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Feasibility Analysis of Cultivating Shallots (*Allium cepa* var.*aggregatum* L.) Using True Shallot Seed and Tuber Seed

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Abstract
The availability of quality seeds is a major obstacle to the sustainability of shallot cultivation. Botanical seeds or True Shallot Seed (TSS) can be an alternative seed source. The study aimed to compare the technical and economic feasibility of shallot cultivation using TSS of the Lokananta variety with the Bauji variety bulbsThe experiment was conducted using completely randomized subsampling. There were two treatments, each replicated 100 times, resulting in 200 experimental plots. The plots were in the form of beds, with an area of 2.2 m2 (2 × 1.1 m). Each bed was planted with shallots with a spacing of 10 × 10 cm. In each planting hole, one bulb seed or one botanical seed seed was used. Two plants were selected for each seedbed as samples, resulting in a total of 400 data units. Observation parameters included the number of leaves and tillers, as well as wet and dry weights. Data were analyzed using the Mann-Whitney test. Economic feasibility was measured using a farming analysis approach. The test results showed that TSS seeds produced better plant height and tuber diameter, but conventional tubers were superior in leaf number, number of tillers, wet weight, and dry weight. The diameter of tubers from TSS reached 22.31 cm, while from seeds it reached 15.26. The economic feasibility results showed that revenue and profits were higher in the TSS treatment. TSS tubers had a larger diameter, resulting in a 50% higher price. The cost-benefit ratio obtained from the TSS treatment was 1.48 and the tuber treatment was 1.11.

INTRODUCTION

Shallots (Allium cepa var. aggregatum) are far more than a simple ingredient; they are a cornerstone of Indonesian cuisine, culture, and agricultural economy. Classified as a crucial spice vegetable, the pungent, aromatic bulbs form the base flavor profile for countless national dishes, driving massive domestic demand. Consequently, shallot cultivation plays a vital role in national food security and serves as a major source of income for millions of farmers, particularly in Java.

The economic significance of this commodity is reflected in its production output. According to data from the Central Bureau of Statistics (BPS, 2024), shallot production across Indonesia demonstrated robust growth in recent years. In 2021, the national yield increased significantly by 10.4%, rising from 1.81 million tons to over 2 million tons of fresh shallots. This upward trajectory underscores the viability and strong market absorption of the crop. Geographically, this success is heavily concentrated in key regions, with East Java Province emerging as the second-largest national producer, contributing a substantial 500,992 tons to the national total.

Within East Java, the Nganjuk Regency is celebrated as the primary shallot production hub, showcasing exceptional productivity. BPS (2024) records indicate that Nganjuk alone contributed 176,179 tons. Focusing further, our area of interest, the Bagor sub-district, stands out as one of the top five producers in Nganjuk. Productivity data over a three-year span confirms a positive growth trend in Bagor: production climbed from 34,758.5 tons in 2019, to 37,590 tons in 2020, and reached 53,627 tons in 2021. These figures clearly establish the high economic stakes and the critical role this specific region plays in sustaining the nation's shallot supply.

The impressive growth in production, however, masks a fundamental and growing vulnerability within the supply chain: the paradox of seed quality and scarcity. Although production output is rising, this achievement is hindered by a severe constraint in the availability of high-quality, certified seeds. Current estimates from BPS (2024) suggest that only 20% of the total shallot seed required by farmers is currently available as high-quality stock.

This critical shortage is exacerbated by farmers' heavy reliance on the conventional method of using consumption bulbs as planting material. Farmers prefer specific varieties, such as the Bauji variety, which is highly sought after for its combination of high productivity, excellent bulb quality, and reliable resistance to common diseases. Because high-quality certified seeds are scarce, farmers are compelled to reserve or purchase bulbs originally intended for market consumption to replenish their seed stocks.

