YIELD OF SHALLOT (*ALLIUM CEPA VAR. AGGREGATUM L.*) FROM DIFFERENT HARVESTING AGE

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ABSTRACT

This experiment was conducted to evaluate the influence of different harvest timings on shallot yield and bulb characteristics, focusing on the Indian Variety, and to provide insights into optimizing shallot cultivation practices. The experiment was carried out at MARDI Serdang, employing a randomized complete block design with four replications. Consumption bulbs of the Indian Variety were harvested at five different time points: 45, 55, 65, 75, and 85 Days After Planting (DAP). Data analysis was performed using SAS version 9.4, with Duncan New Multiple Range Test (DNMRT) for specific differences. The highest yield was recorded at 65 DAP, with a dried bulb weight of 13.3 kg per plot, equivalent to 6.6 tons per hectare (t/ha). Harvesting before 65 DAP resulted in diminished yields due to bulbs still in the growing stage or delayed germination. Harvesting beyond 65 DAP also led to reduced yields, primarily caused by an increased number of rotten bulbs. Furthermore, the study revealed that the harvested shallots could be categorized into two types: single and aggregate bulbs, with each type constituting approximately 50% of the total. Single bulbs were larger than aggregate bulbs, and the 75 DAP and 65 DAP harvests produced the heaviest and widest bulbs for both categories. The findings suggest that Indian Variety shallots are best harvested at 65 DAP to achieve optimal yields. Harvesting before or after this critical period significantly impacts yield. Additionally, the use of consumption bulbs as planting material may result in the development of two distinct bulb types: aggregate and single bulbs. This study provides valuable insights into shallot cultivation practices and can guide efforts to enhance shallot production and food security.

Keywords: *yield performance, shallot, bulb, harvest timing*

INTRODUCTION

Shallots, scientifically known as *Allium cepa* L. var. *aggregatum* G. Don, are a bulbous herb belonging to the Alliaceae family (Simpson, 2010). Distinguished by their basal, slender leaves, umbrella-like inflorescence arrangement, and typically superior ovary, they are informally referred to as ever-ready onions, multiplier onions, and potato onions. In Malaysia, they are commonly known as "bawang merah." The term "aggregatum" in their scientific name aptly signifies their unique trait of producing multiple bulbs through splitting or multiplying (UPOV, 2008).

Shallots are believed to have originated in Central Asia, specifically between Turkmenistan and Afghanistan, with wild species like *A. vavilovii*, *A. asarense* and *A. oschaninii* O. Fedtsch considered as precursors to *A. cepa* (Messiaen & Rouamba, 2004). Over time, cultivated shallots spread to various regions, including Mesopotamia, Egypt, India, and Southeast Asia. Historically, shallots were introduced to Egypt from their native region and subsequently found their way to the Mediterranean area. From there, they disseminated throughout the Roman Empire (Messiaen & Rouamba, 2004).

Beyond their historical significance, shallots are renowned for their role as a prominent food flavouring agent encompass a rich nutritional profile. A 100g serving of shallots provides various essential nutrients, including calcium (3% of the daily value), iron (7% DV), magnesium (5% DV), phosphorus (5% DV), potassium (7% DV), zinc (4% DV), and folate (9% DV). Moreover, shallots are rich in antioxidant compounds such as quercetin, kaempferol and allicin (Panoff, 2019). Quercetin, found in shallots, acts as a natural antihistamine, modulating inflammation and enhancing immune response (Li et al., 2016). Kaempferol, another phytochemical present in shallots, exhibits anti-inflammatory properties and demonstrates potential as an anticancer agent at higher concentrations (Kim & Choi, 2013). Additionally, allicin derived from shallots is associated with the reduction of glucose levels, cholesterol, and blood pressure, conferring several health benefits (Garcia Trejo et al., 2016). Incorporating shallots into diets not only enhances culinary experiences but also provides a valuable source of these health-promoting bioactive compounds, emphasizing their significance in health-conscious dietary practices.

Shallots is adaptable to various soil types, provided the soil is enriched with organic matter, well-drained, adequately moist and fertile, with a pH range of 5.5 to 7.0 (Iannotti, 2022). Shallots can be grown from either sets (young, underdeveloped bulbs from the previous planting, typically grown from seeds) or bulbs obtained from the market. Sets are favoured for their quicker results, while the practice of using market-sourced bulbs or consumption bulb is widespread, especially in regions like Asia, where professional set producers are relatively scarce. Shallots grown from seeds generally produce fewer bulbs, typically ranging from 1 to 3 per plant, while those grown from bulbs yield a greater quantity, usually falling within the range of 8 to 12 bulbs per bunch (Melchor, 2020). Shallots typically mature 75 to 85 days after planting (DAP), with the optimal harvest time indicated by yellowing and natural shedding of leaves (Iannotti, 2022; Melchor, 2020).

