.41 a	59.78 ± 4.55 a	43.22 ± 4.48
Significance	ns	**	**	ns
LSD value	7.996	6.040	4.381	4.615
	Cow manure (ton/ha)			
P_0 (0)	68.16 ± 2.38	45.31 ± 2.88 c	40.90 ± 2.71 c	31.21 ± 4.08 c
P_1 (10)	75.74 ± 5.19	58.48 ± 5.77 ab	56.21 ± 4.35 b	44.61 ± 2.93 b
P_2 (15)	78.27 ± 4.09	55.78 ± 4.94 b	55.98 ± 3.73 b	46.60 ± 2.09 b
P_3 (20)	82.54 ± 2.98	65.00 ± 6.08 a	64.04 ± 5.28 a	53.60 ± 3.80 a
Significance	ns	**	**	**
LSD value	11.307	8.542	6.197	6.527
	Farming practices x cow manure (ton/ha)			
Conventional xP_0	68.47 ± 5.10	46.81 ± 1.43 b	43.29 ± 3.72 ef	39.69 ± 3.16 c
Conventional xP_1	74.13 ± 10.00	46.93 ± 1.68 b	48.02 ± 1.74 de	43.42 ± 10.00 bc
Conventional xP_2	74.01 ± 4.26	46.00 ± 1.36 b	50.87 ± 0.68 bc	46.57 ± 4.26 bc
Conventional xP_3	82.13 ± 4.21	52.99 ± 3.47 b	52.98 ± 1.17 cd	49.46 ± 4.21 ab
Floating x P_0	67.86 ± 1.46	43.81 ± 6.11 b	38.52 ± 4.15 f	22.73 ± 1.46 d
Floating x P_1	77.37 ± 5.68	70.03 ± 5.53 a	64.41 ± 4.95 b	45.81 ± 5.68 bc
Floating x P_2	82.54 ± 6.90	65.56 ± 4.94 a	61.10 ± 6.57 bc	46.63 ± 6.90 bc
Floating x P_3	82.97 ± 5.15	77.01 ± 5.35 a	75.11 ± 3.96 a	57.73 ± 5.15 a
Significance	ns	*	**	ns
LSD value	15.991	12.081	8.763	9.231

Note: Data represent mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05

Table 3. Regression analysis correlations of SPAD value with several mathematical models of farming practices on several doses of cow manure

Farming practices	Linear model, y = ax+b	Logarithmic model, y = a ln x+b	Polynomial model, y=ax2+bx+c	Power model, $y = ax^b$
Conventional	y=-8.9073x+76.38	y=-21.1ln(x)+70.877	y=5.6238x2-37.026x+104.5	$y=70.35x^{0.357}$
	R^2 =0.6917 r = 0.8316**	R^2 =0.8417 r = 0.9174**	R^2=0.9123 r = 0.9551**	R^2 = 0.8842 r =0.9432**
Floating	y=-10.769x+88.122	y=-22.56ln(x)+79.122	$y=-0.7451x^2-7.0429x+84.39$	$y=80.712x^{0.375}$
	R^2 = 0.9581 r = 0.9788**	R^2 = 0,9116 r = 0.9547**	R^2 =0.9618 r = 0.9807**	R^2 =0.8804 r = 0.9383**

Note: ** means significant difference p < 0.05

Bulb number, bulb diameter (mm), weight of fresh and air-dried bulb (g)

The yield components include the number of bulbs, bulbs diameter, and weight for both fresh and air-dried bulbs. The farming practices treatment had no significant impact on the quantity of bulbs but had a very significant impact on the weight of fresh bulb, bulb diameter, and weight of air-dried bulb. The conventional method produced the greatest number of bulbs, whereas floating cultivation resulted the best results in terms bulb diameter and weight of fresh and air-dried bulbs. The growing media conditions strongly affected how bulbs were initially formed. Since water was constantly accessible from beneath the growing media through capillaries, floating cultivation used growing media that were somewhat moist. There was also intense rainfall during early growth of shallot causing the planting media to be very wet. There were about 7.78±0.35 bulbs formed in conventional cultivation and 7.75±0.33 in floating cultivation. The number of bulbs was somehow not linearly correlated with the greater dose of cow manure applied as the largest number of bulbs was obtained at a dose of 15 tons/ha (Table 4). The largest number of bulbs (8.33 in conventional cultivation and 8.22 in floating cultivation) were obtained from the same manure treatment, which was P_2. The lowest data, 6.78 bulbs in conventional cultivation and 6.67 bulbs in floating cultivation, were also obtained at the same manure treatment, P_0 (Figure 5A). Plant growth can be supported by appropriate cultivation methods (Cahyaningrum et al., 2023; Khorasgani and Pessarakli, 2019).

Table 4. Shallot yield components on different farming practices with the application of cow manure

Treatment	Number of bulb	Diameter of bulb (cm)	Fresh weight of bulb (g)	Air-dried weight of bulb (g)
Farming practices				
Conventional	7.78 ± 0.35	20.62 ± 1.76 b	35.36 ± 6.14 b	26.79 ± 5.64 b
Floating	7.75 ± 0.33	23.51 ± 1.29 a	42.33 ± 3.52 a	35.69 ± 2.94 a
Significance	ns	**	*	**
LSD value	1.016	1.741	6.419	4.703
Cow manure				
P_0 (0)	7.44 ± 0,45	15.44 ± 0.77 c	20.57 ± 2.85 c	14.71 ± 2.12 d
P_1 (10)	7.44 ± 0.50	19.88 ± 0.84 b	34.46 ± 2.36 b	25.64 ± 1.49 c
P_2 (15)	8.28 ± 0.53	27.10 ± 1.74 a	58.24 ± 7.76 a	48.22 ± 7.75 a
P_3 (20)	7.89 ± 0.44	25.84 ± 0.81 a	42.11 ± 2.94 b	36.39 ± 1.84 b
Significance	ns	**	**	**
LSD value	1.437	2.461	9.078	6.651
Farming practices x cow manure				
Conventional xP_0	6.78 ± 0.72	15.22 ± 1.40 e	19.58 ± 4.90 e	13.15 ± 3.18 f
Conventional xP_1	8.22 ± 0.58	18.49 ± 0.98 de	33.01 ± 3.72 cd	24.57 ± 1.99 de
Conventional xP_2	8.33 ± 0.76	23.43 ± 0.81 bc	42.08 ± 1.87 bc	31.61 ± 0.73 bcd
Conventional xP_3	7.78 ± 0.44	25.36 ± 1.03 b	46.77 ± 4.21 b	37.84 ± 0.89 b
Floating x P_0	8.11 ± 0.22	15.66 ± 0.99 e	21.57 ± 3.95 de	16.28 ± 3.15 ef
Floating x P_1	6.67 ± 0.57	21.28 ± 0.80 cd	35.92 ± 3.45 bc	26.71 ± 2.44 cd
Floating x P_2	8.22 ± 0.90	30.77 ± 1.02 a	74.40 ± 6.05 a	64.82 ± 4.92 a
Floating x P_3	8.00 ± 0.88	26.32 ± 1.40 b	37.45 ± 1.96 b	34.96 ± 2.56 b
Significance	ns	*	**	**
LSD value	2.032	3.481	12.838	9.406

Note: Data represent mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05

The average diameter of bulbs grown using floating cultivation was 23.51±1.29 mm, which was much larger than the 20.62±1.62 mm average diameter of bulbs grown using conventional cultivation (Figure 4). The largest diameter of bulbs produced as a result of the usage of cow manure was at a dose of 15 tons/ha, and the lowest was at a dose of 0 tons/ha (Table 4). Based on the combination of treatments, the P_2 treatment (15 tons/ha) in floating cultivation produced the largest bulb diameter of 30.78 mm, whereas the P_3 treatment (20 tons/ha) in conventional cultivation produced the largest bulb diameter of 25.36 mm. The two cultivation methods produced the smallest bulb diameters in the same treatment, P_0 (0 ton/ha), with conventional system producing 15.22 mm and floating system producing 15.66 mm (Figure 5B). The high bulb diameter in the floating culture was greatly supported by the conditions of the growing media, where during growth stages, the rainfall continued to decline so that the media in floating culture was not saturated with water and oxygen was still available. Nutrients absorption, water uptake, and root respiration are all affected by oxygen availability, which is a crucial component for plant growth. The use of biological fertilizers or a combination of biological fertilizers and organic fertilizers can increase onion bulb diameter compared to controls ((Xiong et al., 2015; Neira et al., 2015; Widyastuti et al., 2021; Purba et al, 2020).

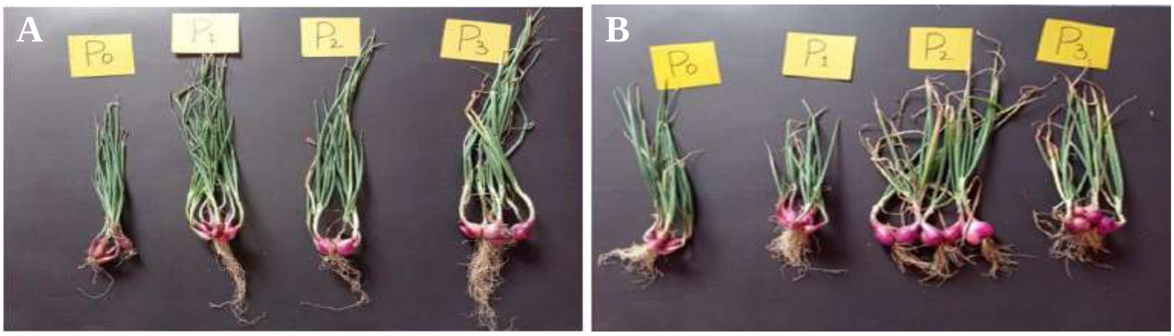

Figure 4. Shallot bulbs produced by conventional (A) and floating (B) systems with the application of cow manure

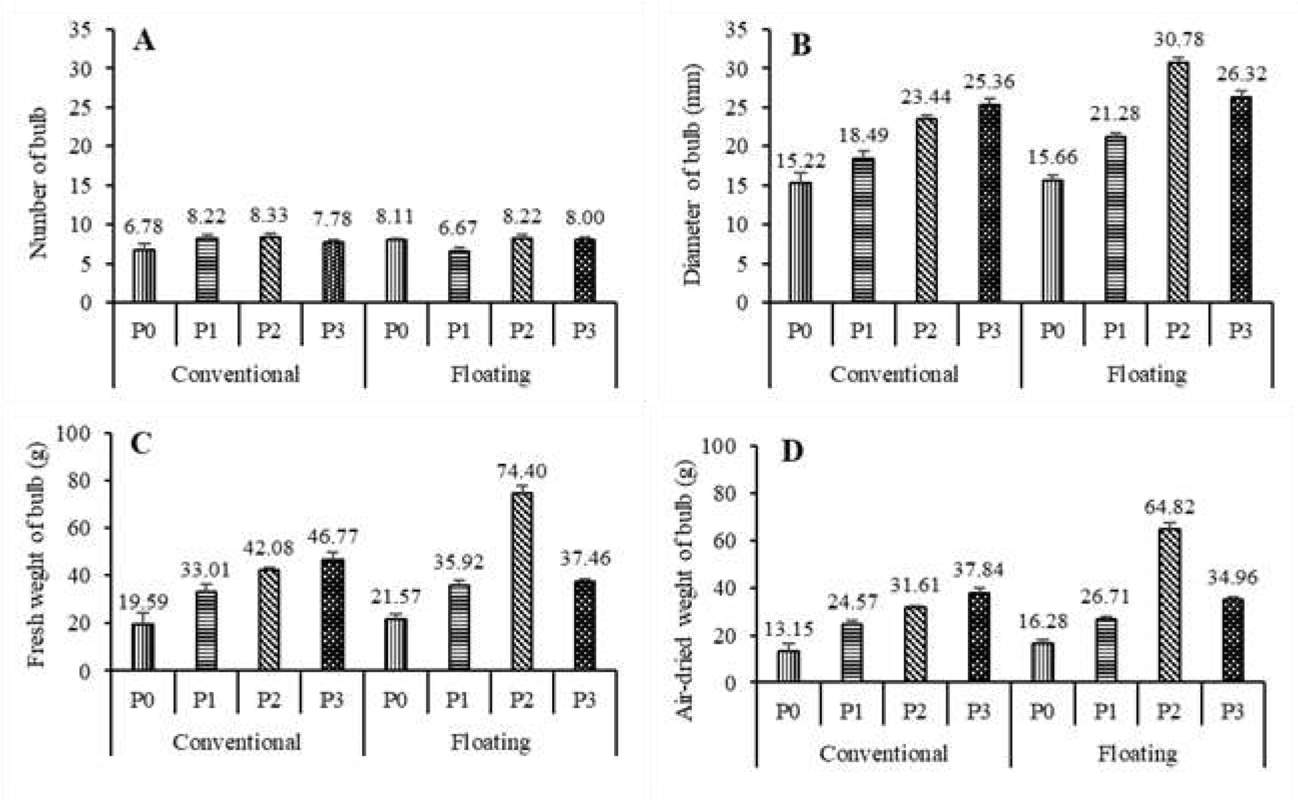

Figure 5. The application of cow manure on the parameters of bulb number (A), bulb diameter (B), fresh weight of bulb (C) and air-dried weight of bulb in different farming practices

Shallot production is highly dependent on the weight of fresh and air-dried bulbs. Floating cultivation system yielded the greatest average data, which was significantly different from conventional cultivation (42.33±3.52 g vs. 35.69±2.94 g) (Table 4). According to Jaya et al. (2019), the availability of water below plant media in floating system significantly promotes plant growth and yield. Based on the results (Figures 5C and 5D), conventional farming required a higher dosage of cow manure (20 tons/ha) compared to floating farming, which required only 15 tons/ha. In terms of cost and bulb production, Paputri et al. (2016) found that a cow manure dose of 20 tons/ha was economically feasible. However, Arzad et al. (2017) found that mustard plants needed up to 25 tons/ha of cow manure application.

The estimated production per hectare were then calculated using data on air-dried bulb weight under the assumption of a planting space of 20 cm x 15 cm. The highest estimated production was obtained in the floating system from P_2 treatment with 21.61 tons/ha, while in conventional system was from P_3 treatment with 12.61 tons/ha. The P_0 treatment had the lowest estimated yield, at 4.38 tons per hectare and 5.43 tons per hectare in the conventional and floating cultivation systems, respectively (Figure 6).

Based on the results, it was concluded that Bima Brebes shallot variety has potency to be cultivated using floating technique with the application of 15 ton per ha cow manure as seen from production estimation reaching 21.61 tons of dry bulb higher than variety description issued by Agricultural Ministry with 9.9 tons/ha of dry bulb.

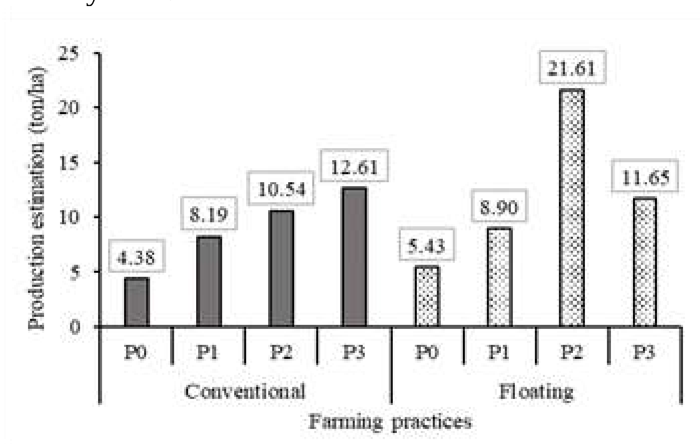

Figure 6. The estimated production of shallot from different farming practices with the application of cow manure

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to our research team and colleagues at Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya for their helpful feedback and valuable support to our research.

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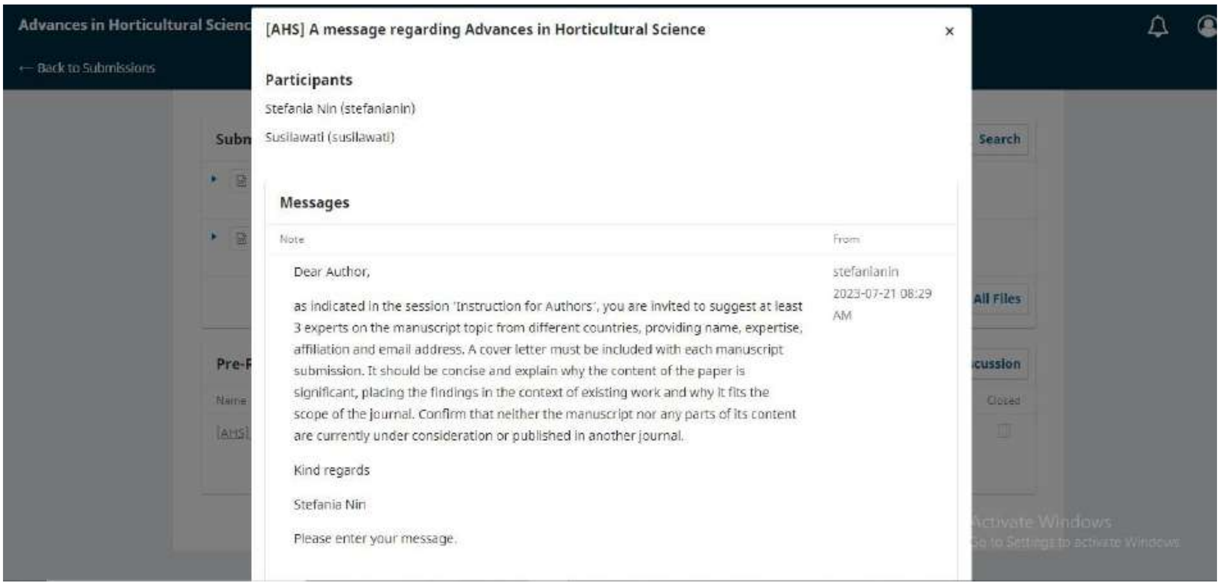

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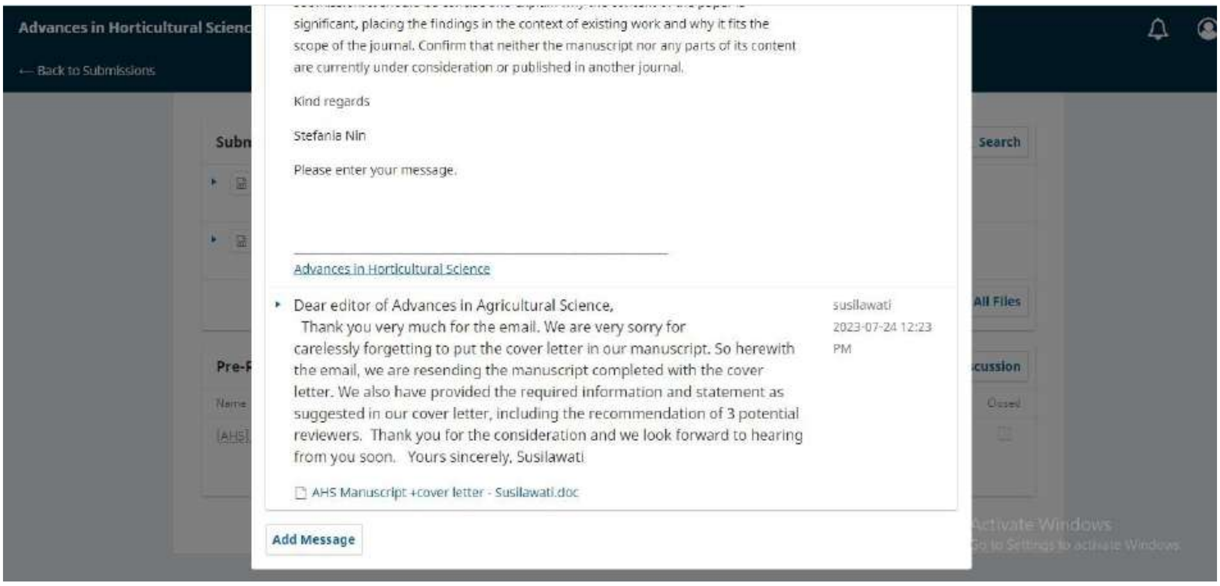

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COVER LETTER

Dr. Stefano Mancuso
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Advances in Horticultural Science

July 24, 2023
Dr. Stefania Nin,

We would like to submit our manuscript entitled "Farming Practices and Cow Manure Application on Growth and Yield of Bima Brebes Shallot Variety in Tropical Climate Ecosystem" for a publication as an article in Advances in Horticultural Science.

Our manuscript provides valuable information on the development of horticultural crops, especially shallot, in wetland areas which clearly fits to the scope of Advances in Horticultural Science Journal. Through the findings of our research, we could suggest that shallot is very potential to be cultivated in a floating system with the application of 15 tons of cow manure per hectare.

We confirm that this manuscript has not been published and is not under consideration for publication to any other journal or any other type of publication (including web hosting). All authors have approved the manuscript to agree with submission to Advances in Horticultural Science. The authors also have no conflict of interest to declare.

We would like to recommend the following researchers as potential reviewers for this paper:

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2. Dr. Preuk Chutimanukul (Email: preuk59@tu.ac.th); (Institution: Thammasat University)
3. Prof. Dr. Yaghoub Raei (Email: yaegoob@yahoo.com); (Institution: University of Tabriz)

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We look forward to hearing from you at your earliest convienience.

Yours sincerely,

Susilawati

Farming Practices and Cow Manure Application on Growth and Yield of Bima Brebes Shallot Variety in Tropical Climate Ecosystem

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Abstract. Compared to other typologies of *lebak* swamp, deep swamp has the longest flooding period which makes it challenging for crops cultivation. However, by adopting floating system, this prolonged duration of flooding can be used for shallot growing. Thus, this study was aimed to ascertain how conventionally and floating grown shallot plants respond to different doses of cow manure in terms of growth and production. The research was located in Experimental Field and Reservoir of Agriculture Faculty, Sriwijaya University (3°13'30.3′′S 104°38'55.1"E). Conventional and floating farming practices were utilized with the application of 0, 10, 15, and 20 tons/ha of cow manure. The findings demonstrated that shallot cultivated in floating system had lower number and length of leaf but could produce more bulbs in comparison to the conventional method. The application of 15 tons/ha manure in floating system resulted higher weight of fresh and air-dried bulbs per plant, weighing 74.40 g and 64.82 g, respectively, compared to that in conventional system with only 46.77 g and 37.84 g. In conclusion, Bima Brebes shallot variety can be potentially cultivated in a floating system with the application of 15 tons of cow manure per hectare.

Keywords: conventional, cow manure, floating**,** shallots

Running title: Shallot Cultivation with Manure Application

INTRODUCTION

As one of strategic commodities widely consumed in Indonesia, shallot (*Allium ascalonicum* L.) is a vegetable crop that significantly contributes to the country's horticultural production and inflation rate. According to the findings of the Socio-Economic Survey from September 2021, Indonesians consume an average of 2.49 kilograms (kg) of shallots per person each month. Shallots are required for the food sector, where they are processed into ready-to-use seasonings, for sprinkling food dishes, as well as for usage in households as a seasoning for cooking (Ministry of Agriculture, 2019; Irjayanti, 2022).

The best height for the growth and development of shallots is between 0 and 450 meters above sea level. Shallot in Indonesia can be grown anywhere from the plains to the highlands at an altitude of up to 1000 m above sea level. Bima Brebes is a shallot variety that is easy to grow and climate-adaptive (Sutrisno, 2015; Anitasari et al., 2019). Since shallot production varies from year to year and there is still a need to cultivate more shallots to meet the population's growing demand, it is still important to maximize shallot farming (Indriyana et al., 2020). In 2021, there will be 1,942,812 tons of shallot produced, with the majority of it coming from Central Java, East Java, East Nusa Tenggara, and West Sumatra. In South Sumatra, shallot production in 2021 was only a total of 1,125 tons (Directorate of Statistical Dissemination, 2022; Central Bureau of Statistics for South Sumatra Province, 2021). The texture and structure of the soil have significant impact on the production and quality of shallots. Applying organic fertilizer will create the fertile, loose soil that shallots need for the development of their bulbs. One of the components that can increase the physical, chemical, and biological qualities of the soil to boost the productivity of shallot plants while reducing the amount of P fertilizers provided to P-deficient soils is organic fertilizer (Susikawati et al., 2018; Noviyanty and Salingkat, 2018; Nguyen et al., 2021). One organic fertilizer that can promote plant development is cow manure (Musdalifah et al., 2021; Atman et al., 2018; Sudarsono et al., 2014).

Swampland limits the growth of shallots in South Sumatra Province. Peatland is potential swamp land for horticulture crops, and it is present in both the 2.62 million hectares of the *lebak* (inland) swamp and the 0.52 million ha of the tidal land, of which 1.20 million ha are in Sumatra (Husen et al., 2015; Susilawati et al., 2022). *Lebak* swamplands have different sensitivity to the risk of waterlogging. Shallow and middle *lebak* swamps are usually cultivated during the dry season; however, the plants are also at risk from drought (Simatupang and Rina, 2019). The productivity of vegetable crops cultivated in *lebak* swamplands may be hampered by drought and flooding. However, deep lebak swamp can be developed depending on the ecological function of the land (Widuri et al., 2016; Suprapto, 2016). The floating farming system is one method for growing plants in deep swamps where the water remains stagnant for longer than six months while the land remains submerged throughout the dry season (low rainfall) (Siaga et al., 2018; Karla et al., 2019; Lakitan, 2021). According to Hasbi et al. (2017), a projected floating farming system for the cultivation of vegetables was created based on the statements of farmers who are interested in using the newly introduced floating farming. Shallots are one of the many crops that may be grown in the floating system. Thus, the aim of this study was to determine the growth response and production of conventional and floating cultivation systems of shallot plants at various doses of cow manure fertilizer.

MATERIALS AND METHODS

Research area

The research was located in the Experimental Field and Reservoir of the Faculty of Agriculture, Sriwijaya University, Indralaya Ogan Ilir (3°13'30.3″S 104°38'55.1"E) where the condition as seen in Figure 1, during dry season in tropical climate ecosystems of South Sumatra, Indonesia, from May to August 2022. Typical agroclimatic conditions at the outdoor research facilities are shown in Figure 2.

Figure 1. Conventional (A) and floating (B) farming practices of shallot cultivation

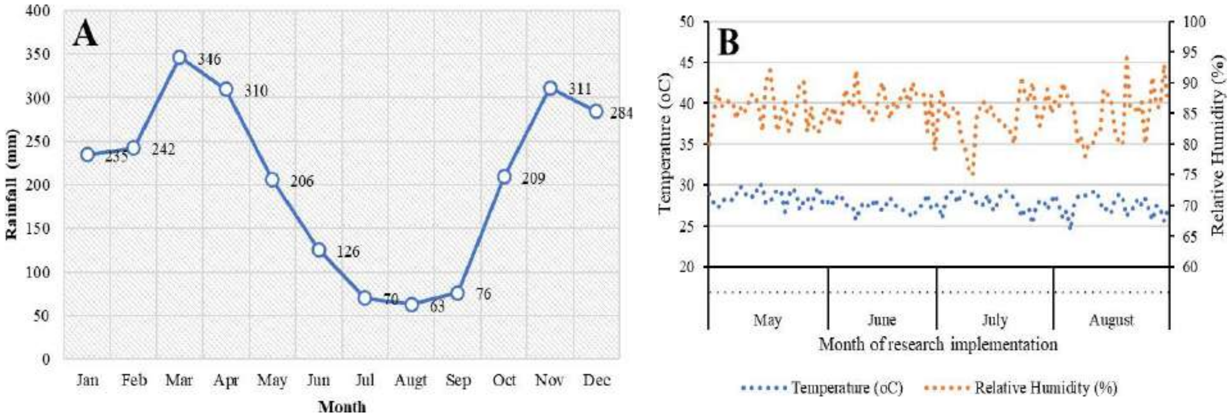

Figure 2. Typical agroclimatic conditions: Rainfall (A), Temperature and Relative Humidity (B) at the outdoor research facilities. Source: https://www.bmkg.go.id

Procedures

The planting materials were cow manure, alluvial soil, bamboo raft, and other supporting materials. The shallot bulbs used were of the Bima Brebes variety originated from the shallot seed farmers in Brebes, Central Java. The experiment was arranged using a factorial randomized block design with two factors and three replicates. The treatments consisted of farming practices (the conventional and floating systems) and dosages of cow manure (0, 10, 15, and 20 tons/ha).

For all farming practice treatments, the planting media were prepared in the same method: after been completely mixed, it was placed into 35 cm x 30 cm polybags. The planting media were a mixture of alluvial topsoil combined with cow manure according to the treatments. In conventional farming technique, the area was prepared by clearing the surrounding weeds and unwanted plants to make a space for placing the polybags filled with the media. In floating cultivation, the polybags were put on a 2 m x 1 m of bamboo raft. Each replicate was put in one bamboo raft. The planting media were sprayed with Bio Soil Grow Booster at a concentration of 4 ml/liter of water one week before planting. Inorganic fertilizers were also used with dosages of TSP (150 kg/ha), urea (100 kg/ha), and KCl (100 kg/ha). TSP fertilizer was applied 7 days before planting, whereas urea and KCl were applied twice, at 7 and 25 days after planting (DAP), each time in half the prescribed amount. Before being planted, bulbs were first cut off by a third of the top end and then placed into the planting hole at a depth of 2–3 cm.

Data analysis

The variables were growth characteristics such leaf length, leaf number and leaf color as well as shallot production variables such as bulb number, bulb diameter, fresh weight, dry weight, and shrinkage percentage, as well as estimated production per hectare. The calculated F-value generated from the analysis of variance (ANOVA) was compared to values of F-table at $p \leq 0.05$ and $p \leq 0.01$ for justifying significant effects of the treatments. Furthermore, if the treatment effect was significant on any measured traits, the least significant difference (LSD) test was conducted for determining significant differences among treatment levels on each of specified traits.

RESULTS AND DISCUSSION

Leaf length (cm) and leaf number of Shallots

Shallot plants grown in tropical climate ecosystems with two farming practices as in conventional (Figure 1A) and floating (Figure 1B) systems at various doses of cow manure showed differences in growth and yield. Rainfall continued to decline from May to August 2022, when the study was conducted. Rainfall reduced from 206 mm in May to 63 mm in August (Figure 2A). High rainfall levels at the start of the study provided a favorable environment for shallot growth in conventional cultivation system (polybags stacked on dry soil). On the other hand, shallots grown in wetlands using floating system (polybags placed on rafts) did not favor heavy rainfall. From May to August 2022, the temperature and humidity remained relatively stable. The range of the temperature and humidity was 27.47–27.92 ºC and 84.51–86.36 %, respectively (Figure 2B).

The variance analysis revealed that the variations in farming practices had a significant impact. The results of the least significant difference (LSD) test on leaf length parameter demonstrated that two farming practices differed significantly. In conventional cultivation, the maximum leaf length was 40.43±1.25 cm at 5 weeks after planting (WAP), whereas in floating system, it was only 30.47±0.47 cm at 4 WAP. In floating agriculture system, water is continuously supplied via the soil pores by capillary force, causing slower oxygen diffusion. Additionally, when it rains heavily, the media becomes more water-saturated, which lowers the amount of accessible oxygen. Oxygen is needed by the roots for respiration and for maintaining healthy cell function (Neira et al., 2015; Ernest, 2018; Jaya et al., 2021; Kartika et al., 2021). The damage on root will eventually affect the upper plant parts growth as seen from the agronomical features. Research by Susilawati et al. (2012) on red pepper plants showed that all cultivars experienced varying degrees of root damage as a result of flooding stress. The amount of oxygen that is present in the growing media is significantly influenced by the height of the water table. Research on bean plants had shown that the roots, particularly the process of root respiration, were significantly impacted by water levels that were 10 cm below the planting media surface. Although organic fertilizer applied to red chilies in a floating system had not affected growth, proper water level and the application of organic matter to shallot plants considerably stimulated growth (Susilawati et al., 2019a; Susilawati et al., 2019b; Susilawati et al., 2022). On leaf length parameter, the application of cow manure showed insignificant result in the first week and significant in the second to eighth weeks. The longest leaves were obtained at a dose of 20 tons per hectare (P_3 treatment) with 40.19±2.96 cm, not significantly different from a dose of 15 tons per hectare (P_2) of 40.06±1.69 cm. The combination of farming practices and cow manure treatments had a significant effect on leaf length only in 6 and 8 WAP in the conventional P_3 treatment with 44.74±1.10 cm and 44.92±1.36 cm, respectively.

On the leaf number parameter, the difference in farming practices only had a significant effect in the first to third weeks. The average number of leaves was mostly higher in the conventional system, except in the fourth week when the leaf number in the floating system was higher at 24.33 ± 1.92 compared to 23.39 ± 1.33 in the conventional system. The research on eggplant showed that increasing the water content of the substrate from 1 to 3 cm would increase the growth of vegetative organs (Jaya et al., 2019). The difference in cow manure doses affected the number of leaves, where the highest leaf number was obtained in P_2 treatment with 31.78 ± 2.65 in 7 WAP (Table 1). Similarly, research by Feriatin et al. (2021) also showed that the use of cow manure would affect leaf number of the Lokananta shallot variety. The P_3 treatment for conventional cultivation and the P_2 treatment for floating cultivation produced the highest average of leaf length and leaf number when cow manure was applied. In the conventional P_3 treatment, the maximum leaf length was 37.45 cm with a 21.33 average leaf number, while in the floating P_2 treatment, the highest leaf length was 29.80 cm with 23.14 leaves. Cow manure is an organic fertilizer that can alter the structure and texture of the soil, making the media crumblier, which explains the difference in the dosage of cow manure between the two cultivation systems (Figure 3). Meanwhile, as a result of the relatively high moisture of the planting media in floating culture, cow manure already affects the texture and structure of the media at lower doses (Gudugi, 2013; Elisabeth et al., 2013; Ekwealor et al., 2020; Wisdom et al., 2021).

