International Journal on Advanced Science Engineering Information Technology

Vol.12 (2022) No. 4
ISSN: 2088-5334

Growth, Seedling Yield, and Feasibility of True Shallot Seed (*Allium cepa* L) Nursery Farming System

Sutardi [a,*], Yayan Apriyana [b], Sugeng Widodo [c], Annisa Dhienar Alifia [c], Popi Rejekiningrum [b], Joko Pramono [a], Nanik Setyowati [d], Christina Astri [a]

[a] *Yogyakarta Assessment Institute for Agricultural Technology, Sleman, 55584, Yogyakarta, Indonesia*
[b] *Indonesian Agroclimate and Hydrology Research Institute, Cimanggu, Indonesia*
[c] *Riau Islands Assessment Institute for Agricultural Technology, Tanjungpinang, 29124, Riau Islands, Indonesia*
[d] *Departement of Crop Production, University of Bengkulu, Bengkulu 38121, Indonesia*
*Corresponding author: *s.pd_sutardi@yahoo.co.id*

Abstract— **The objective of this study was to identify widely adapted true lines under different models of True Shallot Seed (TSS) nurseries that can be easily, quickly, and efficiently developed by farmers. Previous TSS seedling production research showed some low and inefficient results, making TSS nursery farming expensive and difficult for farmers to do. Therefore, a TSS nursery model that produces good seedlings and is economically efficient needs to be found. This research fills the gap by presenting novel TSS nursery models using sediment soil media that have not been tried before to increase the TSS seedling performance. The study was arranged in a randomized complete block design (RCBD) with treatment consisting of three seedling systems: direct sowing models (Tabela), boxes, and polybags. Each treatment was repeated six times, using Bima varieties produced by AIAT of Central Java, seed 0,5 kg per system. Observation data included: media material's chemical contents, seedling growth, and nursery model feasibility. The results showed that seedling emergence and seedling weight, number of leaves, and plant populations were significantly different. Tabela shows the best seedling performance and cost-efficiency results. Hopefully, the study results of the shallot nursery model from TSS will help farmers reduce total production costs. The river sediment soil erosion at 71.1 t ha^{-1}yr^{-1} has not been utilized even though sediment soil's physical and chemical properties are very good for a nursery, making for the novelty point in this study.**

Keywords— **Nursery system; true shallot seed; seedling; sediment soil.**

Manuscript received 16 Feb. 2021; revised 6 Jun. 2021; accepted 21 Jul. 2021. Date of publication 31 Aug. 2022.

I. INTRODUCTION

Shallot (*Allium cepa* var. *ascalonicum*) is one of Indonesia's most widely cultivated bulb crops and a significant contribution to most regions' economic development [1]. Shallot total planting area is estimated to be around 90,000 ha. The majority of the shallots grown in Indonesia are sold for local market. There is a decrease in Indonesian shallot's competitiveness, resulting in sharply increased imports.

To reduce dependence on imports of tubers as planting material, an innovative technology of shallot cultivation was tried using true shallot seeds (TSS) as planting material [2]. Shallot bulb production is limited to low, medium, and highland areas under rain-fed conditions. It is one of the main cash crops and is traditionally produced under rain-fed rice fields after planting rice, both in wet and dry seasons in Java, West Nusa Tenggara (NTB), Sulawesi, and other regions in Indonesia. Shallot is planted by small farmers as an income-generating spice crop and used to flavor local dishes. Climatic and soil adaptations of shallot are considered wide-ranged, cultivated either under rain-fed or irrigated conditions. Shallot's growing period is about three months, suitable to be grown between other crops and during the short rainy season to be planted three times a year throughout the dry and wet seasons [3], [4].

Vegetatively propagated materials were known to promote diseases, viruses, fungi, bacterial pathogens, and nematodes [5]. Common virus infections in shallot are Onion Yellow Dwarf Virus (OYDV), Garlic Common Latent Virus (GarCLV), and Shallot Latent Virus (SLV) [6], [7]. Bulb-seed originated shallot obtained from shallot-production regions in Indonesia were infected with OYDV, Shallot Yellow Stripe Virus (SYSV), Shallot Latent Virus (SLV), and Garlic Common Latent Virus (GarCLV) [1], [8]. True shallot seed, with its advantages and successes, is expected to eventually take over the use of bulb seed which may contain viruses and diseases.

Bulb seeds large volume also posed a challenge in storing them, as traditionally, farmers tied them in tight bunches to be hung above the stove in their kitchen for 3 to 5 months. To tackle this problem, Indonesia has researched efforts to use TSS as a good option to avoid storage problems. Using TSS as planting material makes it easier to handle and avoids the need for a large number of bulbs. TSS can also be stored for a longer time. TSS of the Trisula variety still has 95.5 % viability after 1 year and 90.5% viability after 4 years of storage [9].

Cultivation of shallot traditionally used bulbs seed. Using TSS is still considered to be new. Therefore, innovation in seed technology is necessary. TSS seedlings planted in the field are single seedlings pulled out one at a time from the nursery, which tends to cause damage and stress on the plant. To avoid damaging TSS seedling roots at transplanting, several TSS can be sown in a polybag, a box, a single hole, and a private media release. Some result from earlier TSS studies has recommended producing small bulbs and consumption bulb [10].

So far, not many studies have been carried out to sow the TSS from seeds into ready-to-plant seedlings. Small and light TSS seeds require good media and light soil structure. Sedimentary soil produced from river erosion is quite abundant. River and lake sedimentary soil contain nutrients and organic matter, which can modify soil chemical composition, potentially being used as planting media [11], [12]. Besides that, the average annual soil erosion in agricultural areas north of Progo Watershed, Indonesia, is 71.1 t $ha^{-1}yr^{-1}$, potentially forming sediment soil [13]. It has not been utilized, even though soil sediment's physical and chemical properties are very good for a nursery. Biogas sludge fertilizer is also considered to be good for TSS seedling media. Seedling media made of sediment soil + biogas sludge fertilizer + rice husk ash with a ratio of 1:1:1 has never been studied before, which is why it is used in this study.

