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USE OF GRASS AND SPENT MUSHROOM COMPOST AS A GROWING MEDIUM OF LOCAL TOMATO (*Lycopersicon esculentum* Miller) SEEDLING IN THE NURSERY

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ABSTRACT

The objective of this study was to investigate the response of local tomato (*Lycopersicon esculentum* Miller) seedlings growth on media containing grass and spent mushroom compost in the nursery. The grass compost (GC) was produced by Research Center for Biotechnology-LIPI. Whereas the spent oyster mushroom (*Pleurotus ostreatus*) compost (OC) and spent paddy straw mushroom (*Volvariella volvacea*) compost (PC) were produced by Research Center for Biology-LIPI. Growing media of tomato seedling was a mixture of top soil (TS), rice husk charcoal (HC), grass compost (GC), spent oyster mushroom compost (OC) and spent paddy straw mushroom compost (PC) in the ratio of 1:1 as follows: TS+HC, TS+HC+GC, TS+HC+OC and TS+HC+PC. The experiments were arranged in Completely Randomized Design with three replications. Growth parameters observed i.e. seedling growth, dry weight production and leaf indices. Results showed that growing medium containing spent paddy straw mushroom compost was the best to improve seedlings growth in general. However, the lowest specific leaf area (SLA) and leaf area ratio (LAR) indices were obtained by the seedlings on the medium without compost. Correlation analysis showed that highest correlations were recorded for the TS+HC+OC medium. The tomato seedling growth was improved on the media containing compost in general.

Keywords: grass compost; *Lycopersicon esculentum;* seedling growth analysis; spent mushroom compost (SMC)

INTRODUCTION

Germplasm Garden of Research Center for Biotechnology-LIPI produced a significant amount of plant and livestock wastes. The waste was resulted from maintenance activity of the garden which produced at least 2.1 tons of litter, 750 kg of grass cuttings and 4.8 tons of dung per month. Moreover, organic waste was also generated from mushroom production. Oyster and paddy straw mushroom production of the Research Center for Biology-LIPI in collaboration with farmers in Ciawi, Gadog and Cipayung regions produced 4 tons of fresh mushrooms per day. Furthermore, national mushroom production in 2012 was 40,887 quintals (Statistics Indonesia, 2014). It has been known that about 2.5 kg of spent mushroom substrates (SMS) or fresh SMC (spent mushroom compost) are produced for each kilogram of mushroom. Therefore, SMS management has become a major problem faced by farmers in several countries (Phan & Sabaratnam, 2012). SMS is an organic substance which used for an alternative growing media for horticultural plants so that it is conserving natural resources such as peat (Medina, Paredes, Pérez-Murcia, Bustamante, & Moral, 2009). SMS can be processed into SMC by decomposing them for several weeks so that the negative effect of ammonia gas content on plants can be reduced (Gbolagade, 2006; Maynard, 1994). Nutrient content of those three compost type used in this study is shown in Table 1.

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Table 1. Nutrient content of three compost type as a growing medium of local tomato seedling in the nursery

Compost type	Moisture content (%)	pH	Organic C (%)	Total N (%)	P (P_2O_5) (%)	K (K_2O_5) (%)	C/N ratio
Grass compost (GC)	81.05	7.8	6.31	0.59	0.15	0.20	11
Spent oyster mushroom compost (OC)	73.36	8.4	10.35	0.32	0.29	0.11	32
Spent paddy straw mushroom compost (PC)	75.12	8.5	8.91	0.50	0.36	0.19	18
Standard quality of compost							
Permentan*	15 - 25	4 - 9	>15 %	$N+P_2O_5+K_2O$ >4 %			15-25
SNI**	50	6.80 -7.49	9.8-32	≥ 0.40	≥ 0.10	≥ 0.20	10 - 20

Remarks: *) Minister of Agriculture Regulation No. 70/Permentan/SR.140/10/2011. **) Indonesian National Standard 19-7030-2004

Tomato is originated from the South America. Tomatoes can be consumed directly as a condiment, salad or processed into sweets, dried fruit or canned fruit. Tomato fruit has a good nutritional content. Therefore, it is used to improve community nutrition (Siemonsma & Piluek, 1994). Plant propagation by seed is the most efficient method and has been widely used for cultivated crops (Hartmann, Kester, & Davies, 1990). For horticultural crops that have economic value, direct seed sowing in the nursery before planting is a more reliable method than direct sowing in the field (Herrera, Castillo, Chica, & López Bellido, 2008). The objective of this study was to observe the growth responses of tomato seedlings on the media containing grass compost and SMC in the nursery.