This reliance on consumption bulbs has two significant negative impacts. First, it drives up market prices for shallots, creating supply instability for consumers. Second, and more critically for sustainability, seeds derived from consumption bulbs possess poor storage longevity. These planting bulbs cannot be kept viable for extended periods, leading to a severe depletion of seed stocks during the off-season, particularly during the rainy months. The resulting lack of reliable seed availability directly compromises the potential for continuous cultivation and threatens the long-term sustainability of shallot farming, as highlighted by Kurnianingsih et al. (2019). The industry thus faces a clear challenge: maintaining rapid growth requires breaking the dependency on an unstable, expensive, and disease-prone seed source.

To address this sustainability gap, True Shallot Seeds (TSS)—also known as botanical seeds—are being promoted as a vital alternative planting material. Unlike the bulky and perishable bulbs, TSS are small, resilient, and possess significantly better storage properties, making them an ideal solution for securing year-round seed availability and reducing the risk of disease transmission often carried in conventional bulbs.

However, the adoption of TSS is slow due to significant technical differences in the cultivation process. Planting with TSS is not a direct substitute for bulbs; it requires a longer initial commitment. Farmers must undertake a nursery stage lasting approximately five to six weeks until the seedlings have developed three to four leaves, only then can they be transplanted to the main field. This longer seed-to-bulb cycle, compared to the quick bulb-to-bulb planting method, demands different planning and management skills from the agripreneur.

Despite this extended initial time frame, TSS offers compelling technical advantages that promise greater efficiency. Shallot plants originating from TSS tend to produce only one single tiller per clump. This focused growth directs the plant's photosynthetic energy (photosynthates) predominantly toward the enlargement of a single bulb, often resulting in a superior size and quality compared to bulbs produced via the conventional method. Conversely, planting consumption bulbs immediately produces multiple side shoots and tillers, yielding numerous smaller bulbs per clump.

The inherent differences in growth cycle, resource allocation, and potential yield size between TSS and conventional bulbs create an imperative need for rigorous comparative research. While TSS offers advantages in cost efficiency (since seeds are lighter and cheaper than bulk bulbs) and disease reduction, the extended time-to-harvest and different labor requirements must be quantified to prove their practical value to risk-averse farmers.

Therefore, the primary objective of this research is to conduct a detailed comparative study focusing on the technical and economic feasibility of shallot cultivation using the conventional bulb method versus the True Shallot Seed (TSS) method. This study will precisely measure and compare key metrics, including: the total time required for the seed-to-bulb and bulb-to-bulb cycles; the final yield quantity and quality; the input costs (seeds, fertilizer, labor); and ultimately, the profitability (Return on Investment) under local conditions.

The findings from this research are expected to provide clear, data-driven recommendations that can inform agricultural policies and extension efforts. By demonstrating the competitive viability of TSS, this study aims to encourage wider adoption of botanical seeds, thereby enhancing the sustainability, resilience, and economic profitability of shallot production in high-yield centers like Nganjuk Regency, and supporting the long-term food security objectives of Indonesia.

RESEARCH METHODOLOGY

This research was conducted in Selorejo Village, Bagor Sub-district, Nganjuk Regency, East Java Province, Indonesia, spanning from January to May 2024. The experimental site is situated at an elevation of approximately 75 meters above sea level (masl), with ambient air temperatures ranging between 21 and 35^{o}C. The materials and equipment used comprised the essential production inputs for shallot cultivation, including seed trays, shade nets (paranet), hand sprayers, buckets, sacks, True Shallot Seeds (TSS) of the Lokananta variety, conventional bulb seeds of the Bauji variety, organic manure, compound fertilizers, rice husk charcoal, and standard pesticides. Measuring instruments such as rulers, scales, and calipers were utilized for data collection.