Table 1. Leaf length (cm) and leaf number of shallot with the application of cow manure (ton/ha) on different farming practices

Treatment	Week after planting (WAP)							
	1	2	3	4	5	6	7	8
Farming practices								
Leaf length (cm)								
Conventional	11.67 ± 0.66 a	26.60 ± 0.79 a	36.43 ± 1.03 a	40.32 ± 1.45 a	40.43 ± 1.69 a	38.39 ± 1.71 a	38.39 ± 1.66 a	36.09 ± 1.95 a
Floating	8.28 ± 0.32 b	20.04 ± 0.56 b	27.58 ± 1.09 b	30.47 ± 1.43 b	29.45 ± 1.90 b	26.66 ± 2.08 b	25.66 ± 1.82 b	24.88 ± 1.76 b
Significance	**	**	**	**	**	**	**	**
LSD0.05	1.516	1.375	2.209	1.961	1.992	2.208	2.536	4.549
Leaf number								
Conventional	7.83 ± 0.39 a	12.38 ± 0.43 a	17.78 ± 0.69 a	22.13 ± 0.93	23.39 ± 1.33	25.69 ± 1.50	26.00 ± 1.43	23.64 ± 1.21
Floating	5.88 ± 0.21 b	10.38 ± 0.47 b	15.66 ± 0.61 b	20.94 ± 1.25	24.33 ± 1.92	25.25 ± 2.15	23.61 ± 2.06	20.03 ± 1.91
Significance	**	**	*	ns	ns	ns	ns	ns
LSD0.05	0.777	1.303	1.548	2.479	2.929	3.831	4.679	4.567
Cow manure (ton/ha)								
Leaf length (cm)								
P_0 (0)	9.31 ± 0.90	21.37 ± 1.74 b	27.53 ± 2.37 b	29.07 ± 2.54 b	26.80 ± 2.99 c	24.83 ± 3.09 c	25.61 ± 3.07 c	25.24 ± 2.96 b
P_1 (10)	10.19 ± 1.23	22.09 ± 1.24 b	30.71 ± 1.86 a	33.59 ± 2.21 b	32.72 ± 2.64 b	29.26 ± 3.12 b	29.86 ± 3.00 b	30.29 ± 2.58 b
P_2 (15)	9.54 ± 0.87	25.30 ± 1.58 a	35.52 ± 1.81 a	39.69 ± 1.74 a	40.06 ± 1.69 a	38.93 ± 1.33 a	37.84 ± 1.34 a	37.16 ± 1.80 a
P_3 (20)	10.86 ± 1.12	24.52 ± 1.89 a	34.26 ± 2.31 a	39.23 ± 2.82 a	40.19 ± 2.96 a	37.10 ± 3.46 a	34.76 ± 4.63 a	29.27 ± 4.69 b
Significance	ns	**	**	**	**	**	**	*
LSD0.05	2.144	1.945	2.189	2.773	2.817	3.122	3.587	6.434
Leaf number								
P_0 (0)	6.00 ± 0.40 b	10.33 ± 0.31	14.33 ± 0.41 b	17.55 ± 0.62 b	17.72 ± 0.88 c	19.50 ± 1.64 c	20.50 ± 2.11 b	19.39 ± 2.28
P_1 (10)	6.94 ± 0.59 ab	11.33 ± 1.06	16.78 ± 1.11 a	20.39 ± 1.12 b	22.50 ± 1.32 b	25.99 ± 1.47 b	26.28 ± 2.09 ab	23.11 ± 2.04
P_2 (15)	6.72 ± 0.58 ab	11.39 ± 0.76	17.22 ± 0.99 a	24.00 ± 1.59 a	29.05 ± 2.38 a	31.78 ± 2.65 a	29.67 ± 2.39 b	25.94 ± 1.88
P_3 (20)	7.78 ± 0.68 a	12.50 ± 0.55	18.55 ± 0.59 a	24.22 ± 0.80 a	26.16 ± 1.32 ab	24.61 ± 1.78 bc	22.78 ± 2.14 b	18.89 ± 2.36
Significance	*	ns	**	**	**	**	*	ns
LSD0.05	1.099	1.842	2.189	3.506	4.144	5.418	6.618	6.459

Note: Data represent mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05

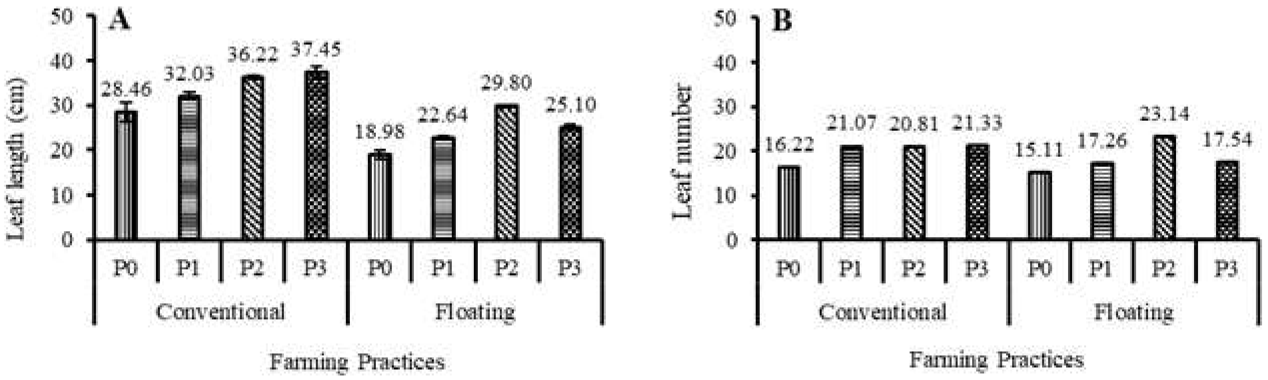

Figure 3. The application of cow manure on the parameters of leaf length (A) and leaf number (B) in different farming practices

SPAD value

In this study, the parameter of leaf greenness—which serves as an indicator for chlorophyll content—was quantified using the SPAD tool without damaging the leaves measured from the second to the eighth week. In the fourth and sixth weeks, the culture technique treatment significantly affected the SPAD value, while had no significant effect in 2 and 8 WAP. Shallots cultivated in floating system was recorded to have higher values in 2, 4 and 6 WAP with 77.69±2.69, 64.10±4.41, and 48.18±1.25, respectively, as compared to that in conventional system with 74.68±3.08, 48.18±1.25, and 48.79±1.43. However, in the eighth week, SPAD value in conventional system was higher than in floating system with 44.78±1.33 and 43.22±4.48, respectively. The SPAD values of the two cultivation techniques was at the highest at 2 WAP, and then continued to decrease until 8 WAP. In comparison to other models, the polynomial model's regression analysis of the SPAD value in the shallot cultivation resulted in the largest determination coefficient (R^2) that is close to 1, with 0.9123 for the conventional system and 0.9618 for the floating system. The magnitude of the R^2 value indicates that the SPAD value is affected by the cultivation technique in a quadratic manner, increasing until it reaches the peak before starting to decline (Table 3). A study on corn resulted in a similar result, where the SPAD values would decrease after reaching their peak which mostly affected by the environment (Ghozali, 2016; Kandel, 2020; Szulc et al., 2021).

This study also found that the increase in cow manure dosage would also increase the SPAD value where the highest SPAD value was obtained in the P_3 treatment at 82.54 and the lowest in the P_0 treatment at 31.21. The SPAD value has been widely used to estimate the chlorophyll content of other crops, such as tomatoes (Jiang et al., 2017). Furthermore, the application of cow manure could also increase leaf chlorophyll, as indicated by the SPAD value in wheat and rice plants (Shah et al., 2017; Atman et al., 2018). The combination of cultivation techniques and cow manure treatments resulted in no significant effect in 2 and 8 WAP, a significant effect in 4 WAP, and a highly significant effect in 6 WAP. The highest SPAD value was obtained in floating cultivation and cow manure at a dose of 20 tons/ha at 77.01±5.35 in 4 WAP and 75.11±3.96 in 6 WAP (Table 2).

Table 2. SPAD value of shallot on different farming practices with the application of cow manure

Treatment	Weeks after planting (WAP)			
	2	4	6	8
		Farming practices		
Conventional	74.68 ± 3.08	48.18 ± 1.25 b	48.79 ± 1.43 b	44.78 ± 1.33
Floating	77.69 ± 2.88	64.10 ± 4.41 a	59.78 ± 4.55 a	43.22 ± 4.48
Significance	ns	**	**	ns
LSD value	7.996	6.040	4.381	4.615
		Cow manure (ton/ha)		
P_0 (0)	68.16 ± 2.38	45.31 ± 2.88 c	40.90 ± 2.71 c	31.21 ± 4.08 c
P_1 (10)	75.74 ± 5.19	58.48 ± 5.77 ab	56.21 ± 4.35 b	44.61 ± 2.93 b
P_2 (15)	78.27 ± 4.09	55.78 ± 4.94 b	55.98 ± 3.73 b	46.60 ± 2.09 b
P_3 (20)	82.54 ± 2.98	65.00 ± 6.08 a	64.04 ± 5.28 a	53.60 ± 3.80 a
Significance	ns	**	**	**
LSD value	11.307	8.542	6.197	6.527
		Farming practices x cow manure (ton/ha)		
Conventional xP_0	68.47 ± 5.10	46.81 ± 1.43 b	43.29 ± 3.72 ef	39.69 ± 3.16 c
Conventional xP_1	74.13 ± 10.00	46.93 ± 1.68 b	48.02 ± 1.74 de	43.42 ± 10.00 bc
Conventional xP_2	74.01 ± 4.26	46.00 ± 1.36 b	50.87 ± 0.68 bc	46.57 ± 4.26 bc
Conventional xP_3	82.13 ± 4.21	52.99 ± 3.47 b	52.98 ± 1.17 cd	49.46 ± 4.21 ab
Floating x P_0	67.86 ± 1.46	43.81 ± 6.11 b	38.52 ± 4.15 f	22.73 ± 1.46 d
Floating x P_1	77.37 ± 5.68	70.03 ± 5.53 a	64.41 ± 4.95 b	45.81 ± 5.68 bc
Floating x P_2	82.54 ± 6.90	65.56 ± 4.94 a	61.10 ± 6.57 bc	46.63 ± 6.90 bc
Floating x P_3	82.97 ± 5.15	77.01 ± 5.35 a	75.11 ± 3.96 a	57.73 ± 5.15 a
Significance	ns	*	**	ns
LSD value	15.991	12.081	8.763	9.231

Note: Data represent mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05

Table 3. Regression analysis correlations of SPAD value with several mathematical models of farming practices on several doses of cow manure

Farming practices	Linear model, y = ax+b	Logarithmic model, y = a ln x+b	Polynomial model, y=ax2+bx+c	Power model, $y = ax^b$
Conventional	y=-8.9073x+76.38	y=-21.1ln(x)+70.877	y=5.6238x2-37.026x+104.5	$y=70.35x^{0.357}$
	R^2 =0.6917 r = 0.8316**	R^2 =0.8417 r = 0.9174**	R^2=0.9123 r = 0.9551**	R^2 = 0.8842 r =0.9432**
Floating	y=-10.769x+88.122	y=-22.56ln(x)+79.122	$y=-0.7451x^2-7.0429x+84.39$	$y=80.712x^{0.375}$
	R^2 = 0.9581 r = 0.9788**	R^2 = 0,9116 r = 0.9547**	R^2 =0.9618 r = 0.9807**	R^2 =0.8804 r = 0.9383**

Note: ** means significant difference $p < 0.05$

Bulb number, bulb diameter (mm), weight of fresh and air-dried bulb (g)

The yield components include the number of bulbs, bulbs diameter, and weight for both fresh and air-dried bulbs. The farming practices treatment had no significant impact on the quantity of bulbs but had a very significant impact on the weight of fresh bulb, bulb diameter, and weight of air-dried bulb. The conventional method produced the greatest number of bulbs, whereas floating cultivation resulted the best results in terms bulb diameter and weight of fresh and air-dried bulbs. The growing media conditions strongly affected how bulbs were initially formed. Since water was constantly accessible from beneath the growing media through capillaries, floating cultivation used growing media that were somewhat moist. There was also intense rainfall during early growth of shallot causing the planting media to be very wet. There were about 7.78±0.35 bulbs formed in conventional cultivation and 7.75±0.33 in floating cultivation. The number of bulbs was somehow not linearly correlated with the greater dose of cow manure applied as the largest number of bulbs was obtained at a dose of 15 tons/ha (Table 4). The largest number of bulbs (8.33 in conventional cultivation and 8.22 in floating cultivation) were obtained from the same manure treatment, which was P_2. The lowest data, 6.78 bulbs in conventional cultivation and 6.67 bulbs in floating cultivation, were also obtained at the same manure treatment, P_0 (Figure 5A). Plant growth can be supported by appropriate cultivation methods (Cahyaningrum et al., 2023; Khorasgani and Pessarakli, 2019).

Table 4. Shallot yield components on different farming practices with the application of cow manure

Treatment	Number of bulb	Diameter of bulb (cm)	Fresh weight of bulb (g)	Air-dried weight of bulb (g)
		Farming practices		
Conventional	7.78 ± 0.35	20.62 ± 1.76 b	35.36 ± 6.14 b	26.79 ± 5.64 b
Floating	7.75 ± 0.33	23.51 ± 1.29 a	42.33 ± 3.52 a	35.69 ± 2.94 a
Significance	ns	**	*	**
LSD value	1.016	1.741	6.419	4.703
		Cow manure		
P_0 (0)	7.44 ± 0,45	15.44 ± 0.77 c	20.57 ± 2.85 c	14.71 ± 2.12 d
P_1 (10)	7.44 ± 0.50	19.88 ± 0.84 b	34.46 ± 2.36 b	25.64 ± 1.49 c
P_2 (15)	8.28 ± 0.53	27.10 ± 1.74 a	58.24 ± 7.76 a	48.22 ± 7.75 a
P_3 (20)	7.89 ± 0.44	25.84 ± 0.81 a	42.11 ± 2.94 b	36.39 ± 1.84 b
Significance	ns	**	**	**
LSD value	1.437	2.461	9.078	6.651
		Farming practices x cow manure		
Conventional xP_0	6.78 ± 0.72	15.22 ± 1.40 e	19.58 ± 4.90 e	13.15 ± 3.18 f
Conventional xP_1	8.22 ± 0.58	18.49 ± 0.98 de	33.01 ± 3.72 cd	24.57 ± 1.99 de
Conventional xP_2	8.33 ± 0.76	23.43 ± 0.81 bc	42.08 ± 1.87 bc	31.61 ± 0.73 bcd
Conventional xP_3	7.78 ± 0.44	25.36 ± 1.03 b	46.77 ± 4.21 b	37.84 ± 0.89 b
Floating x P_0	8.11 ± 0.22	15.66 ± 0.99 e	21.57 ± 3.95 de	16.28 ± 3.15 ef
Floating x P_1	6.67 ± 0.57	21.28 ± 0.80 cd	35.92 ± 3.45 bc	26.71 ± 2.44 cd
Floating x P_2	8.22 ± 0.90	30.77 ± 1.02 a	74.40 ± 6.05 a	64.82 ± 4.92 a
Floating x P_3	8.00 ± 0.88	26.32 ± 1.40 b	37.45 ± 1.96 b	34.96 ± 2.56 b
Significance	ns	*	**	**
LSD value	2.032	3.481	12.838	9.406

Note: Data represent mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05

The average diameter of bulbs grown using floating cultivation was 23.51±1.29 mm, which was much larger than the 20.62±1.62 mm average diameter of bulbs grown using conventional cultivation (Figure 4). The largest diameter of bulbs produced as a result of the usage of cow manure was at a dose of 15 tons/ha, and the lowest was at a dose of 0 tons/ha (Table 4). Based on the combination of treatments, the P_2 treatment (15 tons/ha) in floating cultivation produced the largest bulb diameter of 30.78 mm, whereas the P_3 treatment (20 tons/ha) in conventional cultivation produced the largest bulb diameter of 25.36 mm. The two cultivation methods produced the smallest bulb diameters in the same treatment, P_0 (0 ton/ha), with conventional system producing 15.22 mm and floating system producing 15.66 mm (Figure 5B). The high bulb diameter in the floating culture was greatly supported by the conditions of the growing media, where during growth stages, the rainfall continued to decline so that the media in floating culture was not saturated with water and oxygen was still available. Nutrients absorption, water uptake, and root respiration are all affected by oxygen availability, which is a crucial component for plant growth. The use of biological fertilizers or a combination of biological fertilizers and organic fertilizers can increase onion bulb diameter compared to controls ((Xiong et al., 2015; Neira et al., 2015; Widyastuti et al., 2021; Purba et al, 2020).

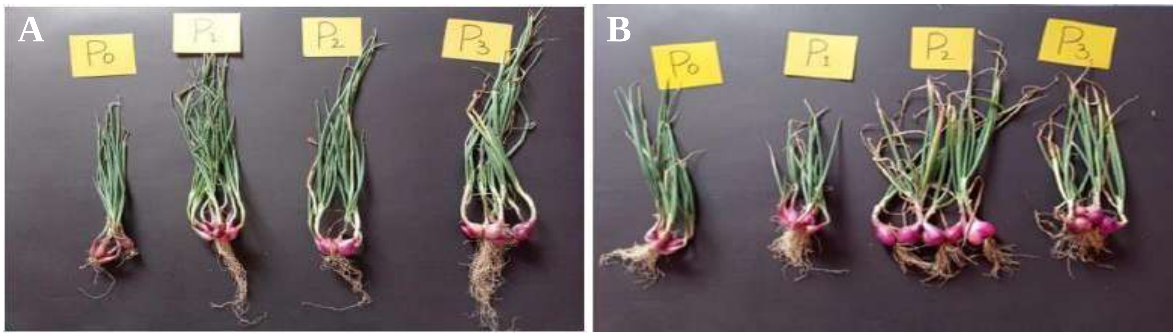

Figure 4. Shallot bulbs produced by conventional (A) and floating (B) systems with the application of cow manure

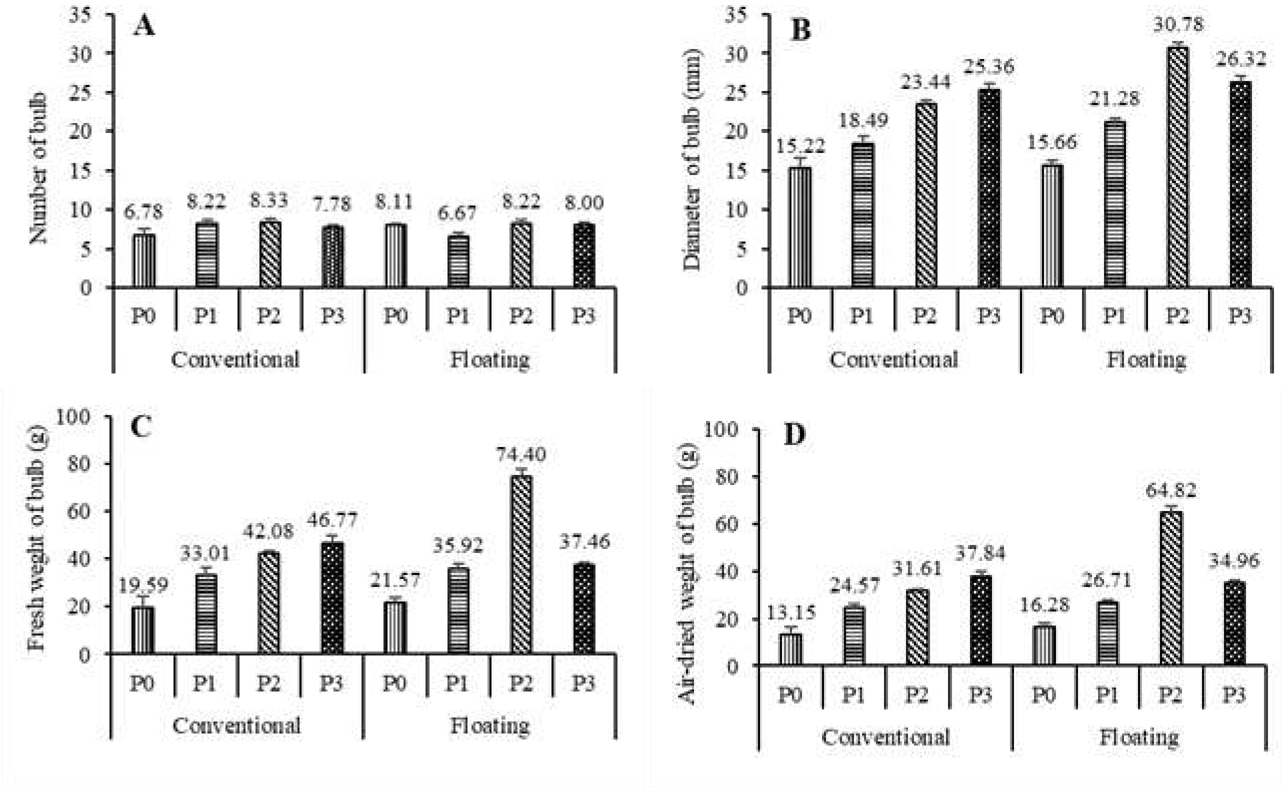

Figure 5. The application of cow manure on the parameters of bulb number (A), bulb diameter (B), fresh weight of bulb (C) and air-dried weight of bulb in different farming practices

Shallot production is highly dependent on the weight of fresh and air-dried bulbs. Floating cultivation system yielded the greatest average data, which was significantly different from conventional cultivation (42.33±3.52 g vs. 35.69±2.94 g) (Table 4). According to Jaya et al. (2019), the availability of water below plant media in floating system significantly promotes plant growth and yield. Based on the results (Figures 5C and 5D), conventional farming required a higher dosage of cow manure (20 tons/ha) compared to floating farming, which required only 15 tons/ha. In terms of cost and bulb production, Paputri et al. (2016) found that a cow manure dose of 20 tons/ha was economically feasible. However, Arzad et al. (2017) found that mustard plants needed up to 25 tons/ha of cow manure application.

The estimated production per hectare were then calculated using data on air-dried bulb weight under the assumption of a planting space of 20 cm x 15 cm. The highest estimated production was obtained in the floating system from P_2 treatment with 21.61 tons/ha, while in conventional system was from P_3 treatment with 12.61 tons/ha. The P_0 treatment had the lowest estimated yield, at 4.38 tons per hectare and 5.43 tons per hectare in the conventional and floating cultivation systems, respectively (Figure 6).

Based on the results, it was concluded that Bima Brebes shallot variety has potency to be cultivated using floating technique with the application of 15 ton per ha cow manure as seen from production estimation reaching 21.61 tons of dry bulb higher than variety description issued by Agricultural Ministry with 9.9 tons/ha of dry bulb.

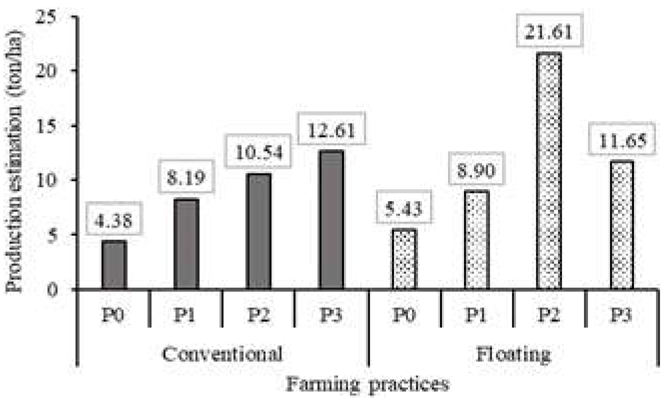

Figure 6. The estimated production of shallot from different farming practices with the application of cow manure

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to our research team and colleagues at Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya for their helpful feedback and valuable support to our research.

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2. Review

Peer review round 1 (14 September 2023)

Advances in Horticultural Science

← Back to Submissions

Workflow | Publication

Submission | Review | Copyediting | Production

Round 1

Round 1 Status
Submission accepted.

Notifications

[AHS] Editor Decision	2023-09-14 02:09 PM
[AHS] Editor Decision	2023-09-28 08:00 AM
[AHS] Editor Decision	2023-11-27 03:36 PM
[AHS] Editor Decision	2023-11-29 11:33 AM
[AHS] Editor Decision	2023-11-29 11:34 AM

[AHS] Editor Decision

2023-09-14 02:09 PM

Susilawati, Irmawati, Muhammad Umar Harun, Budiyati Ichwan:

We have reached a decision regarding your submission to Advances in Horticultural Science, "Farming Practices and Cow Manure Application on Growth and Yield of Bima Brebes Shallot Variety in Tropical Climate Ecosystem".

Our decision is: Major Revisions Required

Reviewers:

The author presented an interesting manuscript with interesting results. The manuscript has potential, but before being accepted, some of the following issues should be addressed:

- Many suggestions are included in the attached file. Feel free to accept the recommendations.
- Extensive editing of English language and style required
- In the introduction, I suggest the authors rewrite because it does not take the readers to the problem (did not tell a history) and does not take the reader to the hypothesis.
- Regarding the methodology, some information are required.Results and discussion can be improved.

Recommendation: Major Revisions Required

[AHS] Editor Decision

Stefania Nin <journals@fupress.it> Kam, 28 Sep 2023, 15.01
kepada saya, Irmawati, Muhammad, Budiyati

Susilawati, Irmawati, Muhammad Umar Harun, Budiyati Ichwan:

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Our decision is: Major Revisions Required

You are advised that the manuscript will be acceptable subject to satisfactory major revision.

The comments below should be taken into account when revising the manuscript. Along with your revised manuscript, you will need to supply a covering letter in which you list all the changes you have made to the manuscript, and in which you detail your responses to all the comments passed by the reviewers. Should you disagree with any comment (s), please explain why.

Please, colour your changes in the revised manuscript or use 'track changes' that reviewers and editors can immediately recognize where the changes have been made.

Your revised manuscript is expected to be submitted within 60 days from now.

Kind regards

Stefania Nin

Comments:

The manuscript has some potential, but before being accepted, some of the following issues should be addressed:

- Many suggestions are included in the attached file.
- Extensive editing of English language and style required.
- The Author must refer to a professional manuscript editing service or to native English speaker for improving the English in the manuscript, otherwise the article cannot be absolutely taken into consideration.
- The introduction has to be rewritten because it does not take the readers to the problem (did not tell a history) and does not take the reader to the hypothesis.
- Regarding the methodology, some information are required.
- Results and discussion must be improved.

Notifications

[AHS] Editor Decision

2023-09-28 08:00 AM

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Advances in Horticultural Science

Farming Practices and Cow Manure Application on Growth and Yield of Bima Brebes Shallot Variety in Tropical Climate Ecosystem

Abstract. Compared to other typologies of *lebak* swamp, the deep swamp has the longest flooding period, making it challenging for crop. However, by adopting floating system, this prolonged duration of flooding can be used for shallot growing. Thus, this study was aimed to ascertain how conventionally and floating grown shallot plants respond to different doses of cow manure in terms of growth and production. The research was located in the Experimental Field and Reservoir of Agriculture Faculty, Sriwijaya University (3° 13'30.3"S 104° 38'55.1"E). Conventional and floating farming practices were utilized with the application of 0, 10, 15, and 20 tons/ha of cow manure. The findings demonstrated that shallot cultivated in floating system had lower number and length of leaf but could produce more bulbs in comparison to the conventional method. The application of 15 tons/ha manure in floating system resulted in higher weight of fresh and air-dried bulbs per plant, weighing 74.40 g and 64.82 g, respectively, compared to that in conventional system with only 46.77 g and 37.84 g. In conclusion, Bima Brebes shallot variety can be potentially cultivated in a floating system with the application of 15 tons of cow manure per hectare.

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Keywords: conventional, cow manure, floating, shallots

Running title: Shallot Cultivation with Manure Application

INTRODUCTION

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As one of strategic commodities widely consumed in Indonesia, shallot (*Allium ascalonicum* L.) is a vegetable crop that significantly contributes to the country's horticultural production and inflation rate. According to the findings of the Socio-Economic Survey from September 2021, Indonesians consume an average of 2.49 kilograms (kg) of shallots per person each month. Shallots are required for the food sector, where they are processed into ready-to-use seasonings, for sprinkling food dishes, as well as for usage in households as a seasoning for cooking (Ministry of Agriculture, 2019; Irjayanti, 2022).

The best height for the growth and development of shallots is between 0 and 450 meters above sea level. Shallot in Indonesia can be grown anywhere from the plains to the highlands at an altitude of up to 1000 m above sea level. Bima Brebes is a shallot variety that is easy to grow and climate-adaptive (Sutrisno, 2015; Anitasari et al., 2019). Since shallot production varies from year to year and there is still a need to cultivate more shallots to meet the population's growing demand, it is still important to maximize shallot farming (Indriyana et al., 2020). In 2021, there will be 1,942,812 tons of shallot produced, with the majority of it coming from Central Java, East Java, East Nusa Tenggara, and West Sumatra. In South Sumatra, shallot production in 2021 was only a total of 1,125 tons (Directorate of Statistical Dissemination, 2022; Central Bureau of Statistics for South Sumatra Province, 2021). The texture and structure of the soil have significant impact on the production and quality of shallots. Applying organic fertilizer will create the fertile, loose soil that shallots need for the development of their bulbs. One of the components that can increase the physical, chemical, and biological qualities of the soil to boost the productivity of shallot plants while reducing the amount of P fertilizers provided to P-deficient soils is organic fertilizer (Susikawati et al., 2018; Noviyanty and Salingkat, 2018; Nguyen et al., 2021). One organic fertilizer that can promote plant development is cow manure (Musdalifah et al., 2021; Atman et al., 2018; Sudarsono et al., 2014).

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Commented [user5]: Produced?

Swampland limits the growth of shallots in South Sumatra Province. Peatland is potential swamp land for horticulture crops, and it is present in both the 2.62 million hectares of the *lebak* (inland) swamp and the 0.52 million ha of the tidal land, of which 1.20 million ha are in Sumatra (Husen et al., 2015; Susilawati et al., 2022). *Lebak* swamplands have different sensitivity to the risk of waterlogging. Shallow and middle *lebak* swamps are usually cultivated during the dry season; however, the plants are also at risk from drought (Simatupang and Rina, 2019). The productivity of vegetable crops cultivated in *lebak* swamplands may be hampered by drought and flooding. However, deep lebak swamp can be developed depending on the ecological function of the land (Widuri et al., 2016; Suprapto, 2016). The floating farming system is one method for growing plants in deep swamps where the water remains stagnant for longer than six months while the land remains submerged throughout the dry season (low rainfall) (Siaga et al., 2018; Karla et al., 2019; Lakitan, 2021). According to Hasbi et al. (2017), a projected floating farming system for the cultivation of vegetables was created based on the statements of farmers who are interested in using the newly introduced floating farming. Shallots are one of the many crops that may be grown in the floating system. Thus, the aim of this study was to determine the growth response and production of conventional and floating cultivation systems of shallot plants at various doses of cow manure fertilizer.

Commented [user6]: How is the soil characteristic in lebak swampland?
How is the current condition of shallot cultivation in South Sumatra's swampland?
Please explain the conventional cultivation system and the newly introduced floating system

MATERIALS AND METHODS

Research area

The research was located in the Experimental Field and Reservoir of the Faculty of Agriculture, Sriwijaya University, Indralaya Ogan Ilir (3° 13'30.3″S 104° 38'55.1"E) where the condition as seen in Figure 1, during dry season in tropical climate ecosystems of South Sumatra, Indonesia, from May to August 2022. Typical agroclimatic conditions at the outdoor research facilities are shown in Figure 2.

Figure 1. Conventional (A) and floating (B) farming practices of shallot cultivation

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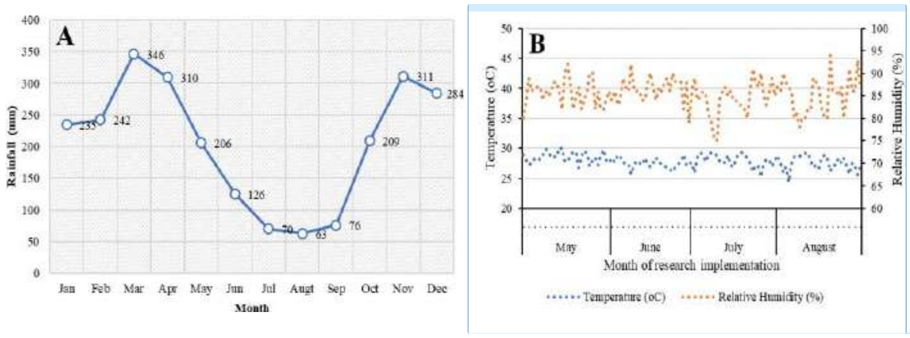

Figure 2. Typical agroclimatic conditions: Rainfall (A), Temperature and Relative Humidity (B) at the outdoor research facilities. Source: https://www.bmkg.go.id

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Procedures

The shallot bulbs used were of the Bima Brebes variety originated from the shallot seed farmers in Brebes, Central Java. The experiment was arranged using a factorial randomized block design with two factors and three replicates. The treatments consisted of farming practices (the conventional and floating systems) and dosages of cow manure (0, 10, 15, and 20 tons/ha).

