Asian Journal of Plant Sciences

ISSN 1682-3974

OPEN ACCESS Asian Journal of Plant Sciences

ISSN 1682-3974
DOI: 10.3923/ajps.2021.560.570

Research Article
Effect of Organic Compost Source and Application Time on Growth and Yield of Beetroot (*Beta vulgaris* L.) in Dry Land of Jatikerto, Indonesia

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Abstract

Background and Objective: The low content of organic matter leads to low carrying capacity for agricultural activities. Therefore, the application of organic matter in the form of compost is needed. This study aimed to obtain accurate information about the source and timing of compost application on dry land in Jatikerto, Indonesia. **Materials and Methods:** Beetroot seeds, a source of organic matter in the form of compost: goat manure, Azolla, urban waste and N, P, K fertilizers. The study used a split-plot design, repeated three times. Sources of compost (goat manure, Azolla and urban waste) are placed in the main plot, while the application time of organic matter (two months before planting, one month before planting and at planting time) are placed in sub-plots. F test level of 5% to determine the effect of treatment, while the levels of 5% HSD test to determine differences among treatments. **Results:** Urban waste compost application with the application time 2 months before planting, can improve the physical, chemical and biological soil early and be able to produce the tuber yield of 2.62 t ha^{-1} (46.45%) and 2.60 t ha^{-1} (45.94%) higher than the other treatment combinations. **Conclusion:** In general, the application time of urban waste compost 2 months before planting has a positive effect on improving the physical properties of the soil and yield of beetroot in the dry land.

Key words: Goat manure compost, Azolla compost, urban waste compost, time application, beetroot

Citation: Suminarti, N.E., N.D. Suprihantono and A.N. Fajrin, 2021. Effect of organic compost source and application time on growth and yield of beetroot (*Beta vulgaris* L.) in dry land of Jatikerto, Indonesia. Asian J. Plant Sci., 20: 560-570.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Dryland is a potential area for the development of various types of plants, from vines to trees. In Indonesia, the land is still quite large, about 21.9 M ha of untapped maximally for agricultural activities. This is due to the complexity of the obstacles that must be faced in dryland farming. This form of constraint is not only caused by the low carrying capacity of the land but climatologically, the area is characterized by high temperatures followed by a short wet period, around 3-4 months/year[1]. Therefore, the availability of water for plants is the main limiting factor in this area. Soil texture is generally dominated by clay, or dust and sand, which leads to lower soil's ability to hold and store water. This condition is also followed by low soil organic matter content. Based on the results of soil analysis, it was found that the soil organic matter content was very low, around 1.11%, with alfisol type soil. The soil N and P content were quite low, respectively 0.09% N and 5.08 mg kg^{-1} P, except for Potassium in the high category, which is 1.25 me/100 g K. Soil with the chemical, physical and biological soil as described above are less able to support good plant growth processes. Therefore the tubers produced are low in quantity and quality. Suminarti *et al.*[2] reported that under normal conditions, the weight of red beetroot can reach 193.78 g, but when planted in dryland, tuber weight only reached 29.70 g. In connection with these problems and to realize a government program that encourages the use of suboptimal land into productive agricultural land, a variety of technological innovation needs to be done. One of them is through the application of organic matter

Organic matter is material derived from residual or waste from plants or animals, as well as various kinds of preparations thereof which are disposed of to the ground. The main role of organic matter is to improve the physical properties of the soil through the improvement and formation of more stable aggregates for inceptisols species and to become crumbly for alfisol soil types. Soil with a high clay content as Alfisol, have specific properties, which expands when wet and shrink when dry, as a result of the high content of mineral montmorillonite[3]. Soil that has a structure like this is prone to compaction, thereby reducing soil pore space, reducing groundwater movement (drainage) and air movement (aeration) in the soil. Therefore, the application of organic matter is indispensable. However, the magnitude of the effect of the application of organic matter on improving the physical, chemical and biological properties of the soil is strongly influenced by the source and timing application of organic matter[4]. Different sources of organic matter, different types, as well as the number of elements it contains, as well as C/N value. The organic matter with high C/N values (>16) are categorized as slow in decomposition, so it takes a longer time for the decomposition process to take place. However, for organic matter that has a low to moderate C/N value (5-5), a shorter time is required and is categorized into a rapid decomposition pool[5]. Therefore, information about the value of C/N is important because it relates to the decomposition process. It is given that through the decomposition process will form a more crumb structure of the soil, which causes the roots would be easy to expand, the absorption of water and nutrients will run normally, so it will have an impact on the growth and development of plants, especially for red beet crop[6]. Several studies of red beet crop have been done in this area, however, until now productivity is still far from normal, as a result of soil texture that is less able to support plant growth.

