Malays. Appl. Biol. (2021) 50(3): 117–122

GERMINATION AND INITIAL GROWTH OF TRUE SHALLOT (*Allium cepa* L. var. *aggregatum*) SEEDS ENCAPSULATED WITH ORGANIC AND INORGANIC MATERIALS

PANGESTI NUGRAHANI*, IDA RETNO MOELJANI and MAKHZIAH

Department of Agrotechnology, Universitas Pembangunan Nasional Veteran Jawa Timur, Surabaya 60294, Indonesia
**E-mail: pangesti_n@upnjatim.ac.id*

Accepted 16 October 2021, Published online 31 December 2021

ABSTRACT

Shallot (*Allium cepa* L. var. *aggregatum*) cultivation is performed using True Shallot Seed (TSS) to obtain seedlings. However, it is difficult to handle when sowing directly, due to the seed's small and irregular shape. Therefore, encapsulation technology is needed to make TSS seeds have a larger size and regular shape. Shallots seeds enable to be more significant, round-shaped through encapsulation. This research was conducted to make a combination treatment between fillers and adhesives that can form strong, round, and smooth capsules. The fillers studied included gypsum, dolomite, lime, vermicompost, compost, and sawdust. While the adhesive material is Arabic gum and polyvinyl alcohol. The parameters observed include viability, germination, vigor index, and maximum growth potential of encapsulated seed were on par with non-encapsulated in germination and seedling vigor. The results showed that the germination, index vigor, and maximum growth potency of non-encapsulated TSS were better than the encapsulated ones. Likewise for the percentage of seed alive and up-normal seed. Furthermore, the organic type of capsule filling material showed better results compared to the inorganic.

Key words: Coating, direct sowing, pelleting, True Shallot Seed (TSS)

INTRODUCTION

Shallots are one of the most important horticultural crops in Indonesia. At a specific time, the price of shallots in the market increased by several percent due to the scarcity of production. Furthermore, the government made various efforts to overcome this scarcity, one of which involves maintaining and expanding the harvest area to provide good seeds (Harmanto & Maharijaya, 2017; Adiyoga 2020).

Currently, farmers use shallot seeds from consumption bulbs, and the demand for, and the use of consumption tubers as seeds take up 30% of the harvest. Meanwhile, the use of tuber seed reduces the productivity of consumption of onions. In the past two decades, farmers introduced shallot seeds derived from botanical sources. These are known as the True Shallot Seed (TSS). They are botanical seeds of shallots produced from old onion flowers/umbels (planting period of about four months) and processed as seeds (Moeljani & Makhziah, 2018). TSS botanical seeds are round, flattened, wrinkled with irregular shapes, and have a black protective coating. Ripe Shallot umbels also produce TSS seeds.

The Indonesian Ministry of Agriculture has begun to recommend the use of True Shallot Seeds (Adiyoga, 2020). Switching the technique of using shallot seeds from tubers to TSS will be economically beneficial. This is because the demand for TSS is less than that of tuber seeds (Sembiring *et al.,* 2018; Makhziah *et al.,* 2019). The recommended seed size for shallots is 4-5 kg/ha, and its demand can be reduced to 2.3-2.5 kg/ha due to the use of pelleted sources (Yogeesha *et al*., 2017).

TSS that are cultivated in Indonesia include the Tuk Tuk, Bima Brebes, Pikatan, Tajuk, BM 8705, Sanren, and Manjung varieties (Wati & Sobir, 2018). In Ethiopia, the Improve Huruta and Minjar varieties have shown superiority in producing bulbs (Muhamed *et al*., 2018; Tsagaye *et al*., 2021). The variety CO (On) 5, produced seeds and propagated by both bulblets and also seed in India (Saraswathi *et al*., 2017). The Sanren*, Manjung*, and BM 8705

* To whom correspondence should be addressed.

varieties derived from TSS were not significantly different from the other types derived from tuber seeds. The cultivation of high-quality, true shallot seeds (TSS) under suitable environmental conditions and agricultural management has several advantages over bulb materials. These include the smaller quantity of planting materials, more comfortable transportation, long-term storing capacity, production of large and disease-free bulbs, and greater yield (Askari-Khorasgani & Pessarakli, 2019).

