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Original Article

Effect of pelleting on germination and vegetative growth of true seed of shallot (*Allium cepa* var ascalonicum L.)

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Abstract

Maintaining the quality of shallot seed bulbs is still challenging. They often have long seed dormancy and high procurement cost. Furthermore, they are easily contaminated with viruses, pests and diseases. The use of true seed of shallot (TSS) is one of the solutions to solve these problems. However, TSS is more difficult to plant because of its light weight and tiny size. Seed enlargement can be done by pelleting the seeds with fillers but this can affect the germination and growth of the seeds. This research aimed to evaluate the effect of pelleting on germination and growth of TSS. Experimental treatments were based on TSS ratio with zeolite (w/w), namely unpelleted, 1:3; 1:4; 1:5 and 1:6 (w/w). The results showed that pelleting TSS with zeolite in the ratio of 1:6 successfully increased the seed size without inhibiting germination. This treatment had also the optimum vegetative growth. This work provides pelleting formulations for TSS enabling further development of shallot seedling.

Keywords: true seed of shallot, zeolite, germination, pelleting

1. Introduction

Shallot (*Allium cepa* var ascalonicum L.) is one of the Alliaceae families widely cultivated in Asian countries. This spice contains bioactive compounds with many functional properties beneficial for health, such as have antioxidant (Leelalugrayub, Rattanapanone, Chanarat, & Gebicki, 2006), anti-fungal (Amin & Kapadnis, 2005; Yin & Tsao, 1999), anti-bacterial (Amin & Kapadnis, 2005), peroxynitrite scavenging capacity (Ho, Tang, Lin, & Liew, 2010), anti-tumor (Ghodrati, Ghaffari, Riazi, Ahmadian, & Vahedi, 2008), anti-cancer and anti-inflammatory (Motlagh, Mostafei, & Mansouri, 2011) activities. With the numerous benefits, shallot consumption has increased. Therefore, the shallot is an agricultural commodity that can cause inflation in Indonesia (Wahyudin, Maksum, & Yuliando, 2015).

Shallots are the main spices in Indonesian cuisine. The demand for shallot in Indonesia has increased along with the population growth. However, this demand cannot be fully fulfilled because the productions of shallot bulbs are not only used for consumption, but also as seeds. The amount of shallot bulbs required for seedling is quite large, ie. 0.9-1.0 tons/ha (Swamy & Gwoda, 2006), or 1.2-2 tons (Arefkhani, Khairkhah, & Naghab, 2017; Cho, Lee, & Park, 2011; Lasmini, Nasir, & Hayati, 2018; Rezvan, Nezami, & Kafi, 2011). This can reduce the availability of shallot bulbs for consumption. In addition, the use of shallot bulbs as seeds has several drawbacks, including low quality of seed bulbs because the bulbs often carry viral diseases transmitted by the original plant, seed dormancy, large seed volume, susceptibility to infections, and high cost of provision of seeds (around 40**%** of the total shallot production) (Palupi, Manik, & Suhartanto, 2017; Sudaryono, 2018). The continuous use of bulbs as seeds by farmers can reduce the quality of seeds due to the accumulation of bulbs-borne pathogens, including viruses, which will decrease crop productivity (Tabor, 2018).
To overcome this problem, new technological innovations that are applicable at the farmer level are needed. The use of true seed of shallot (TSS) as a source of seeds has solved this problem (Darsan, Sulistyaningsih, & Wibowo, 2016; Haile, Tesfaye, & Worku, 2017; Khorasgani & Pessarakli, 2019; Nurul, Nunun, Nurul, & Eko, 2019). The advantages of using TSS are unbulky, cheaper, easy to transport, long shelf life, and free from disease and viruses (Agung & Diara, 2017; Brink & Basuki, 2012; Buda, Agung, & Ardana, 2018; Tabor, 2018; Triharyanto, Sudadi, & Rawandari, 2018). However,

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the use of TSS also has weaknesses, such as its tiny size which makes it difficult for farmers to plant.