In addition to the impact on the improvement of soil physical properties, the application of organic matters also has an impact on the supply of nutrients in the soil[7]. Based on the high role of organic matter, this study aimed to obtain information about the appropriate source and time of application of organic matter, especially for red beet plants on dry land, so that productivity can be increased.

MATERIALS AND METHODS

Description of the study area: Field research has been carried out in the experimental garden of Brawijaya University, in Jatikerto Village, Malang Regency, Indonesia, from March to May, 2019. The location is located at an altitude of 330 m above sea level, in the form of dry land with alfisol soil types. The physical conditions of the soil are as follows: Clay texture, with the proportion of sand, dust and clay, respectively 19:29:52%, the content of C-organic and organic matter is very low, each of 0.64 and 1.11% Table 1. whereas chemically, the N and P status of the soil were low, respectively 0.09% N and 5.08 mg kg^{-1}, but followed by a very high K-soil status, namely 1.25 me 100 g^{-1}) Table 2. Climatologically, the average annual rainfall is 1200 mm, with average daily temperatures ranging from 24-31°C.

Research material: Planting material in the form of red beetroot seeds of Ayumi variety 04 which has been aged 21 days after seedling, sources of organic compost: goat manure, Azolla compost and urban waste compost. Inorganic fertilizers were applied in the form of N fertilizer (urea: 45% N) and phosphate fertilizers (SP_{36}: 36% P_2O_5). The dosage of organic and inorganic fertilizers applied refers to the results of the initial soil analysis and the level of N, P, K fertilizer requirements for red beetroot plants in Table 2. The calculation method refers to the Suminarti *et al.*[2] as below:

Table 1: Status of physical and biological properties of the initial soil and organic compost source

				Soil texture (%)			
Soil samples	C-org. content (%)	Org. matter content (%)	C/N	Sand	Dust	Clay	Criteria
Dry land (Jatikerto)	0.64	1.11	7	19	29	52	Clay
Criteria							
Very low	<1.0	<1.0	<5	-	-	-	
Low	1.0-2.0	2.0-2.0	10-May				
Medium	2.01-3.0	2.01-3.0	15-Nov				
High	3.01-5.00	3.01-5.00	16-25				
Very high	>5.00	>5.00	>25				
Organic compost source							
Goat manure compost	36	62.03	32.14	-	-	-	
Azolla compost	36.8	63.41	32.28	-	-	-	
Urban waste compost	25.6	44.41	24.62	-	-	-	
Criteria							
Very low	<1.0	<1.0	<5				
Low	3.0-2.0	4.0-2.0	10-May				
Medium	2.01-3.0	2.01-3.0	15-Nov				
High	3.01-5.00	3.01-5.00	16-25				
Very high	>5.00	>5.00	>25				

Table 2: Status of the chemical properties of the initial soil and various sources of organic compost and the level of fertilizer requirements for N, P, K for red beet plants

