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Optimizing the Propagation of Potato by Stem Cutting using Different Growing Media

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Abstract | Potato (*Solanum tuberosum* L.) is to the actual optimum productivity up to 40 t ha^{-1}. The biggest challenge is the unavailability of a strategic horticultural commodity intended for crop production in Indonesia, essential for food diversification. However, potato productivity in Indonesia is considered low (15 t ha^{-1}) compared to high-quality potato seeds planted by the farmers. In increasing potato productivity, innovative technology in potato seed production in tubers or seeds cutting is requisite. This research investigates the effect of growing media composition on the propagation of stem cutting potato (G0) planted in the screen house. Conducted in Sumber Brantas Village (1 700 m a.s.l.), Bumiaji Regency, City of Batu, East Java, Indonesia, this research utilized Randomized Complete Block Design with seven growing media compositions and four replicates in a micro-cutting planting. The growing mix media composition contained husk charcoal + cocopeat + bokashi (goat manure) + bokashi (cow manure), and husk charcoal + cocopeat + bokashi (cow manure) + bokashi (poultry manure) resulted 13.38 stem cutting (G0). The beneficial roles of bokashi in increasing organic matters concentration in the soil, and it was able to repair air and groundwater systems that supported plant roots growth and optimum capability to absorb nutrients.

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Introduction

Potato (*Solanum tuberosum* L.) is a strategic horticultural commodity to support national food sovereignty in Indonesia (Ishartati *et al*., 2017). Potato contains several phytochemicals such as antioxidants, flavonoids, phenolic, polyamines, and carotenoids, which are beneficial for health (Ezekiel *et al*., 2013). The nutrient circle assumed that potato is associated with high-fat diets because it contains more fat calories than carbohydrate calories (King and Slavin, 2013). Several obstacles of potato production include technical, socio-economic, policy, and institutional factors (Pinho *et al*., 2012). The technical factors include maintaining certified seed distribution in developing countries, diseases, and insects pest. While socio-economic relates to the price instability, high production costs, and limited production quantity. The support to potato farmer organization on upgrading the skills, increasing productivity and quality, becomes the main agenda by providing high-quality potato seeds (Karjadi, 2016). Potato productivity in Indonesia is low. It is approximately 17.67 t ha^{-1} with the total production up to 1 347 815 t from 16 291 ha (Balitsa, 2014; Efi *et al*., 2015; Sri *et al*., 2014). Hence, good agriculture practices (GAP) need to apply for increasing plant productivity, such as soil management including organic matter, proper organic fertilizer applied such as animal manure that important as biomass (Friedel *et al*., 2012; Gregersen, 2011; Husen *et al*., 2021; Jacob *et al*., 2018; Siskawardani *et al*., 2015), controlling Mn toxicity, and ensuring water irrigation (Damongrak *et al*., 2014; Hernandez- Soriano *et al*., 2012; Khan *et al*., 2014; Siskawardani *et al*., 2016).

The high quality of seed selection gave a substantial contribution to the quality of potato production. Therefore, seed variety selection, which can adapt to the local climate and be free from pests or diseases, plays an important role (Ishartati *et al*., 2017). Primarily, potato seeds available in the market obtained from previous planting seasons result in potato tubers' quality derivation, mainly caused by virus infection in the tubers (Dianawati *et al*., 2013; Hidayat, 2011).

The provision of high-quality seeds is necessary to meet sustainable potato cultivation and production. Stem cutting is a vegetative propagation method using potato bud cultivated from tuber tissue culture. Stem cutting is a massive propagation mainly observed through the off-springs generated from the multiplication of nursery transplants. To obtain an optimum stem cutting transplantation time and sustain its normal growth, the nutrient supply is necessary to maintain. This research explores the optimum growing media composition to produce the first generation of potato stem cuttings seed (G0) planted in the screen house.