MATERIALS AND METHODS

Seeds Collection

Commercial tomato seeds with a purity of 98% and viability of 85% were obtained from a local market in Bogor. The seeds were produced by RiawanTani (Ritan Seeds) Blitar Indonesia. The seeds were stratified in warm water (30-40°C for 15-20 minutes) prior to sowing on the growing media in the nursery.

Growing Medium

The tomato seeds were sown manually on each 30 g of growing media in polystyrene trays with 128 compartments consist of top soil (TS), rice husk charcoal (HC), grass compost (GC), spent oyster mushroom compost (OC) and spent paddy straw mushroom compost (PC) as follows: TS+HC+PR, TS+HC+OC, TS+HC+PC and TS+HC (without compost) at the proportion of 1:1. According to FAO (1998), top soil is an important soil part and can be used for growing media of plants producing food. Rice husk charcoal is commonly used as growing medium because it has a good porosity to facilitate plant roots growth.

Grass compost was made from a mixture of grass cuttings and cattle dung (1:1) with the addition of 0.1% (w/w) compost bioactivator of *Biosmic*. The substrates were then decomposed aerobically for at least 7 weeks. Spent mushroom compost was made from spent oyster or paddy straw mushroom substrates mixed with cattle dung (3:1) were decomposed aerobically for 1 month with the addition of 0.2% (w/w) compost bioactivator of “ikokasmur” (inoculated from SMS). The seeds were then sown manually on the growing medium in polystyrene trays. Each compartment was filled with a seed of tomato.

Growth Parameter

At the final observation of seedling growth period (day-24), the parameters of seedling height, stem diameter, ratio of height/diameter; first internode height, number of leaves per seedling, leaf area per seedling, total dry weight per seedling, specific leaf area (SLA) and leaf area ratio (LAR) were recorded. According to Herrera, Castillo, Chica, & López Bellido (2008) the SLA and LAR index is used to evaluate seedling resistance at transplant.

Seedling emergences were recorded when a normal seedling was visible above the growing media at 2-day intervals. Normal seedling is defined when seedling complete with cotyledons and hypocotyl. Rates of seedling emergence were calculated following Herrera, Castillo, Chica, & López Bellido (2008) using a modified

Timson's emergence velocity index (G/t). G is the number of seeds emerged and t is the total time of seeds germination (Herrera, Castillo, Chica, & López Bellido, 2008).

Seedling height was measured using a digital caliper (Nankai) on 30 seedlings of each growing medium. Seedling leaf area was calculated using digital image analysis method (Bradshaw, Rice, & Hill, 2007) on all leaves taken randomly from 10 seedlings of each growing medium. Digital image analysis of leaf is a simple, inexpensive and accurate method and it has been applied for measuring existing leaf area and leaf area removed as a result of herbivory (O'Neal, Landis, & Isaacs, 2002).

Changes in the chemical characters of the growing medium were observed by measurement the degree of acidity (pH) and electrical conductivity (EC) at the initial and final of seedling growth period using a digital pH and EC meter (Bluelab). Measurement of pH and EC were done in triplicate using water/soil (2:1) extraction method (Jones, 2001).

The water content of tomato seedling was measured on a fresh weight basis method according to ISTA (2006) using an oven (Proilabo) at 130°C for 2 hours. Measurement of water content was done in triplicate on each part of seedling of each growing medium.

Seedling Maintenance

All experiments were conducted in the screen house of nursery of Germplasm Garden belongs to RC for Biotechnology-LIPI. Tomato seedlings were maintained by watering the seedlings with ground water. Temperature and relative humidity in the screen house during seedling growth period were 27-34ºC and 40-70% respectively.