We hypothesize this study as follows:

- The practice of the nursery media utilizes the appropriate sediment soil erosion media to grow TSS seeds.
- The results of the three models of nurseries encourage farmers to do business by providing healthier and more profitable TSS seeds.
- Replacement of planting shallot seeds from bulb to TSS seeds is 25-30% more efficient, so it impacts increasing the net income of farmers. Bulb propagated from true seed shallot (TSS) has the potency to become a good seed bulb [14].

TSS nursery media is currently limited to organic fertilizer, rice husk ash, and topsoil with a 1:3 or 1:4 ratio. Using biogas sludge waste and erosion sediment soil in this research made the nursery media more fertile, cost less, and more efficient in its utilization. The objective of this study was to identify widely adapted true lines under different models and media of TSS nurseries to support production and seedling quality enhancement.

II. Materials and Methods

A. Experimental Materials

The TSS used was Bima Brebes variety, produced in an ecogeographic area at an altitude of 1,500 m above sea level in Mount Lawu, Karanganyar Regency, Central Java (AIAT Central Java). The cultivar was chosen to represent shallots growing in the tropics at shallot production centers in Indonesia.

1) Pre-Sowing Treatment of True Shallot Seeds: TSS were given pre-sowing treatment by immersing in warm water (45-50 °C) + Previcur N fungicide solution at 2 cc $liter^{-1}$ for 3 hours, then drained and left for 12 hours. It is then sown according to treatment.

2) Preparation of Seed Seedling Media: Seedling nursery media was made from a mixture of river erosion sediment soil + biogas sludge + rice husk ash (1:1:1). Sedimen soil material was obtained from an erosion mine carried away by the flow of Progo River in Yogyakarta Province. The biogas sludge originated from cow dung, while the rice husk ash was obtained from rice mill waste. The nursery media mixture was then stirred and fumigated at 60 °C for 10 hours to control soil borne diseases. The thickness of the nursery medium is 5-6 cm. Each sample of the nursery system mix was analyzed for its chemical contents (Table 1) and seed agronomic performance (Table 3). The sampling method used purposive random sampling [15]. Each sample of seed medium was analyzed for its chemical contents, which include:

- pH analysis: Sample weighed to 10.00 g twice, each put in a shake bottle, plus 50 ml ion-free water to the first bottle (pH H_2O) and 50 ml of 1 M KCl into the second bottle (pH KCl). Shake with a whisk for 30 minutes. Soil suspension is measured by pH meter that has been calibrated using a buffer solution of pH 7.0 and pH 4.0. pH value data collected was in one decimal [16].
- Organic C-content: On a 100 ml volumetric flask, 0.5 g soil sample-sized <0.5 mm and 5 ml of $K_2Cr_2O_7$ 1 N were mixed and shaken. 7.5 ml of concentrated H_2SO_4 were then added, shaken, and let stand for 30 minutes. It is then diluted with ion-free water, let cool, and squeezed. The clear solution's absorbance was measured the next day using a spectrophotometer at 561 nm wavelength. A standard of 0 and 250 ppm was made by pipetting 0 and 5 ml of the 5,000 ppm standard solution into a 100 ml volumetric flask with the same treatment as the sample work [17]–[19].
- N content analysis: Soil sample with <0.5 mm size was weighed to 0.5 g and then put into digest tube. 1 g of selenium mixture and 3 ml of concentrated sulfuric acid were added and digested to 350 ºC (3-4 hours). Destruction is complete when the steam color that escaped is white and clear extract is obtained (about 4 hours). The tube is removed, cooled, and then the extract is diluted with ion-free water to exactly 50 ml. The tube is shaken until homogeneous and left overnight to settle the particles. The extract was used for measurement of N utilizing distillation or colorimetric way [17]

- Determination of P and K extract of HCl 25%: Soil samples sized <2 mm was weighed to 2.5 g, plus Bray extract and Kurt I as much as 25 ml, then shaken for 5 minutes. The cloudy solution was filtered and returned to the original filter (filtering process 5 minutes maximum). Pipette 2 ml of clear extract into the test tube. The sample and standard series were respectively added with 10 ml phosphate dye reagent, shaken and left for 30 minutes. The absorbance was measured with a spectrophotometer at 889 nm wavelength. For potassium, the diluted sample extract and the standard series K are measured emission directly with SSA tools [16]
- Determination of Cation Arrangements, Cation Exchange Capacity and Saturation 1M NH_4OAc Extract Base, pH 7.0: Soil colloids (clay minerals and humus) were negatively charged to be able to absorb cations. Exchangeable cations (dd) ($Ca^{2+,}$ $Mg^{2+,}$ $K^{+,}$ and Na^{+}) in the soil seepage complex are exchanged for $NH4^{+}$ cations from the extractor and are scalable. To determine the soil cation exchange capacity (CEC), excess cation exchanger was washed with 96% ethanol. $NH4^{+}$ which was absorbed, replaced with Na^{+} cations of the NaCl solution so that it can be measured as CEC. The cations can be exchanged ($Ca^{2+,}$ Mg^{2+}, $K^{+,}$ and Na^{+}) set with SSA. $NH4^{+}$ (CEC) was determined by colorimetry by the Blue method Indophenol [16]
- Determination of Fe and Mn Dithionite-Citrate extract: The dithionite-citrate solution extracts free Fe and Mn, namely in the form of hydrous oxides. The soil sample was shaken with the solution a mixture of sodium citrate and sodium dithionite which is complex and reducer. AAS measured this Fe and Mn in extract. Weigh 1,000 g of fine sample (<0.5 mm) plus 60 ml dithionite citrate was shaken for 16 hours. Filtered or centrifuged to get supernatant (clear solution). The supernatant is diluted 50 times with ion-free water. Fe and Mn in aqueous solution were measured by AAS using a series standard mixture of Fe and Mn as a comparison [20].