The level of acceptance of farmers to TSS technology in Indonesia's shallot cultivation is quite significant (Mardiyanto *et al.,* 2017; Prahardini & Sudaryono, 2018; Makhziah *et al.,* 2018). However, direct planting in the field by farmers encounters several obstacles. One of the barriers includes handling shallot seeds that are irregular in shape and very small in size. An effort to overcome this obstacle is to create a larger TSS with stable and uniform conditions. It also involves the use of growth regulators, insecticides, and other materials to obtain sources with better viability (Agung & Diara, 2017).

Seed coating technology has been successfully used on a wide variety of food crops and horticultural seeds, using a wide variety of coatings and adhesives. Onion seed coating has been performed in a lot of countries, especially onion-producing countries. Onion seed coating uses starch, water, alginate, Arabic gum, and chitosan as a film coating for polymers and binders. Some fillers often used include lime, clay, talc, dolomitic lime, wood dust, vermiculite, sand, others (Pedrini, 2018), vermicompost, cow dung (Yogeesha *et al.,* 2016). Furthermore, Pedrini (2018) also uses starch, water, alginate, Arabic gum, chitosan, and others as film coatings and binders (Afzal *et al*., 2020). Some fillers usually used are lime, clay, talc, dolomitic lime, wood dust, vermiculite, sand, others (Pedrini 2018), vermicompost, cow dung (Yogeesha *et al.,* 2016). Pedrini (2018) also uses starch, water, alginate, Arabic gum, chitosan, and others as film coatings and binders.

Yogeesha *et al*. (2016) used polyvinyl alcohol and polyvinyl acetate as film coatings and binders for the onion seeds. Panwar and Takur (2019) utilized the leaves of the *Azadirachta indica* and *Melia azedarach* plants as pellets on onion seed. The results showed that onion seeds pelleted with *Azadirachta indica leaf* powder + clay and *M. azedarach* leaf powder + clay showed significant effects in enhancing seed quality, growth, and yield bulb raised through direct seeding. Muhie *et al.* (2020) concluded that vermicompost priming can improve germination and seedling emergence of onion seeds in the presence of abiotic stress. Priming with vermicompost improved the performance of onion seeds. A combination of vermicompost, clay, and cow dung powders as stuffing materials and the variety of methylcellulose and polyvinyl alcohol as the adhesive was suitable to obtain firm, round, and smooth seed pellets in onion (Yogeesha *et al.,* 2017).

There have not been many scientific publications in Indonesia on True Shallot Seed coatings and pellets. To improve TSS handling during direct sowing, Sopha and Basuki (2017) conducted pelleting of shallot TSS by gluing several seeds together. The results did not show significant differences with single sources. However, the results showed that shallots from the pellet had lower growth rates and yields than shallots from a single TSS, but there was no significant difference in the bulb's diameter.

TSS as a planting material needs to be accompanied by several technologies to facilitate planting by farmers. Seed coating and pelleting technology is an effort made on seeds that require special treatment. Furthermore, seed coating improves seed performance, including protection from physical damage and disease pests, promoting germination, increasing growth, modifying the shape and size of seeds to facilitate handling.

This study aims to determine the suitable TSS coating materials for improving seed performance, to enable easier handling of indirect sowing cultivation of shallot. Therefore, research on germination and early growth of encapsulated seeds is essential. The research was designed in a laboratory completely randomized experimental design.