Malaysia relies entirely on imports for its onion and shallot supply. In 2021, the country imported USD 207.07 million worth of shallots, totalling 484.87 million metric tons in volume. The primary sources of these imports were India (contributing 37.3%), Pakistan (28.6%), the Netherlands (12%) and China (7%) (Tridge, 2023). However, despite being an importer, many Southeast Asian countries, including Malaysia, have the potential to cultivate shallots domestically. Large-scale shallot farming has not been extensively adopted in Malaysia due to the high production costs, including expenses related to agricultural inputs and labor. As a result, importing onions and shallots has been more economically viable. However, recent global developments, such as the Covid-19 pandemic, the Russian-Ukraine conflict, and erratic weather patterns, have disrupted agricultural imports, eroding their affordability and reliability. For instance, in 2020, due to the Covid-19 pandemic and floods in India, shallot supplies to Malaysia were disrupted, leading to a price surge to RM13 per kg, compared to the previous range of RM5-7 per kg (Nor Fazlina et al., 2020). Although prices have since stabilized at around RM5.50 per kg (FAMA, 2023), ensuring domestic shallot cultivation in Malaysia is essential for the country's food security.

In response to these challenges, efforts are underway to encourage shallot cultivation within Malaysia. One such effort is research conducted by the Malaysian Agricultural Research and Development Institute (MARDI) during the 12th Malaysia Plan. This research focused on the impact of harvest timing on shallot yield, with the aim of formulating guidelines for optimal harvest timing.

MATERIALS AND METHODS

The experiment was conducted at MARDI Serdang from August to December 2022. For this study, Indian Shallot bulbs, which were readily available in local markets, were used as the planting material. This particular variety was chosen because it has previously demonstrated good performance in the lowland agroclimatic conditions of Malaysia, as reported by Wan Rozita et al. in 2022.

The experiment was organized following a randomized complete block design with four replications. A total of 20 beds, each measuring 20 meters in length and 1 meter in width, were utilized for this study. Each age at harvest treatment was allocated to four beds as separate replications. Shallots were planted in four rows on each bed, with a spacing of 15cm x 15cm between individual plants. Each planting hole was occupied by a single bulb.

In this experiment, each plant received 10 grams of NPK 15:15:15 fertilizer two weeks after being planted. Additionally, organic foliar fertilizer was applied every two weeks, and at 25 days after planting (DAP), 5 grams of organic fertilizer were given to each plant. The experimental plot was irrigated daily using a drip irrigation system. To control diseases, Mancozeb or Propineb fungicide sprays were applied as early as the first week after planting and repeated as needed.

Harvesting of shallots was carried out at specific time intervals: 45 days after planting (DAP), 55 DAP, 65 DAP, 75 DAP, and 85 DAP. For each replication, the entire plant's fresh weight was measured and then converted to tons per hectare. The harvested bulbs were categorized into four groups: single bulbs, aggregate bulbs, rotten bulbs, and slow-germinating bulbs. The percentage of bulbs in each category was calculated. Subsequently, the harvested shallots were air-dried in a rain shelter structure until all the wilted leaves turned brown. Once fully dried, the total dry weight of bulbs, including leaves and excluding leaves, was recorded. Further data, such as individual bulb dry weight, length, and width, were collected from ten randomly selected bulbs for both single and aggregate bulb categories within each replication. For aggregate bulbs, data were recorded for individual cloves rather than as bunches because cloves tend to separate during storage.

Statistical analysis was performed using the Proc GLM procedures of SAS version 9.4, and a post hoc test was conducted using the Duncan New Multiple Range Test (DNMRT) to assess specific differences between pairs of means.

RESULTS AND DISCUSSION

Fresh yield, dry yield and bulb category

The analysis of variance revealed that the timing of harvesting, measured in days after planting (DAP), had a highly significant impact ($\rho < 0.01$) on various aspects of shallot yield and yield categories. Specifically, it had a significant effect on fresh yield per plot, dry yield per plot, dried bulb yield per plot, fresh yield per hectare, dry yield per hectare, dried bulb yield per hectare, the percentage of aggregate bulb production, the percentage of rotten bulbs, and the percentage of non-germinated bulbs. Additionally, there was a significant difference ($\rho < 0.05$) observed in the percentage of single bulb production across different harvesting times.