3) Seedling Media Planting: TSS are sown evenly on the planting media according to treatment with a dose of 40-50g m^2. The sown seedlings were covered with 1 cm thick planting media and rice husk ash. Then watered until wet with a fuzzy irrigation or sprinkler. It is covered tightly with silver-black plastic mulch to maintain moisture for 5-7 days after sowing. Seed will germinate in 4 -7 days, and the cover can be opened. TSS is cared for intensively in the nursery by watering and applying fertilizer (NPK 16:16:16) 2 g m^{-2} at the age of two weeks after sowing. The TSS seedlings are ready to be transplanted to the field after 25 days after sowing. Watering is done twice a day while pest control is installed with an insect trap (yellow lattice bottle model), and control of diseases and fungi every 5-7 days by applying fungicide and insecticide at a dose of 2 cc $liter^{-1}$. The fertilizer dose is 10 tons ha^{-1} of chicken manure and 5 g per polybag, and 50 gr per box of NPK 16-16-16.

B. Experimental Methods

1) Seedling Nursery Models Study

- *Place and Time*: The field study of TSS seedling nursery was carried out at the IAAT Experimental Garden, Sitimulyo Village, Pleret District, Bantul Regency, Yogyakarta Province (-7.85061, 110.043437, 89.7 m, 58^0) in June-August 2018.
- *Research Methodology*: The study used Randomized Complete Block Design (RCBD) with three nursery system treatments and repeated ten times with a single factor. The treatments were (A) box model sized 30 x 40 cm, (B) polybag models using 12 x 25 cm polybag, and (C) direct seed planting or Tabela system on a bed-sized 1 x 5 m. Seedling are cared for until ready for transplanting 35 days after sowing (DAS). The nursery media was made of river erosion sediment soil + biogas sludge + rice husk ash (1:1:1) mixture, with 10 cm thickness. Experiments were monitored for thirty days after planting. This TSS nursery study's detailed process can be seen in Figure 1.
- *Data collection*: Observations were done on 10 plants in a 1 m^2 planting area at 35 DAS. The data included:

Seedling vigor was calculated as seed germination percentage. The number of normal seedlings (NS) at 5 and 7 DAS were counted and put into the following formula [21]:

$$\text{Germination (\%)}=\frac{\Sigma\text{ NS at 5 DAS}+\Sigma\text{ NS at 7 DAS}}{\Sigma\text{ seeds sown}}\text{ x 100}$$

Using a ruler, plant height (cm) is measured from the ground to the terminal end of the longest leaf. The number of leaves were counted from all perfectly formed leaves. The total weight of seedlings (roots + shoots) fresh weight (g) was measured by weighing fresh seedling root and leaves. The seedling population was measured by counting all normal seedling grown in the 1 m^2 area. The adaptability (AD, %) were measured by counting all the normal TSS seedling at 10 days after transplanting (DAT) to the filed, using the following formula:

$$\text{AD (\%)} = \frac{\Sigma\text{ seedling transplanted} + \Sigma\text{ seedling at 10 DAT}}{\Sigma\text{ seedling transplanted}}\text{ x 100}$$

2) Feasibility Analysis Data by Recording the Input and Output of TSS Originated Shallot Nursery Farming of Each Treatment: Number and wages of nursery workers: media preparation, nursery, watering, and maintenance. The quantity and price of inputs used: seeds, compost, artificial fertilizers, and pesticides. The amount and price of supporting materials used are plastic tray, polybag, plastic nursery cover, bamboo, plastic mulch, and others [22].

3) Cost Efficiency Analysis of The Shallot Seed Nursery Model: Cost efficiency analysis was done by comparing the three TSS nursery models costs and using the cost of using bulb seed. The analysis result showed savings or efficiency value of TSS nursery compared to bulb seed. Cost analysis was done for a 2,000 m^2 area scale, using a variable cost approach that was assumed to have a major impact on the nursery practice.

4) Statistical Analysis: Variables observed were nursery media chemical content (Table 1) and agronomic performance (Table 3). The data obtained were then analyzed using Microsoft Excel 2003 (Microsoft Cooperation, USA) for the basic descriptive statistics. Analysis of variance was used to analyze the result data [23] and further tested with Duncan Multiple Range Test (DMRT) for significant difference[24]. Statistical significance was assumed at α < 0.05.