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For all farming practice treatments, the planting media were prepared in the same method: after been completely mixed, it was placed into 35 cm x 30 cm polybags. The planting media were a mixture of alluvial topsoil combined with cow manure according to the treatments. In conventional farming technique, the area was prepared by clearing the weeds to make a space for placing the polybags filled with the media. In floating cultivation, the polybags were put on a 2 m x 1 m of bamboo raft. Each replicate was put in one bamboo raft. The planting media were sprayed with Bio Soil Grow Booster at a concentration of 4 ml/liter of water one week before planting. Inorganic fertilizers were also used with dosages of TSP (150 kg/ha), urea (100 kg/ha), and KCl (100 kg/ha). TSP fertilizer was applied 7 days before planting, whereas urea and KCl were applied twice, at 7 and 25 days after planting (DAP), each time in half the prescribed amount. Before being planted, bulbs were first cut off by a third of the top end and then placed into the planting hole at a depth of 2–3 cm.

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Data analysis

The variables were growth characteristics such leaf length, leaf number and leaf color as well as shallot production variables such as bulb number, bulb diameter, fresh weight, dry weight, and shrinkage percentage, as well as estimated production per hectare. The calculated F-value generated from the analysis of variance (ANOVA) was compared to values of F-table at $p \leq 0.05$ and $p \leq 0.01$ for justifying significant effects of the treatments. Furthermore, if the treatment effect was significant on any measured traits, the least significant difference (LSD) test was conducted for determining significant differences among treatment levels on each of specified traits.

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RESULTS AND DISCUSSION

Leaf length (cm) and leaf number of Shallots

Shallot plants grown in tropical climate ecosystems with two farming practices as in conventional (Figure 1A) and floating (Figure 1B) systems at various doses of cow manure showed differences in growth and yield. Rainfall continued to decline from May to August 2022, when the study was conducted. Rainfall reduced from 206 mm in May to 63 mm in August (Figure 2A). High rainfall levels at the start of the study provided a favorable environment for shallot growth in conventional cultivation system (polybags stacked on dry soil). On the other hand, shallots grown in wetlands using floating system (polybags placed on rafts) did not favor heavy rainfall. From May to August 2022, the temperature and humidity remained relatively stable. The range of the temperature and humidity was 27.47–27.92 ºC and 84.51–86.36 %, respectively (Figure 2B).

The variance analysis revealed that the variations in farming practices had a significant impact. The results of the least significant difference (LSD) test on leaf length parameter demonstrated that two farming practices differed significantly. In conventional cultivation, the maximum leaf length was 40.43±1.25 cm at 5 weeks after planting (WAP), whereas in floating system, it was only 30.47±0.47 cm at 4 WAP. In floating agriculture system, water is continuously supplied via the soil pores by capillary force, causing slower oxygen diffusion. Additionally, when it rains heavily, the media becomes more water-saturated, which lowers the amount of accessible oxygen. Oxygen is needed by the roots for respiration and for maintaining healthy cell function (Neira et al., 2015; Ernest, 2018; Jaya et al., 2021; Kartika et al., 2021). The damage on root will eventually affect the upper plant parts growth as seen from the agronomical features. Research by Susilawati et al. (2012) on red pepper plants showed that all cultivars experienced varying degrees of root damage as a result of flooding stress. The amount of oxygen that is present in the growing media is significantly influenced by the height of the water table. Research on bean plants had shown that the roots, particularly the process of root respiration, were significantly impacted by water levels that were 10 cm below the planting media surface. Although organic fertilizer applied to red chilies in a floating system had not affected growth, proper water level and the application of organic matter to shallot plants considerably stimulated growth (Susilawati et al., 2019a; Susilawati et al., 2019b; Susilawati et al., 2022). On leaf length parameter, the application of cow manure showed insignificant result in the first week and significant in the second to eighth weeks. The longest leaves were obtained at a dose of 20 tons per hectare (P_3 treatment) with 40.19±2.96 cm, not significantly different from a dose of 15 tons per hectare (P_2) of 40.06±1.69 cm. The combination of farming practices and cow manure treatments had a significant effect on leaf length only in 6 and 8 WAP in the conventional P_3 treatment with 44.74±1.10 cm and 44.92±1.36 cm, respectively.

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On the leaf number parameter, the difference in farming practices only had a significant effect in the first to third weeks. The average number of leaves was mostly higher in the conventional system, except in the fourth week when the leaf number in the floating system was higher at 24.33 ± 1.92 compared to 23.39 ± 1.33 in the conventional system. The research on eggplant showed that increasing the water content of the substrate from 1 to 3 cm would increase the growth of vegetative organs (Jaya et al., 2019). The difference in cow manure doses affected the number of leaves, where the highest leaf number was obtained in P_2 treatment with 31.78 ± 2.65 in 7 WAP (Table 1). Similarly, research by Feriatin et al. (2021) also showed that the use of cow manure would affect leaf number of the Lokananta shallot variety. The P_3 treatment for conventional cultivation and the P_2 treatment for floating cultivation produced the highest average of leaf length and leaf number when cow manure was applied. In the conventional P_3 treatment, the maximum leaf length was 37.45 cm with a 21.33 average leaf number, while in the floating P_2 treatment, the highest leaf length was 29.80 cm with 23.14 leaves. Cow manure is an organic fertilizer that can alter the structure and texture of the soil, making the media crumblier, which explains the difference in the dosage of cow manure between the two cultivation systems (Figure 3). Meanwhile, as a result of the relatively high moisture of the planting media in floating culture, cow manure already affects the texture and structure of the media at lower doses (Gudugi, 2013; Elisabeth et al., 2013; Ekwealor et al., 2020; Wisdom et al., 2021).

Table 1. Leaf length (cm) and leaf number of shallot with the application of cow manure (ton/ha) on different farming practices

Treatment	Week after planting (WAP)							
	1	2	3	4	5	6	7	8

Farming practices								
Leaf length (cm)								
Conventional	11.67 ± 0.66 a	26.60 ± 0.79 a	36.43 ± 1.03 a	40.32 ± 1.45 a	40.43 ± 1.69 a	38.39 ± 1.71 a	38.39 ± 1.66 a	36.09 ± 1.95 a
Floating	8.28 ± 0.32 b	20.04 ± 0.56 b	27.58 ± 1.09 b	30.47 ± 1.43 b	29.45 ± 1.90 b	26.66 ± 2.08 b	25.66 ± 1.82 b	24.88 ± 1.76 b
Significance	**	**	**	**	**	**	**	**
LSD0.05	1.516	1.375	2.209	1.961	1.992	2.208	2.536	4.549
Leaf number								
Conventional	7.83 ± 0.39 a	12.38 ± 0.43 a	17.78 ± 0.69 a	22.13 ± 0.93	23.39 ± 1.33	25.69 ± 1.50	26.00 ± 1.43	23.64 ± 1.21
Floating	5.88 ± 0.21 b	10.38 ± 0.47 b	15.66 ± 0.61 b	20.94 ± 1.25	24.33 ± 1.92	25.25 ± 2.15	23.61 ± 2.06	20.03 ± 1.91
Significance	**	**	*	ns	ns	ns	ns	ns
LSD0.05	0.777	1.303	1.548	2.479	2.929	3.831	4.679	4.567
Cow manure (ton/ha)								
Leaf length (cm)								
P_0 (0)	9.31 ± 0.90	21.37 ± 1.74 b	27.53 ± 2.37 b	29.07 ± 2.54 b	26.80 ± 2.99 c	24.83 ± 3.09 c	25.61 ± 3.07 c	25.24 ± 2.96 b
P_1 (10)	10.19 ± 1.23	22.09 ± 1.24 b	30.71 ± 1.86 a	33.59 ± 2.21 b	32.72 ± 2.64 b	29.26 ± 3.12 b	29.86 ± 3.00 b	30.29 ± 2.58 b
P_2 (15)	9.54 ± 0.87	25.30 ± 1.58 a	35.52 ± 1.81 a	39.69 ± 1.74 a	40.06 ± 1.69 a	38.93 ± 1.33 a	37.84 ± 1.34 a	37.16 ± 1.80 a
P_3 (20)	10.86 ± 1.12	24.52 ± 1.89 a	34.26 ± 2.31 a	39.23 ± 2.82 a	40.19 ± 2.96 a	37.10 ± 3.46 a	34.76 ± 4.63 a	29.27 ± 4.69 b
Significance	ns	**	**	**	**	**	**	*
LSD0.05	2.144	1.945	2.189	2.773	2.817	3.122	3.587	6.434
Leaf number								
P_0 (0)	6.00 ± 0.40 b	10.33 ± 0.31	14.33 ± 0.41 b	17.55 ± 0.62 b	17.72 ± 0.88 c	19.50 ± 1.64 c	20.50 ± 2.11 b	19.39 ± 2.28
P_1 (10)	6.94 ± 0.59 ab	11.33 ± 1.06	16.78 ± 1.11 a	20.39 ± 1.12 b	22.50 ± 1.32 b	25.99 ± 1.47 b	26.28 ± 2.09 ab	23.11 ± 2.04
P_2 (15)	6.72 ± 0.58 ab	11.39 ± 0.76	17.22 ± 0.99 a	24.00 ± 1.59 a	29.05 ± 2.38 a	31.78 ± 2.65 a	29.67 ± 2.39 b	25.94 ± 1.88
P_3 (20)	7.78 ± 0.68 a	12.50 ± 0.55	18.55 ± 0.59 a	24.22 ± 0.80 a	26.16 ± 1.32 ab	24.61 ± 1.78 bc	22.78 ± 2.14 b	18.89 ± 2.36
Significance	*	ns	**	**	**	**	*	ns
LSD0.05	1.099	1.842	2.189	3.506	4.144	5.418	6.618	6.459

Note: Data represent mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05

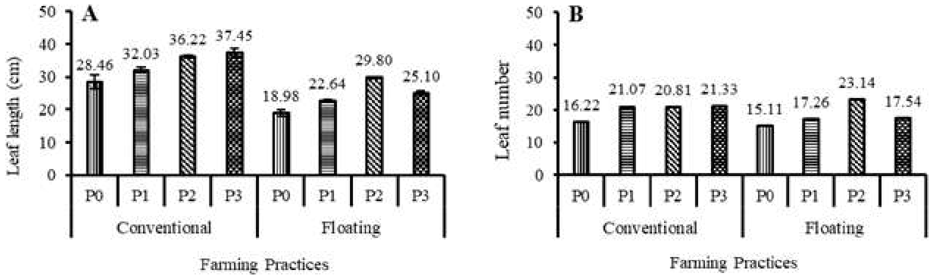

Figure 3. The application of cow manure on the parameters of leaf length (A) and leaf number (B) in different farming practices

SPAD value

In this study, the parameter of leaf greenness—which serves as an indicator for chlorophyll content—was quantified using the SPAD tool without damaging the leaves measured from the second to the eighth week. In the fourth and sixth weeks, the culture technique treatment significantly affected the SPAD value, while had no significant effect in 2 and 8 WAP. Shallots cultivated in floating system was recorded to have higher values in 2, 4 and 6 WAP with 77.69±2.69, 64.10±4.41, and 48.18±1.25, respectively, as compared to that in conventional system with 74.68±3.08, 48.18±1.25, and 48.79±1.43. However, in the eighth week, SPAD value in conventional system was higher than in floating system with 44.78±1.33 and 43.22±4.48, respectively. The SPAD values of the two cultivation techniques was at the highest at 2 WAP, and then continued to decrease until 8 WAP. In comparison to other models, the polynomial model's regression analysis of the SPAD value in the shallot cultivation resulted in the largest determination coefficient (R^2) that is close to 1, with 0.9123 for the conventional system and 0.9618 for the floating system. The magnitude of the R^2 value indicates that the SPAD value is affected by the cultivation technique in a quadratic manner, increasing until it reaches the peak before starting to decline (Table 3). A study on corn resulted in a similar result, where the SPAD values would decrease after reaching their peak which mostly affected by the environment (Ghozali, 2016; Kandel, 2020; Szulc et al., 2021).

This study also found that the increase in cow manure dosage would also increase the SPAD value where the highest SPAD value was obtained in the P_3 treatment at 82.54 and the lowest in the P_0 treatment at 31.21. The SPAD value has been widely used to estimate the chlorophyll content of other crops, such as tomatoes (Jiang et al., 2017). Furthermore, the application of cow manure could also increase leaf chlorophyll, as indicated by the SPAD value in wheat and rice plants (Shah et al., 2017; Atman et al., 2018). The combination of cultivation techniques and cow manure treatments resulted in no significant effect in 2 and 8 WAP, a significant effect in 4 WAP, and a highly significant effect in 6 WAP. The highest SPAD value was obtained in floating cultivation and cow manure at a dose of 20 tons/ha at 77.01±5.35 in 4 WAP and 75.11±3.96 in 6 WAP (Table 2).

Table 2. SPAD value of shallot on different farming practices with the application of cow manure

Treatment	Weeks after planting (WAP)			
	2	4	6	8
Farming practices				
Conventional	74.68 ± 3.08	48.18 ± 1.25 b	48.79 ± 1.43 b	44.78 ± 1.33
Floating	77.69 ± 2.88	64.10 ± 4.41 a	59.78 ± 4.55 a	43.22 ± 4.48
Significance	ns	**	**	ns
LSD value	7.996	6.040	4.381	4.615
Cow manure (ton/ha)				
P_0 (0)	68.16 ± 2.38	45.31 ± 2.88 c	40.90 ± 2.71 c	31.21 ± 4.08 c
P_1 (10)	75.74 ± 5.19	58.48 ± 5.77 ab	56.21 ± 4.35 b	44.61 ± 2.93 b
P_2 (15)	78.27 ± 4.09	55.78 ± 4.94 b	55.98 ± 3.73 b	46.60 ± 2.09 b
P_3 (20)	82.54 ± 2.98	65.00 ± 6.08 a	64.04 ± 5.28 a	53.60 ± 3.80 a
Significance	ns	**	**	**
LSD value	11.307	8.542	6.197	6.527
Farming practices x cow manure (ton/ha)				
Conventional xP_0	68.47 ± 5.10	46.81 ± 1.43 b	43.29 ± 3.72 ef	39.69 ± 3.16 c
Conventional xP_1	74.13 ± 10.00	46.93 ± 1.68 b	48.02 ± 1.74 de	43.42 ± 10.00 bc
Conventional xP_2	74.01 ± 4.26	46.00 ± 1.36 b	50.87 ± 0.68 bc	46.57 ± 4.26 bc
Conventional xP_3	82.13 ± 4.21	52.99 ± 3.47 b	52.98 ± 1.17 cd	49.46 ± 4.21 ab
Floating x P_0	67.86 ± 1.46	43.81 ± 6.11 b	38.52 ± 4.15 f	22.73 ± 1.46 d
Floating x P_1	77.37 ± 5.68	70.03 ± 5.53 a	64.41 ± 4.95 b	45.81 ± 5.68 bc
Floating x P_2	82.54 ± 6.90	65.56 ± 4.94 a	61.10 ± 6.57 bc	46.63 ± 6.90 bc
Floating x P_3	82.97 ± 5.15	77.01 ± 5.35 a	75.11 ± 3.96 a	57.73 ± 5.15 a
Significance	ns	*	**	ns
LSD value	15.991	12.081	8.763	9.231

Note: Data represent mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05

Commented [user16]: It shows that the cow manure application in floating system resulted in a significantly higher SPAD compared to conventional. Please discuss, why?

Table 3. Regression analysis correlations of SPAD value with several mathematical models of farming practices on several doses of cow manure

Farming practices	Linear model, y = ax+b	Logarithmic model, y = a ln x+b	Polynomial model, y=ax2+bx+c	Power model, $y = ax^b$
Conventional	y=-8.9073x+76.38	y=-21.1ln(x)+70.877	y=5.6238x2-37.026x+104.5	$y=70.35x^{0.357}$
	R^2 =0.6917	R^2 =0.8417	R^2=0.9123	R^2 = 0.8842
	r = 0.8316**	r = 0.9174**	r = 0.9551**	r =0.9432**
Floating	y=-10.769x+88.122	y=-22.56ln(x)+79.122	$y=-0.7451x^2-7.0429x+84.39$	$y=80.712x^{0.375}$
	R^2 = 0.9581	R^2 = 0,9116	R^2 =0.9618	R^2 =0.8804
	r = 0.9788**	r = 0.9547**	r = 0.9807**	r = 0.9383**

Note: ** means significant difference p < 0.05

Bulb number, bulb diameter (mm), weight of fresh and air-dried bulb (g)

The yield components include the number of bulbs, bulbs diameter, and weight for both fresh and air-dried bulbs. The farming practices treatment had no significant impact on the quantity of bulbs but had a very significant impact on the weight of fresh bulb, bulb diameter, and weight of air-dried bulb. The conventional method produced the greatest number of bulbs, whereas floating cultivation resulted the best results in terms bulb diameter and weight of fresh and air-dried bulbs. The growing media conditions strongly affected how bulbs were initially formed. Since water was constantly accessible from beneath the growing media through capillaries, floating cultivation used growing media that were somewhat moist. There was also intense rainfall during early growth of shallot causing the planting media to be very wet. There were about 7.78±0.35 bulbs formed in conventional cultivation and 7.75±0.33 in floating cultivation. The number of bulbs was somehow not linearly correlated with the greater dose of cow manure applied as the largest number of bulbs was obtained at a dose of 15 tons/ha (Table 4). The largest number of bulbs (8.33 in conventional cultivation and 8.22 in floating cultivation) were obtained from the same manure treatment, which was P_2. The lowest data, 6.78 bulbs in conventional cultivation and 6.67 bulbs in floating cultivation, were also obtained at the same manure treatment, P_0 (Figure 5A). Plant growth can be supported by appropriate cultivation methods (Cahyaningrum et al., 2023; Khorasgani and Pessarakli, 2019).

Table 4. Shallot yield components on different farming practices with the application of cow manure

Treatment	Number of bulb	Diameter of bulb (cm)	Fresh weight of bulb (g)	Air-dried weight of bulb (g)
		Farming practices		
Conventional	7.78 ± 0.35	20.62 ± 1.76 b	35.36 ± 6.14 b	26.79 ± 5.64 b
Floating	7.75 ± 0.33	23.51 ± 1.29 a	42.33 ± 3.52 a	35.69 ± 2.94 a
Significance	ns	**	*	**
LSD value	1.016	1.741	6.419	4.703
		Cow manure		
P_0 (0)	7.44 ± 0,45	15.44 ± 0.77 c	20.57 ± 2.85 c	14.71 ± 2.12 d
P_1 (10)	7.44 ± 0.50	19.88 ± 0.84 b	34.46 ± 2.36 b	25.64 ± 1.49 c
P_2 (15)	8.28 ± 0.53	27.10 ± 1.74 a	58.24 ± 7.76 a	48.22 ± 7.75 a
P_3 (20)	7.89 ± 0.44	25.84 ± 0.81 a	42.11 ± 2.94 b	36.39 ± 1.84 b
Significance	ns	**	**	**
LSD value	1.437	2.461	9.078	6.651
		Farming practices x cow manure		
Conventional xP_0	6.78 ± 0.72	15.22 ± 1.40 e	19.58 ± 4.90 e	13.15 ± 3.18 f
Conventional xP_1	8.22 ± 0.58	18.49 ± 0.98 de	33.01 ± 3.72 cd	24.57 ± 1.99 de
Conventional xP_2	8.33 ± 0.76	23.43 ± 0.81 bc	42.08 ± 1.87 bc	31.61 ± 0.73 bcd
Conventional xP_3	7.78 ± 0.44	25.36 ± 1.03 b	46.77 ± 4.21 b	37.84 ± 0.89 b
Floating x P_0	8.11 ± 0.22	15.66 ± 0.99 e	21.57 ± 3.95 de	16.28 ± 3.15 ef
Floating x P_1	6.67 ± 0.57	21.28 ± 0.80 cd	35.92 ± 3.45 bc	26.71 ± 2.44 cd
Floating x P_2	8.22 ± 0.90	30.77 ± 1.02 a	74.40 ± 6.05 a	64.82 ± 4.92 a
Floating x P_3	8.00 ± 0.88	26.32 ± 1.40 b	37.45 ± 1.96 b	34.96 ± 2.56 b
Significance	ns	*	**	**
LSD value	2.032	3.481	12.838	9.406

Note: Data represent mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05

Commented [user17]: Did the plants in conventional methods supplied with sufficient water?

The average diameter of bulbs grown using floating cultivation was 23.51±1.29 mm, which was much larger than the 20.62±1.62 mm average diameter of bulbs grown using conventional cultivation (Figure 4). The largest diameter of bulbs produced as a result of the usage of cow manure was at a dose of 15 tons/ha, and the lowest was at a dose of 0 tons/ha (Table 4). Based on the combination of treatments, the P_2 treatment (15 tons/ha) in floating cultivation produced the largest bulb diameter of 30.78 mm, whereas the P_3 treatment (20 tons/ha) in conventional cultivation produced the largest bulb diameter of 25.36 mm. The two cultivation methods produced the smallest bulb diameters in the same treatment, P_0 (0 ton/ha), with conventional system producing 15.22 mm and floating system producing 15.66 mm (Figure 5B). The high bulb diameter in the floating culture was greatly supported by the conditions of the growing media, where during growth stages, the rainfall continued to decline so that the media in floating culture was not saturated with water and oxygen was still available. Nutrients absorption, water uptake, and root respiration are all affected by oxygen availability, which is a crucial component for plant growth. The use of biological fertilizers or a combination of biological fertilizers and organic fertilizers can increase onion bulb diameter compared to controls ((Xiong et al., 2015; Neira et al., 2015; Widyastuti et al., 2021; Purba et al, 2020).

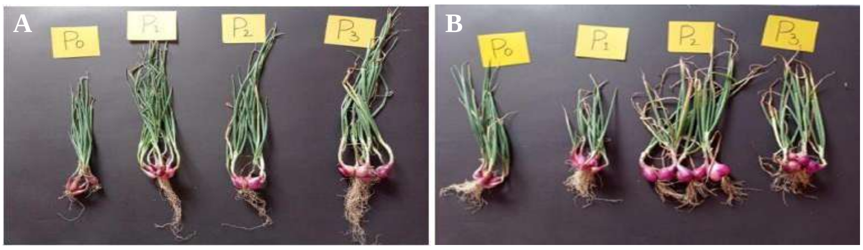

Figure 4. Shallot bulbs produced by conventional (A) and floating (B) systems with the application of cow manure

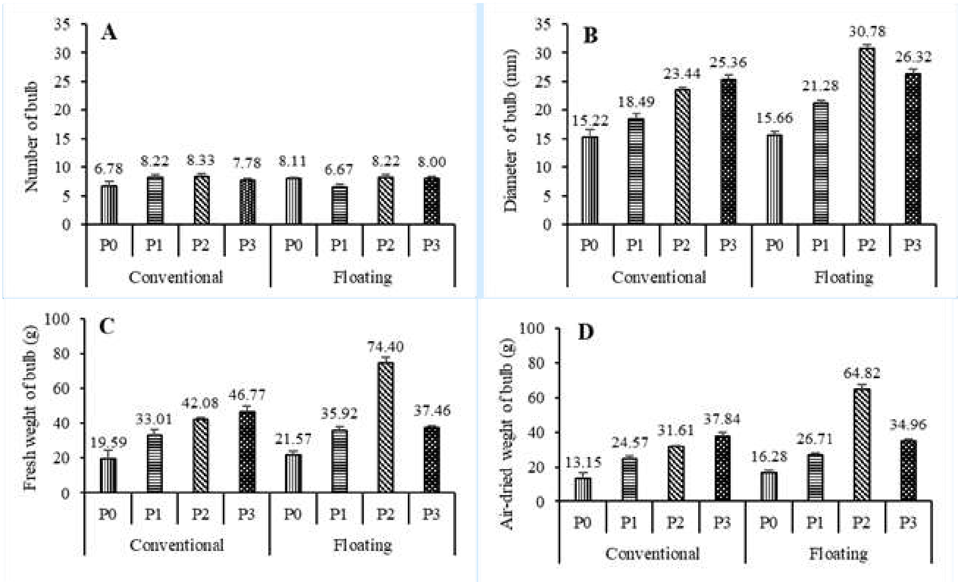

Figure 5. The application of cow manure on the parameters of bulb number (A), bulb diameter (B), fresh weight of bulb (C) and air-dried weight of bulb in different farming practices

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Shallot production is highly dependent on the weight of fresh and air-dried bulbs. Floating cultivation system yielded the greatest average data, which was significantly different from conventional cultivation (42.33±3.52 g vs. 35.69±2.94 g) (Table 4). According to Jaya et al. (2019), the availability of water below plant media in floating system significantly promotes plant growth and yield. Based on the results (Figures 5C and 5D), conventional farming required a higher dosage of cow manure (20 tons/ha) compared to floating farming, which required only 15 tons/ha. In terms of cost and bulb production, Paputri et al. (2016) found that a cow manure dose of 20 tons/ha was economically feasible. However, Arzad et al. (2017) found that mustard plants needed up to 25 tons/ha of cow manure application.

The estimated production per hectare were then calculated using data on air-dried bulb weight under the assumption of a planting space of 20 cm x 15 cm. The highest estimated production was obtained in the floating system from P_2 treatment with 21.61 tons/ha, while in conventional system was from P_3 treatment with 12.61 tons/ha. The P_0 treatment had the lowest estimated yield, at 4.38 tons per hectare and 5.43 tons per hectare in the conventional and floating cultivation systems, respectively (Figure 6).

Based on the results, it was concluded that Bima Brebes shallot variety has potency to be cultivated using floating technique with the application of 15 ton per ha cow manure as seen from production estimation reaching 21.61 tons of dry bulb higher than variety description issued by Agricultural Ministry with 9.9 tons/ha of dry bulb.

Commented [user19]: This study resulted in an outstanding yield. Please repeat the study in a different location and suggest the farmers to cultivate shallot following procedure in floating system.

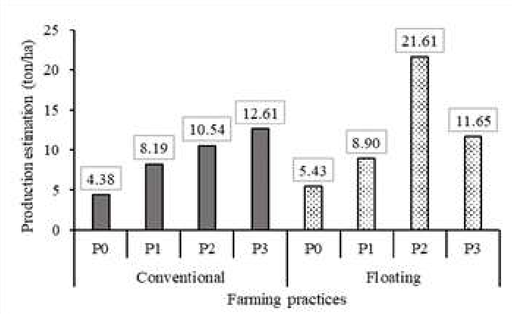

Figure 6. The estimated production of shallot from different farming practices with the application of cow manure

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to our research team and colleagues at Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya for their helpful feedback and valuable support to our research.

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kepada Stefania

22 Okt 2023, 23.10

Dear editor of Advances in Horticultural Science,

Thank you very much for giving us the opportunity to submit a revised manuscript entitled "Shallot cultivation in tropical climate ecosystems using floating and non-floating systems with different doses of cow manure" for publication in the Advances in Horticultural Science Journal. We really appreciate the time and effort that the editor and the reviewers have dedicated to our manuscript and are grateful for the feedback and valuable improvements to our manuscript. We have taken into account the suggestions made by the reviewers as highlighted within the manuscript.

By this email we are sending our revised manuscript along with the cover letter and proofread certificate as requested. We also have uploaded the required files on the journal website.

Thank you very much.

We are looking forward to hearing from you soon.

Best regards,

Susilawati

...

Manuscript B-AHS_14940

Dear Dr. Stefania Nin,

Thank you very much for giving us the opportunity to submit a revised manuscript entitled "Shallot cultivation in tropical climate ecosystems using floating and non-floating systems with different doses of cow manure" for publication in the Advances of Horticultural Science Journal. We really appreciate the time and effort that the editor and the reviewers have dedicated on our manuscript and are grateful for the feedback and valuable improvements to our manuscript. We have taken into account the suggestions made by the reviewers as highlighted within the manuscript. Please see below, in blue, for a point-by-point response to the editor's and reviewers' comments and concerns. All the changes are indicated with the yellow highlight in the revised manuscript.

Comments from Editor:

- Many suggestions are included in the attached file.

  Author response: Thank you very much for the suggestion, we have revised the manuscript following the suggestions given.

- Extensive editing of English language and style required.

  Author response: We have revised the manuscript as we refer to professional English editing service. We have also revised the manuscript following the guideline of the Advances in Horticultural Science Journal.

- The Author must refer to a professional manuscript editing service or to native English speaker for improving the English in the manuscript, otherwise the article cannot be absolutely taken into consideration.

  Author response: We have revised the manuscript, referring to the professional manuscript editing service, with a proof of certificate attached.

- The introduction has to be rewritten because it does not take the readers to the problem (did not tell a history) and does not take the reader to the hypothesis.

  Author response: The introduction has been rewritten to give a better understanding of the problem and solution that we proposed.

- Regarding the methodology, some information is required.

  Author response: Some information required has been added to the methodology.

- Results and discussion must be improved.

  Author response: Some information has been added to improve the results and discussion.

Comments from Reviewer:

- There are many grammatical errors and unsuitable terms used. Please recheck the whole text and use academic writing English

  Author response: The title has been revised and has been proofread to avoid grammatical errors and use the suitable terms. (Page 1 Line 1)

- Please rewrite the introduction and consider the flow

  Author response: The introduction has been rewritten to give a better understanding of the problem and solution that we proposed.

- Do you mean altitude?

  Author response: The term has been deleted since we revised the introduction.

- What do you refer?

  Author response: The term has been deleted since we revised the introduction.

- Produced?

  Author response: The term has been deleted since we revised the introduction.

- How is the soil characteristic in lebak swampland?

  Author response: The soil in lebak swampland is alluvial soil type, and the information has been added in the manuscript. (Page 2 Line 4)

- How is the current condition of shallot cultivation in South Sumatra's swampland?

  Author response: Swampland in South Sumatra is mostly used for rice cultivation, while vegetable crops, including shallot is still rare to cultivate considering the water availability during dry season in swampland. This situation has been described in Line 8-10 in Page 2.

- Please explain the conventional cultivation system and the newly introduced floating system!

  Author response: The conventional cultivation system that we indicated in the study is typical cultivation without using a floating system. This type of cultivation in swampland can only performed during dry season when the land is not flooded. However, limited water availability during dry season will also affect plant growth. Thus, we proposed to use floating system to utilize the swampland during high flooding period. This situation has been described in Line 11-15 Page 2.

- Is it common in Indonesia for farmers to use plastic bag for shallot cultivation?

  Author response: Yes, it is common in Indonesia to use plastic or polystyrene bags for plant cultivation, including shallot.

- Did you observe the actual humidity in the research location? Is it valid? Is not it very low, especially in deep swampland ecosystem?

  Author response: The agroclimatic data were obtained from a climatology station near the research location. The humidity is not that low. From Figure 2, the humidity value was presented in the second y axis with a range of 75% to 95% and an average humidity of around 85%. (Page 4 Line 3)

- How was the watering application?

  Author response: The information about watering application has been added in Page 5 Line 2-5.

- Is it obtained from the inland wetland?

  Author response: Yes, it is. Information has been added in Page 4 Line 14.

- How long is the space?

  Author response: The planting space was 20 cm x 20 cm. The information has been added in Page 4 Line 16.

- Please convert to nutrient content

  Author response: The dosages have been converted into nutrient content (Page 4 Line 20-21).

- Please make a brief explanation regarding the observation methods of each variable, including the specification of instrument used

  Author response: Information has been added (Page 5 Line 10-13).

- Is there any software used for statistical analysis?

  Author response: R studio statistical analysis software was used. (Page 5 Line 13)

- Can you adjust the position of plants?

  Author response: Yes, the position of plants can be adjusted. The information has been added in Page 6 Line 7-9.

- It shows that the cow manure application in floating system resulted in a significantly higher SPAD compared to conventional. Please discuss, why?

  Author response: The information regarding the result of SPAD value has been added in Page 9 Line 14-22 and Page 10 Line 1-6.

- Did the plants in conventional methods supplied with sufficient water?

  Author response: Yes, the shallot plants in conventional non-floating method was watered regularly so it was assumed that the plants had sufficient water supply.

- It was available in Table 4. Just delete this

  Author response: Table 4 has been deleted.

- This study resulted in an outstanding yield. Please repeat the study in a different location and suggest the farmers to cultivate shallot following procedure in floating system.

  Author response: Thank you very much. Now we are still doing similar researches to obtain more data about shallow cultivation using floating system. By the end of our project, we would like to make a procedure recommendation for shallot floating farming system. (Page 13 Line 22-24)

Shallot cultivation in tropical climate ecosystems using floating and non-floating systems with different doses of cow manure

Keywords: cow manure; floating; non-floating; shallots.