The table below summarizes the results of the analysis of variance for yield performance and yield categories in relation to the five harvesting ages of shallots:

Table 1: Analysis of variance for yield performance and yield category in five harvesting age of shallot

Data	Means square		
	Bulb age (df = 4)	Replication (df = 3)	Error (df = 12)
Fresh yield/plot	208.5**	4.2	6.7
Dry yield/plot	106.7**	1.8	1.8
Dried bulb yield/plot	94.7**	1.7	1.7
Fresh yield/hectare	52131437.5**	1059500.0	1672937.5
Dry yield/hectare	26677183.1**	450218.3	451409.0
Dried bulb yield / hectare	23677491.87**	414423.33	419574.4
% of single bulb	225.6*	32.3	43.2
% of aggregate bulb	529.8**	67.1	54.2
% of rotten bulb	1115.3**	14.8	35.2
% of non-germinated bulb	281.3**	26.3	26.0

*Significant at 0.05 level, ** Significant at 0.01 level

Fresh yield

The "fresh yield per plot" refers to the total weight of the entire crop, including the bulbs, leaves, and roots, immediately after harvest. The data showed that this yield increased from 13 kg at 45 days after planting (DAP) to 29 kg at 65 DAP harvest. When converted to hectares, this corresponds to a range of 6.3 tons per hectare (ha) to 14.6 tons/ha for the 45 DAP and 65 DAP harvests, respectively. However, the yield per plot began to decrease at the 75 DAP harvest, where it measured 24 kg, and further dropped to 13 kg per plot for the 85 DAP harvest. This translates to 12 tons/ha and 6.7 tons/ha, respectively (Table 2).

Dry yield

The "dry yield" refers to the weight of the entire plant after it has been dried, while "dried bulb" specifically pertains to the weight of the bulb and roots that remain after drying, with the leaves removed. Both dry yield and dried bulb exhibited a similar pattern to that of fresh yield. For instance, at the 45-day after planting (DAP) harvest, the dry yield per plot measured 3.8 kg, and after the leaves were removed, the weight of the bulb was 3 kg. When converted to hectares, this equates to 1.9 tons per hectare (ha) for dry yield and 1.5 tons/ha for the dried bulb, respectively. The highest dry yield per plot was achieved at the 65 DAP harvest, reaching 14 kg per plot (equivalent to 7.1 tons/ha). After the leaves were removed, this value decreased to 13.3 kg per plot (6.7 tons/ha) (Table 2).

Table 2: Yield performance and harvest category of five harvesting age in shallot

DAP	Mean					
	FY/plot (kg)	**DY/plot (kg)**	**DB/ plot (kg)**	**FY/ha (ton)**	**DY/ha (ton)**	**DB/ha (ton)**
45	12.78 c	3.79 c	3.06 c	6.4 c	1.9 c	1.5 c
55	22.95b	8.28 b	7.51 b	11.5 b	4.1 b	3.8 b
65	29.18 a	14.10 a	13.32 a	14.6 a	7.1 a	6.7 a
75	24.65b	9.11 b	7.68 b	12.3 b	4.6 b	3.8 b
85	13.40c	0.67 d	0.67 d	6.7 c	0.3 d	0.3 d
Mean	20.59	7.18	6.45	10295.0	3.6	3.2
CV	12.6	18.7	20.1	12.56	18.7	20.09

Means with different letter within same column are significantly different at < 0.05 according to DNMRT
FY/plot: Fresh yield per plot, DY/plot: Dry yield per plot, DB/plot: dried bulb per plot, FY/ha: Fresh yield per hectare, DY/Ha: Dry yield/ha, DB/ha: dry bulb per hectare.

The yield of shallots is influenced by a variety of factors, including fertilization, the duration of seed storage, the type of planting materials used, environmental conditions, and the specific variety being cultivated. A study conducted by Sinaga et al. in 2021 found that the duration of seed storage significantly affects shallot yield. The study revealed that the maximum storage period for planting materials was 5 months, with a substantial reduction in yield observed after storage periods of 6 months or longer. Triharyanti and Purnomo, in their research in 2020, reported that different types of planting materials can result in varying yields. Tuber aerial plant material showed the highest potential yield, reaching up to 17.1 tons per hectare (t/ha), followed by in vitro culture at 15.3 t/ha and true shallot seed (TSS) at 9.9 t/ha.