MATERIALS AND METHODS

Materials

This research was conducted from July to December 2020 at the Seed Technology Laboratory of the Faculty of Agriculture, UPN Veteran, East Java. The study used the Tri Sula variety of shallot botanical seeds (TSS) obtained from the Batu Horticultural Seed Center of Malang. The seed treatments consisted of nine different encapsulation treatments. The fillers and adhesives in the encapsulation process are as follows:

T0: control, without encapsulation
T1: wood powder filler + polyvinyl acetate (PVA) adhesive
T2: vermicompost powder filler + PVA adhesive
T3: compost powder filler+ PVA adhesive
T4: dolomite filler + Arabic gum adhesive
T5: lime filler + Arabic gum adhesive
T6: gypsum filler + Arabic gum adhesive

All fillers were mashed and sieved with sizes 0.05 – 0.002 mm. The capsule material was formed manually by mixing every 100 g of the stuffing with

25 mL of adhesive. Furthermore, TSS seeds were cleaned and selected from dirt and other materials. After the encapsulation process, the seeds were air-dried and stored for 2 × 24 h.

METHODS

The encapsulation test used seeds in a petri dish covered with two sheets of filter paper and moistened with 15 mL of distilled water. In each treatment, the Petri dish was filled with 25 TSS seeds. The first observation was carried out six days after sowing, and the second 12 days after. The data were analyzed statistically using analysis of variance (ANOVA) based on a completely randomized design and 5% LSD Advanced Test. Furthermore, data retrieval was carried out on the following parameters:

Germination (%)

This calculation involves counting the number of seeds that grow into normal sprouts (in %) on the laboratory's growth medium. Germination capacity (G, %), calculated based on the percentage of normal sprouts (NS), the first count (5 days after sowing), and the second/last (seven days after sowing). The analysis was carried out using Equation 1 (Widjajati, 2013).

$$G = \frac{(\sum \text{NS count I} + \sum \text{NS count II})}{\sum \text{Number of seeds sown}} \times 100\% \qquad \text{– Equation 1}$$

Vigor index (%)

The vigor index was assessed based on the percentage of normal sprouts (NS) that appear on the first count observation (5 days after sowing). The analysis was carried out using Equation 2 (Widjajati, 2013).

$$= \frac{\sum \text{NS at first count}}{\sum \text{Number of seeds sown}} \times 100\% \qquad \text{– Equation 2}$$

Maximum growth potential (MGP) (%)

Maximum growth potential was obtained by counting the number of sprouts that grew normally or abnormally at 7 days after sowing. The analysis was carried out using Equation 3 (Widjajati, 2013).

$$\text{MGP} = \frac{\sum \text{sprout}}{\sum \text{Number of seeds sown}} \times 100\% \qquad \text{– Equation 3}$$

The data analysis

Statistical data analysis involved the analysis of variance based on a completely randomized design, with four replications, followed by the 5% LSD Test.

RESULTS AND DISCUSSION

Performance of TSS seed encapsulation

TSS have a triangular shape, slightly rounded, flattened, irregular, small in size, and low in weight. The weight of 100 TSS was 0.35–0.40 g. TSS encapsulation aims to increase the size of the source to be bigger than the initial size. The average weight of 100 encapsulated TSS seeds was 6.45 g. Furthermore, Gautam *et al.* (2016) observed an increase in the diameter of pelleted onion seeds by 0.45 – 1.07 mm. Afzal *et al.* (2020) also stated that the dosage of coating agents applied to seeds ranged from 0.06 to 1.0% of the seed's weight. The amount of coating required is inversely proportional to the size of the grain.