Experimental Design and Statistical Analysis

The experiments were arranged in Completely Randomized Design (CRD) with 3 replications. Each treatment of growing medium consisted of 30 seedlings with the exception of 10 seedlings for leaf area measurement. Obtained data was analyzed using Analysis of Variance (Anova) followed by Duncan's Multiple Range Test (DMRT). The relationship between parameters was observed using Pearson coefficient. Data was processed using SPSS statistical software 16.0.

RESULTS AND DISCUSSION

Chemicals Characteristic of Growing Medium

Table 2 showed that pH of all growing medium tends to increase from 7.0 at the beginning of seed sowing until 7.8 (slightly alkaline) at the end of seedling growth period. On the contrary, the EC of growing medium was decreased in the range of 0.10 – 0.17 at the end of seedling growth period. Nutrient salts absorption by the seedling from the growing medium during seedling growth period caused a higher pH on growing medium at the end of the seedling growth period. A study conducted by Putra, Damanik, & Hanum (2015) showed that higher pH of the medium was caused by organic acid chelation process as the effect of the addition of dung in the compost. In contrast, EC of those growing media was lower at the end of seedling growth as a result of salts leaching when watering. Pardo, Clemente, & Bernal (2011) found that alkaline compost has low EC, is rich in nutrients and organic matter and has a high degree of humification. The best pH of growing medium for horticultural plants in the nursery was in the range of 5.2-7.0 (Herrera, Castillo, Chica, & López Bellido, 2008). In this experiment, this condition was achieved by the growing medium at the beginning of seed sowing.

Table 2. Initial and final pH and Electrical Conductivity (EC) of growing medium of tomato seedlings in the screen house

Growing Medium	Initial		Final	
	pH	EC ($dS\ m^{-1}$)	pH	EC ($dS\ m^{-1}$)
TS+HC+GC	7.13	0.20	7.53	0.10
TS+HC+OC	7.00	0.40	7.33	0.17
TS+HC+PC	7.20	0.40	7.80	0.10
TS+HC	7.20	0.20	7.57	0.10

Remarks: TS=top soil; HC=rice husk charcoal; GC=grass compost; OC=spent oyster mushroom compost; PC=spent paddy straw mushroom compost

Seedling Growth

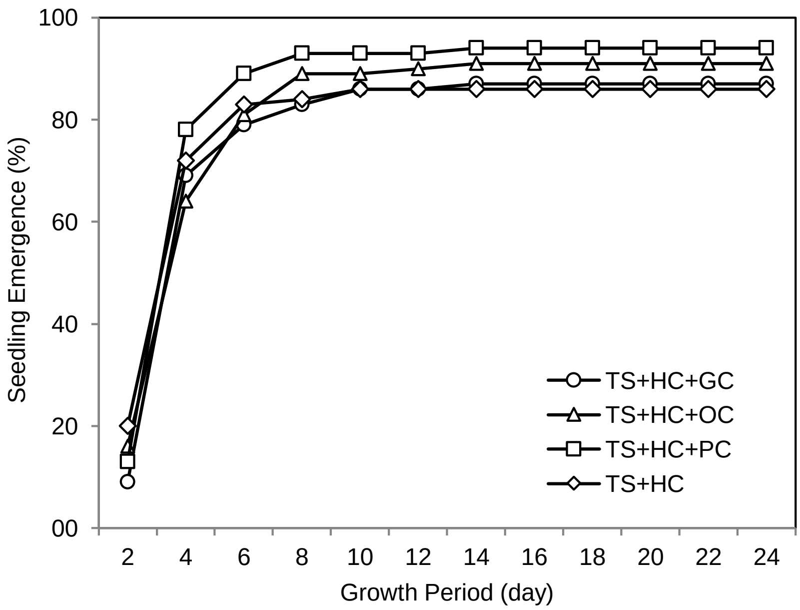
Growing media containing both spent oyster and paddy straw mushroom compost resulted in the highest average value of all growth parameters, although there was no significant difference in term of emergence rate as same as the ratio of the height and diameter of seedlings