At the 65-day after planting (DAP) stage, the dry bulb yield per hectare was found to be 6.6 t/ha, a range that aligns with findings by Lee (no publication date provided). It's important to note that different shallot varieties exhibit distinct performance characteristics, which can also be influenced by local environmental factors. For instance, in Vietnam, fresh shallot yields have been reported to range from 12 t/ha to 17 t/ha, as stated by Agridecovietnam in 2016. A study conducted in West Sumatra, Indonesia, as reported in 2021 by Atman et al., showed varying dry bulb yields for different varieties. The Lokananta variety achieved a yield of up to 10 t/ha, while Sanren yielded 6.7 t/ha, Bima yielded 6.2 t/ha, and Trisula yielded 8.9 t/ha. Additionally, it's worth noting that the performance of shallots tends to be better in lowland regions compared to highland areas. These findings emphasize the importance of considering multiple factors, including storage duration, planting materials, variety selection, and local conditions, when aiming to optimize shallot yields in agricultural practices.

Bulb category

The harvest performance revealed an interesting observation: not all shallots multiplied; instead, a single bulb type was also identified. These two types exhibited distinct characteristics. The aggregate clove type had a more elongated shape, whereas the single bulb type had a round shape. Additionally, it was noted that the bulb size of the single type appeared larger than the cloves of the aggregate shallots at each harvesting time (Fig. 1).

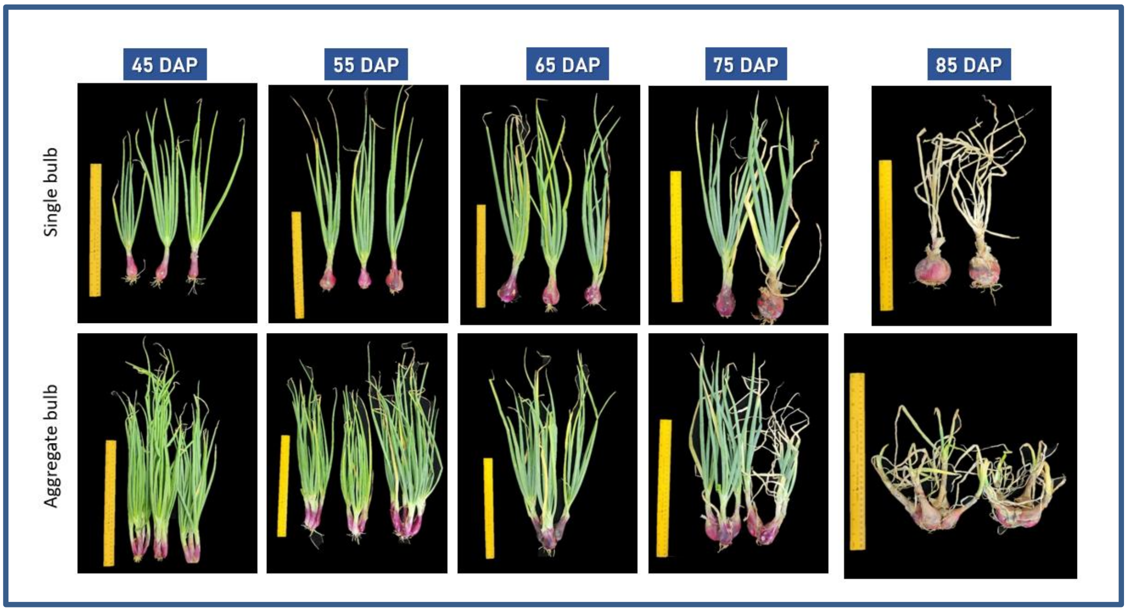

Figure 1: Two shallot types obtained from Indian Shallot Variety at several harvesting time.

At the point of optimum yield (65DAP), both aggregate and single bulb types were produced in equal proportions, each accounting for 50% of the total. Before that, at the 45-day after planting (DAP) harvest, the distribution was different. Approximately 19.9% of the bulbs had not yet germinated, 38.7% were of the single bulb type, 31.8% were aggregate bulbs, and 9.5% were found to be rotten. By the time of the 55 DAP harvest, around 53% of the bulbs were of the aggregate bulb type, while approximately 34.1% were single bulbs. The percentage of rotten and damaged bulbs was minimal, at about 3.5%, and the number of bulbs that had not germinated decreased to 10.3%.

Similar trends persisted in the 65 DAP and 75 DAP harvests, where the percentages of aggregate and single bulb types remained balanced at around 50% each. However, the occurrence of rotten bulbs increased from 2.3% at the 75 DAP harvest to a significant 40.6% at the 85 DAP harvest. This increase in rotten bulbs was attributed to the elevated rainfall during the December 2023 harvest period.