Evaluation of seed capsule materials

There were six fillers used in the TSS encapsulation in this study: wood powder, vermicompost powder, dolomite, lime, and gypsum. The first three fillers (wood powder, vermicompost powder, compost powder) are organic materials, while the other three (dolomite, lime, and gypsum) are inorganic materials. Furthermore, polyvinyl acetate (PVA) and Arabic gum were used as adhesives. The type of filler and adhesive is highly influential for the success of TSS encapsulation. The variable that may play a role in pellet seed germination is oxygen availability to the seeds through the pelleting layer (Pedrini, 2018). Table 1 shows that inorganic fillers decreased germination and increased the number of dead seeds. This can be compared between the percentage of germination on control treatment (73%), which is significantly different from the treatment of dolomite, lyme, and gypsum fillers with germination percentages of 50%, 51%, and 50%, respectively. In comparison, Lowther and Johnstone (1979) succeeded in using lime and gypsum as a coating for clover seeds. This phenomenon is related to the process of seed physiology, including seed imbibition and transpiration. There are three essential stages in germination: absorption of water, breakdown of sugars in the endosperm, and cell division for seed growth. The time between the water absorption stage and this radical appearance is known as germination (Bareke, 2018). Furthermore, the first stage is highly dependent on the level of porosity due to the skin covering the seeds.

Germination

Table 1 shows a decrease in the appearance of TSS after receiving the encapsulation treatment. The decrease in the percentage of live seeds was 14.67% on average. Likewise, there was an increase in dead

Table 1. Germination, Vigor Index, and Maximum Growth Potency of TSS Encapsulation

Code	Treatment		Germination (%)	Vigor index (%)	Maximum growth potency
	Filler	Adhesive material			
T0	–	73 a	71 a	88 a	
T1	Wood powder	PVA	52 b	51 bc	63 c
T2	Vermicompost powder	PVA	54 b	53 bc	73 b
T3	Compost powder	PVA	59 b	58 bc	71 b
T4	Dolomite	Arabic gum	50 b	49 c	64 bc
T5	Lime	Arabic gum	51 b	51 bc	68 bc
T6	Gypsum	Arabic gum	50 b	49 c	59 c

Mean values within a column followed by the same letters are not significantly different at $p<0.05$ according to LSD Test.

Table 2. Percentage Seed Alive, Dead Seed, Normal Seed, and Up-normal Seed of TSS Encapsulation

Code	Treatment		Percentage seed alive (%)	Percentage of normal seeds (%)	Percentage up-normal seeds (%)
	Filler	Adhesive material			
T0	–	81a	64a	17a	
T1	Wood powder	VPA	54b	11ab	37bc
T2	Vermicompost powder	VPA	54b	19a	27b
T3	Compost powder	VPA	59b	12ab	28b
T4	Dolomite	Arabic gum	50b	14ab	36bc
T5	Lime	Arabic gum	51b	17a	33bc
T6	Gypsum	Arabic gum	50b	9c	41c

Mean values within a column followed by the same letters are not significantly different at $p<0.05$ according to LSD test.

seeds. Yogeesha (2017) observed that pelleted onion seeds showed lower vigor and germination indexes than non-pelleted seeds. Furthermore, the germination and production of Tuk Tuk onion varieties from pelleted TSS were also lower in yield than TSS without pellets (Sopha & Basuki, 2017). Nugrahani *et al*. (2019) stated that onion TSS had a viability of 80%, but was still complicated to grow. Furthermore, according to Prayudi *et al*. (2014), the proportion of live shallots planted directly on land from seeds is still deficient (<50%). The results showed that the mortality rate from seedlings to ready-to-plant seeds was very high (72.6%), therefore the number of seedlings capable of growing was 27.4% (Prayudi *et al*., 2014). In Table 1, it can be seen that the seed germination without encapsulation treatment was 70%. With various encapsulation treatments, the germination decreased up to 50% (in the treatment of dolomite + Arabic gum and gypsum + Arabic gum). However, according to Prahardini and Sudaryono (2018), planting TSS in Batu, Malang, had a viability of 96%.