Materials and Methods

The research location was in the screen house in Sumber Brantas Village, Bumiaji Regency, the City of Batu, East Java, with an altitude of 1 700 m a.s.l., local daily temperature 12 °C to 22 °C and rainfall ± 195.83 mm yr^{-1}. Randomized Complete Block Design with seven different growing media and four replications was used. The media compositions in volume were applied as followed:

1. HCC: Husk charcoal + Cocopeat (1:1)
2. HCCBG : Husk charcoal + Cocopeat + bokashi goat manure (1:1:1)
3. HCCBC: Husk charcoal + Cocopeat + bokashi cow manure (1:1:1)
4. HCCBP: Husk charcoal + Cocopeat + bokashi poultry manure (1:1:1)
5. HCCBGBC: Husk charcoal + Cocopeat + bokashi goat manure + bokashi cow manure (1:1:1:1)
6. HCCBCBP : Husk charcoal + Cocopeat + bokashi cow manure + bokashi poultry manure (1:1:1:1)
7. HCCBPBG : Husk charcoal + Cocopeat +bokashi poultry manure + bokashi goat manure (1:1:1:1).

The micro-cutting from tissue culture plantlet potato cv. Granola produced by the University of Muhammadiyah Malang was used as a material plant. The acclimation technique aimed to improve the adaptation ability of plants in heterogeneous environments by removing plantlets from culture bottles (controlled) to a new environment was applied. It started with the hardening process, which was moving culture bottles containing potato plantlets to the open space. Then, preparation of growing media based on the treatments.

Cocopeat was produced from coconut husk. In contrast, husk charcoal was made of roasted rice husk charcoal. Bokashi was organic fertilizer that was made by fermentation of organic raw materials. This research consisted of poultry and goat manure inoculated by effective microorganisms Agriculture-EM4 (https://emindonesia.com/menu/87/aplikasi-em4) and fermented for about 14 d to 15 d. The plantlet was removed from the culture bottle, shortened the base of stems (removing the roots), and cleaned. The base of the plant was dipped in the root-stimulating paste, and growing media was watered. Plantlets coated with stimulant paste were planted with spacing about 10 cm x 10 cm and hooded with plastics to reduce transpiration rate. The plant cultivation was controlled intensively, including watering used sprayer and adding NPK fertilizer with a ratio of 15-15-15 (dosage about 2 g per plant) every week. Pest controlling by protective action was attempted whenever the signs of crops attacked by pest or disease, such as insecticide, was used for aphid, while fungicide for fungi or specifically *Phytophthora*. A systemic fungicide concentrated 1 g L^{-1} with the active ingredient Simoxanil was applied (Figure 1).