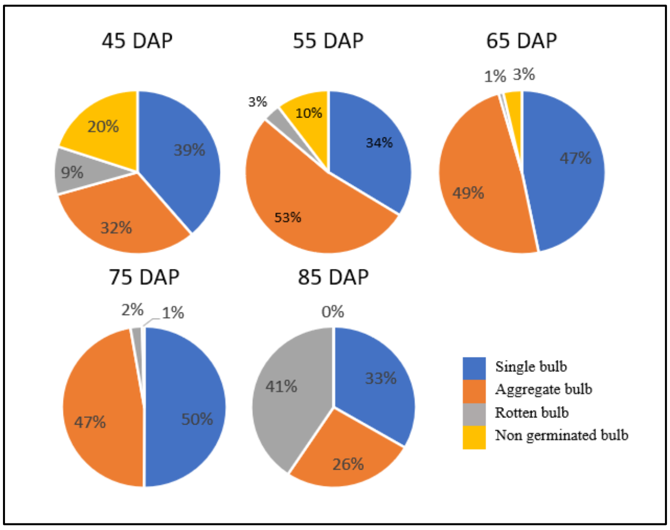

Figure 2: Four bulbs' categories from different harvesting time

The discovery of two distinct types of shallots was unexpected and their equal proportions within the population pointed to a lack of uniformity in the planting materials. Despite being marketed under the same label, it is possible that smaller-grade onions were inadvertently mixed in. Notably, significant differences exist between single shallots and aggregate shallots, with single shallots being larger in size. This difference could be attributed to the absence of competition for nutrients, as each single shallot clove has access to its own nutrient supply, while in a bunch of aggregate cloves, they share nutrients, potentially limiting individual growth.

The germination and cloving behaviour of shallots usually follow a specific pattern but subjected to varieties. For Indian Shallot, germination typically begins around 7 days after planting (DAP) and multiplication or cloving usually occurs between 45 DAP and 50 DAP (MARDI, no publication date provided). Plant materials from consumption bulbs are often treated with growth inhibitors to prevent sprouting (Campbell, 2017), which can potentially impact the germination rate and cloving of the bulbs.

Furthermore, cloving in shallots is influenced by a range of environmental factors, including photoperiod, storage temperature, irrigation, temperature, and soil type. Bulbing in shallots requires exposure to a long photoperiod, typically ranging from 10.5 to 16 hours of light. Additionally, the storage temperature of the bulb plays a role in bulb multiplication. Other contributing factors include night temperatures, irrigation practices, fertilization, and soil type (Kamenetsky and Rabinowitch, 2017).

Regarding bulb characteristics at different harvesting times, the analysis of variance indicated that the age at harvest had a highly significant effect ($\rho < 0.01$) on various characteristics of shallots, including their dry weight, length, and diameter, for both single and aggregate shallots. Some level of replication effect was observed at the 5% level for bulb dry weight and bulb length in the case of single bulb harvest (Table 3).

Bulb character at different harvesting time

The analysis of variance (ANOVA) revealed that the age at which shallots were harvested had highly significant effect ($\rho < 0.01$) on various characteristics, including the dry weight, length, and diameter of both single and aggregate shallots. Additionally, there was an observed effect of replication at a significance level of 5% for bulb dry weight and bulb length in the case of single bulb harvest (Table 3).

Table 3: Analysis of variance character of single and aggregate bulb at different harvesting day.

		Mean square					
		Single bulb			**Bulb from aggregate shallot**		
Source	**d.f**	**BDW**	**BL**	**BD**	**BDW**	**BL**	**BD**
Bulb age (DAP)	4	23157.24**	6517.31**	8339.39**	13306.70**	6339.60**	7906.14**
Replication	3	670.39*	148.63*	97.35	27.10	5.80	4.15
Error	12	177.84	42.24	42.63	272.72	74.42	91.45

d.f: degree of freedom, *, ** significant at $\rho < 0.05$ and <0.01 respectively
BDW: bulb dry weight, BL: bulb length, BD: bulb diameter
DAP: Days after planting

Bulb dry weight
At the 45-day after planting (DAP) stage, the bulb dry weight for single bulbs was 6.8 grams, while for aggregate shallots, it was only 4.8 grams (Fig. 3). The optimum dry bulb weights were achieved at the 65 DAP and 75 DAP harvests. Specifically, at 65 DAP, the dry weight for single bulbs reached 47.3 grams and for aggregate bulbs, it was 36.5 grams. At the 75 DAP harvest, the dry weight for single bulbs was 48.6 grams, and for aggregate bulbs, it was 35.3 grams.

However, by the time of the 85 DAP harvest, the bulb dry weight had decreased to 29.9 grams for single bulbs and 19.4 grams for aggregate bulbs. The differences in dry weight between these two shallot categories ranged from 12% to 54% across all harvesting times. Nevertheless, in terms of their contribution to the total yield, aggregate shallots played a more significant role as they typically formed 3 to 6 cloves within each bunch, effectively increasing the total yield per plant.