		Soil nutrient content		
Soil samples	pH H_2O	N (%)	P Bray1 (mg kg^{-1} P_2O_5)	K NH_4OAC1N pH 7 (me 100 g^{-1})
Dry land (Jatikerto)	5.3	0.09	5.08	1.25
Criteria				
Very low	<4.0	<0.10	<10	<0.1
Low	4.1-5.5	0.11-0.20	15-Oct	0.1-0.2
Medium	5.6-7.5	0.21-0.50	16-25	0.3-0.5
High	7.6-8.0	0.51-0.75	26-35	0.6-1.0
Very high	>8.0	>0.75	>35	>1.0
		Soil nutrient content		
Source of organic compost	pH H_2O	N (%)	P_2O_5 olsen (ppm)	K NH_4OAC1N pH7 (me 100 g^{-1})
Goat manure compost	-	1.12	0.73	-
Azolla compost	-	1.14	0.57	-
Urban waste compost	-	1.04	0.57	-
Criteria				
Very low	<4.0	<0.10		
Low	4.1-5.5	0.11-0.20		
Medium	5.6-7.5	0.21-0.50		
High	7.6-8.0	0.51-0.75		
Very high	>8.0	>0.75		
Range of N, P, K doses of red beetroot crop				
N (kg ha^{-1})	130-170 kg ha^{-1} = 288.89-377.77 kg urea ha^{-1}			
P_2O_5 (kg ha^{-1})	70-120 kg ha^{-1} = 194.44-333.33 kg SP_{36} ha^{-1}			
K_2O (kg ha^{-1})	120-150 kg ha^{-1} = 200-250 kg KCl ha^{-1}			

$$N = \frac{A_2 - B}{A_1 - A_2} = \frac{N - X_A}{X_A - X_B}$$

Where:

- N : Nutrient dose that must be added according to soil criteria (kg ha^{-1})
- A_1 : Top content of the total soil N range (%)
- A_2 : Lowest level of the range of total soil N (%)
- B : Total N content of the soil (%)
- X_A : Highest value of the required dose of N plants (kg ha^{-1})
- X_B : Lowest value of the required dose of N plants (kg ha^{-1})

While the results of chemical analysis of the soil and the source of early organic matter are presented in Table 2.

Based on initial soil analysis found that the N and P content of the soil in the low category, respectively by 0.09% N and 5.08 ppm P_2O_5, so it needs to be upgraded to medium status in Table 2. The method of calculating the fertilizer requirement is based on the results of the initial soil analysis and the dose of fertilizer needed by the beetroot plant. As an example, calculation for fertilizer N: When it is known that the:

Table 3: Organic and inorganic fertilizers applied in each treatment combination

	Doses of organic matter that should be applied		
Source of organic compost	t ha^{-1}	kg $plot^{-1}$	g $plant^{-1}$
Goat manure compost	15.55	8.39	133.22
Azolla compost	16.36	8.25	130.88
Urban waste compost	17.94	9.04	140
Source of inorganic fertilizers			
N (urea)	186.55 kg N ha^{-1} (405.54 kg urea ha^{-1})	0.094 kg N/plot (204.3 g urea/plot)	1.49 g N/plot (3.24 g urea/plant)
P_2O_5 (SP_{36})	194 kg P_2O_5 ha^{-1} (538.88 SP_{36} ha^{-1})	0.098 kg P_2O_5/plot (272.22 g SP_{36}/plot	1.55 g P_2O_5/plant (4.31 g SP_{36}/plant)
K (KCl)	K fertilization was not done because the K-soil status is very high		

- A_1: The top content of the total soil N range (%): 0:50
- A_2: The lowest level of the total soil N range (%): 0:21
- B: The total N content of the soil (%): 0:09
- X_A: The highest value of the required dose of N plants ha^{-1}: 170 kg
- X_B: The lowest value of the required dose of N plants ha^{-1}: 130 kg

So based on the data above and referring to Augustine's formula, the N fertilizer should be applied amounted to 186.55 kg ha^{-1}. In the same way and based on Table 2, the doses of inorganic and organic fertilizers that must be applied to the soil are shown in Table 3.

Experimental design: The study used a Split Plot Design and was repeated 3 times. Sources of organic compost (goat manure, Azolla and urban waste) are placed in the main plot. Meanwhile, the application time for organic compost consists of 3 types, namely: at planting, 1 month before planting and 2 months before planting, placed in the sub-plot. F test at 5% level is used to determine the interaction or the significant effect of the treatment. As for knowing the difference between treatments refers to the Honestly Significant Difference (HSD) test at 5%. Regression analysis is used to explore the relationship between two or more variables observed.