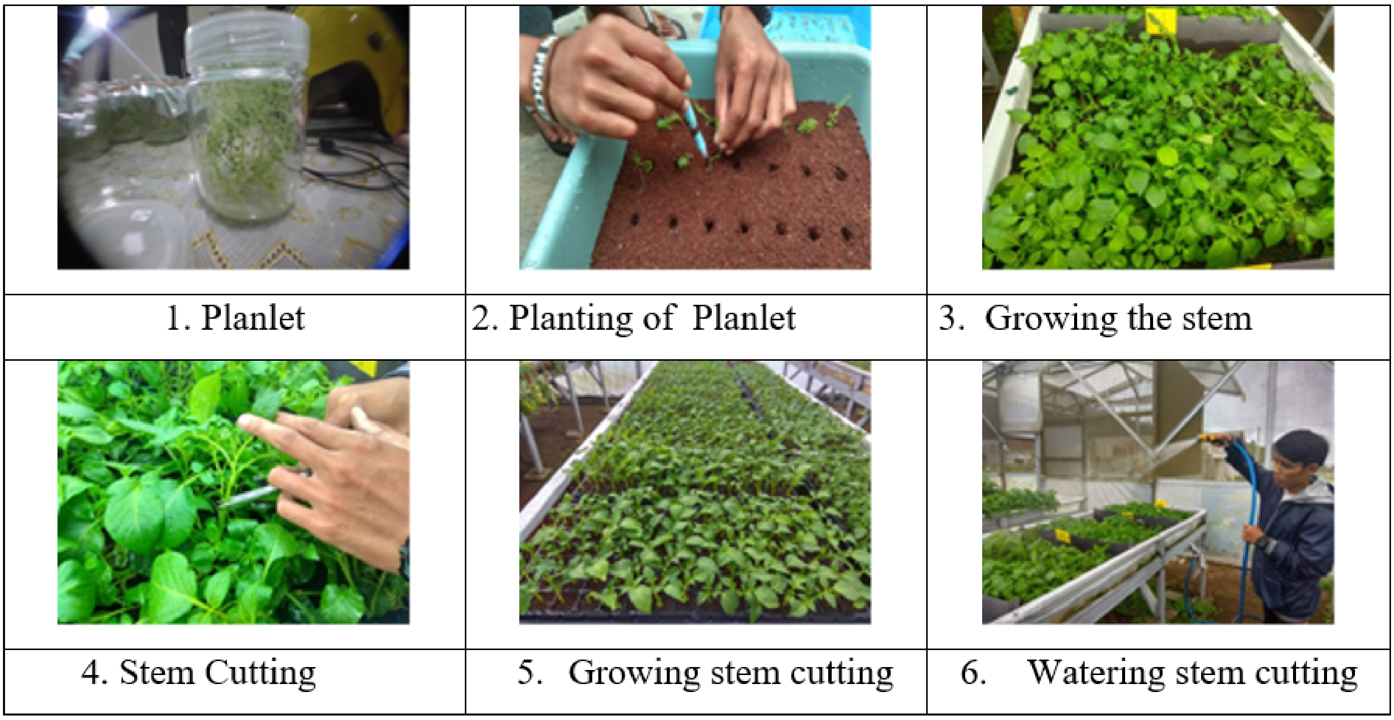

Figure 1: *Propagation of stem cuttings from potato seed plantlets.*

The data was collected every week with the main parameters focusing on the number of potato buds and the number of stem cuttings that resulted in every cutting period. The obtained data was analyzed using *F*-statistics and verified by Tukey's HSD test at a 5 % significance level (Adinurani, 2016).

Results and Discussion

Potato bud number

According to the analysis of variance, the growing media had a very significant effect on the stem numbers. Based on Table 1, there were two types of optimum growing media producing more bud numbers starting from 42 DAP to 77 DAP (days after planting): (i) HCCBGBC husk charcoal + cocopeat + bokashi goat manure + bokashi cow manure; and (ii) HCCBCBP husk charcoal + cocopeat + bokashi cow manure + bokashi poultry manure, with the highest potato bud number 15.63.

Khalafalla (2001) stated that the plant spacing, cultivar, and quality of seed size, affected the marketable tuber weight and the number of stems per plant. Multiple techniques have been developed in the last decades to improve the rate of seed productivity, such as aeroponics technology (Rykaczewska, 2016). The alternative and formal seed systems such as availing new varieties, designing quality control methods, and improving farmers' awareness should prioritize to improve the production capacity of quality seed (Hirpa *et al*., 2010). Pacifico *et al*. (2017) investigated that the organic management in the soil had a positive correlation on the tuber metabolism associated with nutritional such as flavonoid, phenylpropanoid, asparagine, ascorbic acid, and glycoalkaloid. As a result quality of potato bud would grow better. In addition, proper organic fertilizer applied could improve seed germination percentage (Al-Shaheen *et al*., 2020; Al-Shomali *et al*., 2017).

The optimum growing media to produce higher potato bud was expected due to the nutrient composition of planting media. Based on the data, it was explained that the addition of bokashi goat manure and bokashi cow manure at treatment 5, also at treatment 6, which added the bokashi cow manure and bokashi poultry manure got the optimum potato bud (15.63) at 77 DAP. When it was compared to the control (husk charcoal + cocopeat) without the addition of bokashi that resulted in the lowest potato bud 9.31 at 77 DAP.