One of the technologies to increase TSS size is seed pelleting. In seed pelleting, the inert materials such as binding agents and fine powders or filler are added to the seed coat to change its size, shape, and weight (Iacomi & Popescu, 2015; Pedrini, Merritt, Stevens, & Dixon, 2017; Sikhao, Taylor, Marino, Catranis, & Siri, 2015). The success of the pelleting depends on the compatibility of the filler materials with the seed viability and germination (Smith & Miller, 1987). The filler materials of seed pelleting should be compatible with a common binding agent, absorb water, easily cracked and dissolved, and neither inhibit germination nor inhibit radicle or shoot emergence (Taylor, 2003). One of the filler materials used for pelleting is zeolite. Zeolite was a material that has been proven to be used as a material for seed pelleting and planting medium (Cruz *et al.*, 2014; Giuseppe, Ibanez, Melchiorre, & Coltorti, 2018). Other materials such as chitosan and polyvinyl alcohol (PVA) are often used in seed pelleting. Chitosan has been widely used in agriculture because of its biodegradable nature, biocompatibility, harmlessness, and its ability to act as a binding agent (Badawi & Rabea, 2011; Mahdavi & Rahimi, 2013; Nayan *et al.*, 2018). PVA also has binding properties providing coating integrity during and after drying (Afzal, Javed, Amirkhani, & Taylor, 2020). It is widely used in the agricultural industry as a material for the production of fertilizers, insecticides and fungicides with excellent physical properties, high hydrophilicity, processability, and biodegradability (Gaaz *et al.*, 2015; Nayan *et al.*, 2018; Pajak, Ziemski, & Nowak, 2010). This research aimed to develop formulations to produce a pelleted TSS and evaluate the effect of the pelleting on the germination and vegetative growth.

2. Material and Methods

2.1 Making the pelleting binding agent

The binding agents used for TSS pelleting were chitosan and PVA solution. Chitosan solution was prepared by dissolving 5 g of chitosan into 987.5 ml of acetic acid solution and stirring at 700 rpm at 60 ºC for 2 hours until homogeneous. The dissolved chitosan was then mixed with 7.5 g of glycerol and stirred at 700 rpm at ambient temperature for 30 minutes until it is homogeneous. The pH of the chitosan solution was adjusted using NaOH solution to 5.6. PVA solution was prepared by dissolving 30 g of PVA in 970 ml of distilled water and stirred at a speed of 700-800 rpm at 120 ºC for 10 hours until homogeneous. The PVA solution was then cooled at room temperature and subsequently mixed with 1**%** NPK fertilizer solution at a ratio of 1:1 to form a PVA solution enriched with NPK fertilizer.

2.2 TSS pelleting

TSS was pelleted using zeolite as a filler material at ratios of TSS to zeolite of 1:3, 1:4, 1:5, and 1:6. TSS (20 g) was placed in a granulator chamber. The pelleting was carried out in layers by successive additions of zeolite, NPK-enriched PVA solution, zeolite, and chitosan solution. The granulator was operated at a speed of 5.5 rpm. Pelleted TSS was subsequently dried at ambient temperature. Each treatment was replicated 3 times. The pelleted TSS was analysed for their weight, hardness and diameter.

2.3 The germination and seedling testing of pelleted seeds

The germination and seedling testing of pelleted seeds were carried out by seedling TSS, both pelleted and unpelleted, in trays with 69 holes using a mixture of soil, manure and compost as the seedling medium (Javed & Afzal, 2020). The trays used for TSS seedling were filled with soil mixed with manure and watered evenly. One seedling hole was filled with one TSS. All TSS seedled were watered by spraying. Seed germination was measured at 7 and 10 days after seedling (DAS). Plant height and number of leaves was carried out by measuring 10 sample plants per experimental unit at 7, 14, 21 and 28 days after plantig (DAP) (Javed & Afzal, 2020).

2.4 Statistical analysis

This experiment was conducted in a randomised complete design (RCD), with 5 treatment of ratios of seed to zeolite (1: 3, 1: 4, 1: 5 and 1: 6) and unpelleted TSS. Each treatment was repeated in 3 replications so that there were 15 experimental units. Experimental data were analyzed by analysis of variance (ANOVA), and the means were separated at the 5**%** probability level by Duncan**'**s multiple range tests (DMRT).

3. Results and Discussion

3.1 The weight and diameter of pelleted TSS

The use of TSS as planting material has several advantages when compared to tuber seeds, including more cost-efficient, smaller amount of seed needs ((3-7.5 kg per ha) as compared to tubers (1-1.5 ton/ha), being free of viruses and seed-borne diseases, producing healthier plants, and higher yields (Sumarno, Hiola, & Nur, 2021).