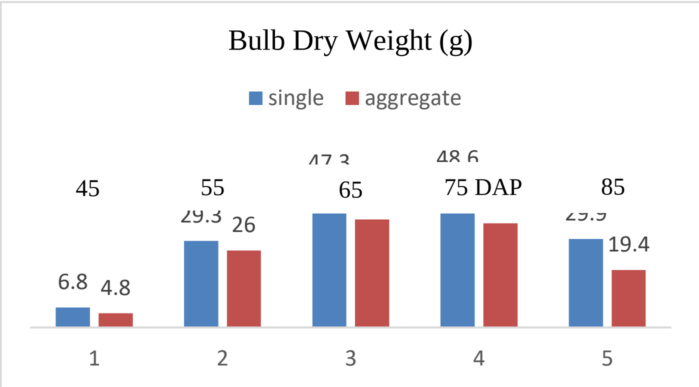

Figure 3: Bulb dry weight of two shallot category harvested at different times (g)

Bulb length.
The length of single bulbs ranged from 21.8 mm to 44.9 mm, while in aggregate form, the bulb length ranged from 20 mm to 42 mm. The longest bulbs for both single and aggregate forms were obtained at the 75-day after planting (DAP) stage, but at 85 DAP, the recorded lengths were lower. This decrease in length at 85 DAP could be attributed to unfavourable weather conditions, particularly heavy rain, which may have affected the size of the shallots. Overall, the difference in length between single bulbs and aggregate bulbs ranged from 0.1% (at 55 DAP) to 4.9% (at 85 DAP) (Fig. 4).

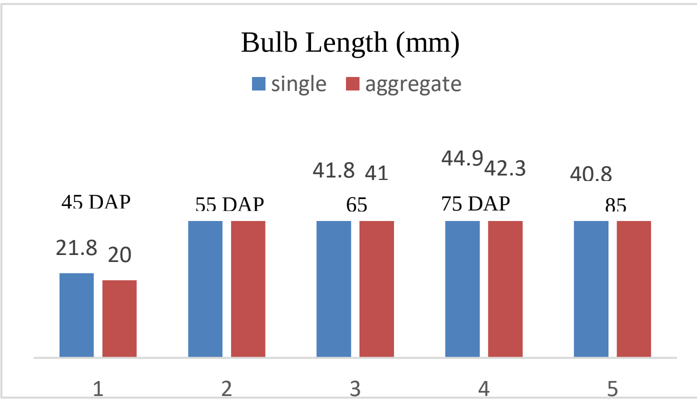

Figure 4: Bulb length (mm) of two shallot categories harvested at different time Dry weight of two shallot category harvested at different times (g)

Bulb diameter
The bulb diameter of single bulbs ranged from 20.3 mm (at 45 days after planting, DAP) to 45.7 mm (at 75 DAP). The bulbs harvested at 65 DAP and 75 DAP had the widest diameters for both shallot categories. Specifically, for single bulbs, the diameters were 44.9 mm and 45.7 mm at 65 DAP and 75 DAP, respectively. For aggregate bulbs, the diameters were 40.6 mm and 40.2 mm at 65 DAP and 75 DAP, respectively (Fig. 5).

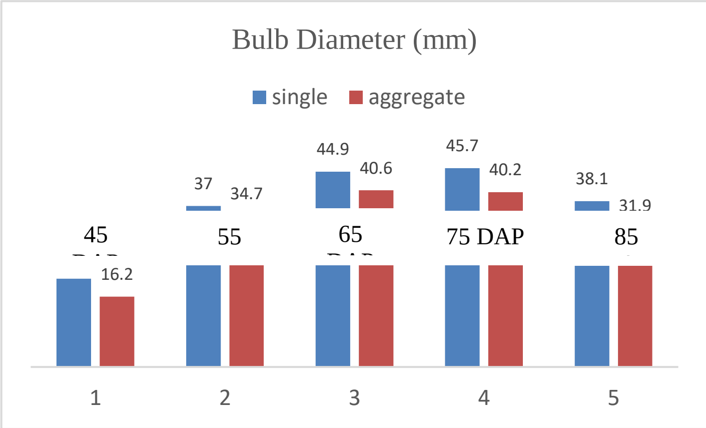

Figure 5: Bulb diameter (mm) of two shallot categories harvested at different times Dry weight of two shallot category harvested at different times (g)

The bulb size obtained in our experiment not only met acceptable standards but consistently fell within the desirable grade range. Starting from the 55th day after planting (DAP), the Indian Shallot Variety examined consistently met the criteria for high-quality shallots. Traditionally, shallot bulbs are categorized based on their size, with specific classifications including:

1. Super grade: Bulbs with a diameter exceeding 25 mm.
2. Grade A bulbs: Bulbs characterized by diameters ranging from 19 to 25 mm.
3. Grade B bulbs: Bulbs exhibiting diameters within the range of 13 to 19 mm (Lee, no publication date provided).