Commonly, all treatments consisted of the husk charcoal and cocopeat, but compositions that makes the difference were the type of bokashi added. The husk charcoal nutrients consisted of SiO_2 with levels of 72.28 % and C as much as 31 %, while the micronutrients were composed of Fe_2O_3, K_2O, MgO, CaO, MnO and Cu in small amounts (Bakri, 2009).

Table 1: *The potato bud number at 35 d to 56 d after planting (DAP).*

Treatment	Growing Media	Days after planting (DAP)						
		35	42	49	56	63	70	77
1	HCC	1.13 a	2.19 a	3.31 a	4.13 a	5.63 a	7.69 a	9.31 a
2	HCCBG	1.19 a	3.38 abcd	5.25 cd	6.88 c	8.75 c	10.88 c	12.94 cd
3	HCCBC	1.00 a	2.88 abc	4.94 bc	6.88 bc	8.69 bc	10.13 bc	12.06 bc
4	HCCBP	1.06 a	2.38 ab	3.44 ab	4.75 abc	6.63 a	8.75 abc	11.44 abc
5	HCCBGBC	1.75 b	4.44 e	7.31 f	10.25 f	12.38 f	14.19 f	15.63 f
6	HCCBCBP	1.13 a	4.06 de	6.75 ef	9.69 e	11.63 ef	13.63 ef	15.63 ef
7	HCCBPBG	1.31 ab	3.94 cde	6.31 def	9.31 def	11.06 def	13.06 def	15.00 def
	Tukey HSD	0.47	1.11	1.34	2.20	2.01	2.16	2.44

Remarks: *The average number followed by the same notation in the same column indicated no significant difference based on the Tukey HSD test at 5 %.*

Table 2: *Stem cuttings number based on growing media.*

Treatment	Growing Media	Stem Cuttings						
		1	2	3	4	5	6	7
1	HCC	1.00 a	1.38 a	2.13 a	2.50 a	4.00 a	5.88 a	7.81 a
2	HCCBG	1.00 a	2.25 bcde	3.50 bc	4.63 ab	6.88 c	8.94 bc	10.69 abc
3	HCCBC	1.00 a	2.00 abcd	3.38 ab	4.69 b	6.69 bc	8.15 ab	10.38 ab
4	HCCBP	1.00 a	1.19 a	2.13 a	2.94 ab	4.56 a	6.88 ab	9.50 a
5	HCCBGBC	1.19 b	3.00 e	5.38 e	8.31 e	9.94 f	11.94 e	13.38 d
6	HCCBCBP	1.00 a	2.50 cde	4.94 de	7.44 de	9.31 ef	11.38 de	13.38 cd
7	HCCBPBG	1.06 ab	2.69 de	4.75 cde	7.31 cde	8.88 def	11.00 cde	12.88 bcd
	Tukey HSD	017	0.82	1.30	2.14	1.94	2.35	2.92

Remarks: *the average number followed by the same notation in the same column indicated no significant difference based on the Tukey HSD test at 5 %.*

The macro and micronutrients in cocopeat are composed of (K) Potassium, (P) Phosphorus, (Ca) Calcium, (Mg) Magnesium, and (Na) Sodium. While the bokashi cow manure consisted of N 2.33 %, P_2O_5 0.61 %, K_2O 1.58 %, Ca 1.04 %, Mg 0.33 %, Mn 179 mg kg^{-1} and Zn 70.5 mg kg^{-1}. Whereas the chicken manure is composed of N 3.21 %, P_2O_5 3.21 %, K_2O 1.57 %, Ca 1.57 %, Mg 1.44 %, Mn 250 mg kg^{-1} and Zn 315 mg kg^{-1} (Oktabriana, 2018). While nutrients of goat manure consisted of N 2.10 %, P_2O_5 0.66 %, K_2O 1.97 %, Ca 1.64 %, Mg 0.60 %, Mn 233 mg kg^{-1} and Zn 90.8 mg kg^{-1}. Therefore, the addition of bokashi on the growing media was able to improve potato bud production.