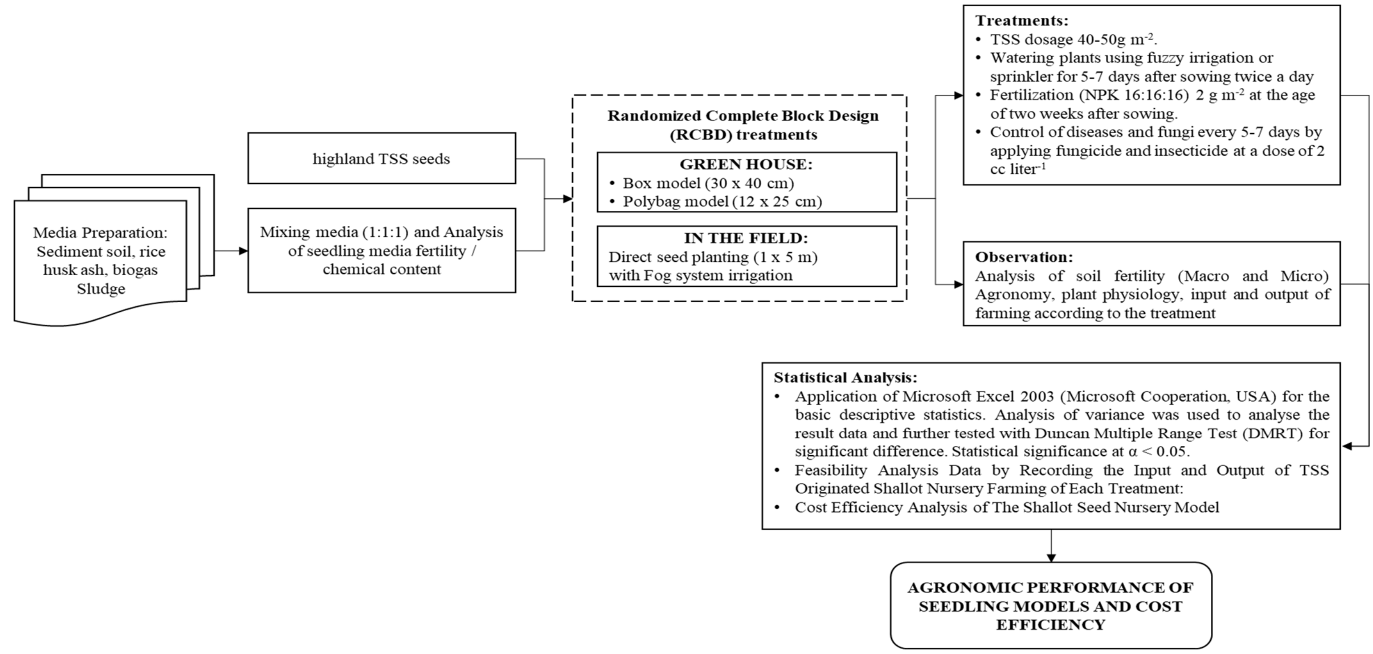

Fig. 1 Flow chart of growth, seedling yield, and feasibility of true shallot seed (Allium cepa L) nursery farming system study

III. Result and Discussion

A. *Seedling Media Materials Properties*

Commonly used organic fertilizer was also tested as a comparison to nursery media materials. Based on the analysis, rice husk ash and solid biogas waste (sludge) contain better nutrients than organic fertilizer. P_2O_5 content in rice husk ash and biogas sludge, at 29.97% and 20.26% both higher than organic fertilizer, at 18.1% (Table 1). Although rice husk ash and sediment soil river contain very little N content, both at 0.02% and 0.31%, biogas sludge contains 12.77% N, which can improve the nutrient quality of the media mixture. The soil analysis results by [25] showed that the content of river sediment on topsoil material of N, P, and K was the highest (2.30, 0.29, and 4.96 %). Seedling media composition is very important because the composition forms a good structure. Some nutrient content of biogas sludge is lower than organic fertilizer, but it excels in its high Mn content (13,089 mg kg $^{-1}$). From the test result, the composition of rice husk ash + sludge at 1:4 ratio can be a good seedling media. Organic fertilizer + soil with a ratio of 1:1 is the second alternative. The third media alternative is rice husks ash + sludge + soil (1:1:1). Excess media of rice husk ash and sludge was free from weed seeds and soil-borne pathogens.

River sediment soil can improve planting media texture because it can increase surface layer's macropores, thus affecting the media's physical behavior, root penetration, and water movement [26]. This makes sediment soil potential to be used as TSS seedling media because the small-sized TSS needs light soil structure to be able to emerge. TSS germination rate is found to be better in media with a light texture. The lighter the media, the better [27].

The addition of biogas byproducts as organic fertilizers has been widely studied. The use of biogas digestate as organic fertilizer helps recover nutrients from animal waste and increases farmer's yield from their field [28]. Onion given 75% recommended dose fertilizer plus 4 t ha^{-1} biogas slurry produced the highest yield compared to other treatments, at 13.95 t ha^{-1} [29]. Application of biogas sludge combined with wood ash also increased grasses and leguminous pasture yield than the combination of manure and wood ash application [30]. A study using rice husk ash as TSS nursery media produced a high germination rate at 83.42% but could not retain the seedling population number as it drops to just 7.38% after 56 DAP. Rice husks ash does not have enough solidity to support the seedling, resulting in the emergence of roots or seeds atop the media. Mixing rice husk ash with more solid media like soil and compost was better. The detailed result of the analysis is presented in Table 1.

TABLE I
CHEMICAL CONTENT IN VARIOUS SEEDLING MEDIA

Parameter	Rice husk ash	Sludge	Organic fertilizer	Sediment Soil
H_2O pH	7.2	6.57	8.34	5.6
C-organic (%)	1. 7	6.57	8.34	3.36
N (%)	0.02	12.77	16.00	0.31
C / N ratio	13.69	0.63	0.88	10.64
P_2O_5 (%)	29.97	20.26	18.18	137
K_2O (%)	29.02	0.71	0.86	19
Na (%)	-	0.41	2.42	-
Ca (%)	-	0.11	0.19	-
Mg (%)	-	0.61	1.09	-
Fe (mg kg $^{-1}$)	-	0.24	0.44	-
Mn (mg kg^{-1})	-	13,089	9,594	-

Source: INSTIPER Yogyakarta soil laboratory 2018.

The addition of river sediment on topsoil material was able to increase clay fraction and soil micropore of the planting media, while the bulk density and percentage of total soil pore decreased [25].

B. Agronomic Performances

The observations on seed vigor and seedling weight of plants were significantly different at 1% level. The number of leaves was also significantly different at 5% level, but plant height, root length, and population size were not significantly different (Table 2).