Abstract: Deep swamp is swampland with the longest flooding period, making it challenging for crop cultivation. However, by adopting a floating system, this prolonged duration of flooding can be used for shallot growing. Thus, this study aimed to ascertain the growth and yield of shallots cultivated in polybags using conventional non-floating and floating systems with the application of different doses of cow manure. The research was located in the experimental field and reservoir of the Faculty of Agriculture, Sriwijaya University (3°13'30.3"S; 104°38'55.1"E). Non-floating and floating farming systems were utilized with the application of 0, 10, 15 and 20 ton/ha of cow manure. The findings demonstrated that shallots cultivated in the floating system had lower numbers and length of leaf but could produce more bulbs in comparison to the conventional method. The application of 15 ton/ha manure in the floating system resulted in higher weights of fresh and air-dried bulbs per plant, weighing 74.40 g and 64.82 g, respectively, compared to those in the non-floating system (46.77 g and 37.84 g, respectively). In conclusion, the Bima Brebes shallot variety potentially can be cultivated in a floating system with the application of 15 tons of cow manure per hectare.

INTRODUCTION

As one of the strategic commodities widely consumed in Indonesia, shallot (*Allium ascalonicum* L.) is a vegetable crop that significantly contributes to the country's horticultural production and inflation rate. According to the findings of the Socio-Economic Survey in September 2021, Indonesians consume an average of 2.49 kg of shallots per person each month. Shallots are required for the food sector, where they are processed into ready-to-use seasonings for sprinkling on food dishes, as well as for usage in households as a seasoning for cooking (Ministry of Agriculture, 2019; Irjayanti, 2022).

The amount of shallots needed for household consumption and the food industry continues to increase. The government's involvement in meeting these needs is through a program to organize and grow shallot production centers outside Java Island so that production centers are not just concentrated on Java. This program aims to realize shallot self-sufficiency in every province in Indonesia (Ministry of Agriculture, 2019; Indriyana et al., 2020). South Sumatra is one of the provinces targeted by this program; this is because shallot production in South Sumatra is still low at only 0.057% of national production or 1125 tons in 2021 (Central Bureau of Statistics for South Sumatra Province, 2022; Directorate of Statistical Dissemination, 2022). Even though South Sumatra is a lowland region that is suitable for growing shallots, there are still several challenges that may affect the shallot growth. One of these is the land's condition as swampland, particularly *lebak* swampland.

Lebak swampland, with its alluvial soil type, has considerable potential to increase the production of food and horticultural crops. However, the use of *lebak* for crop cultivation is faced with high-water fluctuations that cause flooding in the rainy season and drought in the dry season. The typology of *lebak* swampland based on the height and duration of standing water is divided into shallow, middle and deep swamp. Once or twice a year, rice can be grown in the shallow and middle swamps. During the dry season, horticultural crops, particularly vegetable crops, can also be grown, although there is a risk from drought (Djafar, 2013; Suprapto, 2016; Suryana, 2016; Widuri et al., 2016; Pujiharti, 2017; Simatupang & Rina, 2019). Deep swamp is an inland swamp area with stagnant water for more than six months and even during the dry season it remains stagnant. As a result, cultivating plants becomes quite challenging. The deep swamp is mostly left unutilized during the high flooding period. Utilizing a floating cultivation technique is one option for making use of this area (Siaga et al., 2018; Jaya et al., 2019; Lakitan et al., 2021, Susilawati et al., 2022). According to Hasbi et al. (2017), a projected floating farming system for the cultivation of vegetables was created based on the statements of farmers who are interested in using the newly introduced floating farming. Shallots are one of the many crops that may be grown in the floating system.

One of the factors that affect the growth of shallots is the planting medium used. The texture and structure of the soil have significant impact on the production and quality of shallots. Applying organic fertilizer will create the fertile, loose soil that shallots need for the development of their bulbs. One of the components that can increase the physical, chemical and biological qualities of the soil to boost the productivity of shallot plants while reducing the amount of phosphorus (P) fertilizers added to P-deficient soils is organic fertilizer (Noviyanty & Salingkat, 2018; Susikawati et al., 2018; Nguyen et al., 2021). One organic fertilizer that can promote plant development is cow manure (Sudarsono et al., 2014; Atman et al., 2018; Musdalifah et al., 2021). Thus, this research was conducted with the aim of evaluating the growth response and production of shallot plants cultivated in polybags using non-floating and floating systems with the application of various doses of cow manure fertilizer.

MATERIALS AND METHODS

Research area

The research was located in the experimental field and reservoir of the Faculty of Agriculture, Sriwijaya University, Indralaya Ogan Ilir (3°13'30.3′′S; 104°38'55.1"E). Figure 1 shows the arrangement during the dry season in tropical climate ecosystems of South Sumatra, Indonesia, from May to August 2022. Typical agroclimatic conditions at the outdoor research facilities are shown in Figure 2.

Figure 1. Non-floating (A) and floating (B) farming practices of shallot cultivation.

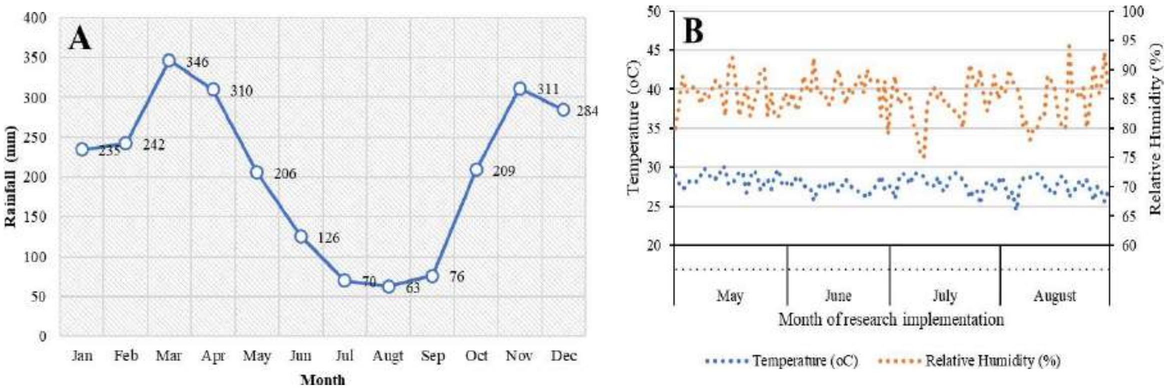

Figure 2. Typical agroclimatic conditions at the outdoor research facilities: (A) rainfall; (B) temperature and relative humidity. Source: https://www.bmkg.go.id.

Procedures

The shallot bulbs used were of the Bima Brebes variety originated from the shallot seed farmers in Brebes, Central Java. The experiment was arranged using a factorial randomized block design with two factors and three replicates. The treatments consisted of different farming practices (conventional non-floating and floating systems) and dosages of cow manure (0, 10, 15 and 20 ton/ha).

For all farming practice treatments, the planting media were prepared using the same method: after being completely mixed, they was placed into 35 cm x 30 cm polybags. The planting media were a mixture of alluvial topsoil gathered from *lebak* swamp combined with cow manure according to the treatments. In the conventional farming technique, the area was prepared by clearing the weeds to make a space for placing the polybags filled with the media. The planting space was 20 cm x 20 cm, following the recommendation for shallot cultivation. In the floating cultivation, the polybags were put on a 2 m x 1 m bamboo raft. Each replicate was put on one bamboo raft. The planting media were sprayed with Bio Soil Grow Booster at a concentration of 4 ml/L of water one week before planting. Inorganic fertilizers were also used, with dosages of 69 kg/ha of P_2O_5, 46 kg/ha of N and 60 kg/ha of K_2O. Phosphorus fertilizer was applied 7 days before planting, whereas nitrogen and potassium were applied twice, 7 and 25 days after planting, each time in half the prescribed amount.

Before being planted, the top one-third of the bulb was cut off and the bulb was placed into a planting hole at depth 2–3 cm. Shallot plants cultivated in the non-floating system were watered regularly to ensure sufficient water availability. In the floating system, the plants were not watered because water was continuously supplied through the soil pores by capillary force from the swamp water below.

Data analysis

The variables were growth characteristics such leaf length, leaf number and leaf color, shallot production variables such as bulb number, bulb diameter, fresh weight, dry weight and shrinkage percentage, as well as estimated production per hectare. Leaf color was measured using a chlorophyll meter (SPAD-502, Minolta) to estimate leaf greenness level correlated to the chlorophyll content (SPAD value). Growth parameters were observed every week, whereas the production data were gathered after the harvest. The collected data were analyzed using R Studio statistical analysis software. The calculated F-value generated from the analysis of variance (ANOVA) was compared to values at $p \leq 0.05$ and $p \leq 0.01$ for justifying the significant effects of the treatments. Furthermore, if the treatment effect was significant for any measured trait, the least significant difference (LSD) test was conducted to determine significant differences among treatment levels for each specified trait.

RESULTS AND DISCUSSION

Leaf length (cm) and leaf number of shallots

Shallot plants grown in tropical climate ecosystems using two farming practices – conventional non-floating (Figure 1A) and floating (Figure 1B) systems with various doses of cow manure – showed differences in growth and yield. Rainfall continued to decline from May to August 2022, the period when the study was conducted. The rainfall reduced from 206 mm in May to 63 mm in August (Figure 2A). High rainfall levels at the start of the study provided a favorable environment for shallot growth in the non-floating cultivation system (polybags stacked on dry soil). On the other hand, shallots grown in wetlands using the floating system (polybags placed on rafts) did not favor heavy rainfall. From May to August 2022, the temperature and humidity remained relatively stable at 27.47–27.92°C and 84.51–86.36%, respectively (Figure 2B).

ANOVA revealed that the variations in farming practices had a significant impact. The results of the LSD test on leaf length demonstrated that the two farming practices differed significantly. In conventional cultivation, the maximum leaf length was 40.43 ± 1.25 cm at 5 weeks after planting (WAP), whereas in the floating system it was only 30.47 ± 0.47 cm at 4 WAP. In the floating agriculture system, the position of the plants was adjusted so that they would always be waterlogged to a height of about 3 cm from the base. In that case, water was continuously supplied via the soil pores by capillary force, causing slower oxygen diffusion. Additionally, when it rains heavily, the media become more water-saturated, which lowers the amount of accessible oxygen. Oxygen is needed by the roots for respiration and for maintaining healthy cell function (Neira et al., 2015; Ernest, 2018; Jaya et al., 2021; Kartika et al., 2021). Damage to the root will eventually affect the upper plant growth, as seen from the agronomical features. Research by Susilawati et al. (2012) on red pepper plants showed that all cultivars experienced varying degrees of root damage as a result of flooding stress. The amount of oxygen present in the planting media is significantly influenced by the height of the water table. Research on bean plants has shown that the roots, particularly the process of root respiration, were significantly impacted by water levels that were 10 cm below the surface of the planting media. Although organic fertilizer applied to shallots in a floating system did not affect growth, a proper water level and the application of organic matter to shallot plants considerably stimulated growth (Susilawati & Lakitan, 2019; Susilawati et al., 2019, 2022). With regard to leaf length, the application of cow manure showed insignificant results in the first week but significant results at 2–8 WAP. The longest leaves (40.19 ± 2.96 cm) were obtained at a P_3 treatment dose of 20 ton/ha, which is not significantly different from the 40.06 ± 1.69 cm obtained at a P_2 dose of 15 ton/ha. The combination of farming practices and cow manure treatments had a significant effect on leaf length only at 6 and 8 WAP in the conventional P_3 treatment, with lengths of 44.74 ± 1.10 cm and 44.92 ± 1.36 cm, respectively.

For leaf number, the difference in farming practices only had a significant effect in the first three weeks. The average number of leaves was mostly higher in the conventional system, except in the fourth week when the leaf number in the floating system was higher at 24.33 ± 1.92 compared to 23.39 ± 1.33 in the conventional system. The research on eggplant showed that increasing the water content of the substrate from 1 to 3 cm would increase the growth of vegetative organs (Jaya et al., 2019). The difference in cow manure dose affected the number of leaves, with the highest leaf number of 31.78 ± 2.65 obtained in P_2 treatment at 7 WAP (Table 1).

Table 1. Leaf length (cm) and leaf number of shallot with the application of cow manure (ton/ha) in different farming practices

Treatment	Weeks after planting (WAP)							
	1	2	3	4	5	6	7	8
				Farming practice				
				Leaf length (cm)				
Conventional	11.67 ± 0.66 a	26.60 ± 0.79 a	36.43 ± 1.03 a	40.32 ± 1.45 a	40.43 ± 1.69 a	38.39 ± 1.71 a	38.39 ± 1.66 a	36.09 ± 1.95 a
Floating	8.28 ± 0.32 b	20.04 ± 0.56 b	27.58 ± 1.09 b	30.47 ± 1.43 b	29.45 ± 1.90 b	26.66 ± 2.08 b	25.66 ± 1.82 b	24.88 ± 1.76 b
Significance	**	**	**	**	**	**	**	**
LSD0.05	1.516	1.375	2.209	1.961	1.992	2.208	2.536	4.549
				Leaf number				
Conventional	7.83 ± 0.39 a	12.38 ± 0.43 a	17.78 ± 0.69 a	22.13 ± 0.93	23.39 ± 1.33	25.69 ± 1.50	26.00 ± 1.43	23.64 ± 1.21
Floating	5.88 ± 0.21 b	10.38 ± 0.47 b	15.66 ± 0.61 b	20.94 ± 1.25	24.33 ± 1.92	25.25 ± 2.15	23.61 ± 2.06	20.03 ± 1.91
Significance	**	**	*	ns	ns	ns	ns	ns
LSD0.05	0.777	1.303	1.548	2.479	2.929	3.831	4.679	4.567
				Cow manure (ton/ha)				
				Leaf length (cm)				
P_0 (0)	9.31 ± 0.90	21.37 ± 1.74 b	27.53 ± 2.37 b	29.07 ± 2.54 b	26.80 ± 2.99 c	24.83 ± 3.09 c	25.61 ± 3.07 c	25.24 ± 2.96 b
P_1 (10)	10.19 ± 1.23	22.09 ± 1.24 b	30.71 ± 1.86 a	33.59 ± 2.21 b	32.72 ± 2.64 b	29.26 ± 3.12 b	29.86 ± 3.00 b	30.29 ± 2.58 b
P_2 (15)	9.54 ± 0.87	25.30 ± 1.58 a	35.52 ± 1.81 a	39.69 ± 1.74 a	40.06 ± 1.69 a	38.93 ± 1.33 a	37.84 ± 1.34 a	37.16 ± 1.80 a
P_3 (20)	10.86 ± 1.12	24.52 ± 1.89 a	34.26 ± 2.31 a	39.23 ± 2.82 a	40.19 ± 2.96 a	37.10 ± 3.46 a	34.76 ± 4.63 a	29.27 ± 4.69 b
Significance	ns	**	**	**	**	**	**	*
LSD0.05	2.144	1.945	2.189	2.773	2.817	3.122	3.587	6.434
				Leaf number				
P_0 (0)	6.00 ± 0.40 b	10.33 ± 0.31	14.33 ± 0.41 b	17.55 ± 0.62 b	17.72 ± 0.88 c	19.50 ± 1.64 c	20.50 ± 2.11 b	19.39 ± 2.28
P_1 (10)	6.94 ± 0.59 ab	11.33 ± 1.06	16.78 ± 1.11 a	20.39 ± 1.12 b	22.50 ± 1.32 b	25.99 ± 1.47 b	26.28 ± 2.09 ab	23.11 ± 2.04
P_2 (15)	6.72 ± 0.58 ab	11.39 ± 0.76	17.22 ± 0.99 a	24.00 ± 1.59 a	29.05 ± 2.38 a	31.78 ± 2.65 a	29.67 ± 2.39 b	25.94 ± 1.88
P_3 (20)	7.78 ± 0.68 a	12.50 ± 0.55	18.55 ± 0.59 a	24.22 ± 0.80 a	26.16 ± 1.32 ab	24.61 ± 1.78 bc	22.78 ± 2.14 b	18.89 ± 2.36
Significance	*	ns	**	**	**	**	*	ns
LSD0.05	1.099	1.842	2.189	3.506	4.144	5.418	6.618	6.459

Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05.

Similarly, research by Feriatin et al. (2021) also showed that the use of cow manure would affect leaf number of the Lokananta shallot variety. The P_3 treatment for conventional cultivation and the P_2 treatment for floating cultivation produced the highest average leaf length and leaf number when cow manure was applied. In the conventional P_3 treatment, the maximum leaf length was 37.45 cm with an average of 21.33 leaves, while in the floating P_2 treatment the highest leaf length was 29.80 cm with 23.14 leaves. Cow manure is an organic fertilizer that can alter the structure and texture of the soil, making the media crumblier, which explains the difference in the dosage of cow manure between the two cultivation systems (Figure 3). Meanwhile, as a result of the relatively high moisture of the planting media in the floating culture, cow manure already affects the texture and structure of the media at lower doses (Elisabeth et al., 2013; Gudugi, 2013; Ekwealor et al., 2020; Wisdom et al., 2021).

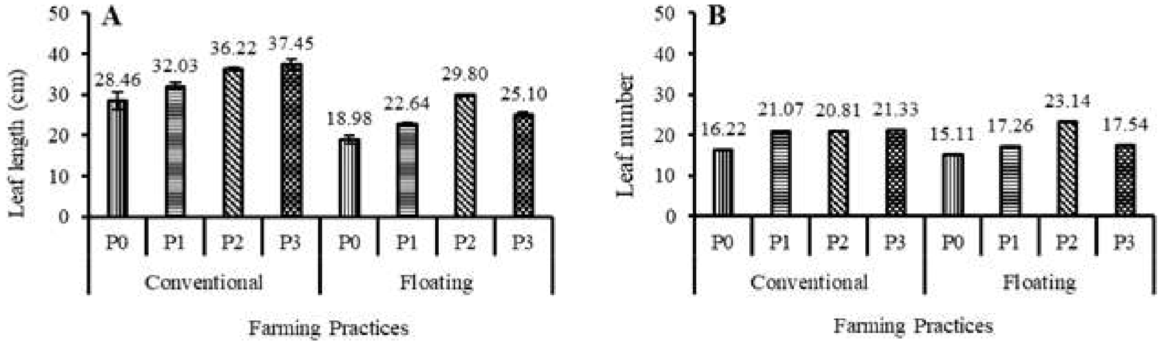

Figure 3. Effect of cow manure dosage on leaf length (A) and leaf number (B) in the different farming practices.

SPAD value

In this study, the parameter of leaf greenness – which serves as an indicator for chlorophyll content – was quantified using the SPAD tool without damaging the leaves measured from the second to the eighth week. At 4 and 6 WAP, the culture technique treatment significantly affected the SPAD value but had no significant effect at 2 and 8 WAP. Shallots cultivated in the floating system were recorded to have higher values at 2, 4 and 6 WAP (77.69 ± 2.69, 64.10 ± 4.41 and 48.18 ± 1.25, respectively) compared to those in the conventional system (74.68±3.08, 48.18±1.25 and 48.79±1.43). However, at 8 WAP, the SPAD value in the conventional system was higher than in the floating system (44.78±1.33 vs. 43.22±4.48). The SPAD value of the two cultivation techniques was at its highest at 2

WAP and then continued to decrease until 8 WAP. In comparison to other models, the polynomial model's regression analysis of the SPAD value in the shallot cultivation resulted in the largest determination coefficient (R^2), which is close to 1: 0.9123 for the conventional system and 0.9618 for the floating system. The magnitude of the R^2 value indicates that the SPAD value is affected by the cultivation technique in a quadratic manner, increasing until it reaches the peak before starting to decline (Table 2). A study on corn resulted in a similar result, where the SPAD values would decrease after reaching their peak, mostly affected by the environment (Ghozali, 2016; Kandel, 2020; Szulc et al., 2021).

Table 2. Regression analysis correlations of the SPAD value with several mathematical models of farming practices using different doses of cow manure

Farming practice	Linear model, $y = ax + b$	Logarithmic model, $y = a \ln x + b$	Polynomial model, $y = ax^2 + bx + c$	Power model, $y = ax^b$
Conventional	$y = -8.9073x + 76.38$ $R^2 = 0.6917$ $r = 0.8316$**	$y = -21.1\ln(x) + 70.877$ $R^2 = 0.8417$ $r = 0.9174$**	$y = 5.6238x^2 - 37.026x + 104.5$ $R^2 = 0.9123$ $r = 0.9551$**	$y = 70.35x^{0.357}$ $R^2 = 0.8842$ $r = 0.9432$**
Floating	$y = -10.769x + 88.122$ $R^2 = 0.9581$ $r = 0.9788$**	$y = -22.56\ln(x) + 79.122$ $R^2 = 0.9116$ $r = 0.9547$**	$y = -0.7451x^2 - 7.0429x + 84.39$ $R^2 = 0.9618$ $r = 0.9807$**	$y = 80.712x^{0.375}$ $R^2 = 0.8804$ $r = 0.9383$**

** Significant difference at $p < 0.05$.

The higher SPAD values in the floating system, especially at 4 and 6 WAP, indicated that the photosynthesis process is going well due to sufficient water availability. In contrast, if there is a deficit of water (moisture stress), photosynthetic activity will be reduced due to chlorophyll damage (Pallavolu et al., 2023). The research results of Ai Nio et al. (2019) showed that the water deficit induced by PEG 8000 with media water potential (WP) –0.25 and –0.5 MPa reduced the total leaf chlorophyll content, leaf chlorophyll *a* and leaf chlorophyll *b*.

This study also found that the increase in cow manure dosage increases the SPAD value, with the highest SPAD value of 82.54 obtained in the P_3 treatment and the lowest (31.21) in the P_0 treatment. The SPAD value has been widely used to estimate the chlorophyll content of other crops, such as tomatoes (Jiang et al., 2017). Furthermore, the application of cow manure could also increase leaf chlorophyll, as indicated by the SPAD value in wheat and rice plants (Shah et al., 2017; Atman et al., 2018). The combination of cultivation techniques and cow manure treatments resulted in no significant effect at 2 and 8 WAP, a significant effect at 4 WAP and a highly significant effect at 6 WAP. The highest SPAD values were obtained in the floating cultivation with a cow manure dose of 20 ton/ha: 77.01 ± 5.35 at 4 WAP and 75.11 ± 3.96 at 6 WAP (Table 3).

Table 3. The SPAD value of shallot in different farming practices with the application of cow manure

Treatment	Weeks after planting (WAP)			
	2	4	6	8
		Farming practice		
Conventional	74.68 ± 3.08	48.18 ± 1.25 b	48.79 ± 1.43 b	44.78 ± 1.33
Floating	77.69 ± 2.88	64.10 ± 4.41 a	59.78 ± 4.55 a	43.22 ± 4.48
Significance	ns	**	**	ns
LSD value	7.996	6.040	4.381	4.615
		Cow manure (ton/ha)		
P_0 (0)	68.16 ± 2.38	45.31 ± 2.88 c	40.90 ± 2.71 c	31.21 ± 4.08 c
P_1 (10)	75.74 ± 5.19	58.48 ± 5.77 ab	56.21 ± 4.35 b	44.61 ± 2.93 b
P_2 (15)	78.27 ± 4.09	55.78 ± 4.94 b	55.98 ± 3.73 b	46.60 ± 2.09 b
P_3 (20)	82.54 ± 2.98	65.00 ± 6.08 a	64.04 ± 5.28 a	53.60 ± 3.80 a
Significance	ns	**	**	**
LSD value	11.307	8.542	6.197	6.527
		Farming practice x Cow manure (ton/ha)		
Conventional x P_0	68.47 ± 5.10	46.81 ± 1.43 b	43.29 ± 3.72 ef	39.69 ± 3.16 c
Conventional x P_1	74.13 ± 10.00	46.93 ± 1.68 b	48.02 ± 1.74 de	43.42 ± 10.00 bc
Conventional x P_2	74.01 ± 4.26	46.00 ± 1.36 b	50.87 ± 0.68 bc	46.57 ± 4.26 bc
Conventional x P_3	82.13 ± 4.21	52.99 ± 3.47 b	52.98 ± 1.17 cd	49.46 ± 4.21 ab
Floating x P_0	67.86 ± 1.46	43.81 ± 6.11 b	38.52 ± 4.15 f	22.73 ± 1.46 d
Floating x P_1	77.37 ± 5.68	70.03 ± 5.53 a	64.41 ± 4.95 b	45.81 ± 5.68 bc
Floating x P_2	82.54 ± 6.90	65.56 ± 4.94 a	61.10 ± 6.57 bc	46.63 ± 6.90 bc
Floating x P_3	82.97 ± 5.15	77.01 ± 5.35 a	75.11 ± 3.96 a	57.73 ± 5.15 a
Significance	ns	*	**	ns
LSD value	15.991	12.081	8.763	9.231

Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05.

Bulb number, bulb diameter (mm) and weight of fresh and air-dried bulbs (g)

The yield components include the number of bulbs, bulb diameter and weight for both fresh and air-dried bulbs. The farming practice had no significant impact on the quantity of bulbs but a very significant impact on the weight of fresh and air-dried bulb and the bulb diameter. The conventional method produced the greatest number of bulbs, whereas floating cultivation produced the best results in terms of bulb diameter and weight of fresh and air-dried bulbs. The growing media conditions strongly affected how the bulbs were initially formed. Since water was constantly accessible from beneath the growing media through capillaries, floating cultivation used growing media that were somewhat moist. There was also intense rainfall during early growth of the shallots, causing the planting media to be very wet. There were about 7.78 ± 0.35 bulbs formed in conventional cultivation and 7.75 ± 0.33 in the floating cultivation. However, the number of bulbs was not linearly correlated with the greater dose of cow manure applied, as the largest number of bulbs was obtained at a dose of 15 ton/ha (Table 4). The largest numbers of bulbs (8.33 in conventional cultivation and 8.22 in floating cultivation) were obtained from the same manure treatment, which was P_2. The lowest numbers (6.78 in conventional cultivation and 6.67 in floating cultivation) were also obtained from the same manure treatment, P_0. Plant growth can thus be supported by appropriate cultivation methods (Khorasgani & Pessarakli, 2019; Cahyaningrum et al., 2023).

Table 4. Shallot yield components for different farming practices with the application of cow manure

Treatment	Number of bulbs	Diameter of bulb (cm)	Fresh weight of bulb (g)	Air-dried weight of bulb (g)
		Farming practice		
Conventional	7.78 ± 0.35	20.62 ± 1.76 b	35.36 ± 6.14 b	26.79 ± 5.64 b
Floating	7.75 ± 0.33	23.51 ± 1.29 a	42.33 ± 3.52 a	35.69 ± 2.94 a
Significance	ns	**	*	**
LSD value	1.016	1.741	6.419	4.703
		Cow manure		
P_0 (0)	7.44 ± 0,45	15.44 ± 0.77 c	20.57 ± 2.85 c	14.71 ± 2.12 d
P_1 (10)	7.44 ± 0.50	19.88 ± 0.84 b	34.46 ± 2.36 b	25.64 ± 1.49 c
P_2 (15)	8.28 ± 0.53	27.10 ± 1.74 a	58.24 ± 7.76 a	48.22 ± 7.75 a
P_3 (20)	7.89 ± 0.44	25.84 ± 0.81 a	42.11 ± 2.94 b	36.39 ± 1.84 b
Significance	ns	**	**	**
LSD value	1.437	2.461	9.078	6.651
		Farming practice x Cow manure		
Conventional x P_0	6.78 ± 0.72	15.22 ± 1.40 e	19.58 ± 4.90 e	13.15 ± 3.18 f
Conventional x P_1	8.22 ± 0.58	18.49 ± 0.98 de	33.01 ± 3.72 cd	24.57 ± 1.99 de
Conventional x P_2	8.33 ± 0.76	23.43 ± 0.81 bc	42.08 ± 1.87 bc	31.61 ± 0.73 bcd
Conventional x P_3	7.78 ± 0.44	25.36 ± 1.03 b	46.77 ± 4.21 b	37.84 ± 0.89 b
Floating x P_0	8.11 ± 0.22	15.66 ± 0.99 e	21.57 ± 3.95 de	16.28 ± 3.15 ef

Floating x P_1	6.67 ± 0.57	21.28 ± 0.80 cd	35.92 ± 3.45 bc	26.71 ± 2.44 cd
Floating x P_2	8.22 ± 0.90	30.77 ± 1.02 a	74.40 ± 6.05 a	64.82 ± 4.92 a
Floating x P_3	8.00 ± 0.88	26.32 ± 1.40 b	37.45 ± 1.96 b	34.96 ± 2.56 b
Significance	ns	*	**	**
LSD value	2.032	3.481	12.838	9.406

Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05.

The average diameter of bulbs grown using floating cultivation was 23.51 ± 1.29 mm, which is much larger than the 20.62 ± 1.62 mm average diameter of bulbs grown using conventional cultivation (Figure 4). The largest diameter of bulbs produced as a result of cow manure application was at a dose of 15 ton/ha, and the lowest was at 0 ton/ha (Table 4). Based on the combination of treatments, P_2 treatment (15 ton/ha) in floating cultivation produced the largest bulb diameter of 30.78 mm, and P_3 treatment (20 ton/ha) in conventional cultivation produced the largest bulb diameter of 25.36 mm. The two cultivation methods produced the smallest bulb diameters in the same treatment, P_0 (0 ton/ha), with the conventional system producing a diameter of 15.22 mm and the floating system a diameter of 15.66 mm. The high bulb diameter in the floating culture was greatly supported by the conditions of the growing media, where during the growth stages the rainfall continued to decline, so the media in floating culture was not saturated with water and oxygen was still available. Nutrient absorption, water uptake and root respiration are all affected by oxygen availability, which is a crucial component for plant growth. The use of biological fertilizers or a combination of biological and organic fertilizers can increase the shallot bulb diameter compared to controls (Neira et al., 2015; Xiong et al., 2015; Purba et al, 2020; Widyastuti et al., 2021).

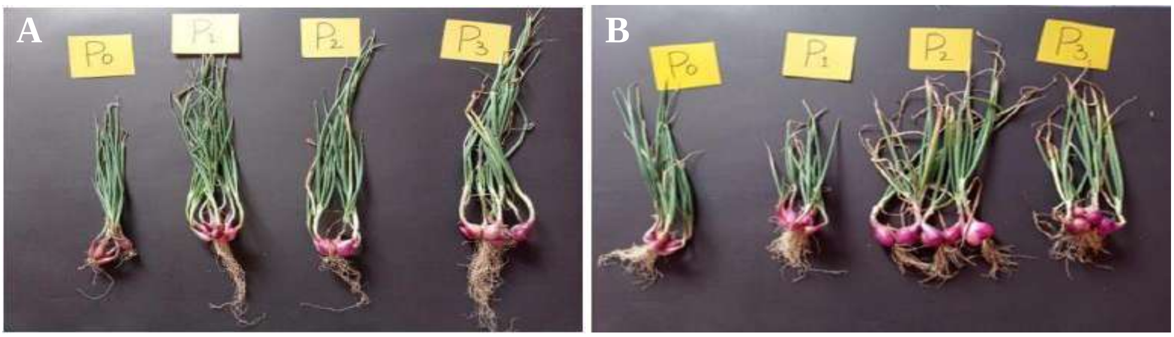

Figure 4. Shallot bulbs produced by the conventional (A) and floating (B) systems with the application of cow manure.

Shallot production is highly dependent on the weight of fresh and air-dried bulbs. The floating cultivation system yielded the greatest average data, which was significantly different from conventional cultivation (42.33 ± 3.52 g vs. 35.69 ± 2.94 g; Table 4). According to Jaya et al. (2019), the availability of water below the plant media in the floating system significantly promotes plant growth and yield. Based on the results, conventional farming required a higher dosage of cow manure (20 ton/ha) compared to floating farming, which required only 15 ton/ha. In terms of cost and bulb production, Paputri et al. (2016) found that a cow manure dose of 20 ton/ha was economically feasible. However, Arzad et al. (2017) found that mustard plants needed up to 25 ton/ha of cow manure.

The estimated production per hectare was calculated using data on air-dried bulb weight under the assumption of a planting space of 20 cm x 20 cm. The highest estimated production was obtained in the floating system from P_2 treatment with 21.61 ton/ha, while the highest production in the conventional system was from P_3 treatment with 12.61 ton/ha. The P_0 treatment had the lowest estimated yield, at 4.38 and 5.43 ton/ha in the conventional and floating cultivation systems, respectively (Figure 5).

Based on the results, it was concluded that the Bima Brebes shallot variety has the potential to be cultivated using the floating technique with the application of 15 ton/ha cow manure, as seen from production estimation reaching 21.61 tons of dry bulb, which is higher than the 9.9 ton/ha of dry bulb reported by the Ministry of Agriculture (2019). Based on this large potential yield, further research has been carried out again in 2023 to obtain more accurate production data. The results obtained will be the basis for considering recommendations for floating shallot development.

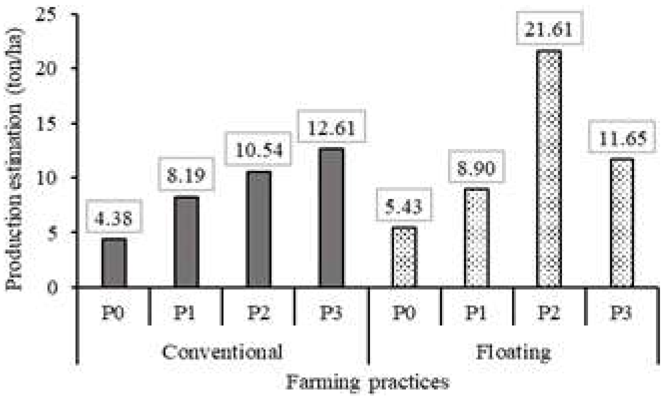

Figure 5. Estimated production of shallot from different farming practices with the application of cow manure.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to our research team and colleagues at the Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya, for their helpful feedback and valuable support for our research.