Research implementation: The application of organic compost is carried out according to the treatment, namely at planting time, 1 month before planting and 2 months before planting by spreading and mixing organic compost with soil in each planting hole. Whereas for in-organic fertilizers in the form of P fertilizer (SP36: 538.88 ha^{-1}), N fertilizer in the form of urea: 405.54 kg ha^{-1}. The P fertilizer applied at the beginning of planting the entire dose, while for N fertilizer, applied gradually. Phase I is done when the plant was 7 days after planting as much as 1/3 dose and the rest (2/3 dose) performed when the plant has been aged 15 days after planting. Fertilizer application is carried out in each fertilizer hole on the left or right side of the plant with a distance of 5 cm and with a depth of 7 cm. Planting is done in the morning starting at 5:00 am to finish by putting 1 seed (healthy and uniform) on each hole. The spacing used is 40 cm (in a row)×20 cm (between rows).

Data collection: The data was collected destructively by taking 3 sample plants for each treatment combination, carried out when the plants were 15, 25, 35, 45 and harvesting (63 daps). However, the observation of growth and yield parameters was focused on the age of 45 daps, assuming the plant had entered its maximum phase. Observations include growth and yield parameters as well as harvest. While the soil analysis was done after the application of organic matter (2 months after planting).

Growth and yield parameters

Leaf surface area: The leaf surface area was calculated using the LI-3100 C Leaf Area Meter multiplied by the correction factor. The correction factor is obtained by dividing the actual paper area (eg 100 cm^2) by the area of the paper measured by LAM (eg 90 cm^2). Thus, the correction factor value is 0.90. Leaves that are counted are leaves that have fully opened, excluding young leaves and leaves that have experienced senescence. Leaves that are too wide should be cut into pieces for accurate measurement data. Similarly, laying the leaf on glass lenses also may not overlap[2].

Total dry weight of the plant: Measurement of the total dry weight of the plant is done by using an oven-type OVL 12 with a temperature of 81°C. Plant samples that will be in the oven should be separated between plant parts, such as roots, stems, leaves and tubers. This is because achieving a constant dry weight requires different times. To get uniform drying, plant samples must be chopped and after chopping, put in cement paper bags that have been given a treatment code, then put in an oven until a constant dry weight is achieved. Determination of total dry weight of plant was done by weighing and summing of the parts of plants that have been put into an oven[8].

Harvest observations

Fresh weight of tuber ha^{-1}: Weighing the fresh weight of tubers ha^{-1} by converting the yield/plot of the harvest to units of hectares using the formula[1]:

$$\text{Tuber weight ha}^{-1} = \frac{\text{Land area 1 ha}}{\text{harvest plot area } (1.2\ \text{m}^2)} \times \frac{\text{Tuber weight}}{\text{Harvest plot}} \times \text{Correction factor (0.60)}$$

Soil analysis: Soil analysis was carried out in the Soil Science Laboratory, Faculty of Agriculture, Brawijaya University, which included initial soil analysis, organic compost sources (goat manure, Azolla and urban waste compost). The results of the initial soil analysis and source of organic compost are presented in Table 1, while the second soil analysis was carried out 2 months after planting.

RESULTS

Growth and yield parameters

Leaf surface area: The results showed that there was a significant interaction between the source of organic compost and the time of its application to the variable leaf surface area in Table 4.

Table 4 showed that for various organic compost sources, the application time of 1 month before planting resulted in a leaf surface area that was not significantly different from the application at planting, or 2 months before planting. However, for the application time of two months before planting, the leaf area produced more extensive than the application at planting time. Table 4 also shows that there is no effect of application time on the three organic compost sources used.

A total dry weight of the plant: There was an interaction between the source and the time of application of organic compost on the variable total dry weight of the plant. The average total dry weight of the plant due to the interaction between the source and timing of application is presented in Table 5.