The weight of pelleted TSS varied between 74.57 **–** 109.00 g, while the zeolite that was un-pelleted (remaining free zeolite) ranged from 7.00 **–** 32.83 g (Table 1). The highest weight of pelleted TSS was shown by the ratio of TSS to zeolite of 1: 6 (109.00), but the weight of unpelleted zeolite was was also the highest (32.83 g). These were related to the insufficient amount of binding agent, leading to presence of large amount of free zeolite (unpellted). In contrast, the lowest weight pelleted TSS was found in the ratio of TSS to zeolite of 1: 4 (Table 1). It is due to the lack of mixing techniques of making TSS pelleting, where the stirring stage is critical when making seed pelleting, requiring mixing skills. The weight percentage increased after pelleting and drying ranging from 500 to >5000 percent; it common that the percent weight percentage increase was expressed as a ratio of seed weight to dried pellet weight, so a 500**%** weight increase is a 1:5 build-up of seed to coating (Afzal *et al.*, 2020). With this comparison, the seed coating carried out was included in seed pelleting (Afzal *et al.*, 2020).

TSS pelleting would increase the TSS size, enabling farmers to seedling shallots easily. Kangsopa, Hynes and Siri (2018) reported that one of the primary purposes of seed

Table 1. The weight and diameter of pelleted TSS

Ratio of TSS to zeolite	Weight of TSS (g)	Weight of Zeolite (g)	Pelleted TSS			Diameter of pelleted TSS (mm)
			Wet weight (g)	Weight (g dry basis)		
				Free Zeolite (unpelled)	Pelleted TSS	
1:0 (Unpelleted)	20	-	20	-	20	1.23[c]
1:3	20	60	86.17	7.00	79.17	2.43[b]
1:4	20	80	101.90	19.33	82.57	2.63[b]
1:5	20	100	122.47	47.90	74.57	2.75[b]
1:6	20	120	141.83	32.83	109.00	4.13[a]

Remarks: the numbers followed by the same letter in the same column are not significantly based on Duncan test at 5%

pelleting was to change the size, shape and weight of seeds to increase the ease of planting by manual or mechanical means. The diameter of pelleted TSS varied between 2.43 – 4.13 g, while the zeolite that was un-pelleted (remaining free zeolite) was 1.23 mm. The zeolite added treatment with a ratio TSS and zeolite of 1: 6 was 4.13 mm, the largest diameter compared to other treatments (Table 1). The results of this study are in line with the results of Hoeung, Bindar, and Senda (2011) that reported that the optimum diameter in the production of urea fertilizer granules mixed with zeolite was 3-4 mm. It has optimum hardness and can increase the slow release process of nutrient uptake. The larger diameter of TSS is expected to increase the willingness of farmers to apply TSS in cultivation for the production of shallot bulbs.

3.2 The hardness of TSS pelleting

The hardness of pelleted TSS ranged from 541.50 – 1492.33 (Table 2). The ratio of TSS to zeolite of 1:5 had the highest hardness (1492.33). While the lowest hardness of pelleted TSS was shown by the ratio of TSS to zeolite to 1:6 (541.50). The hardness of pelleted TSS was high by giving a lot of PVA and chitosan during the pelleting process. The increased hardness in TSS can inhibit the germination process for the seeds (Table 2). The hardness of pelleted TSS can determine how strong the zeolite layer is in coating seeds. The low hardness value of the layer determines that the seeds will be easily brittle, while the high hardness value indicates the stronger zeolite attached to the seeds. The TSS with a high hardness value had to wait to break down the zeolite layer and then germinate.

3.3 Germination

The germination of pelleted TSS was around 37.50-75.46% (7 DAS) and 76.85-85.19% (10 DAS), respectively (Table 3). The highest germination at 7 DAS had been unpelleted treatment (Table 3). There was no zeolite added in the unpelleted treatment. The shoot of TSS leaves uncoated with zeolite (unpelleted) would appear faster on the surface of the seedling medium (75.46%), whereas in pelleted TSS, it had to wait for the zeolite layer to break down it could germinate (37.50 – 49.07%). This also happened to the germination at 10 DAS (Table 3). However, there was no difference in germination at 10 DAS.