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Shallot cultivation in tropical climate ecosystems using floating and non-floating systems with different doses of cow manure

Keywords: fertilizer, raft, shallot bulb, swamp, yield.

Abstract: Deep swamp is swampland with the longest flooding period, making it challenging for crop cultivation. However, by adopting a floating system, this prolonged duration of flooding can be used for shallot growing. Thus, this study aimed to ascertain the growth and yield of shallots cultivated in polybags using conventional non-floating and floating systems with the application of different doses of cow manure. The research was located in the experimental field and reservoir of the Faculty of Agriculture, Sriwijaya University (3°13'30.3”S; 104°38'55.1"E). Non-floating and floating farming systems were utilized with the application of 0, 10, 15 and 20 ton/ha of cow manure. The findings demonstrated that shallots cultivated in the floating system had lower numbers and length of leaf but could produce more bulbs in comparison to the conventional method. The application of 15 ton/ha manure in the floating system resulted in higher weights of fresh and air-dried bulbs per plant, weighing 74.40 g and 64.82 g, respectively, compared to those in the non-floating system (46.77 g and 37.84 g, respectively). In conclusion, the Bima Brebes shallot variety potentially can be cultivated in a floating system with the application of 15 tons of cow manure per hectare.

INTRODUCTION

As one of the strategic commodities widely consumed in Indonesia, shallot (*Allium ascalonicum* L.) is a vegetable crop that significantly contributes to the country's horticultural production and inflation rate. According to the findings of the Socio-Economic Survey in September 2021, Indonesians consume an average of 2.49 kg of shallots per person each month. Shallots are required for the food sector, where they are processed into ready-to-use seasonings for sprinkling on food dishes, as well as for usage in households as a seasoning for cooking (Ministry of Agriculture, 2019; Irjayanti, 2022).

The amount of shallots needed for household consumption and the food industry continues to increase. The government's involvement in meeting these needs is through a program to organize and grow shallot production centers outside Java Island so that production centers are not just concentrated on Java. This program aims to realize shallot self-sufficiency in every province in Indonesia (Ministry of Agriculture, 2019; Indriyana et al., 2020). South Sumatra is one of the provinces targeted by this program; this is because shallot production in South Sumatra is still low at only 0.057% of national production or 1125 tons in 2021 (Central Bureau of Statistics for South Sumatra Province, 2022; Directorate of Statistical Dissemination, 2022). Even though South Sumatra is a lowland region that is suitable for growing shallots, there are still several challenges that may affect the shallot growth. One of these is the land's condition as swampland, particularly *lebak* swampland.

Lebak swampland, with its alluvial soil type, has considerable potential to increase the production of food and horticultural crops. However, the use of *lebak* for crop cultivation is faced with high-water fluctuations that cause flooding in the rainy season and drought in the dry season. The typology of *lebak* swampland based on the height and duration of standing water is divided into shallow, middle and deep swamp. Once or twice a year, rice can be grown in the shallow and middle swamps. During the dry season, horticultural crops, particularly vegetable crops, can also be grown, although there is a risk from drought (Djafar, 2013; Suprapto, 2016; Suryana, 2016; Widuri et al., 2016; Pujiharti, 2017; Simatupang & Rina, 2019). Deep swamp is an inland swamp area with stagnant water for more than six months and even during the dry season it remains stagnant. As a result, cultivating plants becomes quite challenging. The deep swamp is mostly left unutilized during the high flooding period. Utilizing a floating cultivation technique is one option for making use of this area (Siaga et al., 2018; Jaya et al., 2019; Lakitan et al., 2021, Susilawati et al., 2022). According to Hasbi et al. (2017), a projected floating farming system for the cultivation of vegetables was created based on the statements of farmers who are interested in using the newly introduced floating farming. Shallots are one of the many crops that may be grown in the floating system.

One of the factors that affect the growth of shallots is the planting medium used. The texture and structure of the soil have significant impact on the production and quality of shallots. Applying organic fertilizer will create the fertile, loose soil that shallots need for the development of their bulbs. One of the components that can increase the physical, chemical and biological qualities of the soil to boost the productivity of shallot plants while reducing the amount of phosphorus (P) fertilizers added to P-deficient soils is organic fertilizer (Noviyanty & Salingkat, 2018; Susikawati et al., 2018; Nguyen et al., 2021). One organic fertilizer that can promote plant development is cow manure (Sudarsono et al., 2014; Atman et al., 2018; Musdalifah et al., 2021). Thus, this research was conducted with the aim of evaluating the growth response and production of shallot plants cultivated in polybags using non-floating and floating systems with the application of various doses of cow manure fertilizer.

MATERIALS AND METHODS

Research area

The research was located in the experimental field and reservoir of the Faculty of Agriculture, Sriwijaya University, Indralaya Ogan Ilir (3°13'30.3′′S; 104°38'55.1"E). Figure 1 shows the arrangement during the dry season in tropical climate ecosystems of South Sumatra, Indonesia, from May to August 2022. Typical agroclimatic conditions at the outdoor research facilities are shown in Figure 2.

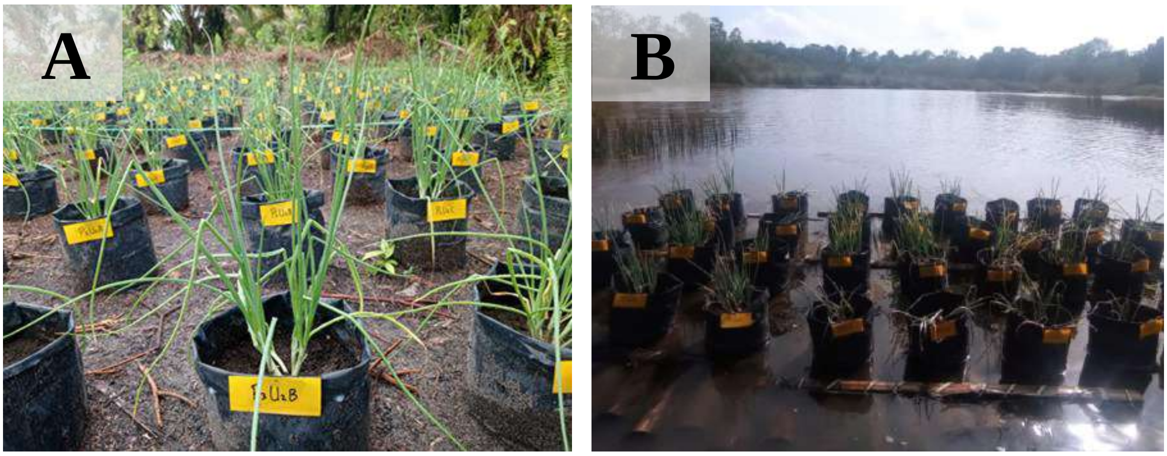

Figure 1. Non-floating (A) and floating (B) farming practices of shallot cultivation.

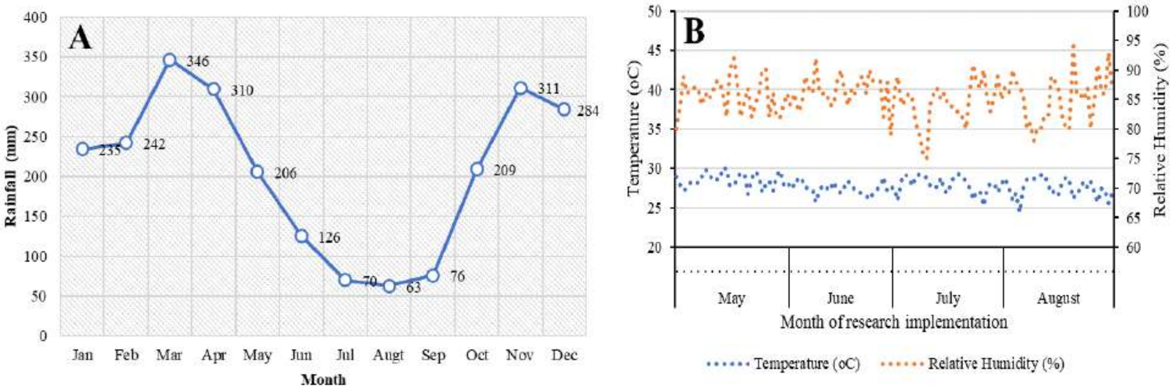

Figure 2. Typical agroclimatic conditions at the outdoor research facilities: (A) rainfall; (B) temperature and relative humidity. Source: https://www.bmkg.go.id.

Procedures

The shallot bulbs used were of the Bima Brebes variety originated from the shallot seed farmers in Brebes, Central Java. The experiment was arranged using a factorial randomized block design with two factors and three replicates. The treatments consisted of different farming practices (conventional non-floating and floating systems) and dosages of cow manure (0, 10, 15 and 20 ton/ha).

For all farming practice treatments, the planting media were prepared using the same method: after being completely mixed, they was placed into 35 cm x 30 cm polybags. The planting media were a mixture of alluvial topsoil gathered from *lebak* swamp combined with cow manure according to the treatments. In the conventional farming technique, the area was prepared by clearing the weeds to make a space for placing the polybags filled with the media. The planting space was 20 cm x 20 cm, following the recommendation for shallot cultivation. In the floating cultivation, the polybags were put on a 2 m x 1 m bamboo raft. Each replicate was put on one bamboo raft. The planting media were sprayed with Bio Soil Grow Booster at a concentration of 4 ml/L of water one week before planting. Inorganic fertilizers were also used, with dosages of 69 kg/ha of P_2O_5, 46 kg/ha of N and 60 kg/ha of K_2O. Phosphorus fertilizer was applied 7 days before planting, whereas nitrogen and potassium were applied twice, 7 and 25 days after planting, each time in half the prescribed amount.

Before being planted, the top one-third of the bulb was cut off and the bulb was placed into a planting hole at depth 2–3 cm. Shallot plants cultivated in the non-floating system were watered regularly to ensure sufficient water availability. In the floating system, the plants were not watered because water was continuously supplied through the soil pores by capillary force from the swamp water below.

Data analysis

The variables were growth characteristics such leaf length, leaf number and leaf color, shallot production variables such as bulb number, bulb diameter, fresh weight, dry weight and shrinkage percentage, as well as estimated production per hectare. Leaf color was measured using a chlorophyll meter (SPAD-502, Minolta) to estimate leaf greenness level correlated to the chlorophyll content (SPAD value). Growth parameters were observed every week, whereas the production data were gathered after the harvest. The collected data were analyzed using R Studio statistical analysis software. The calculated F-value generated from the analysis of variance (ANOVA) was compared to values at $p \leq 0.05$ and $p \leq 0.01$ for justifying the significant effects of the treatments. Furthermore, if the treatment effect was significant for any measured trait, the least significant difference (LSD) test was conducted to determine significant differences among treatment levels for each specified trait.

RESULTS AND DISCUSSION

Leaf length (cm) and leaf number of shallots

Shallot plants grown in tropical climate ecosystems using two farming practices – conventional non-floating (Figure 1A) and floating (Figure 1B) systems with various doses of cow manure – showed differences in growth and yield. Rainfall continued to decline from May to August 2022, the period when the study was conducted. The rainfall reduced from 206 mm in May to 63 mm in August (Figure 2A). High rainfall levels at the start of the study provided a favorable environment for shallot growth in the non-floating cultivation system (polybags stacked on dry soil). On the other hand, shallots grown in wetlands using the floating system (polybags placed on rafts) did not favor heavy rainfall. From May to August 2022, the temperature and humidity remained relatively stable at 27.47–27.92°C and 84.51–86.36%, respectively (Figure 2B).

ANOVA revealed that the variations in farming practices had a significant impact. The results of the LSD test on leaf length demonstrated that the two farming practices differed significantly. In conventional cultivation, the maximum leaf length was 40.43 ± 1.25 cm at 5 weeks after planting (WAP), whereas in the floating system it was only 30.47 ± 0.47 cm at 4 WAP. In the floating agriculture system, the position of the plants was adjusted so that they would always be waterlogged to a height of about 3 cm from the base. In that case, water was continuously supplied via the soil pores by capillary force, causing slower oxygen diffusion. Additionally, when it rains heavily, the media become more water-saturated, which lowers the amount of accessible oxygen. Oxygen is needed by the roots for respiration and for maintaining healthy cell function (Neira et al., 2015; Ernest, 2018; Jaya et al., 2021; Kartika et al., 2021). Damage to the root will eventually affect the upper plant growth, as seen from the agronomical features. Research by Susilawati et al. (2012) on red pepper plants showed that all cultivars experienced varying degrees of root damage as a result of flooding stress. The amount of oxygen present in the planting media is significantly influenced by the height of the water table. Research on bean plants has shown that the roots, particularly the process of root respiration, were significantly impacted by water levels that were 10 cm below the surface of the planting media. Although organic fertilizer applied to shallots in a floating system did not affect growth, a proper water level and the application of organic matter to shallot plants considerably stimulated growth (Susilawati & Lakitan, 2019; Susilawati et al., 2019, 2022). With regard to leaf length, the application of cow manure showed insignificant results in the first week but significant results at 2–8 WAP. The longest leaves (40.19 ± 2.96 cm) were obtained at a P_3 treatment dose of 20 ton/ha, which is not significantly different from the 40.06 ± 1.69 cm obtained at a P_2 dose of 15 ton/ha. The combination of farming practices and cow manure treatments had a significant effect on leaf length only at 6 and 8 WAP in the conventional P_3 treatment, with lengths of 44.74 ± 1.10 cm and 44.92 ± 1.36 cm, respectively.

For leaf number, the difference in farming practices only had a significant effect in the first three weeks. The average number of leaves was mostly higher in the conventional system, except in the fourth week when the leaf number in the floating system was higher at 24.33 ± 1.92 compared to 23.39 ± 1.33 in the conventional system. The research on eggplant showed that increasing the water content of the substrate from 1 to 3 cm would increase the growth of vegetative organs (Jaya et al., 2019). The difference in cow manure dose affected the number of leaves, with the highest leaf number of 31.78 ± 2.65 obtained in P_2 treatment at 7 WAP (Table 1).

Table 1. Leaf length (cm) and leaf number of shallot with the application of cow manure (ton/ha) in different farming practices

Treatment	Weeks after planting (WAP)							
	1	2	3	4	5	6	7	8
Farming practice								
Leaf length (cm)								
Conventional	11.67 ± 0.66 a	26.60 ± 0.79 a	36.43 ± 1.03 a	40.32 ± 1.45 a	40.43 ± 1.69 a	38.39 ± 1.71 a	38.39 ± 1.66 a	36.09 ± 1.95 a
Floating	8.28 ± 0.32 b	20.04 ± 0.56 b	27.58 ± 1.09 b	30.47 ± 1.43 b	29.45 ± 1.90 b	26.66 ± 2.08 b	25.66 ± 1.82 b	24.88 ± 1.76 b
Significance	**	**	**	**	**	**	**	**
LSD0.05	1.516	1.375	2.209	1.961	1.992	2.208	2.536	4.549
Leaf number								
Conventional	7.83 ± 0.39 a	12.38 ± 0.43 a	17.78 ± 0.69 a	22.13 ± 0.93	23.39 ± 1.33	25.69 ± 1.50	26.00 ± 1.43	23.64 ± 1.21
Floating	5.88 ± 0.21 b	10.38 ± 0.47 b	15.66 ± 0.61 b	20.94 ± 1.25	24.33 ± 1.92	25.25 ± 2.15	23.61 ± 2.06	20.03 ± 1.91
Significance	**	**	*	ns	ns	ns	ns	ns
LSD0.05	0.777	1.303	1.548	2.479	2.929	3.831	4.679	4.567
Cow manure (ton/ha)								
Leaf length (cm)								
P_0 (0)	9.31 ± 0.90	21.37 ± 1.74 b	27.53 ± 2.37 b	29.07 ± 2.54 b	26.80 ± 2.99 c	24.83 ± 3.09 c	25.61 ± 3.07 c	25.24 ± 2.96 b
P_1 (10)	10.19 ± 1.23	22.09 ± 1.24 b	30.71 ± 1.86 a	33.59 ± 2.21 b	32.72 ± 2.64 b	29.26 ± 3.12 b	29.86 ± 3.00 b	30.29 ± 2.58 b
P_2 (15)	9.54 ± 0.87	25.30 ± 1.58 a	35.52 ± 1.81 a	39.69 ± 1.74 a	40.06 ± 1.69 a	38.93 ± 1.33 a	37.84 ± 1.34 a	37.16 ± 1.80 a
P_3 (20)	10.86 ± 1.12	24.52 ± 1.89 a	34.26 ± 2.31 a	39.23 ± 2.82 a	40.19 ± 2.96 a	37.10 ± 3.46 a	34.76 ± 4.63 a	29.27 ± 4.69 b
Significance	ns	**	**	**	**	**	**	*
LSD0.05	2.144	1.945	2.189	2.773	2.817	3.122	3.587	6.434
Leaf number								
P_0 (0)	6.00 ± 0.40 b	10.33 ± 0.31	14.33 ± 0.41 b	17.55 ± 0.62 b	17.72 ± 0.88 c	19.50 ± 1.64 c	20.50 ± 2.11 b	19.39 ± 2.28
P_1 (10)	6.94 ± 0.59 ab	11.33 ± 1.06	16.78 ± 1.11 a	20.39 ± 1.12 b	22.50 ± 1.32 b	25.99 ± 1.47 b	26.28 ± 2.09 ab	23.11 ± 2.04
P_2 (15)	6.72 ± 0.58 ab	11.39 ± 0.76	17.22 ± 0.99 a	24.00 ± 1.59 a	29.05 ± 2.38 a	31.78 ± 2.65 a	29.67 ± 2.39 b	25.94 ± 1.88
P_3 (20)	7.78 ± 0.68 a	12.50 ± 0.55	18.55 ± 0.59 a	24.22 ± 0.80 a	26.16 ± 1.32 ab	24.61 ± 1.78 bc	22.78 ± 2.14 b	18.89 ± 2.36
Significance	*	ns	**	**	**	**	*	ns
LSD0.05	1.099	1.842	2.189	3.506	4.144	5.418	6.618	6.459

Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05.

Similarly, research by Feriatin et al. (2021) also showed that the use of cow manure would affect leaf number of the Lokananta shallot variety. The P_3 treatment for conventional cultivation and the P_2 treatment for floating cultivation produced the highest average leaf length and leaf number when cow manure was applied. In the conventional P_3 treatment, the maximum leaf length was 37.45 cm with an average of 21.33 leaves, while in the floating P_2 treatment the highest leaf length was 29.80 cm with 23.14 leaves. Cow manure is an organic fertilizer that can alter the structure and texture of the soil, making the media crumblier, which explains the difference in the dosage of cow manure between the two cultivation systems (Figure 3). Meanwhile, as a result of the relatively high moisture of the planting media in the floating culture, cow manure already affects the texture and structure of the media at lower doses (Elisabeth et al., 2013; Gudugi, 2013; Ekwealor et al., 2020; Wisdom et al., 2021).

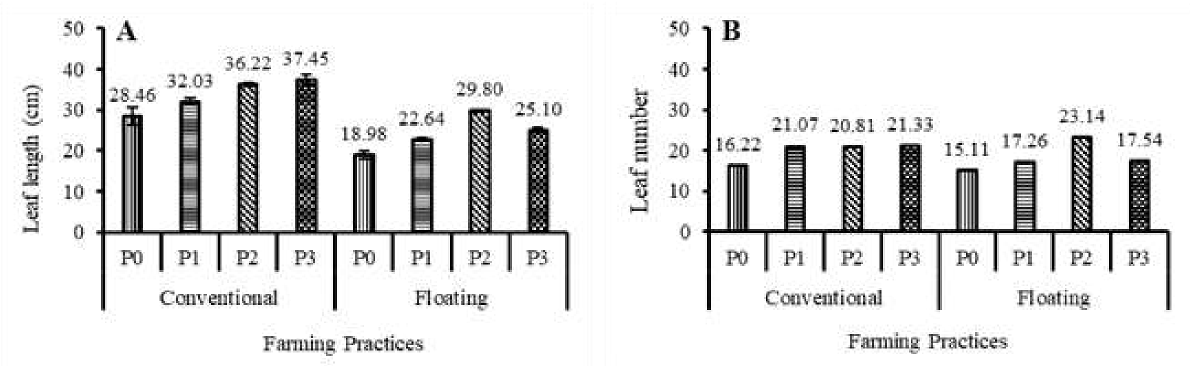

Figure 3. Effect of cow manure dosage on leaf length (A) and leaf number (B) in the different farming practices.

SPAD value

In this study, the parameter of leaf greenness – which serves as an indicator for chlorophyll content – was quantified using the SPAD tool without damaging the leaves measured from the second to the eighth week. At 4 and 6 WAP, the culture technique treatment significantly affected the SPAD value but had no significant effect at 2 and 8 WAP. Shallots cultivated in the floating system were recorded to have higher values at 2, 4 and 6 WAP (77.69 ± 2.69, 64.10 ± 4.41 and 48.18 ± 1.25, respectively) compared to those in the conventional system (74.68±3.08, 48.18±1.25 and 48.79±1.43). However, at 8 WAP, the SPAD value in the conventional system was higher than in the floating system (44.78±1.33 vs. 43.22±4.48). The SPAD value of the two cultivation techniques was at its highest at 2

WAP and then continued to decrease until 8 WAP. In comparison to other models, the polynomial model's regression analysis of the SPAD value in the shallot cultivation resulted in the largest determination coefficient (R^2), which is close to 1: 0.9123 for the conventional system and 0.9618 for the floating system. The magnitude of the R^2 value indicates that the SPAD value is affected by the cultivation technique in a quadratic manner, increasing until it reaches the peak before starting to decline (Table 2). A study on corn resulted in a similar result, where the SPAD values would decrease after reaching their peak, mostly affected by the environment (Ghozali, 2016; Kandel, 2020; Szulc et al., 2021).

Table 2. Regression analysis correlations of the SPAD value with several mathematical models of farming practices using different doses of cow manure

Farming practice	Linear model, $y = ax + b$	Logarithmic model, $y = a \ln x + b$	Polynomial model, $y = ax^2 + bx + c$	Power model, $y = ax^b$
Conventional	$y = -8.9073x + 76.38$ $R^2 = 0.6917$ $r = 0.8316$**	$y = -21.1\ln(x) + 70.877$ $R^2 = 0.8417$ $r = 0.9174$**	$y = 5.6238x^2 - 37.026x + 104.5$ $R^2 = 0.9123$ $r = 0.9551$**	$y = 70.35x^{0.357}$ $R^2 = 0.8842$ $r = 0.9432$**
Floating	$y = -10.769x + 88.122$ $R^2 = 0.9581$ $r = 0.9788$**	$y = -22.56\ln(x) + 79.122$ $R^2 = 0.9116$ $r = 0.9547$**	$y = -0.7451x^2 - 7.0429x + 84.39$ $R^2 = 0.9618$ $r = 0.9807$**	$y = 80.712x^{0.375}$ $R^2 = 0.8804$ $r = 0.9383$**

** Significant difference at $p < 0.05$.

The higher SPAD values in the floating system, especially at 4 and 6 WAP, indicated that the photosynthesis process is going well due to sufficient water availability. In contrast, if there is a deficit of water (moisture stress), photosynthetic activity will be reduced due to chlorophyll damage (Pallavolu et al., 2023). The research results of Ai Nio et al. (2019) showed that the water deficit induced by PEG 8000 with media water potential (WP) –0.25 and –0.5 MPa reduced the total leaf chlorophyll content, leaf chlorophyll *a* and leaf chlorophyll *b*.

This study also found that the increase in cow manure dosage increases the SPAD value, with the highest SPAD value of 82.54 obtained in the P_3 treatment and the lowest (31.21) in the P_0 treatment. The SPAD value has been widely used to estimate the chlorophyll content of other crops, such as tomatoes (Jiang et al., 2017). Furthermore, the application of cow manure could also increase leaf chlorophyll, as indicated by the SPAD value in wheat and rice plants (Shah et al., 2017; Atman et al., 2018). The combination of cultivation techniques and cow manure treatments resulted in no significant effect at 2 and 8 WAP, a significant effect at 4 WAP and a highly significant effect at 6 WAP. The highest SPAD values were obtained in the floating cultivation with a cow manure dose of 20 ton/ha: 77.01 ± 5.35 at 4 WAP and 75.11 ± 3.96 at 6 WAP (Table 3).

Table 3. The SPAD value of shallot in different farming practices with the application of cow manure

Treatment	Weeks after planting (WAP)			
	2	4	6	8
	Farming practice			
Conventional	74.68 ± 3.08	48.18 ± 1.25 b	48.79 ± 1.43 b	44.78 ± 1.33
Floating	77.69 ± 2.88	64.10 ± 4.41 a	59.78 ± 4.55 a	43.22 ± 4.48
Significance	ns	**	**	ns
LSD value	7.996	6.040	4.381	4.615
	Cow manure (ton/ha)			
P_0 (0)	68.16 ± 2.38	45.31 ± 2.88 c	40.90 ± 2.71 c	31.21 ± 4.08 c
P_1 (10)	75.74 ± 5.19	58.48 ± 5.77 ab	56.21 ± 4.35 b	44.61 ± 2.93 b
P_2 (15)	78.27 ± 4.09	55.78 ± 4.94 b	55.98 ± 3.73 b	46.60 ± 2.09 b
P_3 (20)	82.54 ± 2.98	65.00 ± 6.08 a	64.04 ± 5.28 a	53.60 ± 3.80 a
Significance	ns	**	**	**
LSD value	11.307	8.542	6.197	6.527
	Farming practice x Cow manure (ton/ha)			
Conventional x P_0	68.47 ± 5.10	46.81 ± 1.43 b	43.29 ± 3.72 ef	39.69 ± 3.16 c
Conventional x P_1	74.13 ± 10.00	46.93 ± 1.68 b	48.02 ± 1.74 de	43.42 ± 10.00 bc
Conventional x P_2	74.01 ± 4.26	46.00 ± 1.36 b	50.87 ± 0.68 bc	46.57 ± 4.26 bc
Conventional x P_3	82.13 ± 4.21	52.99 ± 3.47 b	52.98 ± 1.17 cd	49.46 ± 4.21 ab
Floating x P_0	67.86 ± 1.46	43.81 ± 6.11 b	38.52 ± 4.15 f	22.73 ± 1.46 d
Floating x P_1	77.37 ± 5.68	70.03 ± 5.53 a	64.41 ± 4.95 b	45.81 ± 5.68 bc
Floating x P_2	82.54 ± 6.90	65.56 ± 4.94 a	61.10 ± 6.57 bc	46.63 ± 6.90 bc
Floating x P_3	82.97 ± 5.15	77.01 ± 5.35 a	75.11 ± 3.96 a	57.73 ± 5.15 a
Significance	ns	*	**	ns
LSD value	15.991	12.081	8.763	9.231

Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05.

Bulb number, bulb diameter (mm) and weight of fresh and air-dried bulbs (g)

The yield components include the number of bulbs, bulb diameter and weight for both fresh and air-dried bulbs. The farming practice had no significant impact on the quantity of bulbs but a very significant impact on the weight of fresh and air-dried bulb and the bulb diameter. The conventional method produced the greatest number of bulbs, whereas floating cultivation produced the best results in terms of bulb diameter and weight of fresh and air-dried bulbs. The growing media conditions strongly affected how the bulbs were initially formed. Since water was constantly accessible from beneath the growing media through capillaries, floating cultivation used growing media that were somewhat moist. There was also intense rainfall during early growth of the shallots, causing the planting media to be very wet. There were about 7.78 ± 0.35 bulbs formed in conventional cultivation and 7.75 ± 0.33 in the floating cultivation. However, the number of bulbs was not linearly correlated with the greater dose of cow manure applied, as the largest number of bulbs was obtained at a dose of 15 ton/ha (Table 4). The largest numbers of bulbs (8.33 in conventional cultivation and 8.22 in floating cultivation) were obtained from the same manure treatment, which was P_2. The lowest numbers (6.78 in conventional cultivation and 6.67 in floating cultivation) were also obtained from the same manure treatment, P_0. Plant growth can thus be supported by appropriate cultivation methods (Khorasgani & Pessarakli, 2019; Cahyaningrum et al., 2023).

Table 4. Shallot yield components for different farming practices with the application of cow manure

Treatment	Number of bulbs	Diameter of bulb (cm)	Fresh weight of bulb (g)	Air-dried weight of bulb (g)
		Farming practice		
Conventional	7.78 ± 0.35	20.62 ± 1.76 b	35.36 ± 6.14 b	26.79 ± 5.64 b
Floating	7.75 ± 0.33	23.51 ± 1.29 a	42.33 ± 3.52 a	35.69 ± 2.94 a
Significance	ns	**	*	**
LSD value	1.016	1.741	6.419	4.703
		Cow manure		
P_0 (0)	7.44 ± 0,45	15.44 ± 0.77 c	20.57 ± 2.85 c	14.71 ± 2.12 d
P_1 (10)	7.44 ± 0.50	19.88 ± 0.84 b	34.46 ± 2.36 b	25.64 ± 1.49 c
P_2 (15)	8.28 ± 0.53	27.10 ± 1.74 a	58.24 ± 7.76 a	48.22 ± 7.75 a
P_3 (20)	7.89 ± 0.44	25.84 ± 0.81 a	42.11 ± 2.94 b	36.39 ± 1.84 b
Significance	ns	**	**	**
LSD value	1.437	2.461	9.078	6.651
		Farming practice x Cow manure		
Conventional x P_0	6.78 ± 0.72	15.22 ± 1.40 e	19.58 ± 4.90 e	13.15 ± 3.18 f
Conventional x P_1	8.22 ± 0.58	18.49 ± 0.98 de	33.01 ± 3.72 cd	24.57 ± 1.99 de
Conventional x P_2	8.33 ± 0.76	23.43 ± 0.81 bc	42.08 ± 1.87 bc	31.61 ± 0.73 bcd
Conventional x P_3	7.78 ± 0.44	25.36 ± 1.03 b	46.77 ± 4.21 b	37.84 ± 0.89 b
Floating x P_0	8.11 ± 0.22	15.66 ± 0.99 e	21.57 ± 3.95 de	16.28 ± 3.15 ef

Floating x P_1	6.67 ± 0.57	21.28 ± 0.80 cd	35.92 ± 3.45 bc	26.71 ± 2.44 cd
Floating x P_2	8.22 ± 0.90	30.77 ± 1.02 a	74.40 ± 6.05 a	64.82 ± 4.92 a
Floating x P_3	8.00 ± 0.88	26.32 ± 1.40 b	37.45 ± 1.96 b	34.96 ± 2.56 b
Significance	ns	*	**	**
LSD value	2.032	3.481	12.838	9.406

Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD0.05.

The average diameter of bulbs grown using floating cultivation was 23.51 ± 1.29 mm, which is much larger than the 20.62 ± 1.62 mm average diameter of bulbs grown using conventional cultivation (Figure 4). The largest diameter of bulbs produced as a result of cow manure application was at a dose of 15 ton/ha, and the lowest was at 0 ton/ha (Table 4). Based on the combination of treatments, P_2 treatment (15 ton/ha) in floating cultivation produced the largest bulb diameter of 30.78 mm, and P_3 treatment (20 ton/ha) in conventional cultivation produced the largest bulb diameter of 25.36 mm. The two cultivation methods produced the smallest bulb diameters in the same treatment, P_0 (0 ton/ha), with the conventional system producing a diameter of 15.22 mm and the floating system a diameter of 15.66 mm. The high bulb diameter in the floating culture was greatly supported by the conditions of the growing media, where during the growth stages the rainfall continued to decline, so the media in floating culture was not saturated with water and oxygen was still available. Nutrient absorption, water uptake and root respiration are all affected by oxygen availability, which is a crucial component for plant growth. The use of biological fertilizers or a combination of biological and organic fertilizers can increase the shallot bulb diameter compared to controls (Neira et al., 2015; Xiong et al., 2015; Purba et al, 2020; Widyastuti et al., 2021).

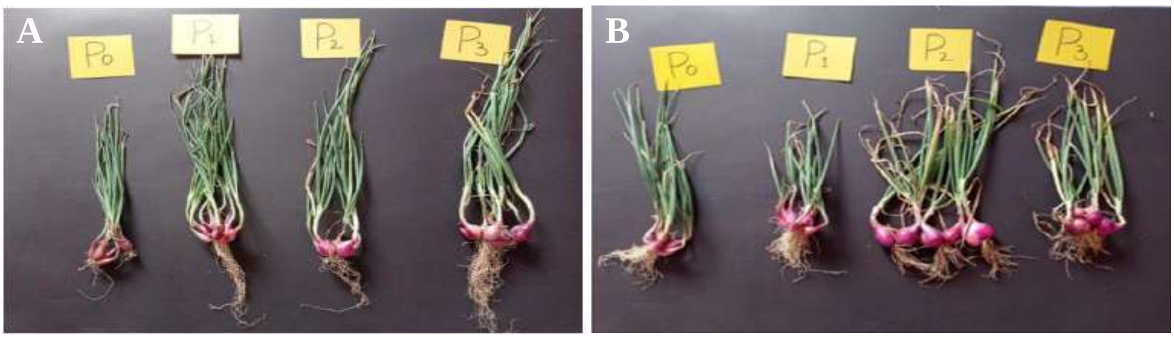

Figure 4. Shallot bulbs produced by the conventional (A) and floating (B) systems with the application of cow manure.