Table 5 shows the significant effect of the source of organic compost at various times of application. On the use of goat manure composted, application time 1 month before planting produces the total dry weight of plants that are not significantly different from the application at planting and 2 months before planting. However, when organic compost was given 2 months before planting, the total dry weight of the plants produced was higher than at planting, at 6.2 and 2.2 g plant^{-1}, respectively. This pattern was also found in the use of Azolla compost. While the use of urban waste compost, the highest total plant dry weight, which amounted to 11.78 g plant^{-1} obtained on application two months before planting, rather than the application time 1 month before planting, as well as the time of planting, each at 6.67 and 2:33 g plant^{-1}. When the application was 1 month before planting, the total dry weight of the plants produced was also higher than at planting. When viewed from the effect of application time on various sources, it was found that the organic compost was applied during planting, the total dry

Table 4: Average leaf surface area at various sources and time application of organic compost at the age of 45 daps

Treatments	Time application of organic matter		
	At planting	1 month before planting	2 months before planting
Source of organic compost			
Goat manure compost	99.90^{aA}	182.70^{abA}	220.10^{bA}
Azolla compost	103.10^{aA}	201.77^{abA}	283.07^{bA}
Urban waste compost	103.10^{aA}	201.77^{abA}	283.07^{bA}
HSD 5%	115.11		

Numbers that are accompanied by the same letter in the same row, or the same capital letters in the same column are not significantly different based on the HSD test at a 5% level, daps: Days after planting, ns: Not significant effect

Table 5: Average total dry weight of the plant (g) at various sources and time application of organic compost at the age of 45 daps

Treatments	Time application of organic matter		
	At planting	1 month before planting	2 months before planting
Source of organic compost			
Goat manure compost	2.20^{aA}	4.88^{abAB}	6.20^{bA}
Azolla compost	1.42^{aA}	2.8^{abA}	5.92^{bA}
Urban waste compost	2.33^{aA}	6.67^{bB}	11.78^{cB}
HSD 5%	3.58		

Numbers that are accompanied by the same letter in the same row, or the same capital letters in the same column are not significantly different based on the HSD test at a 5% level, daps: Days after planting, ns: Not significant effect

Table 6: Average fresh weight of tuber ha^{-1} (t) at various sources and time application of organic compost at harvest

	Time application of organic matter		
Treatments	At planting	1 month before planting	2 months before planting
Source of organic compost			
Goat manure compost	3.93^{aA}	$5,17^{abA}$	$5,66^{bA}$
Azolla compost	$3,88^{aA}$	$4,10^{abA}$	$5,64^{bA}$
Urban waste compost	$4,42^{aA}$	$7,36^{bB}$	$8,26^{bB}$
HSD 5%	1,71		

Numbers that are accompanied by the same letter in the same row, or the same capital letters in the same column are not significantly different based on the HSD test at a 5% level, daps: days after planting, ns: Not significant effect

weight of the plant showed no significant difference in all sources of organic compost used. However, in the application 1 month before planting, the use of urban waste compost was able to produce a higher total plant dry weight which was 6.67 g $plant^{-1}$, compared to Azolla compost which only reached 2.8 g $plants^{-1}$. As for the application 2 months before planting, the highest total plant dry weight was found in urban waste compost, which amounted to 11.78 g $plant^{-1}$. Whereas in the use of goat manure and Azolla compost, the total dry weight of the plants produced was not significantly different, respectively 6.20 and 5.92 g $plant^{-1}$.

Harvest observations

Fresh weight of tubers ha^{-1}: There is a significant interaction between the source and the time of application of organic compost on the fresh weight of tubers ha^{-1}. The average fresh weight of tuber ha^{-1} as a result of the interaction is presented in Table 6.

Table 6 shows the presence of significant effects of organic compost sources at various times of application. In the use of goat manure and Azolla compost, the application time of 1 month before planting, the fresh weight of tubers ha^{-1} produced was not significantly different from the application 2 months before planting, or at planting time. However, with application 2 months before planting, the fresh weight of tubers ha^{-1} produced was higher than at planting, respectively 5.66 and 3.93 t ha^{-1} for goat manure compost and equal to 5.64 and 3.88 t ha^{-1} for compost Azolla. But for urban waste compost, a higher fresh weight of tubers was obtained in the application 1 and 2 months before planting compared at planting and the two treatments showed no significant difference.