(Table 3). This is in accordance with a study conducted by Wang, Lohr, & Coffey (1984) that SMC of 0-50% in the growing media did not affect final seedling emergence. However, the rate of seedlings emergence can be delayed. According to Hartmann, Kester, & Davies (1990) germination was measured on two parameters i.e. seedling emergence percentage and emergencerate. The vigor of seedling may be indicated by these measurements. However, growth rate and morphological appearance of the seedlings should be considered. An experiment conducted by Eudoxie & Alexander (2011) showed that tomato seedling growth on media containing SMC resulted in the best of seedling height and growth rate. Nevertheless, the effect of SMC on seedling growth depends on the tomato varieties as shown by the experiment of Medina, Paredes, Pérez-Murcia, Bustamante, & Moral (2009) using a mixture of spent oyster mushroom compost and peat at the ratio of 50-75%. Meanwhile, Sendi, Mohamed, Anwar, & Saud (2013) and Marques et al. (2014) suggested that the using of 42-50% of SMC was the optimum ratio for potting medium. The pattern of the seedling emergence and its morphological appearance are shown in Figure 1 and Figure 2 respectively.

Table 3. Effects of different media on growth parameters of tomato seedlings in the screen house

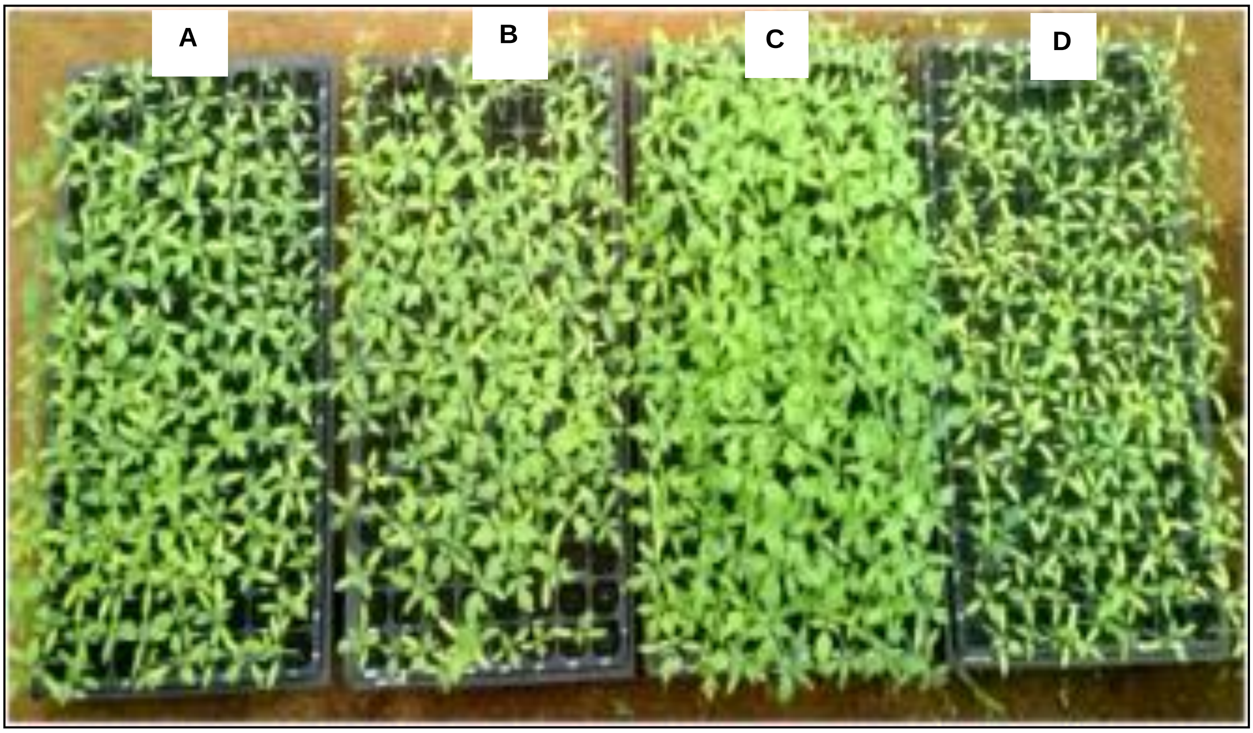
Media	Seedling emergence (%)	Rate of emergence	Height (H) (mm)	Diameter (D) (mm)	Ratio of H/D	First node height (mm)
TS+HC+GC	87 a	3.6 a	61.9 c	1.8 c	35.5 a	46.4 b
TS+HC+OC	91 a	3.8 a	68.0 b	2.0 b	34.3 a	49.3 b
TS+HC+PC	94 a	3.9 a	80.2 a	2.2 a	37.3 a	54.3 a
TS+HC	86 a	3.6 a	58.0 c	1.6 d	36.5 a	44.7 b