The experimental treatments focused on the type of planting material used, consisting of two distinct types: Treatment 1 (P1) using conventional Bauji bulb seeds and Treatment 2 (P2) using Lokananta TSS seedlings. The experiment was designed with 100 replications for each treatment. Each replicate utilized a raised bed measuring 2 times 1.1 meters, planted with 100 shallot plants. Within each replicate, two plants were randomly selected and tagged to serve as sample units, resulting in a total of 200 data points collected for each treatment. All cultural practices were uniformly applied across all beds, except for the planting material: P1 used bulbs, while P2 used seedlings derived from TSS.Cultivation ProceduresTSS Seedling Preparation (P2)The nursery growing medium was prepared by mixing soil, cow manure, and rice husk charcoal in a ratio of 2:1:1. TSS seeds were sown at a density of 2-3 seeds per sowing hole. The nursery was protected using plastic sheeting during the rainy season or shade nets during the dry season. Maintenance during the nursery period included weekly application of foliar fertilizers, fungicides, NPK, KNO_3 and *Trichoderma* spp. solids as a biological agent, along with watering twice daily or as needed. Transplanting of TSS seedlings occurred at 35-40 days after sowing (DAS), or once 3-4 leaves had fully formed. Land preparation involved clearing weeds using herbicides, primary soil cultivation, and the construction of raised beds. Basal fertilization was executed one week before planting with a mixture of: Dolomite 2 ton.ha^{-1} , Glicompost 2 ton.ha^{-1} , Furadan 3G 100 kg.ha^{-1}, and SP 36 fertilizer 250 kg.ha^{-1}

Treatment P2 (TSS), one seedling clump was planted per hole. In Treatment P1 (conventional bulbs), bulbs measuring 1.5-2 cm in diameter were used. Post-planting care included gap-filling (penyulaman), daily weed control, and pest and disease management using mechanical methods or pesticides. Top dressing (side-dressing) fertilization was performed twice: at 11 days after transplanting (DAT) with Saprodap fertilizer, and at 25 DAT with NPK Mutiara 250 $kg.ha^{-1}$and KCl 50 $kg.ha^{-1}$.

Harvesting was carried out when plants were 50-60 days old, typically when approximately 75% of the plant leaves began to lodge or turn yellow. The bulbs were carefully lifted with their roots intact.Technical Feasibility AssessmentTechnical feasibility in this study is defined as the degree of suitability between plant growth performance and its genetic potential when cultivated using practices aligned with local farmer customs. The indicators for technical feasibility, based on Basuki (2009), are growth and yield parameters.Growth parameters include plant height and leaf count measured up to 60 days after transplanting (DAT). Yield parameters comprise the number of bulbs per clump, fresh weight, dry weight, and bulb diameter at the time of harvest.The findings are anticipated to reinforce the notion that while TSS requires an extended allocation of time during the nursery phase, it can produce larger bulbs because the vegetative growth is concentrated into a single main bulb. This aligns with the findings of Gardner et al. (1991), which suggest that the distribution of photosynthates in plants with a single growing point tends to produce larger storage organs. Consequently, even if the number of tillers from TSS is lower, its economic value remains competitive due to the premium market price associated with larger bulb size.Data analysis will employ the Mann-Whitney U Test at an α level of 5%. A non-parametric test was chosen because the prerequisite of data normality is difficult to satisfy, particularly given that the number of bulbs produced by TSS often averages only one per plant.Economic Feasibility AssessmentThe economic feasibility component of this study aims to quantify the potential profit obtained by farmers in each cultivation cycle. Key indicators for economic feasibility, following Firdaus (2015), are the Benefit-Cost Ratio (BC ratio) and the Break-Even Point (BEP). The farm business analysis will be conducted based on a standard cultivation scale of 352 m^2 for each planting material treatment.

RESULT AND DISCUSSION

Technical Feasibility

The observations conducted on the technical feasibility indicators between P1 (conventional bulbs) and P2 (TSS seedlings) revealed significant differences across several key parameters. These parameters include plant height, leaf count, number of tillers, bulb diameter, and bulb weight.Specifically, the measurement of plant height at 14, 28, and 42 days after transplanting (DAT) demonstrated a statistically significant difference. The average height of plants derived from TSS was consistently and significantly greater than that of plants originating from conventional bulbs. This finding clearly indicates that the growth rate of TSS-derived plants is superior to that of the conventional bulb method (as summarized in Table 1).