TABLE II
ANALYSIS OF VARIANCE FROM SEEDLING MODELS RECAPITULATION

Character	**Seedling model**	**CV (%)**
Seedling vigor (%)	**	4.95
Plant height (cm)	Ns	23.76
Number of leaves	*	8.77
Seedling weight (g)	**	7.83
Root length (cm)	Ns	12.27
Population (1 m^2)	Ns	53.01

Description: * = real at P <0.05, ** = real at P <0.01, Ns = not significantly different

The best seedling emergence result is from direct seed sowing (Tabela) seedbed model at 93.57 % compared to the box and polybag systems, each at 72.74% and 87.43%. (Table 3). Seedlings aged 30 days after sowing (DAS) in the Tabela model treatment's overall agronomic performance is better than those from Box and Polybag models. Seedling on the three nursery models develops well at growth stage. The Seedling height from the three treatments were not significantly different, but box treatment resulted in the highest seedling compared to others. Seedling root length were also quite similar for all treatments. The highest average number of leaves was recorded from Tabela model treatment (3.57 leaves), which is why it is also resulted in heaviest seedling weight per plant, at 2.38 grams. The seedling population in 1 m^2 area of polybag model treatment was the lowest, at 136 plant per square meter. It can be affected by the area lost because of the polybag shape. The result agrees with research showing TSS directly sown on para net-covered raised beds with 93.5% seedling growth. The growth percentage of TSS seedling after transplanting reached more than 80%, achieving 4.9 t ha^{-1} productivity [31].

Seedling emergence from this study is higher than several other previous studies. The germination rate, plant height, and number of leaf per plant of TSS seedlings were not affected by interaction between seedling media and sowing method + sowing depth [27]. The TSS germination rate for Bima variety was generally low on each treatment of seedling media and seed sowing method, averaging 36.67%-77.33% [32]. Research identifying Bima variety seed structure showed low seedling emergence because of its thick seed skin (testa), which hinders water absorption. TSS germination can be improved by immersing the seed in gibberellin before sowing [33]. Meanwhile, another research of three nursery systems: soil block, plastic bag, and pullout system resulted in 60% average seed viability, with leaves first appearing five days after planting [34].

The use of seedling media consisting of soil + manure + cocopeat or rice husk ash mixture with TSS sowing method of spreading evenly on beds at 1 cm depth were found to produce the most seedlings compared to other treatments, although there were no significant differences [27]. Research found the best combination to produce TSS seedling is by seedling media from mixture of soil + manure, sown with TSS by spreading evenly at a depth of 2 cm and transplanting seedling at 6 weeks after sowing. using [27]. Higher TSS seedlings emergence in this study was probably affected by the improved media texture by the added sediment soil and rice husk, both creating light texture that enables the delicate seedling to push through.

TABLE III
AGRONOMIC PERFORMANCE OF SEEDLING MODELS FROM TSS SEED AGED 30 DAYS

Seeding model System	**Seedling Emergence (%)**	**Seedling Height (cm)**	**Number of leaves**	**Seedling weight $plant^{-1}$ (g)**	**Root length (cm)**	**Population 1 m^2 (plant)**
Box	72.74^{c}	27.69	3.14^{b}	1.50^{b}	9.63	213^{b}
Polybag	87.43^{b}	23.11	3.21^{ab}	1.31^{c}	10.31	136^{c}
Tabela	93.57^{a}	25.74	3.57^{a}	2.38^{a}	10.71	243^{a}
CV	4.35	23.76	8.77	7.63	12.27	13.01

Description: Means followed by the same letters are not significantly different at 5% level according to DMRT

Soil, rice husk ash, and a mixture of soil + sand + manure are materials with good water holding ability. Heavier media mixture, such as clay soil + rice husk ash or using manure only, can hinder seedling emergence. The three seedling models in this study have similar root length results, at about 9.63 cm to 10.71 cm, with no significant difference, which indicates that the mixture of sediment soil + biogas sludge + rice husk ash is a suitable TSS nursery media regardless of its model.

The results of transplanting TSS seedling of Bima variety at 6 weeks were the most suitable, resulting in highest yield at 6.78 t ha^{-1} at a study Jeneponto, South Sulawesi [10]. Research [35] also concluded that the seedling nursery system of TSS seed sown directly on media made from rice husk fuel + fertilizer (1:4) resulted in good seedling growth and health. The soil block nursery technique is an alternative to increase shallot production [34].

C. Nursery Models Economic Analysis

The economic feasibility analysis was carried out by directly sowing TSS in situ with a scale of 2,000 m^2 each with

400 g TSS seeds. In the economic efficiency analysis, the variable costs taken into account are costs that changed as a result of making decisions to replace bulb seed technology with TSS technology. These variable costs include costs in the nursery and the field. To confirm whether TSS usage can be considered profitable, the cost taken into account has to be the cost of producing planting materials (ready to plant seedlings), not only the cost of TSS purchase. To give an idea of TSS technology superiority compared to bulb seed, the bulb seed price was calculated based on its applied selling price, which is IDR 32,000.00 kg^{-1}.

The data showed that the largest variable cost in TSS nursery was the cost of input for nursery materials, which ranged 62.5 -71.5% of the total production costs. The labor cost of burning rice husk, mulching, and watering, until harvesting was 28.5-37.5% of the total cost. TSS seed costs are relatively small, around 16.5-18.6 % of the total nursery costs (Table 4).