Remarks: TS=top soil, HC=rice husk charcoal, GC=grass compost, OC=spent oyster mushroom compost, PC=spent paddy straw mushroom compost; Means in the same column followed by the same letter are not significantly different (p<0.05)



Remarks: TS=top soil; HC=rice husk charcoal; GC=grass compost; OC=spent oyster mushroom compost; PC=spent paddy straw mushroom compost

Figure 1. Tomato seedlings emergence on different growing media’s



Remarks: A=TS+HC+GC, B=TS+HC+OC, C=TS+HC+PC, D=TS+HC (TS=top soil; HC=rice husk charcoal; GC=grass compost; OC=spent oyster mushroom compost; PC=spent paddy straw mushroom compost).

Figure 2. Tomato seedlings appearance (14-days old) on different growing media's

Dry Matter of Seedling

Biomass production of each plant may vary. It was affected by seed weight or factors related to the environmental condition (Poorter & Remkes, 1990). The highest dry weight of leaves, roots and whole seedling was obtained by the seedling grown on media containing spent paddy mushroom compost with the exception of stem dry weight. A study conducted by Kandemir, Özer, Özkaraman, & Uzun (2013), showed that the highest stem dry weight of cucumber seedling was obtained from media containing, a mixture of farm yard manure and garden soil, whereas the lowest was obtained from media containing commercial perlite. According to Wang, Lohr, & Coffey (1984), SMC content in the growing media provides additional nutrients and organic matter for seedling growth so that seedling height and dry weight is increased. The highest leaves and roots dry weight (0.035 and 0.026 g respectively) was obtained by the seedlings grown on the media containing spent paddy straw mushroom compost and significantly different ($p<0.05$) with those grown on the other growing media used, with the exception of the seedlings grown on the media containing spent oyster mushroom compost. The highest stem dry weight (0.045 g) was obtained by the seedling grown on the media containing spent oyster mushroom compost and significantly different with the seedlings grown on the other growing media used. The dry weight of whole seedlings on the media containing spent oyster mushroom compost was not significantly different with those grown on the media containing spent paddy straw mushroom compost. On the other hand, the seedlings grown on the media containing grass compost was not significantly different with those grown on the media without compost (Table 4). An experiment conducted by Medina, Paredes, Pérez-Murcia, Bustamante, & Moral (2009) using a mixture of peat and spent oyster mushroom compost in the range of 25-100% showed that the lower dry weight of the seedling caused by a higher ratio of oyster mushroom SMC in the media.

Leaf Indices

The highest total leaves (2.7) and leaf area (8.6 cm^2) of the seedling was obtained by the seedling grown on media containing spent paddy straw mushroom compost. The highest total leaves was significantly different ($p<0.05$) with the seedling grown on the other growing media used. However, the highest leaf area was only significantly different with the seedlings grown on the media containing grass compost. A study conducted by Herrera, Castillo, Chica, & López Bellido (2008) using the mixture substrate of old peat (OP), white peat (WP), perlite and municipal solid waste compost (MSWC) showed that the best growing media of tomato seedlings production was a mixture of WP (65%) and MSW compost (30%).

The lowest SLA index (84.3 cm^2 g^{-1}) was obtained by the seedling grown on media without compost. It was significantly different with the seedling grown on the growing media containing grass compost. However, there was no significant difference for LAR index between the growing media used (Table 5). It supposed to be that tomato seedling resistance at transplant was also supported by the relatively high emergence rate of the seedlings (86-94%).

Correlation among Parameters

Positive correlation was indicated by the majority of growth parameters of tomato seedling on media containing grass compost or SMC. There was not any significant difference correlation between growth parameters on media without SMC. However, there were significant differences ($p<0.05$) between leaf area and seedling height, seedling height and root or leaf dry weight and diameter and root dry weight and a very significant difference ($p<0.01$) between leaf area and leaf or whole seedling dry weight on media containing spent oyster mushroom compost. The only significant difference correlation was between leaf area and leaf dry weight on media containing grass compost but there was no significant difference correlation between parameters on growing media without compost. The significantly different correlation occured between seedling diameter and leaf or whole seedling dry weight and stem and root dry weight (Table 6). The result indicated that the presence of compost on growing media was essential for seedling growth.

