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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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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-

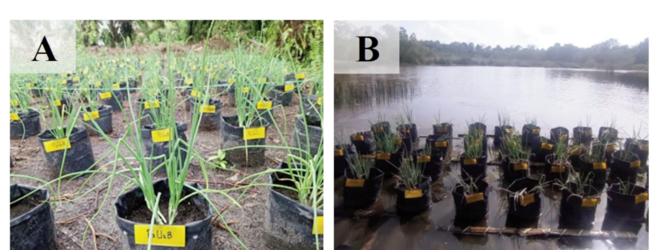

Fig. 1 - Non-floating (A) and floating (B) farming practices of shallot cultivation.

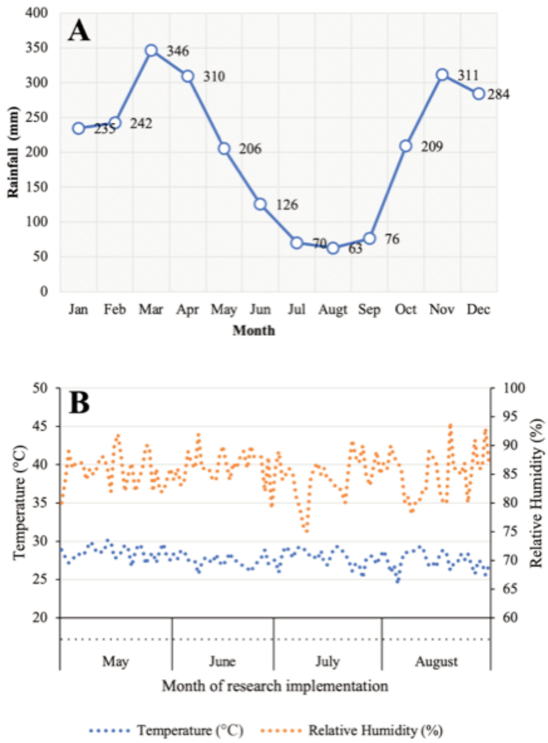

Fig. 2 - Typical agroclimatic conditions at the outdoor research facilities: (A) rainfall; (B) temperature and relative humidity. Source: https://www.bmkg.go.id.

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 $p \leq 0.05$ 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; 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.

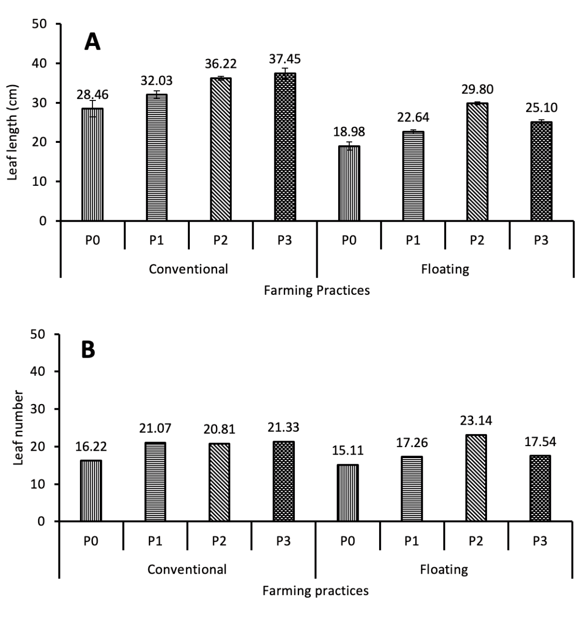

Fig. 3 - Effect of cow manure dosage on leaf length (A) and leaf number (B) in the different farming practices.

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 = ax² + 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).

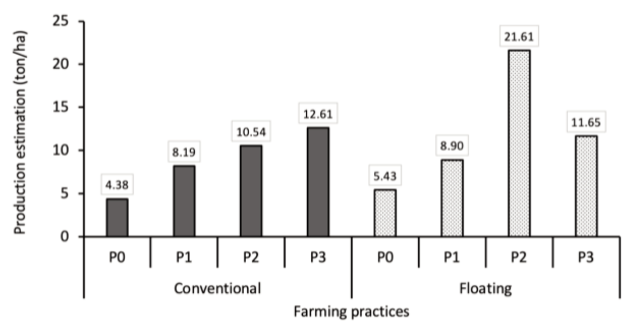

Fig. 5 - Estimated production of shallot from different farming practices with the application of cow manure.

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.

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