Judging from the effect of application time on various sources, it was found that for the application at planting time, the fresh weight of the tubers did not show significant differences in its various sources. However, when the application was carried out 1 and 2 months before planting, the highest fresh weight of tubers ha^{-1} was found in urban waste compost, amounting to 7.36 and 8.26 t ha^{-1}, respectively. The observation of tubers at harvest is presented in Fig. 1(a-i). Figure 1a-c is the result of tuber observations from goat manure compost treatment with application time at planting, 1 month before planting and two months before planting. Figure 1d-f are the results of tuber observations from Azolla compost treatment with application time at planting, 1 month before planting and two months before planting. Whereas Fig. 1g-i is the result of tuber observations with application time at planting, 1 month before planting and 2 months before planting. Through Fig. 1 also demonstrated that the various sources of organic compost (goat manure, Azolla and urban waste compost), by the time application two months before planting (Fig. 1c, f, i), the average size of tubers produced greater than application at planting time (Fig. 1a, d and g).

Soil analysis: The second soil analysis was carried out 2 months after planting, which aims to determine whether the organic compost that has been applied has decomposed, which is indicated by changes in the physical (soil texture), chemical (N, P, K soil status) and biological properties of the soil (C-org content). The results of the initial and second soil analyzes are presented in Table 7.

Table 7 shows that the application of organic compost can improve the physical, chemical and biological properties of the soil. This is indicated by changes in the physical, chemical and biological properties of the soil from the initial soil analysis to the second soil analysis which was carried out 2 months after planting. Based on the physical properties of the soil, the application of goat manure compost, Azolla compost and urban waste compost can change the proportion of the initial soil analysis from 19% sand, 29% dust and 52% clay, to 29% sand: 31% dust: 40% clay for goat manure compost and 30% sand: 29% dust: 41% clay for Azolla compost and 31% sand: 30% dust: 39% clay for urban waste compost. However, from the three sources of organic compost, a significant change in soil physical properties occurred in the urban waste compost which had a C/N value of 24.62. This value is lower than the goat manure compost

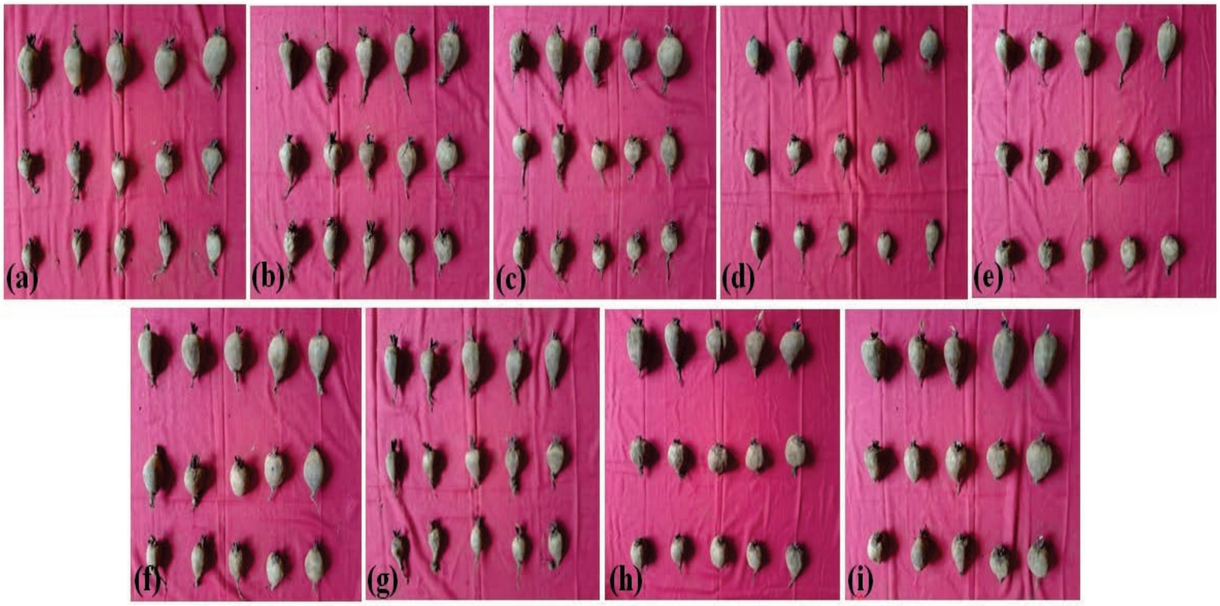

Fig. 1(a-I): Observation of tubers harvested at various sources and application times of organic matter
(a) Compost of goat manure, at planting time, (b) Compost for goat cot, 1 month before planting, (c) Compost for goat manure, 2 months before planting, (d) Compost for Azolla, at planting time, (e) Compost for Azolla, 1 month before planting, (f) Azolla compost, 2 months before planting, (g) Urban waste compost, at planting time, (h) Urban waste compost, 1 month before planting and (i) Urban waste compost, 2 months before planting