Table 4. Effects of different growing media on dry weight of tomato seedling in the screen house

Media	Dry weight (g $seedling^{-1}$)			
	Leaves	Stem	Roots	Whole
TS+HC+GC	0.019 bc	0.011b	0.017 bc	0.047 b
TS+HC+OC	0.031 ab	0.045a	0.022 ab	0.098 a
TS+HC+PC	0.035 a	0.020 b	0.026 a	0.082 a
TS+HC	0.017 c	0.010b	0.012 c	0.039 b

Remarks: TS=top soil, HC=rice husk charcoal, GC=grass compost, OC=spent oyster mushroom compost, PC=spent paddy straw mushroom compost; Means in the same column followed by the same letter are not significantly different ($p<0.05$)

Table 5. Effects of different growing media on leaf indices of tomato seedling in the screen house

Media	Total leaves	Leaf area (cm^2)	SLA (cm^2 g^{-1})	LAR (cm^2 g^{-1})
TS+HC+GC	2.0 b	3.7 b	104.7 a	39.7 a
TS+HC+OC	2.3 b	7.2 a	92.9 ab	40.1 a
TS+HC+PC	2.7 a	8.6 a	85.2 b	36.6 a
TS+HC	2.0 b	8.1 a	84.3 b	34.9 a

Remarks: TS=top soil, HC=rice husk charcoal, GC=grass compost, OC=oyster mushroom compost, PC=paddy straw mushroom compost; SLA=specific leaf area, LAR=leaf area ratio; Means in the same column followed by the same letter are not significantly different ($p<0.05$)

Table 6. Pearson's correlation coefficient among growth parameters on different growing media

Parameters		**Media**			
		TS+HC+GC	**TS+HC+OC**	**TS+HC+PC**	**TS+HC**
Leaf area	Height	0.39	0.74*	0.11	-0.29
	Diameter	-0.20	0.56	0.52	0.19
	Stem dry weight	0.16	0.49	0.27	-
	Root dry weight	0.07	0.55	-0.24	0.20
	Leaf dry weight	0.64*	0.91**	0.56	0.21
	Whole seedling dry weight	0.42	0.86**	0.46	0.06
Height	Diameter	0.19	0.91**	0.06	-0.45
	Stem dry weight	0.22	0.63	0.23	-
	Root dry weight	0.41	0.71*	0.52	0.26
	Leaf dry weight	0.45	0.72*	0.01	-0.42
	Whole seedling dry weight	0.55	0.61	0.13	-0.34
Diameter	Stem dry weight	-0.17	0.56	0.44	-
	Root dry weight	0.46	0.71*	0.03	0.17
	Leaf dry weight	0.14	0.58	0.66*	0.49
	Whole seedling dry weight	0.33	0.41	0.64*	0.23
	Total leaves	-	0.22	0.47	0.30
Leaf dry weight	Root dry weight	0.27	0.59	0.43	0.52
Stem dry weight	Root dry weight	0.23	0.33	0.71*	-

Remarks: TS=top soil, HC=rice husk charcoal, GC=grass compost, OC=oyster mushroom compost, PC=paddy straw mushroom compost; Means in the same column followed by the same letter are not significantly different (p<0.05)*) or very significantly different (p<0.01)**)

CONCLUSION AND SUGGESTION

Growing media containing spent paddy straw or oyster mushroom compost resulted in the best seedling emergence percentage and rate, height, diameter and first node height. The same compost type was also resulted in the highest dry weight of leaves, roots and whole seedlings.

The best SLA index of tomato seedlings was obtained by the seedling grown on media without compost, and it was not significantly different with the seedling grown on the other media used, with the exception of the seedlings grown on media containing grass compost. However, there was no significant difference for LAR index between the growing media used. That means there was no difference seedling resistance at transplant to all media used with the exception of the media containing grass compost.

In general, the media containing spent mushroom compost could improve the tomato seedling growth. However, the best growth of the tomato seedlings was on the media containing spent paddy straw mushroom compost.

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