The germination of pelleted TSS was not significant as compared with unpelleted. Pelleting material does not interfere in tobacco and tomato seeds germination (Govinden & Leventard, 2008; Guan *et al.*, 2013). Zeolite was not affecting the seed germination when zeolite came into contact with the seed surface. There was no evidence that zeolites could penetrate their skin. So, the risk of accumulating the zeolite within the tissues of a plant's embryo did not exist (Giuseppe *et al.*, 2018). Another study reported that the germination with zeolite addition in cacti was 72.67% (Cruz *et al.*, 2014).

Table 2. TSS Hardness of pelleted TSS

Ratio of TSS to zeolite	Seed hardness
1:0 (Unpelleted)	-
1:3	1297.67[b]
1:4	1232.33[b]
1:5	1492.33[a]
1:6	541.50[c]

Remarks: the numbers followed by the same letter in the same column are not significantly based on Duncan test at 5%

Table 3. Germination of pelleted TSS

Ratio of TSS to zeolite	Germination (%)	
	7 DAS	10 DAS
1:0 (Unpelleted)	75.46[a]	85.19[a]
1:3	45.37[b]	80.56[a]
1:4	37.50[c]	79.63[a]
1:5	42.13[b]	76.85[b]
1:6	49.07[b]	81.48[a]

Remarks: the numbers followed by the same letter in the same column are not significantly based on Duncan test at 5%, DAS:days after seedling

3.4 Plant height and number of leaves of shallots

The height of shallot at 14 DAS using pelleted TSS ranged from 6.90-7.12 cm, while unpelleted TSS was 6.98 cm (Table 4). The unpelleted TSS tended to show a higher plant height than the pelleted TSS at 7 DAS, but the unpelleted TSS tended to have a lower plant height than others at 28 DAS (Table 4). The number of leaves in 1:6 treatment were 1.63 and 2.07 for 14 and 28 DAS, respectively. Therefore, pelleted TSS with a ratio of 1: 6 was the best treatment.

The addition of zeolite in planting media for nurseries can control nutrient and water absorption to optimize plant growth (Khan *et al.*, 2013; Palanivell, Ahmed, & Majid, 2015; Sonmez, Kaplan, Demir, & Yilmaz, 2010). The zeolite can function as a material that can increase the efficiency of fertilizer absorption. The efficiency of fertilizer absorption will affect plant growth and development. Sudaryono (2017) stated that shallot using TSS have the height of 8-12 cm and the number of leaves of 1-2 strands at 14 DAS. His statement about the number of leaves is not much different from the results of our study, which produces shallot with 1.43-1.70 of leaves at 14 DAS. But, the height had a different result. Our result produces shallot growth with the height of 6.90-7.12 cm at 14 DAS. These differences can be caused by differences in the variety and location of planting. Furthermore, the number of leaves is an important indicator to indicate plant growth. The high number of leaves will be more optimum for the plant's photosynthetic rate than the low number of leaves. The optimum photosynthetic rate will increase the availability of photosynthate needed by plants.

4. Conclusions

The pelleting treatment successfully increased the weight and size of TSS. The weight, dimension and hardness of pelleted TSS were influenced by the ratio of TSS to zeolite. The pelleting treatment also modified the germination and vegetative growth. The treatment of TSS with zeolite in the ratio of 1:6 provided a largest seed size without inhibiting germination or optimum of vegetative growth. This research facilitates handling and seedling of TSS in the fields.

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Table 4. Plant height of shallot with different pelleting formulations

Ratio of TSS to zeolite	Plant height (cm)			
	7 DAS	14 DAS	21 DAS	28 DAS
1:0 (Unpelleted)	2.38^a	6.98^a	7.33^a	7.85^b
1:3	0.57^b	7.12^a	7.63^a	8.23^a
1:4	0.83^b	7.00^a	7.32^a	8.05^a
1:5	0.99^b	6.98^a	7.35^a	8.08^a
1:6	0.92^b	6.90^a	7.33^a	8.30^a

Remarks: the numbers followed by the same letter in the same column are not significantly based on Duncan test at 5%

Table 5. Number of leaves of shallot with different pelleting formulations

Ratio of TSS to zeolite	Number of leaves (Strands)			
	7 DAS	14 DAS	21 DAS	28 DAS
1:0 (Unpelleted)	1.00	1.70	2.00	2.03
1:3	1.00	1.50	2.03	2.03
1:4	1.00	1.57	2.00	2.03
1:5	1.00	1.43	2.00	2.00
1:6	1.00	1.63	2.00	2.07

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