Table 7: Soil physical, chemical and biological status from the initial and second soil analyzes, namely 2 months after planting from various treatment combinations

Combination treatment	Nitrogen-total (%)	P-soil content (P_2O_5 Olsen) (ppm)	K-soil content (H_4OAC1N pH 7) (me 100 g^{-1})	C-organic content (%)	Soil texture (%) (sand:dust:clay)	Criteria
Initial soil analysis	0.09	5.08	1.25	0.64	19:29:52	Clay
Second soil analysis						
At planting						
Goat manure compost	0.12	49	1.78	1.01	24:34:42	Clay
Azolla compost	0,13	34	1.82	0.96	28:29:43	Clay
Urban waste compost	0.12	51	1.6	0.82	27:30:43	Clay
1 the month before planting						
Goat manure compost	0.21	146	1.82	1.02	30:30:40	Clay
Azolla compost	0.13	44	1.73	1.28	30:29:41	Clay
Urban waste compost	0.09	28	1.42	0.99	33:30:37	Clayey loam
2 months before planting						
Goat manure compost	0.24	873	5.5	2.03	32:30:38	Clayey loam
Azolla compost	0.17	356	3.66	1.35	33:28:39	Clayey loam
Urban waste compost	0.21	419	3.06	1.58	31:31:38	Clayey loam
	Average N-soil content (%)	Average P-soil content (P_2O_5 Olsen/(ppm)	Average K-soil content (H_4OAC1N pH7) (me 100 g^{-1})	Average C-organic content (%)	Average soil texture (sand:dust:clay)	
Based on application time from three organic compost sources						
At planting	0.12	44.67	1.73	0.93	27:31.:43	Clay
1 month before planting	0.14	72.67	1.66	1.1	31:30:39	Clayey loam
2 month before planting	0.21	549	4.07	1.65	32:30:38	Clayey loam
Based on the source of organic compost from three application time						
Goat manure compost (C/N: 32.14)	0.19	356	3.03	1.35	29:31:40	Clay
Azolla compost (C/N: 32.28)	0.14	144.67	2.4	1.2	30:29:41	Clay
Urban waste compost (C/N: 24.62)	0.13	166	2.02	1.13	31:30:39	Clayey loam
Criteria						
Very low	<0.10	<10	<0.1	<1.0		
Low	0.11-0.20	25-Oct	0.1-0.2	1.0-2.0		
Medium	0.21-0.50	26-45	0.2-0.5	2.01-3.0		
High	0.51-0.75	46-60	0.6-1.0	3.01-5.0		
Very high	>0.75	>60	>1.0	>5.0		

and Azolla compost which have C/N values of 32.14 and 32.28. This indicates that urban waste compost has undergone a decomposition process earlier than other organic compost sources and this can be proven by the low levels of all organic elements (N, P, K) and C-organic contained in the second soil analysis, each of which is only 0. , 13% N, 166 ppm P_2O_5, 2.02 me 100 g^{-1} K and 1.13% C-soil organic in Table 7.

The results of this study also found that organic compost, which was applied 2 months before planting, had a significant effect on changes in soil physical, chemical and biological properties, compared to the application at planting and 1 month before planting. The highest soil N, P, K content was also obtained in this treatment, respectively 0.21% N, 549 ppm P_2O_5 and 4.07 me 100 g^{-1} K, compared to concurrent planting which only reached 0.12% N, 44.67ppm P_2O_5 and 1.73 me 100 g^{-1} K. Likewise with the C-organic content which reaches 1.65%. The application time of 2 months before planting also produces a more balanced proportion of each fraction, namely 32% sand: 30% dust: 38 clay, (clayey loam category), rather than simultaneously planting with a proportion of 27% sand: 31% dust: 43 clay and is included in the clay criteria.