Seed viability

The viability of seeds examined in this study included germination, vigor index, and maximum growth potential. The ANOVA results stated significant differences between treatments ($p<0.05$) on the three parameters examined. In Table 2, it is observed that T0 (control) had the highest result compared to the other six treatments. Treatment T2 (vermicompost powder filler + PVA adhesive) looked better than all other treatments but was unable to support seed germination. Even with the encapsulating material of gypsum and dolomite, the germination only reached 50%. This encapsulating material also caused seed mortalities of 36% and 41%, respectively (Table 1). The pellets formed with gypsum alone were fragile, whereas that of gypsum combined with any of clay, neem, Pongamia, vermicompost, or cow dung powders, formed relatively firm pellets (Yogeesha *et al*., 2018).

Yogeesha *et al*. (2018) stated that coating the seeds with vermicompost, cow dung, and clay powder as a filling was successfully carried out on onions (*Allium cepa*). As an adhesive, methylcellulose and polyvinyl alcohol were used. With this material, the quality of pelleted seeds is equivalent to non-pelleted seeds in germination and seed vigor. The encapsulating material made from organic objects tends to give better yields than materials made from inorganic. Table 2 shows that the T4 (dolomite filler + Arabic gum adhesive), T5 (lime filler + Arabic gum adhesive), and T6 (gypsum filler + Arabic gum adhesive) treatments using inorganic fillers had a low percentage of the maximum germination potential (64%, 68%, & 59%).

CONCLUSION

This study concludes that there are significant differences between the various treatments of the different capsule ingredients. The results showed that the viability and germination of non-encapsulated TSS were significantly better than the encapsulated ones. The results showed that the viability and germination of the non-encapsulated TSS were significantly better than the encapsulated ones. Germination percentage (73%), vigor index percentage (71%), and maximum growth potential percentage (88%) in TSS without encapsulation, were significantly different with all encapsulated treatments. The organic type of capsule filling material showed better results than the inorganic type. Efforts to make encapsulated TSS need to be continued to increase planting capacity and support the development of precision agriculture, as it allows precise measurement of seed spacing and depth in the field.

ACKNOWLEDGEMENT

The authors are grateful to the Directorate General of Research and Public Service, Ministry of Research Technology / BRIN Indonesia for funding through the PDUPT scheme year 2020.

REFERENCES

Adiyoga, W. 2020. Shallot Production in Indonesia: Importance, Economic and Prospects. Vegetable Crops Research Institute, Research and Development Center, Agricultural Research and Development Agency, Ministry of Agriculture Republic Indonesia.

Afzal, I., Javed, T., Amirkhani, M. & Taylor, A.G. 2020. Modern Seed Technology: Seed Coating Delivery Systems for Enhancing Seed and Crop Performance, *Agriculture*, **10(526)**: 1-20.

Agung, I.G.A.M.S. & Diara, I.W. 2017. Pre-sowing Treatment Enhanced Germination and Vigour of True Shallot (*Allium cepa* var. *aggregatum*) Seeds, *International Journal of Environment, Agriculture and Biotechnology*, **2(6)**: 3262-3267.

Askari-Khorasgani, O. & Pessarakli, M. 2019. Agricultural management and environmental requirements for production of true shallot seeds – a review. *Advances in Plants & Agriculture Research*, **9(2)**: 318-322.

Bareke, T. 2018. Biology of seed development and germination physiology. *Advances in Plants & Agriculture Research*, **8(4)**: 336-346.

Gautam, A., Khurana, R., Manes, G.S. & Dixit, A.K. 2016. Studies on Physical Properties of Pelleted Onion (*Allium cepa* L.) Seeds. *International Journal of Bio-Resource and Stress Management*, **7(6)**: 1279-1283.

Hermanto, C. & Maharijaya, A. 2017. Guidelines for Shallot Cultivation Using Seeds. Directorate of Vegetables and Medicinal Plants Directorate General of Horticulture, Ministry of Agriculture Republic Indonesia.

Lowther, W.L. & Johnstone, P.D. 1979. Coating materials for commercial inoculated and coated clover seed. *New Zealand Journal of Agricultural Research*, **22(3)**: 475-478.