Table 1. Comparison of Average Plant Height (cm) per Treatment

Treatment	Plant Age (DAP)		
	14	28	42
TSS var. Lokananta	17.61	29.28	37.59
Bulb var. Bauji	16.28	27.70	32.07

Remarks: * means a significant difference based on the results of the Mann-Whitney test with α 5%

Maulida et al. (2023) posit that variations in plant height are influenced by both genetic and environmental factors. Genetic factors endow each variety with distinct characteristics, consequently leading to differences in growth performance among varieties. Specifically, the Lokananta TSS variety, according to its official description, possesses the genetic potential to achieve a leaf length of 47 to 50 cm, whereas the Bauji variety is typically described to range between 35 and 43 cm. This suggests that, genetically, the Lokananta variety is inherently prone to greater length compared to Bauji. Shah et al. (2012) further support this by asserting that inter-varietal height differences stem from the underlying genetic distinctions across all tested varieties and their respective capacities for environmental adaptation. Furthermore, the findings of Ayu et al. (2016) indicate that optimal vegetative growth in a particular plant variety is achieved through successful adaptation to its specific growing environment. Nevertheless, it is noted that neither variety in this current study fully attained its reported genetic potential, particularly concerning the plant height parameter.The analysis of leaf and tiller count at 14, 28, and 42 DAT also revealed significant differences, where the average number of leaves and tillers per plant was significantly higher in the Bauji bulb treatment (P1) compared to the Lokananta TSS treatment (P2) (Tables 2 and 3).

Table 2. Comparison of the average number of shallots per treatment

Treatment	Plant Age (DAP)		
	14	28	42
TSS var. Lokananta	5.54	6.06	7.03
Bulb var. Bauji	6.56*	22.83*	30.98*

Remarks: * means a significant difference based on the results of the Mann-Whitney test with α 5%

Table 3. Comparison of the Number of Shoots and Bulb Diameter per treatment

Treatment	Number of shoots	Bulb diameter (mm)
TSS var. Lokananta	1	22.31*
Bulb var. Bauji	6.24*	15.26

Remarks: * means a significant difference based on the results of the Mann-Whitney test with α 5%

Siswadi et al. (2022) emphasize that a greater number of leaves correlates with enhanced plant growth and development, as leaves are the primary site for photosynthesis. Similarly, Sartika Sari et al. (2015) confirm that an increased leaf count leads to a higher rate of photosynthate production. Shallot cultivation utilizing vegetative bulbs is known to promote quicker development of leaves and tillers. Tillers typically emerge rapidly from side shoots following the severance of the initial bulb, whereas plants grown from True Shallot Seeds (TSS) take longer to form tillers and generally possess a lower total leaf count. The number of shoots or tillers per clump is a crucial growth indicator strongly influenced by genetic factors, such as varietal type (Siswadi et al., 2019). Consistent with its varietal description, the Lokananta TSS variety is reported to produce only 9.32 leaves and 1.5 tillers per plant (Saidah et al., 2019).The genetic traits of the plant play a fundamental role in regulating plant growth from the vegetative to the generative phase (Maulida et al., 2023). Conventional bulb seeds, with their inherently higher average number of tillers per clump (6.24 tillers per plant), offer an advantage in terms of potentially greater overall harvest yield per plant unit. Importantly, this tiller count also corresponds directly to the number of final bulbs produced (Table 3). In contrast, TSS, which produced only one tiller (and thus one primary bulb) per clump, exhibits a distinct growth strategy: prioritizing the development of a single, larger bulb (Gardner et al., 2008).

The observation of shallot bulb diameter revealed a significant difference, with the average diameter of the Lokananta TSS bulbs being superior to that of the Bauji conventional bulbs (Table 3). Bulbs harvested from TSS showed an average diameter of 22.31 mm, while those from the Bauji bulbs averaged 15.26 mm (Figure 1).This difference in average bulb diameter is likely due to the distinct developmental characteristics of each planting material source. Research by Adam et al. (2021) suggests that each plant genotype can exhibit unique responses and characteristics toward varying environmental conditions. TSS generally tends to produce larger-sized bulbs compared to conventional bulbs. In terms of genetic potential, TSS is capable of yielding bulbs with diameters up to 36 mm, whereas the Bauji bulb variety can reach up to 25 mm. In this study, however, the observed bulb diameters for both varieties did not reach the optimal genetic potential as described in the varietal specifications. Bulb diameter is a critical indicator for determining the quality and commercial value of a tuber crop, as larger bulbs typically command a higher selling price in the market (Prathama et al., 2023). This finding aligns with Saidah et al. (2019), who state that TSS seeds result in significantly higher bulb diameters compared to bulb-based planting material.According to Mardiana et al. (2016), shallot bulbs are classified into three categories: large bulbs (diameter> 1.8 cm or weight > 9 g), medium bulbs (diameter 1.5 - 1.8 cm or weight 5-9 g), and small bulbs (diameter < 1.5 cm or weight < 5 g). Based on these criteria, the Lokananta TSS bulbs fall into the large bulb category, while the Bauji conventional bulbs are categorized as medium bulbs.