Shallot production is highly dependent on the weight of fresh and air-dried bulbs. The floating cultivation system yielded the greatest average data, which was significantly different from conventional cultivation (42.33 ± 3.52 g vs. 35.69 ± 2.94 g; Table 4). According to Jaya et al. (2019), the availability of water below the plant media in the floating system significantly promotes plant growth and yield. Based on the results, conventional farming required a higher dosage of cow manure (20 ton/ha) compared to floating farming, which required only 15 ton/ha. In terms of cost and bulb production, Paputri et al. (2016) found that a cow manure dose of 20 ton/ha was economically feasible. However, Arzad et al. (2017) found that mustard plants needed up to 25 ton/ha of cow manure.

The estimated production per hectare was calculated using data on air-dried bulb weight under the assumption of a planting space of 20 cm x 20 cm. The highest estimated production was obtained in the floating system from P_2 treatment with 21.61 ton/ha, while the highest production in the conventional system was from P_3 treatment with 12.61 ton/ha. The P_0 treatment had the lowest estimated yield, at 4.38 and 5.43 ton/ha in the conventional and floating cultivation systems, respectively (Figure 5).

Based on the results, it was concluded that the Bima Brebes shallot variety has the potential to be cultivated using the floating technique with the application of 15 ton/ha cow manure, as seen from production estimation reaching 21.61 tons of dry bulb, which is higher than the 9.9 ton/ha of dry bulb reported by the Ministry of Agriculture (2019). Based on this large potential yield, further research has been carried out again in 2023 to obtain more accurate production data. The results obtained will be the basis for considering recommendations for floating shallot development.

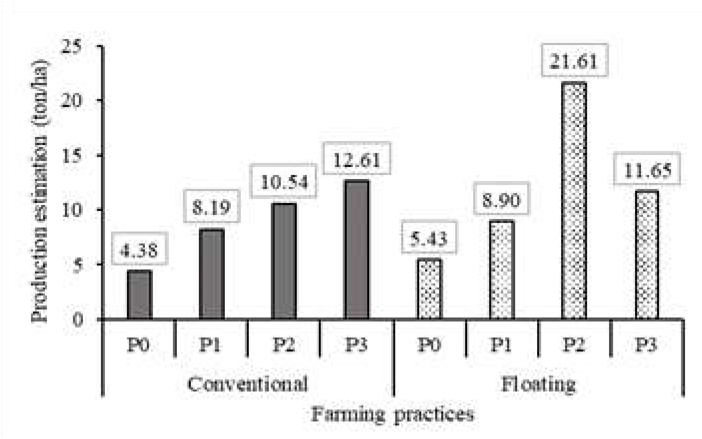

Figure 5. Estimated production of shallot from different farming practices with the application of cow manure.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to our research team and colleagues at the Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya, for their helpful feedback and valuable support for our research.

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3. Editor Decision

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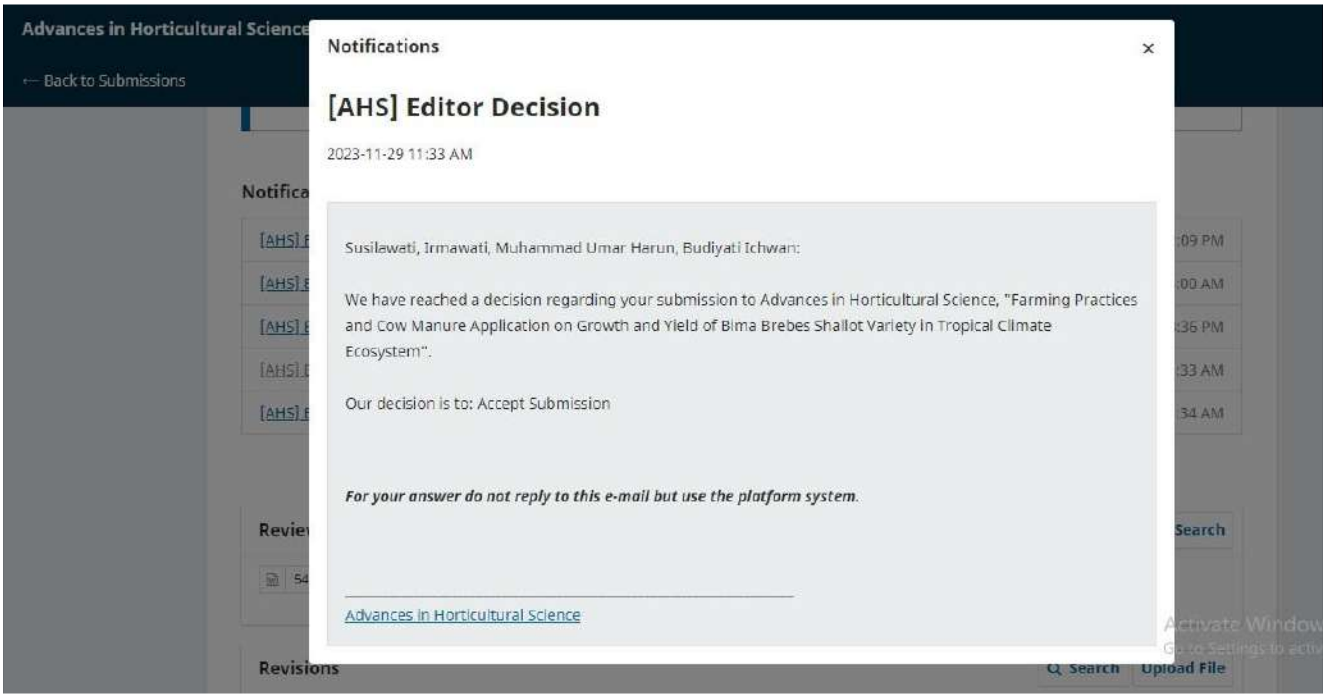

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We have reached a decision regarding your submission to Advances in Horticultural Science, "Farming Practices and Cow Manure Application on Growth and Yield of Bima Brebes Shallot Variety in Tropical Climate Ecosystem".

Our decision is to: Accept Submission

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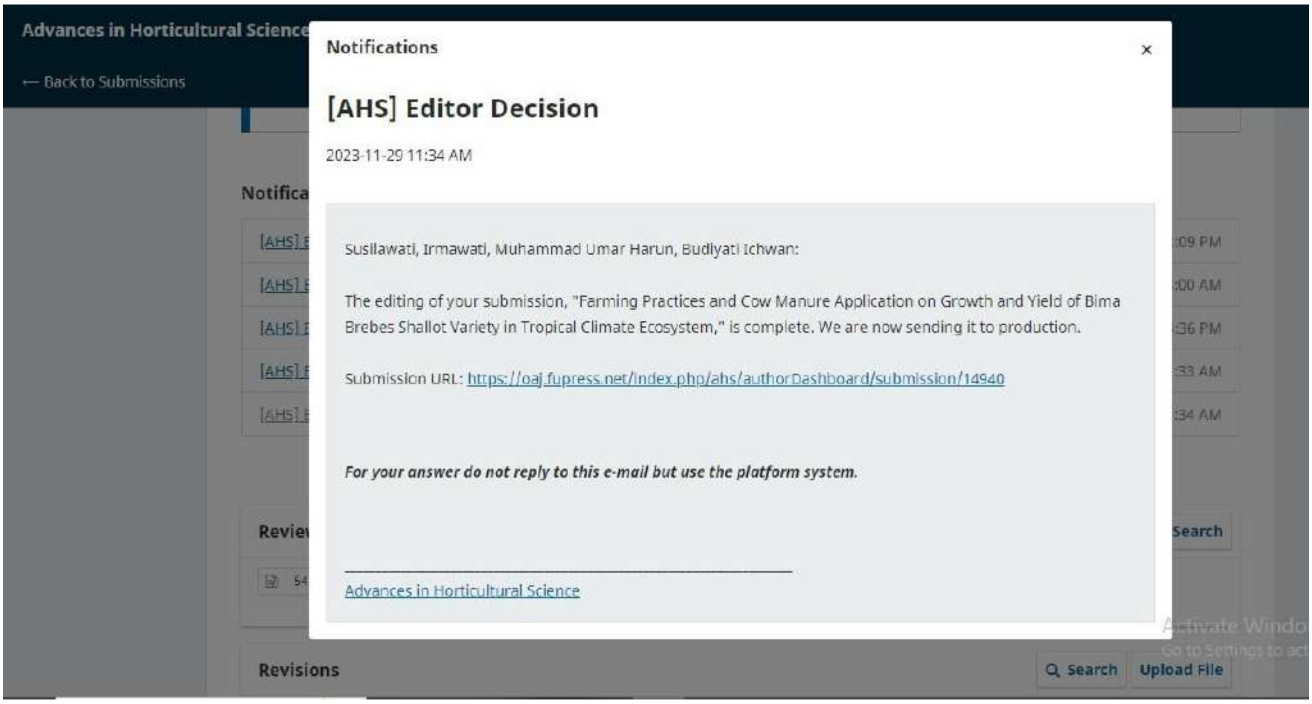

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Advances in Horticultural Science

Shallot cultivation in tropical climate ecosystems using floating and non-floating systems with different doses of cow manure

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Citation:
SUSILAWATI S., IRMAWATI I., HARUN M.U., ICHWAN B., 2023 - *Shallot cultivation in tropical climate ecosystems using floating and non-floating systems with different doses of cow manure.* - Adv. Hort. Sci., 38(1): 25-34.

Data Availability Statement:
All relevant data are within the paper and its Supporting Information files.

Competing Interests:
The authors declare no competing interests.

Received for publication 18 July 2023
Accepted for publication 29 November 2023

Key words: fertilizer, raft, shallot bulb, swamp, yield.

Abstract: Deep swamp is swampland with the longest flooding period, making it challenging for crop cultivation. However, by adopting a floating system, this prolonged duration of flooding can be used for shallot growing. Thus, this study aimed to ascertain the growth and yield of shallots cultivated in polybags using conventional non-floating and floating systems with the application of different doses of cow manure. The research was located in the experimental field and reservoir of the Faculty of Agriculture, Sriwijaya University (3°13'30.3"S; 104°38'55.1"E). Non-floating and floating farming systems were utilized with the application of 0, 10, 15 and 20 ton/ha of cow manure. The findings demonstrated that shallots cultivated in the floating system had lower numbers and length of leaf but could produce more bulbs in comparison to the conventional method. The application of 15 ton/ha manure in the floating system resulted in higher weights of fresh and air-dried bulbs per plant, weighing 74.40 g and 64.82 g, respectively, compared to those in the non-floating system (46.77 g and 37.84 g, respectively). In conclusion, the Bima Brebes shallot variety potentially can be cultivated in a floating system with the application of 15 tons of cow manure per hectare.

1. Introduction

As one of the strategic commodities widely consumed in Indonesia, shallot (*Allium ascalonicum* L.) is a vegetable crop that significantly contributes to the country's horticultural production and inflation rate. According to the findings of the Socio-Economic Survey in September 2021, Indonesians consume an average of 2.49 kg of shallots per person each month. Shallots are required for the food sector, where they are processed into ready-to-use seasonings for sprinkling on food dishes, as well as for usage in households as a seasoning for cooking (Ministry of

Agriculture, 2019; Irjayanti, 2022).

The amount of shallots needed for household consumption and the food industry continues to increase. The government's involvement in meeting these needs is through a program to organize and grow shallot production centers outside Java Island so that production centers are not just concentrated on Java. This program aims to realize shallot self-sufficiency in every province in Indonesia (Ministry of Agriculture, 2019; Indriyana *et al*., 2020). South Sumatra is one of the provinces targeted by this program; this is because shallot production in South Sumatra is still low at only 0.057% of national production or 1125 tons in 2021 (Central Bureau of Statistics for South Sumatra Province, 2022; Directorate of Statistical Dissemination, 2022). Even though South Sumatra is a lowland region that is suitable for growing shallots, there are still several challenges that may affect the shallot growth. One of these is the land's condition as swampland, particularly *lebak* swampland.

Lebak swampland, with its alluvial soil type, has considerable potential to increase the production of food and horticultural crops. However, the use of *lebak* for crop cultivation is faced with high-water fluctuations that cause flooding in the rainy season and drought in the dry season. The typology of *lebak* swampland based on the height and duration of standing water is divided into shallow, middle and deep swamp. Once or twice a year, rice can be grown in the shallow and middle swamps. During the dry season, horticultural crops, particularly vegetable crops, can also be grown, although there is a risk from drought (Djafar, 2013; Suprapto, 2016; Suryana, 2016; Widuri *et al.*, 2016; Pujiharti, 2017; Simatupang and Rina, 2019). Deep swamp is an inland swamp area with stagnant water for more than six months and even during the dry season it remains stagnant. As a result, cultivating plants becomes quite challenging. The deep swamp is mostly left unutilized during the high flooding period. Utilizing a floating cultivation technique is one option for making use of this area (Siaga *et al.*, 2018; Jaya *et al.*, 2019; Lakitan *et al.*, 2021; Susilawati *et al.*, 2022). According to Hasbi *et al.* (2017), a projected floating farming system for the cultivation of vegetables was created based on the statements of farmers who are interested in using the newly introduced floating farming. Shallots are one of the many crops that may be grown in the floating system.

One of the factors that affect the growth of shallots is the planting medium used. The texture and structure of the soil have significant impact on the production and quality of shallots. Applying organic fertilizer will create the fertile, loose soil that shallots need for the development of their bulbs. One of the components that can increase the physical, chemical and biological qualities of the soil to boost the productivity of shallot plants while reducing the amount of phosphorus (P) fertilizers added to P-deficient soils is organic fertilizer (Noviyanty and Salingkat, 2018; Susikawati *et al.*, 2018; Nguyen *et al.*, 2021). One organic fertilizer that can promote plant development is cow manure (Sudarsono *et al.*, 2014; Atman *et al.*, 2018; Musdalifah *et al.*, 2021). Thus, this research was conducted with the aim of evaluating the growth response and production of shallot plants cultivated in polybags using non-floating and floating systems with the application of various doses of cow manure fertilizer.

2. Materials and Methods

Research gate

The research was located in the experimental field and reservoir of the Faculty of Agriculture, Sriwijaya University, Indralaya Ogan Ilir (3°13'30.3''S; 104°38'55.1"E). Figure 1 shows the arrangement during the dry season in tropical climate ecosystems of South Sumatra, Indonesia, from May to August 2022. Typical agroclimatic conditions at the outdoor research facilities are shown in figure 2.

Procedures

The shallot bulbs used were of the Bima Brebes variety originated from the shallot seed farmers in Brebes, Central Java. The experiment was arranged using a factorial randomized block design with two factors and three replicates. The treatments consist-

Fig. 1 - Non-floating (A) and floating (B) farming practices of shallot cultivation.

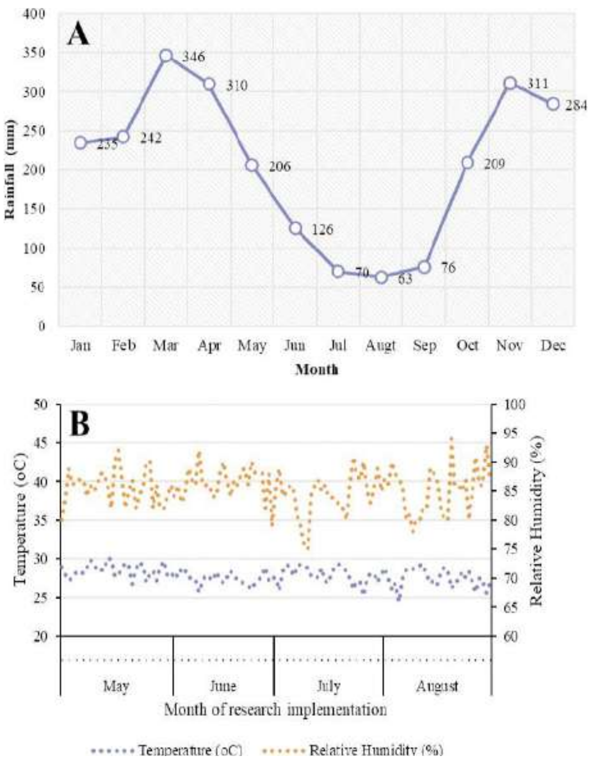

Fig. 2 - Typical agroclimatic conditions at the outdoor research facilities: (A) rainfall; (B) temperature and relative humidity. Source: https://www.bmkg.go.id.

ed of different farming practices (conventional non-floating and floating systems) and dosages of cow manure (0, 10, 15 and 20 ton/ha).

For all farming practice treatments, the planting media were prepared using the same method: after being completely mixed, they was placed into 35 cm x 30 cm polybags. The planting media were a mixture of alluvial topsoil gathered from *lebak* swamp combined with cow manure according to the treatments. In the conventional farming technique, the area was prepared by clearing the weeds to make a space for placing the polybags filled with the media. The planting space was 20 cm x 20 cm, following the recommendation for shallot cultivation. In the floating cultivation, the polybags were put on a 2 m x 1 m bamboo raft. Each replicate was put on one bamboo raft. The planting media were sprayed with Bio Soil Grow Booster at a concentration of 4 ml/L of water one week before planting. Inorganic fertilizers were also used, with dosages of 69 kg/ha of P_2O_5, 46 kg/ha of N and 60 kg/ha of K_2O. Phosphorus fertilizer was applied 7 days before planting, whereas nitrogen and potassium were applied twice, 7 and 25 days after planting, each time in half the prescribed amount. Before being planted, the top one-third of the bulb was cut off and the bulb was placed into a planting hole at depth 2-3 cm. Shallot plants cultivated in the non-floating system were watered regularly to ensure sufficient water availability. In the floating system, the plants were not watered because water was continuously supplied through the soil pores by capillary force from the swamp water below.

Data analysis

The variables were growth characteristics such leaf length, leaf number and leaf color, shallot production variables such as bulb number, bulb diameter, fresh weight, dry weight and shrinkage percentage, as well as estimated production per hectare. Leaf color was measured using a chlorophyll meter (SPAD-502, Minolta) to estimate leaf greenness level correlated to the chlorophyll content (SPAD value). Growth parameters were observed every week, whereas the production data were gathered after the harvest. The collected data were analyzed using R Studio statistical analysis software. The calculated F-value generated from the analysis of variance (ANOVA) was compared to values at $p\leq0.05$ and $p\leq0.01$ for justifying the significant effects of the treatments. Furthermore, if the treatment effect was significant for any measured trait, the least significant difference (LSD) test was conducted to determine significant differences among treatment levels for each specified trait.

3. Results and Discussion

Leaf length (cm) and leaf number of shallots

Shallot plants grown in tropical climate ecosystems using two farming practices - conventional non-floating (Fig. 1A) and floating (Fig. 1B) systems with various doses of cow manure - showed differences in growth and yield. Rainfall continued to decline from May to August 2022, the period when the study was conducted. The rainfall reduced from 206 mm in May to 63 mm in August (Fig. 2A). High rainfall levels at the start of the study provided a favorable environment for shallot growth in the non-floating cultivation system (polybags stacked on dry soil). On the other hand, shallots grown in wetlands using the floating system (polybags placed on rafts) did not favor heavy rainfall. From May to August 2022, the temperature and humidity remained relatively stable at 27.47-27.92°C and 84.51-86.36%, respectively (Fig. 2B).

ANOVA revealed that the variations in farming practices had a significant impact. The results of the LSD test on leaf length demonstrated that the two farming practices differed significantly. In conventional cultivation, the maximum leaf length was 40.43±1.25 cm at 5 weeks after planting (WAP), whereas in the floating system it was only 30.47±0.47 cm at 4 WAP. In the floating agriculture system, the position of the plants was adjusted so that they would always be waterlogged to a height of about 3 cm from the base. In that case, water was continuously supplied via the soil pores by capillary force, causing slower oxygen diffusion. Additionally, when it rains heavily, the media become more water-saturated, which lowers the amount of accessible oxygen. Oxygen is needed by the roots for respiration and for maintaining healthy cell function (Neira *et al*., 2015; Ernest, 2018; Jaya *et al*., 2021; Kartika *et al*., 2021). Damage to the root will eventually affect the upper plant growth, as seen from the agronomical features. Research by Susilawati *et al.* (2012) on red pepper plants showed that all cultivars experienced varying degrees of root damage as a result of flooding stress. The amount of oxygen present in the planting media is significantly influenced by the height of the water table. Research on bean plants has shown that the roots, particularly the process of root respiration, were significantly impacted by water levels that were 10 cm below the surface of the planting media. Although organic fertilizer applied to shallots in a floating system did not affect growth, a proper water level and the application of organic matter to shallot plants considerably stimulated growth (Susilawati and Lakitan, 2019; Susilawati *et al*., 2019, 2022). With regard to leaf length, the application of cow manure showed insignificant results in the first week but significant results at 2–8 WAP. The longest leaves (40.19 ± 2.96 cm) were obtained at a P_3 treatment dose of 20 ton/ha, which is not significantly different from the 40.06 ± 1.69 cm obtained at a P_2 dose of 15 ton/ha. The combination of farming practices and cow manure treatments had a significant effect on leaf length only at 6 and 8 WAP in the conventional P_3 treatment, with lengths of 44.74 ± 1.10 cm and 44.92 ± 1.36 cm, respectively.

For leaf number, the difference in farming practices only had a significant effect in the first three weeks. The average number of leaves was mostly higher in the conventional system, except in the fourth week when the leaf number in the floating system was higher at 24.33 ± 1.92 compared to 23.39 ± 1.33 in the conventional system. The research on eggplant showed that increasing the water content of the substrate from 1 to 3 cm would increase the growth of vegetative organs (Jaya *et al.*, 2019). The difference in cow manure dose affected the number of leaves, with the highest leaf number of 31.78 ± 2.65 obtained in P_2 treatment at 7 WAP (Table 1).

Similarly, research by Feriatin *et al.* (2021) also showed that the use of cow manure would affect leaf number of the Lokananta shallot variety. The P_3 treatment for conventional cultivation and the P_2 treatment for floating cultivation produced the highest average leaf length and leaf number when cow manure was applied. In the conventional P_3 treatment, the maximum leaf length was 37.45 cm with an average of 21.33 leaves, while in the floating P_2 treatment the highest leaf length was 29.80 cm with 23.14 leaves. Cow manure is an organic fertilizer that can alter the structure and texture of the soil, making the media crumblier, which explains the difference in the dosage of cow manure between the two cultivation systems (Fig. 3). Meanwhile, as a result of the relatively high moisture of the planting media in the floating culture, cow manure already affects the texture and structure of the media at lower doses (Elisabeth *et al.*, 2013; Gudugi, 2013; Ekwealor *et al.*, 2020; Wisdom *et al.*, 2021).

SPAD value

In this study, the parameter of leaf greenness - which serves as an indicator for chlorophyll content - was quantified using the SPAD tool without damaging the leaves measured from the second to the eighth week. At 4 and 6 WAP, the culture technique treatment significantly affected the SPAD value but had no significant effect at 2 and 8 WAP. Shallots cultivated in the floating system were recorded to have higher values at 2, 4 and 6 WAP (77.69±2.69, 64.10± 4.41 and 48.18 ± 1.25, respectively) compared to those in the conventional system (74.68±3.08, 48.18±1.25 and 48.79±1.43). However, at 8 WAP, the SPAD value in the conventional system was higher than in the floating system (44.78±1.33 vs. 43.22±4.48). The SPAD value of the two cultivation techniques was at its highest at 2 WAP and then continued to decrease until 8 WAP. In comparison to other models, the polynomial model's regression analysis of the SPAD value in the shallot cultivation resulted in the largest determination coefficient (R^2), which is close to 1: 0.9123 for the conventional system and 0.9618 for the floating system. The magni-

Table 1 - Leaf length (cm) and leaf number of shallot with the application of cow manure (ton/ha) in different farming practices

Treatment	Weeks after planting (WAP)							
	1	2	3	4	5	6	7	8
Farming practice				*Leaf length (cm)*				
Conventional	11.67 ± 0.66 a	26.60 ± 0.79 a	36.43 ± 1.03 a	40.32 ± 1.45 a	40.43 ± 1.69 a	38.39 ± 1.71 a	38.39 ± 1.66 a	36.09 ± 1.95 a
Floating	8.28 ± 0.32 b	20.04 ± 0.56 b	27.58 ± 1.09 b	30.47 ± 1.43 b	29.45 ± 1.90 b	26.66 ± 2.08 b	25.66 ± 1.82 b	24.88 ± 1.76 b
Significance	**	**	**	**	**	**	**	**
LSD0.05	1.516	1.375	2.209	1.961	1.992	2.208	2.536	
	4.549							
				Leaf number				
Conventional	7.83 ± 0.39 a	12.38 ± 0.43 a	17.78 ± 0.69 a	22.13 ± 0.93	23.39 ± 1.33	25.69 ± 1.50	26.00 ± 1.43	23.64 ± 1.21
Floating	5.88 ± 0.21 b	10.38 ± 0.47 b	15.66 ± 0.61 b	20.94 ± 1.25	24.33 ± 1.92	25.25 ± 2.15	23.61 ± 2.06	20.03 ± 1.91
Significance	**	**	*	ns	ns	ns	ns	ns
LSD0.05	0.777	1.303	1.548	2.479	2.929	3.831	4.679	4.567
Cow manure (ton/ha)				*Leaf length (cm)*				
P_0 (0)	9.31 ± 0.90	21.37 ± 1.74 b	27.53 ± 2.37 b	29.07 ± 2.54 b	26.80 ± 2.99 c	24.83 ± 3.09 c	25.61 ± 3.07 c	25.24 ± 2.96 b
P_1 (10)	10.19 ± 1.23	22.09 ± 1.24 b	30.71 ± 1.86 a	33.59 ± 2.21 b	32.72 ± 2.64 b	29.26 ± 3.12 b	29.86 ± 3.00 b	30.29 ± 2.58 b
P_2 (15)	9.54 ± 0.87	25.30 ± 1.58 a	35.52 ± 1.81 a	39.69 ± 1.74 a	40.06 ± 1.69 a	38.93 ± 1.33 a	37.84 ± 1.34 a	37.16 ± 1.80 a
P_3 (20)	10.86 ± 1.12	24.52 ± 1.89 a	34.26 ± 2.31 a	39.23 ± 2.82 a	40.19 ± 2.96 a	37.10 ± 3.46 a	34.76 ± 4.63 a	29.27 ± 4.69 b
Significance	ns	**	**	**	**	**	**	*
LSD0.05	2.144	1.945	2.189	2.773	2.817	3.122	3.587	6.434
				Leaf number				
P_0 (0)	6.00 ± 0.40 b	10.33 ± 0.31	14.33 ± 0.41 b	17.55 ± 0.62 b	17.72 ± 0.88 c	19.50 ± 1.64 c	20.50 ± 2.11 b	19.39 ± 2.28
P_1 (10)	6.94 ± 0.59 ab	11.33 ± 1.06	16.78 ± 1.11 a	20.39 ± 1.12 b	22.50 ± 1.32 b	25.99 ± 1.47 b	26.28 ± 2.09 ab	23.11 ± 2.04
P_2 (15)	6.72 ± 0.58 ab	11.39 ± 0.76	17.22 ± 0.99 a	24.00 ± 1.59 a	29.05 ± 2.38 a	31.78 ± 2.65 a	29.67 ± 2.39 b	25.94 ± 1.88
P_3 (20)	7.78 ± 0.68 a	12.50 ± 0.55	18.55 ± 0.59 a	24.22 ± 0.80 a	26.16 ± 1.32 ab	24.61 ± 1.78 bc	22.78 ± 2.14 b	18.89 ± 2.36
Significance	*	ns	**	**	**	**	*	ns
LSD0.05	1.099	1.842	2.189	3.506	4.144	5.418	6.618	6.459

Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD 0.05.

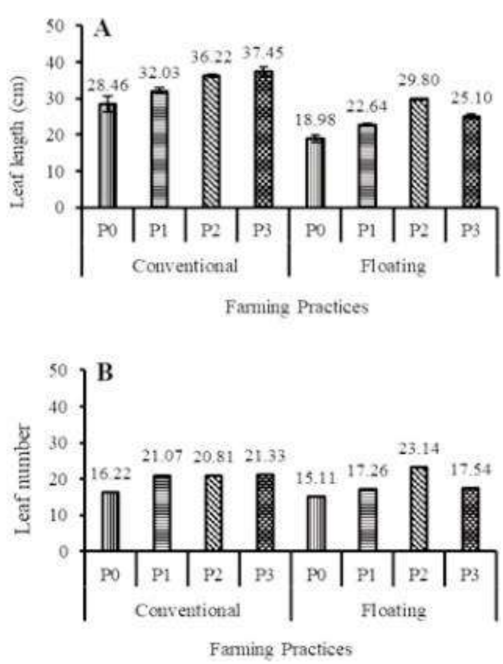

Fig. 3 - Effect of cow manure dosage on leaf length (A) and leaf number (B) in the different farming practices.

tude of the R^2 value indicates that the SPAD value is affected by the cultivation technique in a quadratic manner, increasing until it reaches the peak before starting to decline (Table 2). A study on corn resulted in a similar result, where the SPAD values would decrease after reaching their peak, mostly affected by the environment (Ghozali, 2016; Kandel, 2020; Szulc *et al.*, 2021).

The higher SPAD values in the floating system, especially at 4 and 6 WAP, indicated that the photosynthesis process is going well due to sufficient water availability. In contrast, if there is a deficit of water (moisture stress), photosynthetic activity will be reduced due to chlorophyll damage (Pallavolu *et al.*, 2023). The research results of Ai Nio *et al.* (2019) showed that the water deficit induced by PEG 8000 with media water potential (WP) -0.25 and -0.5 MPa reduced the total leaf chlorophyll content, leaf chlorophyll *a* and leaf chlorophyll *b*.

This study also found that the increase in cow manure dosage increases the SPAD value, with the highest SPAD value of 82.54 obtained in the P_3 treat-

Table 2 - Regression analysis correlations of the SPAD value with several mathematical models of farming practices using different doses of cow manure

Farming practice	Linear model y = ax + b	Logarithmic model y = a ln x + b	Polynomial model $y = ax^2 + bx + c$	Power model $y = ax^b$
Conventional	$y = -8.9073x + 76.38$	$y = -21.1\ln(x) + 70.877$	$y = 5.6238x^2 - 37.026x +$	$y = 70.35x^{0.357}$
	$R^2 = 0.6917$	$R^2 = 0.8417$	$R^2 = 0.9123$	$R^2 = 0.8842$
	$r = 0.8316$**	$r = 0.9174$**	$r = 0.9551$**	$r = 0.9432$**
Floating	$y = -10.769x + 88.122$	$y = -22.56\ln(x) + 79.122$	$y = -0.7451x^2 - 7.0429x +$	$y = 80.712x^{0.375}$
	$R^2 = 0.9581$	$R^2 = 0.9116$	$R^2 = 0.9618$	$R^2 = 0.8804$
	$r = 0.9788$**	$r = 0.9547$**	$r = 0.9807$**	$r = 0.9383$**

** Significant difference at $p < 0.05$.

ment and the lowest (31.21) in the P_0 treatment. The SPAD value has been widely used to estimate the chlorophyll content of other crops, such as tomatoes (Jiang *et al.*, 2017). Furthermore, the application of cow manure could also increase leaf chlorophyll, as indicated by the SPAD value in wheat and rice plants (Shah *et al.*, 2017; Atman *et al.*, 2018). The combination of cultivation techniques and cow manure treatments resulted in no significant effect at 2 and 8 WAP, a significant effect at 4 WAP and a highly significant effect at 6 WAP. The highest SPAD values were obtained in the floating cultivation with a cow manure dose of 20 ton/ha: 77.01 ± 5.35 at 4 WAP and 75.11 ± 3.96 at 6 WAP (Table 3).