Makhziah, Moeljani, I.R. & Santosa, J. 2019. Technology dissemination of true seed of shallot and mini shallot bulbs in Karangploso Malang, East Java. *Agrokreatif*, **5(3)**: 165-172.

Mardiyanto, T.C., Pangestuti, R., Prayudi, B. & Endrasari, R. 2017. Farmers' perceptions of eco-friendly True Seed of Shallot (TSS) production innovation in Grobogan, Indonesia. *Jurnal Ilmu-ilmu Pertanian*, **24(1)**:41-53.

Moeljani, I.R. & Makhziah. 2017. *Seed Technology: True Shallot Seed*. Gosyen Publishing, Yogyakarta. 198 pp. (in Bahasa).

Mohammed, W., Woldetsadik, K. & Kebed, B. 2017. Registration of a new "Improved Huruta" shallot variety with true seed production potential. *East African Journal of Sciences*, **12(1)**: 77-82.

Muhie, S.H., Yildirim, E., Memis, N. & Demir, I. 2020. Vermicompost priming stimulated germination and seedling emergence of onion seeds against abiotic stresses. *Seed Science and Technology*, **48(2)**: 153-157.

Nugrahani, P., Moeljani, I.R., Makhziah. & Novianti, A.K. 2019. True Shallot Seed encapsulation in sodium alginate matrix and MS media, in: Annual Conference of PERHORTI Proceeding. Lambung Mangkurat University Press, Banjarmasin, pp. 407-414.

Panwar, A. & Thakur, A.K. 2019. Effect of Sowing Date and Seed Pelleting on Plant Growth, Yield and Quality of Onion (*Allium cepa* L.). *International Journal of Pharmacognosy and Phytochemical Research*, **11(3)**: 166-172.

Pedrini, S. 2018. Seed Enhancement Research for Improving Ecological Restoration (Ph.D). Curtin University.

Pedrini, S., Bhalsing, K., Cross, A.T. & Dixon, K.W. 2018. Protocol development tool (PDT) for seed encrusting and pelleting. *Seed Science and Technology*, **46(2)**: 393-405.

Prahardini, P.E.R. & Sudaryono, T. 2018. The True Seed of Shalott (TSS) technology production on Trisula variety in East Java. *Jurnal Pembangunan dan Alam Lestari*, **9(1)**: 27-32.

Saraswathi, T., Sathiyamurthy, V.A., Tamilselvi, N.A. & Harish, S. 2017. Review on Aggregatum Onion (*Allium cepa* L. var. *aggregatum* Don.). *International Journal of Current Microbiology and Applied Sciences*, **6(4)**: 1649-1667.

Sembiring, A., Rosliani, R., Simatupang, S., Prahardini, P.E.R. & Rustini, S. 2018. Financial feasibility of true shallot seed production in Indonesia (Case Study: North Sumatera, East Java, and Central Java). *Jurnal Hortikultura*, **28(2)**: 289-298.

Sopha, G.A. & Basuki, R.S. 2017. Optimizing of seed covering materials on direct sowing cultivation of true shallot seed. *Jurnal Galung Tropika*, **6(3)**: 154-161.

Tsagaye, D., Ali, A., Wegayehu, G., Gebretensay, F. Fufa, N. & Fikre, D. 2021. Evaluation of true seed shallot varieties for yield and yield components. *American Journal of Plant Biology*, **6(1)**: 19-22.

Wati, T.A.P. & Sobir. 2018. Performance of seven varieties of shallot *(Allium cepa* L. *Aggregatum group)* TSS (True Shallot Seed), *Comm. Horticulturae Journal*, **2(3)**: 16-24.

Widajati, E. 2013. Seed Testing Method (Basic Seed Science and Technology). IPB Press.

Yogeesha, H., Panneerselvam, P., Bhanuprakash, K. & Hebbar, S.S. 2017. Standardization of Protocol for Seed Pelleting in Onion (*Allium cepa*) to improve seed handling. *Indian Journal of Agricultural Sciences*, **87(7)**: 975-80.