Figure 1. Comparison Bauji Bulb (left) and TSS (right)

Adam et al. (2021) further explain that varietal differences in bulb size are influenced by the plant's ability to effectively distribute photosynthates to the bulb portion.Fresh Weight and Dry WeightThe observations regarding shallot fresh weight and dry weight showed a significant difference, where the average fresh and dry weights of the conventional bulb treatment (P1) were superior to those of the TSS treatment (P2) (Table 4). This outcome is attributed to the fact that although the TSS bulbs achieved a larger diameter, the total number of bulbs produced by the Bauji conventional method was approximately six times greater (6.24 tillers) than the yield from the TSS treatment, which produced only one bulb per clump. Tesfa et al. (2014) confirm that variations in shallot bulb production across varieties are caused by the genetic variability inherent in each tested variety.

The Bauji conventional bulbs resulted in a greater fresh weight. Similarly, this trend was observed in the dry weight parameter. The conventional bulb treatment (P1) achieved the highest average dry weight, reaching 18.32 g per clump, whereas the TSS treatment (P2) only yielded 9.04 g per clump. Dry weight is a crucial measure for evaluating harvest yield as it reflects the true usable mass of the bulbs after accounting for water content removal. Furthermore, the shrinkage percentage of Bauji bulbs was 31%, which was smaller compared to 38% for TSS bulbs. This disparity indicates that conventional bulbs possess the potential for a larger usable yield in terms of dry weight. Nonetheless, larger bulbs (as produced by TSS) possess potentially higher commercial value due to greater consumer preference (Mutia, 2019).

Table 4. Comparison of average wet and dry weight of shallots (g)

Treatment	Wet weight (g)	Dry weight (g)
TSS var. Lokananta	14.66	9.04
Bulb var. Bauji	26.41*	18.32*

Remarks: * means a significant difference based on the results of the Mann-Whitney test with α 5%

Economic Feasibility

The economic feasibility of both cultivation systems was assessed through the ratio of costs to the profit obtained by the farmer. The total cost represents the entirety of the farmer's expenditure, encompassing the cost of production inputs and labor costs. A detailed breakdown of the cost components is presented in Table 5. The total production cost for shallots using TSS (P2) amounted to IDR 3,495,500, while the cost for conventional bulb cultivation (P1) reached IDR 4,455,000 for the same land area 352 m$^{\wedge 2}$. This makes the production cost of conventional bulb cultivation IDR 959,500 higher than that of TSS cultivation. This cost difference is primarily attributable to the substantial difference in the cost of procuring the initial planting material (seeds).

Revenue, or acceptance, encompasses all income generated by farmers from the sale of shallots resulting from the cultivation process. The source of the farmer's revenue is derived from the sale of shallots, with prices reflecting the prevailing market rates at the research location and time. The production quantity and selling price of both shallot treatments are detailed in Table 6. Based on these data, the use of TSS resulted in a higher total revenue, exceeding that of the Bauji bulb seeds by IDR 220,000. Although the overall production quantity from TSS was lower than that of Bauji, the higher market price achieved by the TSS product—due to its larger and more uniform bulb diameter—compensated for the volume difference. Shallots derived from the Bauji variety exhibited high variability in bulb diameter, with approximately 50% categorized as small or medium bulbs, thus resulting in a lower average price per kilogram.