Stem cuttings number

During the seedling phase, stems were gradually cut seven times. Based on the analysis of variance indicated that growing media contributed significantly to the increasing stem cuttings number. Table 2 showed that the number of potatoes by stem cuttings had high productivity on the same types of growing media that produced optimum bud number, with stem cuttings number on each growing media accounted at 13.38; 13.38; 12.88 stem, respectively.

The optimum stem cutting was at the fourth and fifth on all growing media. Stem cuttings had a positive effect on the quality of potato plant seedlings. The uniformity of plantlet used in its stem number, leave numbers, and height contributed to the quality of potato seedlings. Uneven cutting on the stem also could ruin the xylem and phloem tissues; thus, the stem planted in the media decayed on the base. Meanwhile, the old stem might risk high respiration and slow down root growth. According to Hartus (2001), the stem cuttings should have no more than 5 cm between two internodes and stem diameter about 2.5 mm to 3.5 mm.

The growth of potatoes was dependent on the growing media with the optimum adequate nutrients and water availability. The media types, which contained more than one type of bokashi, supplied more nutrients that contributed to the potato seedlings. Additionally, husk charcoal and cocopeat played an essential role in better aeration and water-binding substances. The favorable media for root system in stem cuttings was a media that supported enough aeration, relative humidity, good drainage, and pathogen-free (Struik and Wiersima, 1999). The advantages of using organic materials as growing media are its structural ability to balance and control the aeration system in the media. Furthermore, organic materials were abundantly available as byproducts and relatively cheaper for alternative growing media. It also had distinct characteristics of well decomposed and crumbly; hence water, air, and root could quickly enter the soil fraction and bind the water. This was important for the root system in seedlings because growing media is closely related to the plant root growth.

Husk charcoal characteristic was well-water binding, not easily coagulated, reasonable price, readily available, light, sterile, and good porosity (Tufaila *et al*., 2014). Husen *et al*. (2018), Husen *et al*. (2019) and Pangaribuan *et al*. (2012) explained the beneficial roles of bokashi in increasing organic matters concentration in the soil, and it was able to repair air and groundwater systems that supported plant roots growth and optimum capability to absorb nutrients. The responses of the plant towards fertilization increased significantly, providing that the exact dose, duration, type, and method applied. Nutrient availability and plant genetic composition were also crucial factors in plant productivity.

Conclusions and Recommendations

Growing media composition was significant to produce the first generation of potato stem cuttings seed. The stem cutting number from second to seventh cuttings showed that growing mix media composition using husk charcoal + cocopeat + bokashi goat manure + bokashi cow manure; and husk charcoal + cocopeat + bokashi cow manure + bokashi poultry manure, each resulted in 13.38 initial stem cuttings (G0) and 15.63 potato bud. Compositions that makes the difference were the type of bokashi added. The bokashi support the improving organic matters concentration in the soil, repair air and groundwater systems that supported plant roots growth to absorb nutrients.

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Novelty Statement

The novelty of this study is indicated by the innovative technology in potato seed production in tubers or seeds cutting is requisite. The growing media combination contained husk charcoal + cocopeat + bokashi (goat manure) + bokashi (cow manure), and husk charcoal + cocopeat + bokashi (cow manure) + bokashi (poultry manure) resulted 13.38 stem cutting (G0).

Author's Contribution

SH: Conceptualized and designed the study, elaborated the intellectual content, performed literature search, manuscript review and manuscript revision.
DDS: Elaborated the intellectual content, performed literature search, data acquisition, manuscript review and manuscript revision.
SDR: Carried out experimental studies, data acquisition and data analysis.
EI: Data acquisition, data analysis and manuscript review.
MM: Performed literature search, data acquisition and manuscript preparation.
JO and IZ: Performed literature search, data acquisition, manuscript preparation and guarantor.
All authors read and approve the final manuscript.

Conflict Interest
The authors declare that there is no conflict of interest regarding the publication of this article.

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