Research of shallot farming using bulb seed in three regencies in Indonesia showed that seed cost contributes the most to shallot total farming cost, followed by labor cost and land rental cost. This gives TSS smaller costs than bulb seed an advantage because it can increase farmers' income. The three TSS nursery models cost in this study ranged IDR 1,615,000 to IDR 1,815,000, cheaper than bulb seed cost for the same area at IDR 6,400,000. The biggest variable costs from converting to shallot nursery are the cost of making nursery shade (34% of total production costs) [22], which includes labor cost for frame installation + bamboo costs + wire + depreciation cost of the sewn plastic net, followed by depreciation costs of the plastic tray (24% of the total cost). The costs of the three TSS nursery models are listed in table 4.

TABLE IV
COST EFFICIENCY ANALYSIS OF THREE TSS NURSERY MODELS

No.	Component	Input (IDR)			Percentage (%)		
	Input	**Polybag**	**Box**	**Tabela**	**Polybag**	**Box**	**Tabela**
1.	TSS seeds (400 g pack)	300,000	300,000	300,000	16.5	17.7	18.6
	Rice husk ash (1 truck)	200,000	200,000	200,000	11.0	11.8	12.4
	Sludge Fertilizer (400 kg)	200,000	200,000	200,000	11.0	11.8	12.4
	Polybag (4 kg)	180,000	0	0	9.9	0.0	0.0
	Plastic and MPHP Mulch	0	200,000	200,000	0.0	11.8	12.4
	Mist irrigation hose	0	0	150,000	0.0	0.0	9.3
	Sprinkler (8 units)	100,000	100,000	0	5.5	5.9	0.0
	NPK Fertilizer (4 Kg)	40,000	40,000	40,000	2.2	2.4	2.5
	Pest and Disease Management						
	Exi Pheromone	25,000	25,000	25,000	1.4	1.5	1.5
	Yellow trap	25,000	25,000	25,000	1.4	1.5	1.5
	150 cc Fungicide (Amistartop)	15,000	15,000	15,000	0.8	0.9	0.9
	KBI (5x5 m^2) 20 years (Depreciation)	50,000	50,000	0	2.8	2.9	0.0
	Total Input Cost	**1,135,000**	**1,155,000**	**1,155,000**	62.5	68.1	71.5
2.	**Labor**						
	Rice husk burning	80,000	80,000	80,000	4.4	4.7	5.0
	Mixing media and husks	260,000	160,000	80,000	14.3	9.4	5.0
	Sowing seeds (Tabela model)	20,000	20,000	20,000	1.1	1.2	1.2
	Watering (2 x 1 day) x 30 days (Electricity + Fog Hose)	160,000	160,000	160,000	8.8	9.4	9.9
	Sprinkle irrigation labor for 2 hours x 30 DAT	60,000	60,000	60,000	3.3	3.5	3.7
	2 times fertilization and pest control	20,000	20,000	20,000	1.1	1.2	1.2
	Weeding	0	0	0	0,0	0.0	0.0
	Seedling Harvesting	80,000	40,000	40,000	4.4	2.4	2.5
	Total Labor Cost	**680,000**	**540,000**	**460,000**	37.5	31.9	28.5
3.	**Total Cost (1 + 2) of TSS nursery**	**1,815,000**	**1,695,000**	**1,615,000**	100.0	100.0	100.0
4.	Bulb seed cost for 2000 m^2 (200 kg x 32,000)	6,400,000	6,400,000	6,400,000			
5.	TSS nursery efficiency (IDR)	4,585,000	4,705,000	4,785,000			
	TSS nursery efficiency ha^{-1} (IDR)	**18,340,000**	**18,820,000**	**19,140,000**			

A study reported TSS technology's better economic feasibility due to its smaller needed amount than bulb seed. TSS needs at 3-5 kg ha^{-1} with IDR 1,200,000 kg^{-1} price was a lot cheaper than bulb seed, which were needed at around 1-1.5 t ha^{-1} (IDR 30,000 kg-1) amounting to IDR 30 million – 45 million [36]. In this study, the efficiency of TSS seedling nursery compared to bulb seed ranged from IDR 18,340,000 to IDR 19,140,000 ha-1, already accounting for nursery management labor cost. Labor costs for transplanting TSS to the field are six times higher than bulb seed and higher watering and pest-disease control costs. This happened because the TSS harvest age is longer than bulb seed originated plant, hence the need for extra costs. Planting material from TSS costs 50-71 % cheaper than bulb seeds [22]. Using the usual bulb seed planting cost ha-1 at IDR 800,000, the efficiency of using TSS until transplanting can be seen in Table 5.

TABLE V
COST EFFICIENCY OF USING TSS UNTIL TRANSPLANTING PHASE

Component	Cost (IDR)		
	Polybag	**Box**	**Tabela**
*TSS nursery efficiency ha^{-1}	18,340,000	18,820,000	19,140,000
Bulb seed planting cost ha^{-1}	800,000	800,000	800,000
**TSS transplanting cost ha^{-1} (6 x bulb seed planting cost)	4,800,000	4,800,000	4,800,000
Efficiency of using TSS until transplanting phase	**13,540,000**	**14,020,000**	**14,340,000**

Description: *Primary data from Table 4, **Based on [22]

After considering TSS transplanting cost, there were still saved costs or efficiency from IDR 13,540,000 in the polybag model, IDR 14,020,000 in a box model, and 14,340,000 in Tabela model. Tabela model or in-situ nursery saved more costs due to not using seed houses or plastic trays. a previous study reported [22] that TSS seedling nursery's high cost was due to tray and plastic shade costs. The efficiency of TSS usage as planting material will cause a farmer to utilize it in the future. Therefore, more efficient nursery model innovations are continuing to be sought. TSS use is considered to be feasible for its ability to increase shallot bulb yield, as TSS can produce 2 times shallot yield compared to bulb seed. It's also economically feasible because it increased the net income from 22 to 70 million IDR ha^{-1} as compared to bulb seed [22]. Farmers in one research preferred the soil block technique because TSS were easy to grow. TSS seedlings are also easy to transplant and grow well in the field [34].