Table 5. Total Cost Production

Component		TSS var. Lokananta	Bulb var. Bauj
Nursery			-
- Seed		70,000	
- Composs		20,000	
- Husk		20,000	
- Trichoderma		30,000	
- Fungicide		38,500	

- Tray - UV Plastic - Bamboo - Rope		90,000 100,000 160,000 12,000	
Planting - Seed - Cow manure - Basal fertilizer - Fertilizer - Pesticides Worker		 - 100,000 60,000 175,000 620,000 2,000,000.-	 1,500,000 100,000 60,000 175,000 620,000,- 2,000,000
Total		3,495,000,-	4,455,000

Table 6. Comparison of revenue and profits from shallot cultivation

Treatment	Yield (kg)	Average Price per kg	Revenue (IDR)	Benefit (IDR)
TSS var. Lokananta	172	30,000	5,160,000	1,664,500
Bulb var. Bauji	247	20,000	4,940,000	485,0001

Shallots cultivated using TSS as the seed source possess superior economic potential linked to the favorable characteristics of larger and more uniform bulbs, which are preferred by consumers. This provides valuable information for farmers and farm managers to consider the economic factors and potential profitability when selecting the optimal seed source to enhance production outcomes.The Benefit-Cost Ratio (B/C Ratio) analysis was conducted to determine the profitability and viability of the farming endeavor, assuming that a larger benefit value corresponds to greater operational feasibility (Adiyoga et al., 2021). In this study, both seed types demonstrated the potential to generate economic profit. Ichsan (2019) states that an investment or business activity is considered viable if the B/C Ratio exceeds 1. The B/C Ratio for Lokananta TSS was calculated at 1.48, while the Bauji conventional bulb was 1.11. Both treatments are classified as profitable and viable for enterprise, with TSS showing a slight superiority in terms of return on investment relative to cost.The Break-Even Point (BEP) signifies the point of financial equilibrium where total revenue equals total cost (Adiyoga et al., 2021). At this point, the farm operation experiences neither loss nor profit. The calculation can be performed in physical units (the volume required to cover costs) or in monetary value (the price per unit required to cover costs).

The unit BEP analysis indicated that for TSS, the break-even volume was 116.52 kg out of a total harvest of 172 kg, meaning the production costs were covered by this yield volume. For conventional bulbs, the unit BEP was 222.75 kg out of a total harvest of 247 kg. Furthermore, the price BEP for TSS was calculated at IDR 22,846.41 per kg, and for Bauji bulbs at IDR 18,036.44 per kg. The achievement of unit and price BEPs that are lower than the total production volume and prevailing market price, respectively, indicates that both shallot seed sources are relatively viable for cultivation (Firdaus, 2015). The efficiency level of shallot cultivation using TSS is higher compared to Bauji bulbs. This is substantiated by the B/C ratio, which shows that for every IDR 100 spent on TSS cultivation, the potential profit generated is IDR 48 higher than the potential profit generated using Bauji bulbs IDR 11. This finding provides a deeper understanding of the production efficiency and potential profitability of using TSS, which is essential for the sustainable development of shallot farming.

CONCLUSIONS AND SUGGESTION

Based on the findings of this study, it can be concluded that shallot cultivation utilizing True Shallot Seeds (TSS) consistently resulted in larger and more uniform bulb diameters compared to the conventional bulb-derived yield. The superior size and uniformity of the TSS-derived bulbs offer the potential for a price premium, leading to a price disparity up to 50% higher in the market.Furthermore, the overall cultivation cost for shallots using TSS was more economical, showing a reduction of up to 27.4% compared to the conventional bulb method, primarily attributed to the significantly lower cost of seed procurement. While farmers must allocate additional time—up to 35 days—for the nursery phase, the economic benefits appear to outweigh this requirement.The Benefit-Cost Ratio (B/C Ratio) for TSS was calculated at 1.48, significantly exceeding that of the conventional bulbs at 1.11. Consequently, TSS is demonstrated to be more feasible, both technically (due to superior bulb characteristics) and economically (due to lower costs and higher profitability). Therefore, True Shallot Seeds can serve as a superior alternative to enhance the efficiency and overall profitability of shallot farming enterprises.

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