It's important to note that shallots exhibit a range of sizes depending on factors like the variety and environmental conditions. According to the 2018 standards outlined by the United Nations Economic Commission for Europe (UNECE), shallots are typically classified into three common types: round, demi-long, and long. These classifications come with specific size criteria. For round shallots, the accepted size range spans from a minimum of 15 mm to a maximum of 55 mm, while demi-long and long shallots can reach a maximum diameter of 60 mm.

Shallots are recommended for harvest at around 75-85 DAP, as suggested by the Malaysian Agricultural Research and Development Institute (MARDI, no publication date provided). However, this harvesting timeline can vary depending on factors such as the specific variety and environmental conditions. As indicated by Siti Nur Aeni in 2022, the optimal harvest window for shallots can be quite broad, ranging from 50 to 90 DAP, depending on the specific variety and the geographic location of cultivation. Notably, shallots grown in lowland regions tend to mature faster due to higher rates of photosynthesis compared to those in highland areas.

The decision to harvest early offers several advantages, including reduced production costs and decreased vulnerability to pests and diseases. However, it's worth noting that harvesting as early as 45 DAP is impractical. At this stage, the plants are still in the growth phase, and cloving processes have only just begun. Even at the 55 DAP stage, where harvested bulbs show greater stability during storage and larger sizes, they have not yet reached their optimal dimensions, leading to a reduction in total yield. Harvesting at 65 DAP yielded the highest production (6.6 t/ha) with bulb weights ranging from 36.5 g to 47.3 g. The 75 DAP harvest also resulted in good bulb sizes. However, an increased number of rotten bulbs in the field began to affect yield, reducing it to 3.8 t/ha. Delaying the harvest until 85 DAP further decreased the yield to only 0.3 t/ha due to an increased number of rotten bulbs.

The presence of two distinct bulb types could potentially impact grading and marketing, especially in large-scale cultivation scenarios. This variability may be attributed to the use of consumption bulbs, which are readily available and commonly used by small-scale farmers (Siswonto et al., 2022). It's likely that Malaysian farmers new to shallot cultivation will also opt for consumption bulbs due to their ease of availability. Based on our study findings, it's clear that planting materials derived from consumption bulbs can still yield satisfactory results, provided that the plants receive proper care. However, for long-term and consistent cultivation, it's advisable to consider the use of pure planting materials, such as seeds or sets. This approach may lead to more predictable and uniform outcomes in shallot production.

CONCLUSION

This study provides valuable insights into shallot cultivation in Malaysia's lowland areas. It highlights the importance of optimizing harvest timing, with 65 DAP being the most favourable for Indian Shallot consumption bulbs which can achieve a high yield of approximately 6.6 tons per hectare (t/ha). Additionally, the study sheds light on the potential development of two distinct bulb types when using consumption bulbs as planting materials. While consumption bulbs can yield satisfactory results, considering the use of pure planting materials, such as seeds or sets, may offer more consistent and uniform outcomes for long-term cultivation. These findings are essential for enhancing shallot production and food security in Malaysia.