This study resulted in higher seedling emergence than previous studies, which can result in less need for TSS amount per area, reducing TSS input cost even further. Tabela model systems were shown to have the best seedling performance and the most cost-efficient among the three models tested. A report [31] stated that TSS shallot seeds only require 5-7 kg ha^{-1} whereas it takes around 1,000-1,500 kg ha^{-1} of bulb-seed. This study also agrees with TSS shallot farming research that showed a revenue-cost ratio (R/C ratio) of >1, meaning that TSS shallot farming was efficient. The profit and R/C ratio of TSS shallot farming were higher than that of tuber shallot [31].

IV. CONCLUSION

Seedling nursery model of TSS originated shallot by direct sowing (Tabela) with media mixture of rice husk ash + organic fertilizer + sediment soil (1:1:1) resulting in good seedling emergence with better agronomic performances. The three TSS seedling nursery models, both polybags (12 x 28 cm) and box (40 x 60 cm) model in the greenhouse, and direct sowing (Tabela) outdoor without greenhouse shade, are more economically efficient than using bulb seed. The largest cost in shallot nursery farming models was TSS seed costs, which were relatively small at around 16.5-18.6 % of the total nursery costs. Soil erosion of river sediments at 71.1 t ha^{-1}yr^{-1} needs to be utilized because sedimentary soil's physical and chemical properties are very good for the nursery.

ACKNOWLEDGMENT

The authors thank the Ministry of Research, SMARTD Group Research program in 2018, all the research teams and Prof. Rist Dr. Ms. Suwandi, Indonesian Vegetable Research Institute, West Java (IAARD), and Prof Nanik Setyowati University of Bengkulu Jl. WR Supratman – Kota Bengkulu Indonesia for critical reading and editing of the final draft.

REFERENCES

[1] H. Harti, S. H. Hidayat, Sobir, and S. Wiyono, "Detection of major viruses infecting shallot and molecular characterization of onion yellow dwarf virus from several locations in Indonesia," *Biodiversitas*, vol. 21, no. 4, 2020.

[2] N. F. Devy, R. Setiyani, Hardiyanto, and Puspitasari, "Performance of shallot (Allium cepa var. ascalonicum) derived from true seed under a dry condition area," in *Proc. 2nd ICoSA*, Yogyakarta, Indonesia, 2020, vol. 458, no. 1.

[3] S. S. Girsang, E. D. Manurung, and M. A. Girsang, "Evaluation of land suitability and factors influencing the development of shallots (Allium cepa L.) in North Padang Lawas, North Sumatera," in *Proc. of 1st ICSTLM*, Bogor, Indonesia, 2021, vol. 648, no. 1.

[4] A. M. Kiloes, Puspitasari, D. Mulyono, and M. J. A. Syah, "Land resources management of shallots farming: A case study in the highlands of Solok Regency, West Sumatera," in *Proc. of 1st ICSTLM*, Bogor, Indonesia, 2021, vol. 648, no. 1.

[5] L. Currah and F. J. Proctor, *Onions in tropical regions (NRI Bulletin No. 35)*. Chatham Maritime, Kent: Natural Resource Institute, 1990.

[6] A. I. Santosa and F. Ertunc, "Identification, molecular detection and phylogenetic analysis of four viruses infecting Allium cepa in Ankara Province, Turkey," *J. Plant Dis. Prot.*, vol. 127, no. 4, 2020.

[7] C. A. Putri and S. H. Hidayat, "Sensitivity of serological and polymerase chain reaction methods for detection of viruses in Allium spp.," in *Proc. SEAPPRO 2019*, Bogor, Indonesia, 2020, vol. 468, no. 1.

[8] H. Harti, Sobir, S. Wiyono, and S. Hendrastuti Hidayat, "Hot water treatment on shallot (Allium cepa var. ascalonicum) tuber to suppress viruses infection in the field," *Indones. J. Hortic.*, vol. 9, no. 3, pp. 149–157, 2019.

[9] S. Megawati, Pardono, and E. Triharyanto, "Study of shallot (Allium ascalonicum L) seed viability from true shallot seed (TSS)," in *Proc. ICESAT 2019*, Majalengka, Indonesia, 2020, vol. 466.

[10] S. W. Manwan, Nurjanani, and M. Thamrin, "Effort to increase shallot

productivity using true shallot seed (TSS) from the superior varieties supporting Proliga," in *Proc. of the ICFST 2019*, Makassar, Indonesia, 2020, vol. 484.

[11] L. Edesi, T. Kangor, V. Loide, R. Vettik, I. Tamm, H. J. Kennedy, M. Haljak, Tamm, T. Võsa, K. Tamm, T. Talve, and E. Karron, "Effects of lake sediment on soil chemical composition, dehydrogenase activity and grain yield and quality in organic oats and spring barley succession," *Agron. Res.*, vol. 18, no. 3, 2020.

[12] Y. Niu and C. Guo, "Application of river sediments to soil improvement in urban green space," in *Journal of Physics: Conference Series*, 2020, vol. 1549, no. 2.

[13] A. N. Seika, C. Setyawan, Ngadisih, and R. Tirtalistyani, "Soil erosion mapping using GIS based model in agricultural area of Progo watershed, Central Java, Indonesia," in *Proc. of the ICoSIA 2020*, Yogyakarta, Indonesia, 2021, vol. 686, no. 1.

[14] A. C. Kusumasari, R. Pangestuti, E. Sulistyaningsih, and R. Rosliani, "Growth and production of seed bulbs from true seed shallot planted on dry low land in rainy season," in *Proc. of the 2nd ICSARD*, Purwokerto, Indonesia, 2021, vol. 653, no. 1.