Bulb number, bulb diameter (mm) and weight of fresh and air-dried bulbs (g)

The yield components include the number of bulbs, bulb diameter and weight for both fresh and air-dried bulbs. The farming practice had no

Table 3 - The SPAD value of shallot in different farming practices with the application of cow manure

Treatment	SPAD value			
	2 WAP	4 WAP	6 WAP	8 WAP
Farming practice				
Conventional	74.68 ± 3.08	48.18 ± 1.25 b	48.79 ± 1.43 b	44.78 ± 1.33
Floating	77.69 ± 2.88	64.10 ± 4.41 a	59.78 ± 4.55 a	43.22 ± 4.48
Significance	NS	**	**	ns
LSD value	7.996	6.040	4.381	4.615
Cow manure (ton/ha)				
P_0 (0)	68.16 ± 2.38	45.31 ± 2.88 c	40.90 ± 2.71 c	31.21 ± 4.08 c
P_1 (10)	75.74 ± 5.19	58.48 ± 5.77 ab	56.21 ± 4.35 b	44.61 ± 2.93 b
P_2 (15)	78.27 ± 4.09	55.78 ± 4.94 b	55.98 ± 3.73 b	46.60 ± 2.09 b
P_3 (20)	82.54 ± 2.98	65.00 ± 6.08 a	64.04 ± 5.28 a	53.60 ± 3.80 a
Significance	NS	**	**	**
LSD value	11.307	8.542	6.197	6.527
Farming practice x Cow manure (ton/ha)				
Conventional x P_0	68.47 ± 5.10	46.81 ± 1.43 b	43.29 ± 3.72 ef	39.69 ± 3.16 c
Conventional x P_1	74.13 ± 10.00	46.93 ± 1.68 b	48.02 ± 1.74 de	43.42 ± 10.00 bc
Conventional x P_2	74.01 ± 4.26	46.00 ± 1.36 b	50.87 ± 0.68 bc	46.57 ± 4.26 bc
Conventional x P_3	82.13 ± 4.21	52.99 ± 3.47 b	52.98 ± 1.17 cd	49.46 ± 4.21 ab
Floating x P_0	67.86 ± 1.46	43.81 ± 6.11 b	38.52 ± 4.15 f	22.73 ± 1.46 d
Floating x P_1	77.37 ± 5.68	70.03 ± 5.53 a	64.41 ± 4.95 b	45.81 ± 5.68 bc
Floating x P_2	82.54 ± 6.90	65.56 ± 4.94 a	61.10 ± 6.57 bc	46.63 ± 6.90 bc
Floating x P_3	82.97 ± 5.15	77.01 ± 5.35 a	75.11 ± 3.96 a	57.73 ± 5.15 a
Significance	NS	*	**	NS
LSD value	15.991	12.081	8.763	9.231

WAP= Week after planting.
Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at

significant impact on the quantity of bulbs but a very significant impact on the weight of fresh and air-dried bulb and the bulb diameter. The conventional method produced the greatest number of bulbs, whereas floating cultivation produced the best results in terms of bulb diameter and weight of fresh and air-dried bulbs. The growing media conditions strongly affected how the bulbs were initially formed. Since water was constantly accessible from beneath the growing media through capillaries, floating cultivation used growing media that were somewhat moist. There was also intense rainfall during early growth of the shallots, causing the planting media to be very wet. There were about 7.78 ± 0.35 bulbs formed in conventional cultivation and 7.75 ± 0.33 in the floating cultivation. However, the number of bulbs was not linearly correlated with the greater dose of cow manure applied, as the largest number of bulbs was obtained at a dose of 15 ton/ha (Table 4). The largest numbers of bulbs (8.33 in conventional cultivation and 8.22 in floating cultivation) were obtained from the same manure treatment, which was P_2. The lowest numbers (6.78 in conventional cultivation and 6.67 in floating cultivation) were also obtained from the same manure treatment, P_0. Plant growth can thus be supported by appropriate cultivation methods (Khorasgani and Pessarakli, 2019; Cahyaningrum *et al.*, 2023).

The average diameter of bulbs grown using floating cultivation was 23.51 ± 1.29 mm, which is much larger than the 20.62 ± 1.62 mm average diameter of bulbs grown using conventional cultivation (Fig. 4). The largest diameter of bulbs produced as a result of cow manure application was at a dose of 15 ton/ha, and the lowest was at 0 ton/ha (Table 4). Based on the combination of treatments, P_2 treatment (15 ton/ha) in floating cultivation produced the largest bulb diameter of 30.78 mm, and P_3 treatment (20 ton/ha) in conventional cultivation produced the largest bulb diameter of 25.36 mm. The two cultivation methods produced the smallest bulb diameters in the same treatment, P_0 (0 ton/ha), with the conventional system producing a diameter of 15.22 mm and the floating system a diameter of 15.66 mm. The

Table 4 - Shallot yield components for different farming practices with the application of cow manure

Treatment	Number of bulbs	Diameter of bulb (cm)	Fresh weight of bulb (g)	Air-dried weight of bulb (g)
Farming practice				
Conventional	7.78 ± 0.35	20.62 ± 1.76 b	35.36 ± 6.14 b	26.79 ± 5.64 b
Floating	7.75 ± 0.33	23.51 ± 1.29 a	42.33 ± 3.52 a	35.69 ± 2.94 a
Significance	NS	**	*	**
LSD value	1.016	1.741	6.419	4.703
Cow manure				
P_0 (0)	7.44 ± 0,45	15.44 ± 0.77 c	20.57 ± 2.85 c	14.71 ± 2.12 d
P_1 (10)	7.44 ± 0.50	19.88 ± 0.84 b	34.46 ± 2.36 b	25.64 ± 1.49 c
P_2 (15)	8.28 ± 0.53	27.10 ± 1.74 a	58.24 ± 7.76 a	48.22 ± 7.75 a
P_3 (20)	7.89 ± 0.44	25.84 ± 0.81 a	42.11 ± 2.94 b	36.39 ± 1.84 b
Significance	NS	**	**	**
LSD value	1.437	2.461	9.078	6.651
Farming practice x Cow manure				
Conventional x P_0	6.78 ± 0.72	15.22 ± 1.40 e	19.58 ± 4.90 e	13.15 ± 3.18 f
Conventional x P_1	8.22 ± 0.58	18.49 ± 0.98 de	33.01 ± 3.72 cd	24.57 ± 1.99 de
Conventional x P_2	8.33 ± 0.76	23.43 ± 0.81 bc	42.08 ± 1.87 bc	31.61 ± 0.73 bcd
Conventional x P_3	7.78 ± 0.44	25.36 ± 1.03 b	46.77 ± 4.21 b	37.84 ± 0.89 b
Floating x P_0	8.11 ± 0.22	15.66 ± 0.99 e	21.57 ± 3.95 de	16.28 ± 3.15 ef
Floating x P_1	6.67 ± 0.57	21.28 ± 0.80 cd	35.92 ± 3.45 bc	26.71 ± 2.44 cd
Floating x P_2	8.22 ± 0.90	30.77 ± 1.02 a	74.40 ± 6.05 a	64.82 ± 4.92 a
Floating x P_3	8.00 ± 0.88	26.32 ± 1.40 b	37.45 ± 1.96 b	34.96 ± 2.56 b
Significance	NS	*	**	**
LSD value	2.032	3.481	12.838	9.406

WAP= Week after planting.
Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at

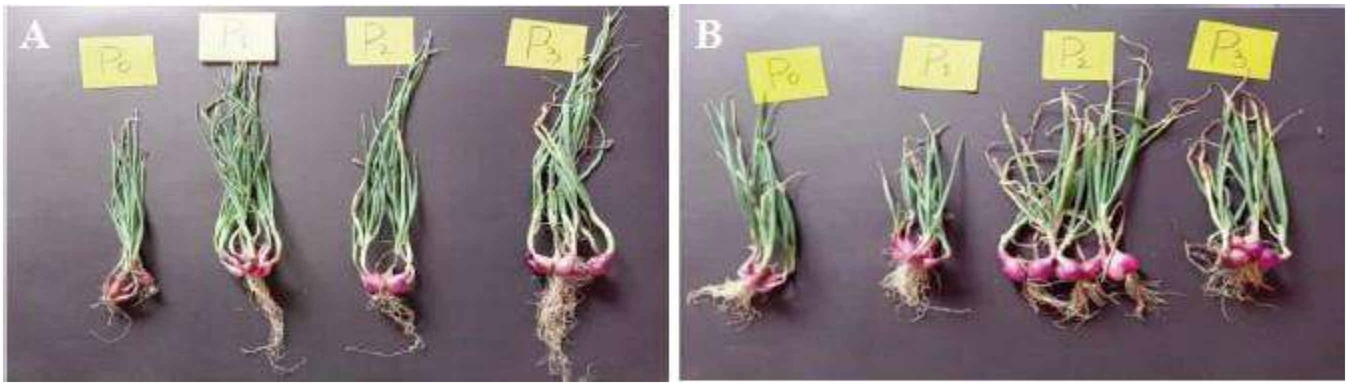

Fig. 4 - Shallot bulbs produced by the conventional (A) and floating (B) systems with the application of cow manure.

high bulb diameter in the floating culture was greatly supported by the conditions of the growing media, where during the growth stages the rainfall continued to decline, so the media in floating culture was not saturated with water and oxygen was still available. Nutrient absorption, water uptake and root respiration are all affected by oxygen availability, which is a crucial component for plant growth. The use of biological fertilizers or a combination of biological and organic fertilizers can increase the shallot bulb diameter compared to controls (Neira *et al.*, 2015; Xiong *et al.*, 2015; Purba *et al.*, 2020; Widyastuti *et al.*, 2021).

Shallot production is highly dependent on the weight of fresh and air-dried bulbs. The floating cultivation system yielded the greatest average data, which was significantly different from conventional cultivation (42.33±3.52 g *vs*. 35.69±2.94 g (Table 4). According to Jaya *et al.* (2019), the availability of water below the plant media in the floating system significantly promotes plant growth and yield. Based on the results, conventional farming required a higher dosage of cow manure (20 ton/ha) compared to floating farming, which required only 15 ton/ha. In terms of cost and bulb production, Paputri *et al*. (2016) found that a cow manure dose of 20 ton/ha was economically feasible. However, Arzad *et al.* (2017) found that mustard plants needed up to 25 ton/ha of cow manure.

The estimated production per hectare was calculated using data on air-dried bulb weight under the assumption of a planting space of 20 cm x 20 cm. The highest estimated production was obtained in the floating system from P_2 treatment with 21.61 ton/ha, while the highest production in the conventional system was from P_3 treatment with 12.61 ton/ha. The P_0 treatment had the lowest estimated yield, at 4.38 and 5.43 ton/ha in the conventional and floating cultivation systems, respectively (Fig. 5).

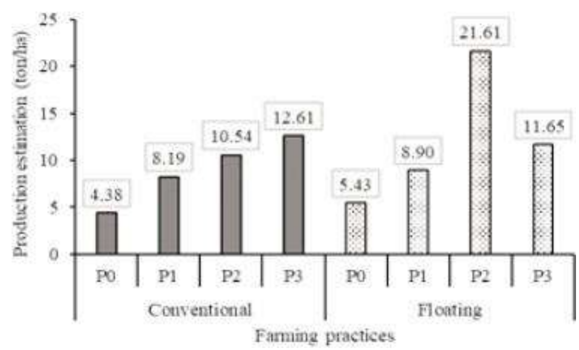

Fig. 5 - Estimated production of shallot from different farming practices with the application of cow manure

Based on the results, it was concluded that the Bima Brebes shallot variety has the potential to be cultivated using the floating technique with the application of 15 ton/ha cow manure, as seen from production estimation reaching 21.61 tons of dry bulb, which is higher than the 9.9 ton/ha of dry bulb reported by the Ministry of Agriculture (2019). Based on this large potential yield, further research has been carried out again in 2023 to obtain more accurate production data. The results obtained will be the basis for considering recommendations for floating shallot development.

Acknowledgements

We would like to express our sincere gratitude to our research team and colleagues at the Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya, for their helpful feedback and valuable support for our research.

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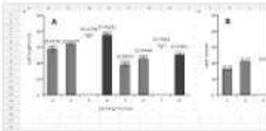

Fig 3 and 5.xlsx


COW MANURE
P_0 = 0 ton/ha; P_1 = 10 ton/ha; P_2 = 15 ton/ha; P_3 = 20 ton/ha
Non-floating farming practices
Floating farming practices
P0
P1
P2
P3
P0
P1
P2
P3

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Shallot cultivation in tropical climate ecosystems using floating and non-floating systems with different doses of cow manure

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Key words: fertilizer, raft, shallot bulb, swamp, yield.
Running title: Shallot cultivation in tropical swampland

Abstract: Deep swamp is swampland with the longest flooding period, making it challenging for crop cultivation. However, by adopting a floating system, this prolonged duration of flooding can be used for shallot growing. Thus, this study aimed to ascertain the growth and yield of shallots cultivated in polybags using conventional non-floating and floating systems with the application of different doses of cow manure. The research was located in the experimental field and reservoir of the Faculty of Agriculture, Sriwijaya University (3°13'30.3"S; 104°38'55.1"E). Non-floating and floating farming systems were utilized with the application of 0, 10, 15 and 20 ton/ha of cow manure. The findings demonstrated that shallots cultivated in the floating system had lower numbers and length of leaf but could produce more bulbs in comparison to the conventional method. The application of 15 ton/ha manure in the floating system resulted in higher weights of fresh and air-dried bulbs per plant, weighing 74.40 g and 64.82 g, respectively, compared to those in the non-floating system (46.77 g and 37.84 g, respectively). In conclusion, the Bima Brebes shallot variety potentially can be cultivated in a floating system with the application of 15 tons of cow manure per hectare.

1. Introduction

As one of the strategic commodities widely consumed in Indonesia, shallot (*Allium ascalonicum* L.) is a vegetable crop that significantly contributes to the country's horticultural production and inflation rate. According to the findings of the Socio-Economic Survey in September 2021, Indonesians consume an average of 2.49 kg of shallots per person each month. Shallots are required for the food sector, where they are processed into ready-to-use seasonings for sprinkling on food dishes, as well as for usage in households as a seasoning for cooking (Ministry of Agriculture, 2019; Irjayanti, 2022).

The amount of shallots needed for household consumption and the food industry continues to increase. The government's involvement in meeting these needs is through a program to organize and grow shallot production centers outside Java Island so that production centers are not just concentrated on Java. This program aims to realize shallot self-sufficiency in every province in Indonesia (Ministry of Agriculture, 2019; Indriyana *et al*., 2020). South Sumatra is one of the provinces targeted by this program; this is because shallot production in South Sumatra is still low at only 0.057% of national production or 1125 tons in 2021 (Central Bureau of Statistics for South Sumatra Province, 2022; Directorate of Statistical Dissemination, 2022). Even though South Sumatra is a lowland region that is suitable for growing shallots, there are still several challenges that may affect the shallot growth. One of these is the land's condition as swampland, particularly *lebak* swampland.

Lebak swampland, with its alluvial soil type, has considerable potential to increase the production of food and horticultural crops. However, the use of *lebak* for crop cultivation is faced with high-water fluctuations that cause flooding in the rainy season and drought in the dry season. The typology of *lebak* swampland based on the height and duration of standing water is divided into shallow, middle and deep swamp. Once or twice a year, rice can be grown in the shallow and middle swamps. During the dry season, horticultural crops, particularly vegetable crops, can also be grown, although there is a risk from drought (Djafar, 2013; Suprapto, 2016; Suryana, 2016; Widuri *et al.*, 2016; Pujiharti, 2017; Simatupang & Rina, 2019). Deep swamp is an inland swamp area with stagnant water for more than six months and even during the dry season it remains stagnant. As a result, cultivating plants becomes quite challenging. The deep swamp is mostly left unutilized during the high flooding period. Utilizing a floating cultivation technique is one option for making use of this area (Siaga *et al.*, 2018; Jaya *et al.*, 2019; Lakitan *et al.*, 2021, Susilawati *et al.*, 2023). According to Hasbi *et al.* (2017), a projected floating farming system for the cultivation of vegetables was created based on the statements of farmers who are interested in using the newly introduced floating farming. Shallots are one of the many crops that may be grown in the floating system.

One of the factors that affect the growth of shallots is the planting medium used. The texture and structure of the soil have significant impact on the production and quality of shallots. Applying organic fertilizer will create the fertile, loose soil that shallots need for the development of their bulbs. One of the components that can increase the physical, chemical and biological qualities of the soil to boost the productivity of shallot plants while reducing the amount of phosphorus (P) fertilizers added to P-deficient soils is organic fertilizer (Noviyanty & Salingkat, 2018; Susikawati *et al.*, 2018; Nguyen *et al.*, 2021). One organic fertilizer that can promote plant development is cow manure (Sudarsono *et al.*, 2014; Atman *et al.*, 2018; Musdalifah *et al.*, 2021). Thus, this research was conducted with the aim of evaluating the growth response and production of shallot plants cultivated in polybags using non-floating and floating systems with the application of various doses of cow manure fertilizer.

2. Materials and Methods

Research gate

The research was located in the experimental field and reservoir of the Faculty of Agriculture, Sriwijaya University, Indralaya Ogan Ilir (3°13'30.3''S; 104°38'55.1"E). Figure 1 shows the arrangement during the dry season in tropical climate ecosystems of South Sumatra, Indonesia, from May to August 2022. Typical agroclimatic conditions at the outdoor research facilities are shown in figure 2.

Procedures

The shallot bulbs used were of the Bima Brebes variety originated from the shallot seed farmers in Brebes, Central Java. The experiment was arranged using a factorial randomized block design with two factors and three replicates. The treatments consisted of different farming practices (conventional non-floating and floating systems) and dosages of cow manure (0, 10, 15 and 20 ton/ha).

For all farming practice treatments, the planting media were prepared using the same method: after being completely mixed, they was placed into 35 cm x 30 cm polybags. The planting media were a mixture of alluvial topsoil gathered from *lebak* swamp combined with cow manure according to the treatments. In the conventional farming technique, the area was prepared by clearing the weeds to make a space for placing the polybags filled with the media. The planting space was 20 cm x 20 cm, following the recommendation for shallot cultivation. In the floating cultivation, the polybags were put on a 2 m x 1 m bamboo raft. Each replicate was put on one bamboo raft. The planting media were sprayed with Bio Soil Grow Booster at a concentration of 4 ml/L of water one week before planting. Inorganic fertilizers were also used, with dosages of 69 kg/ha of P_2O_5, 46 kg/ha of N and 60 kg/ha of K_2O. Phosphorus fertilizer was applied 7 days before planting, whereas nitrogen and potassium were applied twice, 7 and 25 days after planting, each time in half the prescribed amount. Before being planted, the top one-third of the bulb was cut off and the bulb was placed into a planting hole at depth 2-3 cm. Shallot plants cultivated in the non-floating system were watered regularly to ensure sufficient water availability. In the floating system, the plants were not watered because water was continuously supplied through the soil pores by capillary force from the swamp water below.

Data analysis

The variables were growth characteristics such leaf length, leaf number and leaf color, shallot production variables such as bulb number, bulb diameter, fresh weight, dry weight and shrinkage percentage, as well as estimated production per hectare. Leaf color was measured using a chlorophyll meter (SPAD-502, Minolta) to estimate leaf greenness level correlated to the chlorophyll content (SPAD value). Growth parameters were observed every week, whereas the production data were gathered after the harvest. The collected data were analyzed using R Studio statistical analysis software. The calculated F-value generated from the analysis of variance (ANOVA) was compared to values at $p \leq 0.05$ and $p \leq 0.01$ for justifying the significant effects of the treatments. Furthermore, if the treatment effect was significant for any measured trait, the least significant difference (LSD) test was conducted to determine significant differences among treatment levels for each specified trait.

3. Results and Discussion

Leaf length (cm) and leaf number of shallots

Shallot plants grown in tropical climate ecosystems using two farming practices – conventional non-floating (Fig. 1A) and floating (Fig. 1B) systems with various doses of cow manure – showed differences in growth and yield. Rainfall continued to decline from May to August 2022, the period when the study was conducted. The rainfall reduced from 206 mm in May to 63 mm in August (Fig. 2A). High rainfall levels at the start of the study provided a favorable environment for shallot growth in the non-floating cultivation system (polybags stacked on dry soil). On the other hand, shallots grown in wetlands using the floating system (polybags placed on rafts) did not favor heavy rainfall. From May to August 2022, the temperature and humidity remained relatively stable at 27.47-27.92°C and 84.51–86.36%, respectively (Fig. 2B).

ANOVA revealed that the variations in farming practices had a significant impact. The results of the LSD test on leaf length demonstrated that the two farming practices differed significantly. In conventional cultivation, the maximum leaf length was 40.43±1.25 cm at 5 weeks after planting (WAP), whereas in the floating system it was only 30.47±0.47 cm at 4 WAP. In the floating agriculture system, the position of the plants was adjusted so that they would always be waterlogged to a height of about 3 cm from the base. In that case, water was continuously supplied via the soil pores by capillary force, causing slower oxygen diffusion. Additionally, when it rains heavily, the media become more water-saturated, which lowers the amount of accessible oxygen. Oxygen is needed by the roots for respiration and for maintaining healthy cell function (Neira *et al*., 2015; Jaya *et al*., 2021; Kartika *et al*., 2021). Damage to the root will eventually affect the upper plant growth, as seen from the agronomical features. Research by Susilawati *et al.* (2012) on red pepper plants showed that all cultivars experienced varying degrees of root damage as a result of flooding stress. The amount of oxygen present in the planting media is significantly influenced by the height of the water table. Research on bean plants has shown that the roots, particularly the process of root respiration, were significantly impacted by water levels that were 10 cm below the surface of the planting media. Although organic fertilizer applied to shallots in a floating system did not affect growth, a proper water level and the application of organic matter to shallot plants considerably stimulated growth (Susilawati and Lakitan, 2019; Susilawati *et al*., 2019, 2022). With regard to leaf length, the application of cow manure showed insignificant results in the first week but significant results at 2–8

WAP. The longest leaves (40.19 ± 2.96 cm) were obtained at a P_3 treatment dose of 20 ton/ha, which is not significantly different from the 40.06 ± 1.69 cm obtained at a P_2 dose of 15 ton/ha. The combination of farming practices and cow manure treatments had a significant effect on leaf length only at 6 and 8 WAP in the conventional P_3 treatment, with lengths of 44.74 ± 1.10 cm and 44.92 ± 1.36 cm, respectively.

For leaf number, the difference in farming practices only had a significant effect in the first three weeks. The average number of leaves was mostly higher in the conventional system, except in the fourth week when the leaf number in the floating system was higher at 24.33 ± 1.92 compared to 23.39 ± 1.33 in the conventional system. The research on eggplant showed that increasing the water content of the substrate from 1 to 3 cm would increase the growth of vegetative organs (Jaya *et al.*, 2019). The difference in cow manure dose affected the number of leaves, with the highest leaf number of 31.78 ± 2.65 obtained in P_2 treatment at 7 WAP (Table 1).

Similarly, research by Feriatin *et al.* (2021) also showed that the use of cow manure would affect leaf number of the Lokananta shallot variety. The P_3 treatment for conventional cultivation and the P_2 treatment for floating cultivation produced the highest average leaf length and leaf number when cow manure was applied. In the conventional P_3 treatment, the maximum leaf length was 37.45 cm with an average of 21.33 leaves, while in the floating P_2 treatment the highest leaf length was 29.80 cm with 23.14 leaves. Cow manure is an organic fertilizer that can alter the structure and texture of the soil, making the media crumblier, which explains the difference in the dosage of cow manure between the two cultivation systems (Figure 3). Meanwhile, as a result of the relatively high moisture of the planting media in the floating culture, cow manure already affects the texture and structure of the media at lower doses (Elisabeth *et al.*, 2013; Gudugi, 2013; Ekwealor *et al.*, 2020; Wisdom *et al.*, 2021).

SPAD value

In this study, the parameter of leaf greenness – which serves as an indicator for chlorophyll content – was quantified using the SPAD tool without damaging the leaves measured from the second to the eighth week. At 4 and 6 WAP, the culture technique treatment significantly affected the SPAD value but had no significant effect at 2 and 8 WAP. Shallots cultivated in the floating system were recorded to have higher values at 2, 4 and 6 WAP (77.69 ± 2.69, 64.10 ± 4.41 and 48.18 ± 1.25, respectively) compared to those in the conventional system (74.68±3.08, 48.18±1.25 and 48.79±1.43). However, at 8 WAP, the SPAD value in the conventional system was higher than in the floating system (44.78±1.33 vs. 43.22±4.48). The SPAD value of the two cultivation techniques was at its highest at 2 WAP and then continued to decrease until 8 WAP. In comparison to other models, the polynomial model's regression analysis of the SPAD value in the shallot cultivation resulted in the largest determination coefficient (R^2), which is close to 1: 0.9123 for the conventional system and 0.9618 for the floating system. The magnitude of the R^2 value indicates that the SPAD value is affected by the cultivation technique in a quadratic manner, increasing until it reaches the peak before starting to decline (Table 2). A study on corn resulted in a similar result, where the SPAD values would decrease after reaching their peak, mostly affected by the environment (Ghozali, 2016; Kandel, 2020; Szulc *et al.*, 2021).

The higher SPAD values in the floating system, especially at 4 and 6 WAP, indicated that the photosynthesis process is going well due to sufficient water availability. In contrast, if there is a deficit of water (moisture stress), photosynthetic activity will be reduced due to chlorophyll damage (Pallavolu *et al.*, 2023). The research results of Ai Nio *et al.* (2019) showed that the water deficit induced by PEG 8000 with media water potential (WP) -0.25 and -0.5 MPa reduced the total leaf chlorophyll content, leaf chlorophyll *a* and leaf chlorophyll *b*.

This study also found that the increase in cow manure dosage increases the SPAD value, with the highest SPAD value of 82.54 obtained in the P_3 treatment and the lowest (31.21) in the P_0 treatment. The SPAD value has been widely used to estimate the chlorophyll content of other crops, such as tomatoes (Jiang *et al.*, 2017). Furthermore, the application of cow manure could also increase leaf chlorophyll, as indicated by the SPAD value in wheat and rice plants (Shah *et al.*, 2017; Atman *et al.*, 2018). The combination of cultivation techniques and cow manure treatments resulted in no significant effect at 2 and 8 WAP, a significant effect at 4 WAP and a highly significant effect at 6 WAP. The highest SPAD values were obtained in the floating cultivation with a cow manure dose of 20 ton/ha: 77.01 ± 5.35 at 4 WAP and 75.11 ± 3.96 at 6 WAP (Table 3).

Bulb number, bulb diameter (mm) and weight of fresh and air-dried bulbs (g)

The yield components include the number of bulbs, bulb diameter and weight for both fresh and air-dried bulbs. The farming practice had no significant impact on the quantity of bulbs but a very significant impact on the weight of fresh and air-dried bulb and the bulb diameter. The conventional method produced the greatest number of bulbs, whereas floating cultivation produced the best results in terms of bulb diameter and weight of fresh and air-dried bulbs. The growing media conditions strongly affected how the bulbs were initially formed. Since water was constantly accessible from beneath the growing media through capillaries, floating cultivation used growing media that were somewhat moist. There was also intense rainfall during early growth of the shallots, causing the planting media to be very wet. There were about 7.78 ± 0.35 bulbs formed in conventional cultivation and 7.75 ± 0.33 in the floating cultivation. However, the number of bulbs was not linearly correlated with the greater dose of cow manure applied, as the largest number of bulbs was obtained at a dose of 15 ton/ha (Table 4). The largest numbers of bulbs (8.33 in conventional cultivation and 8.22 in floating cultivation) were obtained from the same manure treatment, which was P_2. The lowest numbers (6.78 in conventional cultivation and 6.67 in floating cultivation) were also obtained from the same manure treatment, P_0. Plant growth can thus be supported by appropriate cultivation methods (Khorasgani & Pessarakli, 2019; Cahyaningrum *et al.*, 2023).

The average diameter of bulbs grown using floating cultivation was 23.51 ± 1.29 mm, which is much larger than the 20.62 ± 1.62 mm average diameter of bulbs grown using conventional cultivation (Figure 4). The largest diameter of bulbs produced as a result of cow manure application was at a dose of 15 ton/ha, and the lowest was at 0 ton/ha (Table 4). Based on the combination of treatments, P_2 treatment (15 ton/ha) in floating cultivation produced the largest bulb diameter of 30.78 mm, and P_3 treatment (20 ton/ha) in conventional cultivation produced the largest bulb diameter of 25.36 mm. The two cultivation methods produced the smallest bulb diameters in the same treatment, P_0 (0 ton/ha), with the conventional system producing a diameter of 15.22 mm and the floating system a diameter of 15.66 mm. The high bulb diameter in the floating culture was greatly supported by the conditions of the growing media, where during the growth stages the rainfall continued to decline, so the media in floating culture was not saturated with water and oxygen was still available. Nutrient absorption, water uptake and root respiration are all affected by oxygen availability, which is a crucial component for plant growth. The use of biological fertilizers or a combination of biological and organic fertilizers can increase the shallot bulb diameter compared to controls (Neira *et al*., 2015; Xiong *et al*., 2015; Purba *et al.*, 2020; Widyastuti *et al.*, 2021).

Shallot production is highly dependent on the weight of fresh and air-dried bulbs. The floating cultivation system yielded the greatest average data, which was significantly different from conventional cultivation (42.33 ± 3.52 g *vs*. 35.69 ± 2.94 g (Table 4). According to Jaya *et al.* (2019), the availability of water below the plant media in the floating system significantly promotes plant growth and yield. Based on the results, conventional farming required a higher dosage of cow manure (20 ton/ha) compared to floating farming, which required only 15 ton/ha. In terms of cost and bulb production, Paputri *et al*. (2016) found that a cow manure dose of 20 ton/ha was economically feasible. However, Arzad *et al.* (2017) found that mustard plants needed up to 25 ton/ha of cow manure.

The estimated production per hectare was calculated using data on air-dried bulb weight under the assumption of a planting space of 20 cm x 20 cm. The highest estimated production was obtained in the floating system from P_2 treatment with 21.61 ton/ha, while the highest production in the conventional system was from P_3 treatment with 12.61 ton/ha. The P_0 treatment had the lowest

estimated yield, at 4.38 and 5.43 ton/ha in the conventional and floating cultivation systems, respectively (Figure 5).
Based on the results, it was concluded that the Bima Brebes shallot variety has the potential to be cultivated using the floating technique with the application of 15 ton/ha cow manure, as seen from production estimation reaching 21.61 tons of dry bulb, which is higher than the 9.9 ton/ha of dry bulb reported by the Ministry of Agriculture (2019). Based on this large potential yield, further research has been carried out again in 2023 to obtain more accurate production data. The results obtained will be the basis for considering recommendations for floating shallot development.

Acknowledgements

We would like to express our sincere gratitude to our research team and colleagues at the Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya, for their helpful feedback and valuable support for our research.

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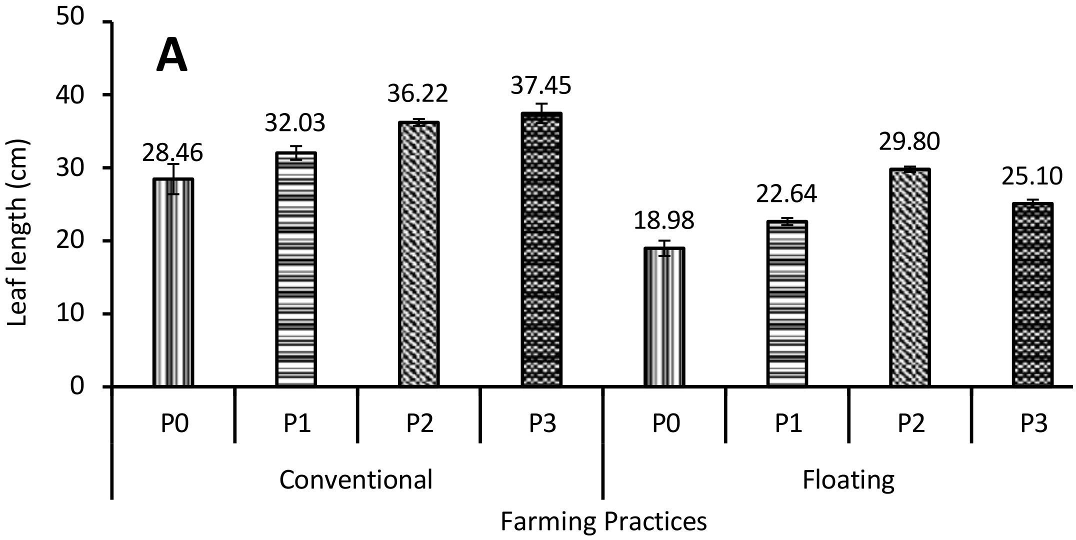
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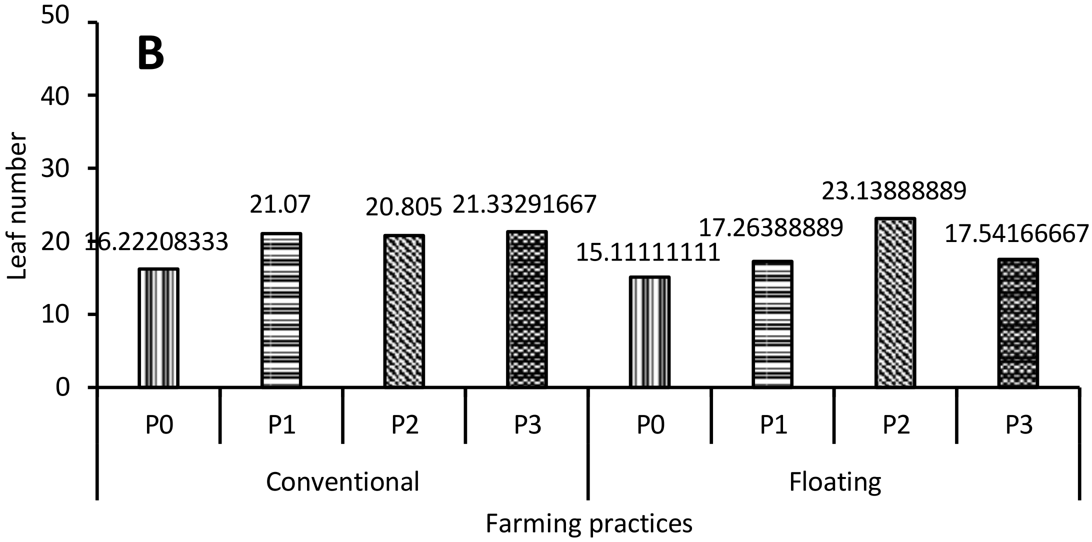
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5. Final paper

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Dear editor of Advances of Horticultural Science Journal,

Thank you very much for the update. We are very pleased with the news.
Hope that we can publish our manuscripts again next time.