REFFERENCES

1. Agridecovietnam. (2017). Vietnamese Fresh Shallot. https://agridecovietnam.com/vietnamese-fresh-shallot/. Accessed March 25, 2023.
2. Atman, S. I., Anwar, A., & Yasin, S. (2021). Growth and Yield of Different Varieties of True Shallot Seed on Highland in West Sumatra, Indonesia. *International Journal of Agronomy, 2021*, Article ID 5563128. https://doi.org/10.1155/2021/5563128
3. Calica, G. B., & Dulay, M. M. N. (2018). Assessment of the Postharvest Systems and Losses of Shallots in Ilocos, Philippines. *Asian Journal of Postharvest and Mechanization*, 100-116.
4. Campbell, C. (2017). Shallots — A Gourmet Treat. *The Garden Shed Newsletter, 3*(11).
5. FAMA. (2023). Harga Pasaran Terkini. https://www.fama.gov.my/harga-pasaran-terkini. Accessed March 26, 2023.
6. Garcia-Trejo, E. M. A., Arellano-Buendia, A. S., Arguello-Garcia, R., Loredo Mendoza, M. L., Garcia-Arroyo, F. E., Arellano-Mendoza, M. G., Osorio-Alonso, H. (2016). Effects of Allicin on Hypertension and Cardiac Function in Chronic Kidney Disease. *Oxidative Medicine and Cellular Longevity, Volume 2016*, Article ID 3850402. https://doi.org/10.1155/2016/3850402
7. Iannotti, M. (2022). How to Grow Shallot. https://www.thespruce.com/growing-shallots-in-the-vegetable-garden-1403464. Accessed March 25, 2023.
8. Kamenetsky, R., & Rabinowitch, H. D. (2017). Crop System; Bulbing. In *Encyclopedia of Applied Plant Sciences (Second Edition)*, Ed. Bryan Thomas.
9. Kim, S. H., & Choi, K. C. (2013). Anti-cancer Effect and Underlying Mechanism(s) of Kaempferol, a Phytoestrogen, on the Regulation of Apoptosis in Diverse Cancer Cell Models. *Toxicological Research, 29*(4), 229-234.
10. Lee, L. L. (n.d). Shallot. *Department of Agriculture Sarawak*. https://doa.sarawak.gov.my/page-0-0-108-Shallots.html. Accessed March 15, 2023.
11. Li, Y., Yao, J., Han, C., Yang, J., Chaudhry, M. T., Wang, S., ... Yin, Y. (2016). Quercetin, Inflammation, and Immunity. *Nutrients, 8*, 167, 1-14. https://doi.org/10.3390/nu8030167
12. Melchor, O. L. (2020). How to Plant and Grow Shallot. *Gardener's Path*. https://gardenerspath.com/plants/vegetables/grow-shallots. Accessed March 25, 2023.
13. Messiaen, C.-M., & Rouamba, A. (2004). Allium cepa L. In *PROTA4U*. Eds. G.J.H. Grubben & O.A. Denton. http://www.prota4u.org/search.asp. Accessed March 26, 2023.
14. Nor Fazlina A. R., Tuty Haryanti A. R., Siti Sofia M. N., Baharom B., & Asrol A. (2020). Harga-Meningkat-Peniaga-Enggan-Jual-Bawang-Merah-Elak-Beban-Pengguna. https://www.bharian.com.my/berita/nasional/2020/01/645701/harga-meningkat-peniaga-enggan-jual-bawang-merah-elak-beban-pengguna. January 10, 2020.
15. Panoff, L. (2019). What Are Shallots? Nutrition, Benefits, and Substitutes. https://www.healthline.com/nutrition/what-are-shallots.
16. Eddy Triharyanto and Djoko Purnomo. (2020). Yield Potential of Shallots (*Allium cepa L. Aggregatum Group*) from Several Sources of Planting Material in Tropical Region. *J. Agron., 19*(3), 138-144. https://doi.org/10.3923/ja.2020.138.144
17. Simpson, M. G. (2010). Diversity and Classification of Flowering Plant; Alliaceae. In *Plant Systematics (Second Edition)*. Elsevier Inc., 220.
18. Sinaga, S., Waluyo, N., Rahayu, R., & Rosliani, R. (2021). Growth and Yield of Shallots (*Allium cepa var aggregatum L.*) Under Different Bulb Storage Period. *E3S Web of Conferences, 306*, 01043. https://doi.org/10.1051/e3sconf/202130601043
19. Siswanto, N., Bintoro, N., Karyadi, J. N. W., & Rahayoe, S. (2022). Effect of Post-Harvest Handling of Shallot in Supporting the Sustainability of the Availability of Shallot Seeds. *IOP Conf. Series.: Earth and Environmental Science, 1059*, 012072. https://doi.org/10.1088/1755-1315/1059/1/012072
20. Siti Nur Aeni. (2022). Ini Umur Panen Bawang Merah dan Cara Tepat Memanennya. *Kompas.com*. https://www.kompas.com/homey/read/2022/08/06/200700576/ini-umur-panen-bawang-merah-dan-cara-tepat-memanennya?page
21. Tridge. (2023). Import of Fresh Shallots to Malaysia. https://www.tridge.com/intelligences/shallot/MY/import. Accessed March 25, 2023.
22. UPOV. (2008). Onion, Enchalion, and Shallot. *Guidelines for the Conduct of Tests for Distinctness, Uniformity, and Stability*.
23. Wan Rozita, W. E., Norfadzilah, A. H., Nor Hazlina M. S., & Najah Y. (2022). Yield Performance and Correlation Study of Shallot Genotypes (*Allium cepa L. var. aggregatum*) Under Lowland Cultivation. In *5th International Plant Breeding Conference 2022 (IPBC2022)* (Online), March 8 - 9, 2022. Programme and Abstract Book, p. 98.