[15] D. P. Turner, "Sampling Methods in Research Design," *Headache*, vol. 60, no. 1. 2020.

[16] L. van Reeuwijk, *Procedures for Soil Analysis*, Sixth Edit. Wageningen, The Netherlands: International Soil Reference and Information Centre, 2002.

[17] American Society of Agronomy, *Methods of Soil Analysis Part 2.Chemical and Microbiological Properties.* 1982.

[18] A. K. Nayak, M. M. Rahman, R. Naidu, B. Dhal, C. K. Swain, A. D. Nayak, R. Tripathi, M. Shahid, M. R. Islam, and H. Pathak, "Current and emerging methodologies for estimating carbon sequestration in agricultural soils: A review," *Science of the Total Environment*, vol. 665. 2019.

[19] D. K. Benbi, "Evaluation of a rapid microwave digestion method for determination of total organic carbon in soil," *Commun. Soil Sci. Plant Anal.*, vol. 49, no. 17, 2018.

[20] J. Liu, G. Izon, J. Wang, G. Antler, Z. Wang, J. Zhao, and M. Egger, "Vivianite formation in methane-rich deep-sea sediments from the South China Sea," *Biogeosciences*, vol. 15, no. 20, pp. 6329–6348, 2018.

[21] A. Tefa, "Test of the viability and vigor of rice seed (Oryza sativa L.) during storage at different moisture levels," *Savana Cendana*, vol. 2, no. 03, 2017.

[22] R. S. Basuki, "Analisis kelayakan teknis dan ekonomis teknologi budidaya bawang merah dengan benih biji botani dan benih umbi tradisional," *J. Hortik.*, vol. 19, no. 2, pp. 214–227, 2009.

[23] K. A. Gomez and A. A. Gomez, *Statistical procedures for agricultural research*, 2nd Ed. Jakarta, Indonesia: Universitas Indonesia Press, 2007.

[24] Cohort, "CoSTAT Version 6.400. Copyright 1998-2008." Cohort Software, Monterey, USA, p. 798, 2008.

[25] S. Priyono, Ibrahim, Soemarno, Sykhfani, and L. M. Limantara, "Utilization of river sludge-sediment as the planting media in reclaiming critical Mined Land: Study of growth and litter production of Jabon (Anthocephalus Cadamba Miq.)," *Int. J. GEOMATE*, vol. 15, no. 52, pp. 230–237, 2018.

[26] W. Mao, S. Kang, Y. Wan, Y. Sun, X. Li, and Y. Wang, "Yellow River Sediment as a Soil Amendment for Amelioration of Saline Land in the Yellow River Delta," *L. Degrad. Dev.*, vol. 27, no. 6, pp. 1595– 1602, 2016.

[27] G. Sopha, N. Sumarni, W. Setiawati, and Suwandi, "Teknik penyemaian benih true shallot seed untuk produksi bibit dan umbi mini bawang merah (sowing technique of true shallot seed to produce seedling and set of shallot)," *J. Hortik.*, vol. 25, no. 4, pp. 318–330, 2015.

[28] M. Zubair, S. Wang, P. Zhang, J. Ye, J. Liang, M. Nabi, Z. Zhou, X. Tao, N. Chen, K. Sun, J. Xiao, and Y. Cai, "Biological nutrient removal and recovery from solid and liquid livestock manure: Recent advance and perspective," *Bioresource Technology*, vol. 301. 2020.

[29] V. K. Borole, A. V. Dhake, P. C. Suryawanshi, and D. G. Patil, "Effect of inorganic fertilizers in combination with biogas slurry and compost on production and quality of white onion (Allium cepa L.)," in *Acta Horticulturae Proc. of VII Int. ISEA 2015*, Nigde, Turkey, 2016, pp. 187–192.

[30] B. P. Bougnom, C. Niederkofler, B. A. Knapp, E. Stimpfl, and H. Insam, "Residues from renewable energy production: Their value for fertilizing pastures," *Biomass and Bioenergy*, 2012.

[31] J. Sumarno, F. Sari Indah Hiola, and A. Nur, "Study on application of TSS (True shallot seed) shallot technology in Gorontalo," in *Proc. of IConARD 2020*, Yogyakarta, Indonesia, 2021, vol. 232, pp. 1–13.

[32] M. Dianawati, Y. Haryati, A. Yulyatin, R. Rosliani, and Liferdi, "Input Saving Technology Package of True Seed of Shallot (TSS) Production in Indonesia," in *Proc. of IConARD 2020*, Yogyakarta, Indonesia, 2021, vol. 232.

[33] A. Wulandari, D. Purnomo, and Supriyono, "Potensi biji botani bawang merah (True shallot seed) sebagai bahan tanam budidaya bawang merah di Indonesia," *El-Vivo*, 2014.

[34] Chanifah, D. Sahara, A. C. Kusumasari, and E. Kushartanti, "Farmers' perceptions of soil block nursery techniques on shallot seeds in Grobogan District, Central Java," in *Proc. of the 1st ICSARD*, Purwokerto, Indonesia, 2021, vol. 653, no. 1.

[35] J. Promono, Sutardi, and B. Sutaryo, "Performance of three varieties on true shallot seed (TSS) seedling in sand soil land area," in *Proc. The 3rd ICoSI 2019*, Yogyakarta, Indonesia, 2019, pp. 455–460.

[36] Makhziah, I. R. Moeljani, and J. Santoso, "Technology dissemination of true seed of shallot and mini shallot bulbs in Karangploso, Malang, East Java," *Agrokreatif J. Ilm. Pengabdi. Kpd. Masy.*, vol. 5, no. 3, pp. 165–172, 2019.