Best regards,
Susilawati

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Adv. Hort. Sci., 2024 38(1): 25-34 DOI: 10.36253/ahsc-14940

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Advances in Horticultural Science

Shallot cultivation in tropical climate ecosystems using floating and non-floating systems with different doses of cow manure

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OPEN ACCESS

Key words: fertilizer, raft, shallot bulb, swamp, yield.

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Citation:
SUSILAWATI S., IRMAWATI I., HARUN M.U., ICHWAN B., 2024 - *Shallot cultivation in tropical climate ecosystems using floating and non-floating systems with different doses of cow manure.* - Adv. Hort. Sci., 38(1): 25-34.

Data Availability Statement:
All relevant data are within the paper and its Supporting Information files.

Competing Interests:
The authors declare no competing interests.

Received for publication 18 July 2023
Accepted for publication 29 November 2023

Abstract: Deep swamp is swampland with the longest flooding period, making it challenging for crop cultivation. However, by adopting a floating system, this prolonged duration of flooding can be used for shallot growing. Thus, this study aimed to ascertain the growth and yield of shallots cultivated in polybags using conventional non-floating and floating systems with the application of different doses of cow manure. The research was located in the experimental field and reservoir of the Faculty of Agriculture, Sriwijaya University (3°13'30.3" S; 104°38'55.1" E). Non-floating and floating farming systems were utilized with the application of 0, 10, 15 and 20 ton/ha of cow manure. The findings demonstrated that shallots cultivated in the floating system had lower numbers and length of leaf but could produce more bulbs in comparison to the conventional method. The application of 15 ton/ha manure in the floating system resulted in higher weights of fresh and air-dried bulbs per plant, weighing 74.40 g and 64.82 g, respectively, compared to those in the non-floating system (46.77 g and 37.84 g, respectively). In conclusion, the Bima Brebes shallot variety potentially can be cultivated in a floating system with the application of 15 tons of cow manure per hectare.

1. Introduction

As one of the strategic commodities widely consumed in Indonesia, shallot (*Allium ascalonicum* L.) is a vegetable crop that significantly contributes to the country's horticultural production and inflation rate. According to the findings of the Socio-Economic Survey in September 2021, Indonesians consume an average of 2.49 kg of shallots per person each month. Shallots are required for the food sector, where they are processed into ready-to-use seasonings for sprinkling on food dishes, as well as for usage in households as a seasoning for cooking (Ministry of

Agriculture, 2019; Irjayanti, 2022).

The amount of shallots needed for household consumption and the food industry continues to increase. The government's involvement in meeting these needs is through a program to organize and grow shallot production centers outside Java Island so that production centers are not just concentrated on Java. This program aims to realize shallot self-sufficiency in every province in Indonesia (Ministry of Agriculture, 2019; Indriyana *et al*., 2020). South Sumatra is one of the provinces targeted by this program; this is because shallot production in South Sumatra is still low at only 0.057% of national production or 1125 tons in 2021 (Central Bureau of Statistics for South Sumatra Province, 2022; Directorate of Statistical Dissemination, 2022). Even though South Sumatra is a lowland region that is suitable for growing shallots, there are still several challenges that may affect the shallot growth. One of these is the land's condition as swampland, particularly *lebak* swampland.

Lebak swampland, with its alluvial soil type, has considerable potential to increase the production of food and horticultural crops. However, the use of *lebak* for crop cultivation is faced with high-water fluctuations that cause flooding in the rainy season and drought in the dry season. The typology of *lebak* swampland based on the height and duration of standing water is divided into shallow, middle and deep swamp. Once or twice a year, rice can be grown in the shallow and middle swamps. During the dry season, horticultural crops, particularly vegetable crops, can also be grown, although there is a risk from drought (Djafar, 2013; Suprapto, 2016; Suryana, 2016; Widuri *et al.*, 2016; Pujiharti, 2017; Simatupang and Rina, 2019). Deep swamp is an inland swamp area with stagnant water for more than six months and even during the dry season it remains stagnant. As a result, cultivating plants becomes quite challenging. The deep swamp is mostly left unutilized during the high flooding period. Utilizing a floating cultivation technique is one option for making use of this area (Siaga *et al.*, 2018; Jaya *et al.*, 2019; Lakitan, 2021; Susilawati *et al.*, 2023). According to Hasbi *et al.* (2017), a projected floating farming system for the cultivation of vegetables was created based on the statements of farmers who are interested in using the newly introduced floating farming. Shallots are one of the many crops that may be grown in the floating system.

One of the factors that affect the growth of shallots is the planting medium used. The texture and structure of the soil have significant impact on the production and quality of shallots. Applying organic fertilizer will create the fertile, loose soil that shallots need for the development of their bulbs. One of the components that can increase the physical, chemical and biological qualities of the soil to boost the productivity of shallot plants while reducing the amount of phosphorus (P) fertilizers added to P-deficient soils is organic fertilizer (Noviyanty and Salingkat, 2018; Susikawati *et al.*, 2018; Nguyen *et al.*, 2021). One organic fertilizer that can promote plant development is cow manure (Sudarsono *et al.*, 2014; Atman *et al.*, 2018; Musdalifah *et al.*, 2021). Thus, this research was conducted with the aim of evaluating the growth response and production of shallot plants cultivated in polybags using non-floating and floating systems with the application of various doses of cow manure fertilizer.

2. Materials and Methods

Research gate

The research was located in the experimental field and reservoir of the Faculty of Agriculture, Sriwijaya University, Indralaya Ogan Ilir (3°13'30.3''S; 104°38'55.1"E). Figure 1 shows the arrangement during the dry season in tropical climate ecosystems of South Sumatra, Indonesia, from May to August 2022. Typical agroclimatic conditions at the outdoor research facilities are shown in figure 2.

Procedures

The shallot bulbs used were of the Bima Brebes variety originated from the shallot seed farmers in Brebes, Central Java. The experiment was arranged using a factorial randomized block design with two factors and three replicates. The treatments consist-

Fig. 1 - Non-floating (A) and floating (B) farming practices of shallot cultivation.

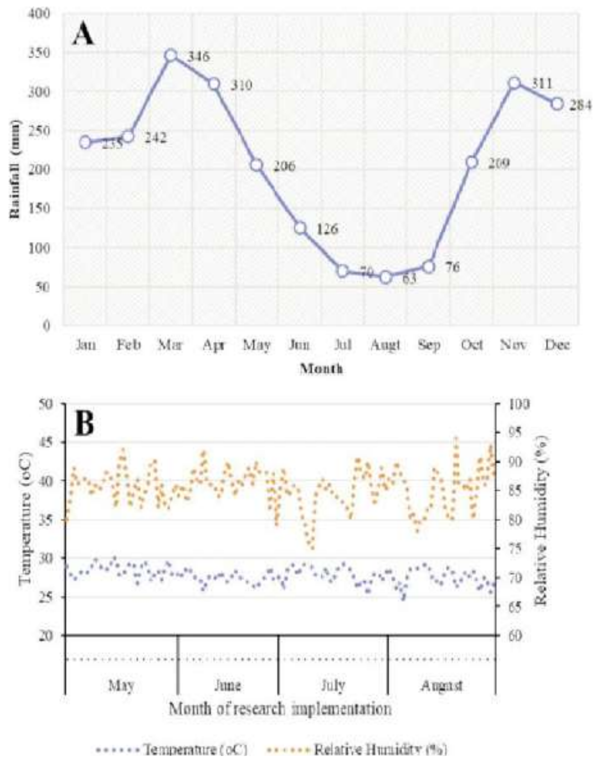

Fig. 2 - Typical agroclimatic conditions at the outdoor research facilities: (A) rainfall; (B) temperature and relative humidity. Source: https://www.bmkg.go.id.

ed of different farming practices (conventional non-floating and floating systems) and dosages of cow manure (0, 10, 15 and 20 ton/ha).

For all farming practice treatments, the planting media were prepared using the same method: after being completely mixed, they was placed into 35 cm x 30 cm polybags. The planting media were a mixture of alluvial topsoil gathered from *lebak* swamp combined with cow manure according to the treatments. In the conventional farming technique, the area was prepared by clearing the weeds to make a space for placing the polybags filled with the media. The planting space was 20 cm x 20 cm, following the recommendation for shallot cultivation. In the floating cultivation, the polybags were put on a 2 m x 1 m bamboo raft. Each replicate was put on one bamboo raft. The planting media were sprayed with Bio Soil Grow Booster at a concentration of 4 ml/L of water one week before planting. Inorganic fertilizers were also used, with dosages of 69 kg/ha of P_2O_5, 46 kg/ha of N and 60 kg/ha of K_2O. Phosphorus fertilizer was applied 7 days before planting, whereas nitrogen and potassium were applied twice, 7 and 25 days after planting, each time in half the prescribed amount. Before being planted, the top one-third of the bulb was cut off and the bulb was placed into a planting hole at depth 2-3 cm. Shallot plants cultivated in the non-floating system were watered regularly to ensure sufficient water availability. In the floating system, the plants were not watered because water was continuously supplied through the soil pores by capillary force from the swamp water below.

Data analysis

The variables were growth characteristics such leaf length, leaf number and leaf color, shallot production variables such as bulb number, bulb diameter, fresh weight, dry weight and shrinkage percentage, as well as estimated production per hectare. Leaf color was measured using a chlorophyll meter (SPAD-502, Minolta) to estimate leaf greenness level correlated to the chlorophyll content (SPAD value). Growth parameters were observed every week, whereas the production data were gathered after the harvest. The collected data were analyzed using R Studio statistical analysis software. The calculated F-value generated from the analysis of variance (ANOVA) was compared to values at $p\leq0.05$ and $p\leq0.01$ for justifying the significant effects of the treatments. Furthermore, if the treatment effect was significant for any measured trait, the least significant difference (LSD) test was conducted to determine significant differences among treatment levels for each specified trait.

3. Results and Discussion

Leaf length (cm) and leaf number of shallots

Shallot plants grown in tropical climate ecosystems using two farming practices - conventional non-floating (Fig. 1A) and floating (Fig. 1B) systems with various doses of cow manure - showed differences in growth and yield. Rainfall continued to decline from May to August 2022, the period when the study was conducted. The rainfall reduced from 206 mm in May to 63 mm in August (Fig. 2A). High rainfall levels at the start of the study provided a favorable environment for shallot growth in the non-floating cultivation system (polybags stacked on dry soil). On the other hand, shallots grown in wetlands using the floating system (polybags placed on rafts) did not favor heavy rainfall. From May to August 2022, the temperature and humidity remained relatively stable at 27.47-27.92°C and 84.51-86.36%, respectively (Fig. 2B).

ANOVA revealed that the variations in farming practices had a significant impact. The results of the LSD test on leaf length demonstrated that the two farming practices differed significantly. In conventional cultivation, the maximum leaf length was 40.43±1.25 cm at 5 weeks after planting (WAP), whereas in the floating system it was only 30.47±0.47 cm at 4 WAP. In the floating agriculture system, the position of the plants was adjusted so that they would always be waterlogged to a height of about 3 cm from the base. In that case, water was continuously supplied via the soil pores by capillary force, causing slower oxygen diffusion. Additionally, when it rains heavily, the media become more water-saturated, which lowers the amount of accessible oxygen. Oxygen is needed by the roots for respiration and for maintaining healthy cell function (Neira *et al*., 2015; Ernest, 2018; Jaya *et al*., 2021; Kartika *et al*., 2021). Damage to the root will eventually affect the upper plant growth, as seen from the agronomical features. Research by Susilawati *et al.* (2012) on red pepper plants showed that all cultivars experienced varying degrees of root damage as a result of flooding stress. The amount of oxygen present in the planting media is significantly influenced by the height of the water table. Research on bean plants has shown that the roots, particularly the process of root respiration, were significantly impacted by water levels that were 10 cm below the surface of the planting media. Although organic fertilizer applied to shallots in a floating system did not affect growth, a proper water level and the application of organic matter to shallot plants considerably stimulated growth (Susilawati and Lakitan, 2019; Susilawati *et al*., 2019, 2022). With regard to leaf length, the application of cow manure showed insignificant results in the first week but significant results at 2–8 WAP. The longest leaves (40.19 ± 2.96 cm) were obtained at a P_3 treatment dose of 20 ton/ha, which is not significantly different from the 40.06 ± 1.69 cm obtained at a P_2 dose of 15 ton/ha. The combination of farming practices and cow manure treatments had a significant effect on leaf length only at 6 and 8 WAP in the conventional P_3 treatment, with lengths of 44.74 ± 1.10 cm and 44.92 ± 1.36 cm, respectively.

For leaf number, the difference in farming practices only had a significant effect in the first three weeks. The average number of leaves was mostly higher in the conventional system, except in the fourth week when the leaf number in the floating system was higher at 24.33 ± 1.92 compared to 23.39 ± 1.33 in the conventional system. The research on eggplant showed that increasing the water content of the substrate from 1 to 3 cm would increase the growth of vegetative organs (Jaya *et al.*, 2019). The difference in cow manure dose affected the number of leaves, with the highest leaf number of 31.78 ± 2.65 obtained in P_2 treatment at 7 WAP (Table 1).

Similarly, research by Feriatin *et al.* (2021) also showed that the use of cow manure would affect leaf number of the Lokananta shallot variety. The P_3 treatment for conventional cultivation and the P_2 treatment for floating cultivation produced the highest average leaf length and leaf number when cow manure was applied. In the conventional P_3 treatment, the maximum leaf length was 37.45 cm with an average of 21.33 leaves, while in the floating P_2 treatment the highest leaf length was 29.80 cm with 23.14 leaves. Cow manure is an organic fertilizer that can alter the structure and texture of the soil, making the media crumblier, which explains the difference in the dosage of cow manure between the two cultivation systems (Fig. 3). Meanwhile, as a result of the relatively high moisture of the planting media in the floating culture, cow manure already affects the texture and structure of the media at lower doses (Elisabeth *et al.*, 2013; Gudugi, 2013; Ekwealor *et al.*, 2020; Wisdom *et al.*, 2021).

SPAD value

In this study, the parameter of leaf greenness - which serves as an indicator for chlorophyll content - was quantified using the SPAD tool without damaging the leaves measured from the second to the eighth week. At 4 and 6 WAP, the culture technique treatment significantly affected the SPAD value but had no significant effect at 2 and 8 WAP. Shallots cultivated in the floating system were recorded to have higher values at 2, 4 and 6 WAP (77.69±2.69, 64.10± 4.41 and 48.18 ± 1.25, respectively) compared to those in the conventional system (74.68±3.08, 48.18±1.25 and 48.79±1.43). However, at 8 WAP, the SPAD value in the conventional system was higher than in the floating system (44.78±1.33 vs. 43.22±4.48). The SPAD value of the two cultivation techniques was at its highest at 2 WAP and then continued to decrease until 8 WAP. In comparison to other models, the polynomial model's regression analysis of the SPAD value in the shallot cultivation resulted in the largest determination coefficient (R^2), which is close to 1: 0.9123 for the conventional system and 0.9618 for the floating system. The magni-

Table 1 - Leaf length (cm) and leaf number of shallot with the application of cow manure (ton/ha) in different farming practices

Treatment	Weeks after planting (WAP)							
	1	2	3	4	5	6	7	8
Farming practice	*Leaf length (cm)*							
Conventional	11.67 ± 0.66 a	26.60 ± 0.79 a	36.43 ± 1.03 a	40.32 ± 1.45 a	40.43 ± 1.69 a	38.39 ± 1.71 a	38.39 ± 1.66 a	36.09 ± 1.95 a
Floating	8.28 ± 0.32 b	20.04 ± 0.56 b	27.58 ± 1.09 b	30.47 ± 1.43 b	29.45 ± 1.90 b	26.66 ± 2.08 b	25.66 ± 1.82 b	24.88 ± 1.76 b
Significance	**	**	**	**	**	**	**	**
LSD0.05	1.516	1.375	2.209	1.961	1.992	2.208	2.536	
	4.549							
	Leaf number							
Conventional	7.83 ± 0.39 a	12.38 ± 0.43 a	17.78 ± 0.69 a	22.13 ± 0.93	23.39 ± 1.33	25.69 ± 1.50	26.00 ± 1.43	23.64 ± 1.21
Floating	5.88 ± 0.21 b	10.38 ± 0.47 b	15.66 ± 0.61 b	20.94 ± 1.25	24.33 ± 1.92	25.25 ± 2.15	23.61 ± 2.06	20.03 ± 1.91
Significance	**	**	*	ns	ns	ns	ns	ns
LSD0.05	0.777	1.303	1.548	2.479	2.929	3.831	4.679	4.567
Cow manure (ton/ha)	*Leaf length (cm)*							
P_0 (0)	9.31 ± 0.90	21.37 ± 1.74 b	27.53 ± 2.37 b	29.07 ± 2.54 b	26.80 ± 2.99 c	24.83 ± 3.09 c	25.61 ± 3.07 c	25.24 ± 2.96 b
P_1 (10)	10.19 ± 1.23	22.09 ± 1.24 b	30.71 ± 1.86 a	33.59 ± 2.21 b	32.72 ± 2.64 b	29.26 ± 3.12 b	29.86 ± 3.00 b	30.29 ± 2.58 b
P_2 (15)	9.54 ± 0.87	25.30 ± 1.58 a	35.52 ± 1.81 a	39.69 ± 1.74 a	40.06 ± 1.69 a	38.93 ± 1.33 a	37.84 ± 1.34 a	37.16 ± 1.80 a
P_3 (20)	10.86 ± 1.12	24.52 ± 1.89 a	34.26 ± 2.31 a	39.23 ± 2.82 a	40.19 ± 2.96 a	37.10 ± 3.46 a	34.76 ± 4.63 a	29.27 ± 4.69 b
Significance	ns	**	**	**	**	**	**	*
LSD0.05	2.144	1.945	2.189	2.773	2.817	3.122	3.587	6.434
	Leaf number							
P_0 (0)	6.00 ± 0.40 b	10.33 ± 0.31	14.33 ± 0.41 b	17.55 ± 0.62 b	17.72 ± 0.88 c	19.50 ± 1.64 c	20.50 ± 2.11 b	19.39 ± 2.28
P_1 (10)	6.94 ± 0.59 ab	11.33 ± 1.06	16.78 ± 1.11 a	20.39 ± 1.12 b	22.50 ± 1.32 b	25.99 ± 1.47 b	26.28 ± 2.09 ab	23.11 ± 2.04
P_2 (15)	6.72 ± 0.58 ab	11.39 ± 0.76	17.22 ± 0.99 a	24.00 ± 1.59 a	29.05 ± 2.38 a	31.78 ± 2.65 a	29.67 ± 2.39 b	25.94 ± 1.88
P_3 (20)	7.78 ± 0.68 a	12.50 ± 0.55	18.55 ± 0.59 a	24.22 ± 0.80 a	26.16 ± 1.32 ab	24.61 ± 1.78 bc	22.78 ± 2.14 b	18.89 ± 2.36
Significance	*	ns	**	**	**	**	*	ns

Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD 0.05.

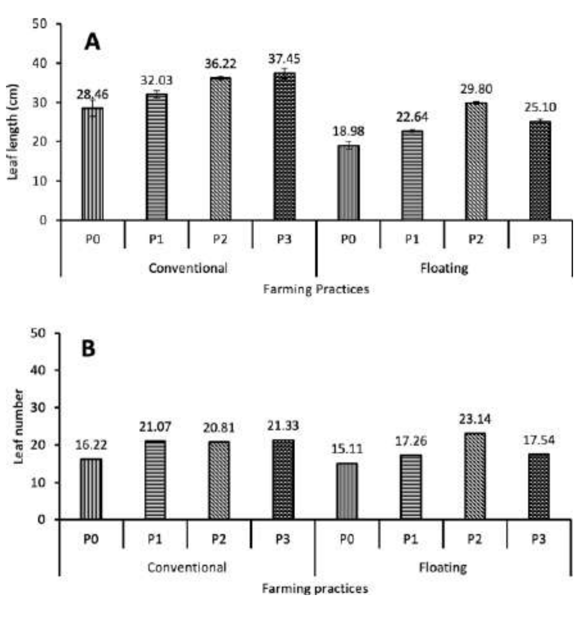

Fig. 3 - Effect of cow manure dosage on leaf length (A) and leaf number (B) in the different farming practices.

tude of the R^2 value indicates that the SPAD value is affected by the cultivation technique in a quadratic manner, increasing until it reaches the peak before starting to decline (Table 2). A study on corn resulted in a similar result, where the SPAD values would decrease after reaching their peak, mostly affected by the environment (Ghozali, 2016; Kandel, 2020; Szulc *et al.*, 2021).

The higher SPAD values in the floating system, especially at 4 and 6 WAP, indicated that the photosynthesis process is going well due to sufficient water availability. In contrast, if there is a deficit of water (moisture stress), photosynthetic activity will be reduced due to chlorophyll damage (Pallavolu *et al.*, 2023). The research results of Ai Nio *et al.* (2019) showed that the water deficit induced by PEG 8000 with media water potential (WP) -0.25 and -0.5 MPa reduced the total leaf chlorophyll content, leaf chlorophyll *a* and leaf chlorophyll *b*.

This study also found that the increase in cow manure dosage increases the SPAD value, with the

Table 2 - Regression analysis correlations of the SPAD value with several mathematical models of farming practices using different doses of cow manure

Farming practice	Linear model $y = ax + b$	Logarithmic model $y = a \ln x + b$	Polynomial model $y = ax^2 + bx + c$	Power model $y = ax^b$
Conventional	$y = -8.9073x + 76.38$	$y = -21.1\ln(x) + 70.877$	$y = 5.6238x^2 - 37.026x +$	$y = 70.35x^{0.357}$
	$R^2 = 0.6917$	$R^2 = 0.8417$	$R^2 = 0.9123$	$R^2 = 0.8842$
	$r = 0.8316$**	$r = 0.9174$**	$r = 0.9551$**	$r = 0.9432$**
Floating	$y = -10.769x + 88.122$	$y = -22.56\ln(x) + 79.122$	$y = -0.7451x^2 - 7.0429x +$	$y = 80.712x^{0.375}$
	$R^2 = 0.9581$	$R^2 = 0.9116$	$R^2 = 0.9618$	$R^2 = 0.8804$
	$r = 0.9788$**	$r = 0.9547$**	$r = 0.9807$**	$r = 0.9383$**

** Significant difference at $p < 0.05$.

highest SPAD value of 82.54 obtained in the P_3 treatment and the lowest (31.21) in the P_0 treatment. The SPAD value has been widely used to estimate the chlorophyll content of other crops, such as tomatoes (Jiang *et al.*, 2017). Furthermore, the application of cow manure could also increase leaf chlorophyll, as indicated by the SPAD value in wheat and rice plants (Shah *et al.*, 2017; Atman *et al.*, 2018). The combination of cultivation techniques and cow manure treatments resulted in no significant effect at 2 and 8 WAP, a significant effect at 4 WAP and a highly significant effect at 6 WAP. The highest SPAD values were obtained in the floating cultivation with a cow manure dose of 20 ton/ha: 77.01 ± 5.35 at 4 WAP and 75.11 ± 3.96 at 6 WAP (Table 3).

Bulb number, bulb diameter (mm) and weight of fresh and air-dried bulbs (g)

The yield components include the number of bulbs, bulb diameter and weight for both fresh and

Table 3 - The SPAD value of shallot in different farming practices with the application of cow manure

Treatment	SPAD value			
	2 WAP	4 WAP	6 WAP	8 WAP
Farming practice				
Conventional	74.68 ± 3.08	48.18 ± 1.25 b	48.79 ± 1.43 b	44.78 ± 1.33
Floating	77.69 ± 2.88	64.10 ± 4.41 a	59.78 ± 4.55 a	43.22 ± 4.48
Significance	NS	**	**	ns
LSD value	7.996	6.040	4.381	4.615
Cow manure (ton/ha)				
P_0 (0)	68.16 ± 2.38	45.31 ± 2.88 c	40.90 ± 2.71 c	31.21 ± 4.08 c
P_1 (10)	75.74 ± 5.19	58.48 ± 5.77 ab	56.21 ± 4.35 b	44.61 ± 2.93 b
P_2 (15)	78.27 ± 4.09	55.78 ± 4.94 b	55.98 ± 3.73 b	46.60 ± 2.09 b
P_3 (20)	82.54 ± 2.98	65.00 ± 6.08 a	64.04 ± 5.28 a	53.60 ± 3.80 a
Significance	NS	**	**	**
LSD value	11.307	8.542	6.197	6.527
Farming practice x Cow manure (ton/ha)				
Conventional x P_0	68.47 ± 5.10	46.81 ± 1.43 b	43.29 ± 3.72 ef	39.69 ± 3.16 c
Conventional x P_1	74.13 ± 10.00	46.93 ± 1.68 b	48.02 ± 1.74 de	43.42 ± 10.00 bc
Conventional x P_2	74.01 ± 4.26	46.00 ± 1.36 b	50.87 ± 0.68 bc	46.57 ± 4.26 bc
Conventional x P_3	82.13 ± 4.21	52.99 ± 3.47 b	52.98 ± 1.17 cd	49.46 ± 4.21 ab
Floating x P_0	67.86 ± 1.46	43.81 ± 6.11 b	38.52 ± 4.15 f	22.73 ± 1.46 d
Floating x P_1	77.37 ± 5.68	70.03 ± 5.53 a	64.41 ± 4.95 b	45.81 ± 5.68 bc
Floating x P_2	82.54 ± 6.90	65.56 ± 4.94 a	61.10 ± 6.57 bc	46.63 ± 6.90 bc
Floating x P_3	82.97 ± 5.15	77.01 ± 5.35 a	75.11 ± 3.96 a	57.73 ± 5.15 a
Significance	NS	*	**	NS
LSD value	15.991	12.081	8.763	9.231

WAP= Week after planting.
Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD 0.05.

air-dried bulbs. The farming practice had no significant impact on the quantity of bulbs but a very significant impact on the weight of fresh and air-dried bulb and the bulb diameter. The conventional method produced the greatest number of bulbs, whereas floating cultivation produced the best results in terms of bulb diameter and weight of fresh and air-dried bulbs. The growing media conditions strongly affected how the bulbs were initially formed. Since water was constantly accessible from beneath the growing media through capillaries, floating cultivation used growing media that were somewhat moist. There was also intense rainfall during early growth of the shallots, causing the planting media to be very wet. There were about 7.78 ± 0.35 bulbs formed in conventional cultivation and 7.75 ± 0.33 in the floating cultivation. However, the number of bulbs was not linearly correlated with the greater dose of cow manure applied, as the largest number of bulbs was obtained at a dose of 15 ton/ha (Table 4). The largest numbers of bulbs (8.33 in conventional cultivation and 8.22 in floating cultivation) were obtained from the same manure treatment, which was P_2. The lowest numbers (6.78 in conventional cultivation and 6.67 in floating cultivation) were also obtained from the same manure treatment, P_0. Plant growth can thus be supported by appropriate cultivation methods (Khorasgani and Pessarakli, 2019; Cahyaningrum *et al.*, 2023).

The average diameter of bulbs grown using floating cultivation was 23.51 ± 1.29 mm, which is much larger than the 20.62 ± 1.62 mm average diameter of bulbs grown using conventional cultivation (Fig. 4). The largest diameter of bulbs produced as a result of cow manure application was at a dose of 15 ton/ha, and the lowest was at 0 ton/ha (Table 4). Based on the combination of treatments, P_2 treatment (15 ton/ha) in floating cultivation produced the largest bulb diameter of 30.78 mm, and P_3 treatment (20 ton/ha) in conventional cultivation produced the largest bulb diameter of 25.36 mm. The two cultivation methods produced the smallest bulb diameters in the same treatment, P_0 (0 ton/ha), with the conventional system producing a diameter of 15.22 mm

Table 4 - Shallot yield components for different farming practices with the application of cow manure

Treatment	Number of bulbs	Diameter of bulb (cm)	Fresh weight of bulb (g)	Air-dried weight of bulb (g)
Farming practice				
Conventional	7.78 ± 0.35	20.62 ± 1.76 b	35.36 ± 6.14 b	26.79 ± 5.64 b
Floating	7.75 ± 0.33	23.51 ± 1.29 a	42.33 ± 3.52 a	35.69 ± 2.94 a
Significance	NS	**	*	**
LSD value	1.016	1.741	6.419	4.703
Cow manure				
P_0 (0)	7.44 ± 0,45	15.44 ± 0.77 c	20.57 ± 2.85 c	14.71 ± 2.12 d
P_1 (10)	7.44 ± 0.50	19.88 ± 0.84 b	34.46 ± 2.36 b	25.64 ± 1.49 c
P_2 (15)	8.28 ± 0.53	27.10 ± 1.74 a	58.24 ± 7.76 a	48.22 ± 7.75 a
P_3 (20)	7.89 ± 0.44	25.84 ± 0.81 a	42.11 ± 2.94 b	36.39 ± 1.84 b
Significance	NS	**	**	**
LSD value	1.437	2.461	9.078	6.651
Farming practice x Cow manure				
Conventional x P_0	6.78 ± 0.72	15.22 ± 1.40 e	19.58 ± 4.90 e	13.15 ± 3.18 f
Conventional x P_1	8.22 ± 0.58	18.49 ± 0.98 de	33.01 ± 3.72 cd	24.57 ± 1.99 de
Conventional x P_2	8.33 ± 0.76	23.43 ± 0.81 bc	42.08 ± 1.87 bc	31.61 ± 0.73 bcd
Conventional x P_3	7.78 ± 0.44	25.36 ± 1.03 b	46.77 ± 4.21 b	37.84 ± 0.89 b
Floating x P_0	8.11 ± 0.22	15.66 ± 0.99 e	21.57 ± 3.95 de	16.28 ± 3.15 ef
Floating x P_1	6.67 ± 0.57	21.28 ± 0.80 cd	35.92 ± 3.45 bc	26.71 ± 2.44 cd
Floating x P_2	8.22 ± 0.90	30.77 ± 1.02 a	74.40 ± 6.05 a	64.82 ± 4.92 a
Floating x P_3	8.00 ± 0.88	26.32 ± 1.40 b	37.45 ± 1.96 b	34.96 ± 2.56 b
Significance	NS	*	**	**
LSD value	2.032	3.481	12.838	9.406

WAP= Week after planting.
Data represent the mean and standard error. Values followed by different letters within each column indicate a significant difference at LSD 0.05.

Fig. 4 - Shallot bulbs produced by the conventional (A) and floating (B) systems with the application of cow manure.

and the floating system a diameter of 15.66 mm. The high bulb diameter in the floating culture was greatly supported by the conditions of the growing media, where during the growth stages the rainfall continued to decline, so the media in floating culture was not saturated with water and oxygen was still available. Nutrient absorption, water uptake and root respiration are all affected by oxygen availability, which is a crucial component for plant growth. The use of biological fertilizers or a combination of biological and organic fertilizers can increase the shallot bulb diameter compared to controls (Neira *et al*., 2015; Xiong *et al*., 2015; Purba *et al*., 2020; Widyastuti *et al.*, 2021).

Shallot production is highly dependent on the weight of fresh and air-dried bulbs. The floating cultivation system yielded the greatest average data, which was significantly different from conventional cultivation (42.33±3.52 g *vs*. 35.69±2.94 g (Table 4). According to Jaya *et al.* (2019), the availability of water below the plant media in the floating system significantly promotes plant growth and yield. Based on the results, conventional farming required a higher dosage of cow manure (20 ton/ha) compared to floating farming, which required only 15 ton/ha. In terms of cost and bulb production, Paputri *et al*. (2016) found that a cow manure dose of 20 ton/ha was economically feasible. However, Arzad *et al.* (2017) found that mustard plants needed up to 25 ton/ha of cow manure.

The estimated production per hectare was calculated using data on air-dried bulb weight under the assumption of a planting space of 20 cm x 20 cm. The highest estimated production was obtained in the floating system from P_2 treatment with 21.61 ton/ha, while the highest production in the conventional system was from P_3 treatment with 12.61 ton/ha. The P_0 treatment had the lowest estimated yield, at 4.38 and 5.43 ton/ha in the conventional and floating cultivation systems, respectively (Fig. 5).

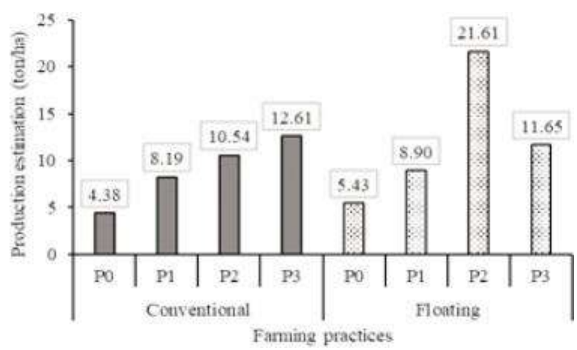

Fig. 5 - Estimated production of shallot from different farming practices with the application of cow manure.

Based on the results, it was concluded that the Bima Brebes shallot variety has the potential to be cultivated using the floating technique with the application of 15 ton/ha cow manure, as seen from production estimation reaching 21.61 tons of dry bulb, which is higher than the 9.9 ton/ha of dry bulb reported by the Ministry of Agriculture (2019). Based on this large potential yield, further research has been carried out again in 2023 to obtain more accurate production data. The results obtained will be the basis for considering recommendations for floating shallot development.

Acknowledgements

We would like to express our sincere gratitude to our research team and colleagues at the Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya, for their helpful feedback and valuable support for our research.

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