DISCUSSION

There is a significant interaction between the source and application time of organic compost in all observed variables. In the variable of leaf surface area, generally wider leaves were obtained at the time of application two months before planting, compared to simultaneously planting for all sources of organic compost (Table 4). The wider the leaf surface area is related to the earlier the organic compost was applied, that is, two months before planting. On the other hand, when viewed from its C/N value, organic matter which has a C/N value of more than 16 is categorized into a slow decomposition pool. Therefore it takes a longer time to get the decomposition process[5]. The results showed that the application time of two months before planting was able to change the physical properties of the soil, namely from *clay* (initial) with a proportion of 19% sand: 29% dust: 52% clay, to *clayey loam* with a proportion of 32% sand: 30% dust: 38% clay. Changes in the physical properties of this soil are still better than when the organic matter is applied at planting which only produces a clay texture with a proportion of 27% sand: 31% sand: 43% clay (Table 7). Sandy clay loam texture is regarded as the optimum texture for agriculture because it has a well-balanced composition between the coarse fraction and the clay fraction. In this condition the soil's ability to absorb nutrients better than sand or clay fraction[3,4]. Soils with high clay and dust content do not support plant growth and development processes. This is because the dust fraction is slippery and less sticky, so the soil's ability to store water is low. Likewise, when the soil is dominated by a clay fraction (>40%), most of the micro and macropores are filled with soil, which hampers the process of moving water and air to the lower soil layers[9]. In this condition, the root penetration is also disturbed. As a result, nutrient and water uptake is also inhibited, resulting in low plant growth rates. On the other hand, an increase in the amount of clay in the sub-soil zone is necessary, with consideration below its maximum limit (<40%). This is because clay has an important role in soil maintenance. Clay with a high surface area and negatively charged capable of clicking the adsorption of water and nutrients is higher, so it will be able to provide nutrients and enough water for plants[10]. Referring to the improvement of the physical, chemical and biological soil causing root development will run normally are reflected in the highest root dry weight produced. Hossain's *et al.*[9] research results, found that through the application of sugarcane waste, the dry weight of the roots produced was 3.64 g (39.06%) higher than the use of urban waste compost. Higher root dry weight was related to a lower value of C/N sugarcane compost, namely 14.25, compared to urban waste compost reaches a value of 16. The higher root dry weight produced will correlate with the development process of other plant organs such as leaves. The leaves are one of the organs that are important for plants because it is a place for the ongoing activities of photosynthesis. Thus, with the extent of the leaf surface, then assimilates produced also increased as a result of increased capacity of the plant in photosynthesis.

The results showed that there was a significant interaction between the source and application time of organic matter on the variables of total dry weight of plant (Table 5). At various sources of organic matter, a higher total plant dry weight was generally obtained at the time of application two months before planting, amounting to 6.20, 5.92 and 11.78 g $plant^{-1}$, respectively compared to simultaneous planting which only reaches the weight of 2.20, 1.42 and 2.33 g $plant^{-1}$, respectively for goat manure compost, Azolla compost and urban waste compost. This is closely related to the earlier application of organic matter so that it will spur the decomposition process earlier. The decomposition process also showed an increase in C-organic content from the initial soil analysis (0.64%) to 1.35% (at planting), 1.20% (one month before planting) and by 1.13% (two months before planting) (Table 7). According to another study[9], indirectly, organic matter has a very important role in improving soil chemical properties, helping to provide N nutrients through N_2 fixation by providing energy for N_2 fixing bacteria. Nitrogen not only serves as a constituent of chlorophyll but also plays a role in the preparation of proteins or enzymes[11]. These enzymes will act as a catalyst in the metabolic processes of plants, so the plant growth and development. Freeing phosphate is fixed chemically and biologically. By releasing the element P to the soil, it can increase the level of soil P availability. This element serves as a storage and transfer of energy to the whole plant's metabolic activity. The positive impact of the exemption is to spur the development of the root system of the plant that causes increased absorption of water and nutrients for plants[12]. Causing chelation of the microelements so that they are not easily lost from the root zone. The availability of microelements (Fe, Zn, B, Cu, Mn, Mo, Si and Cl) is needed by plants, albeit in relatively small quantities. Nevertheless, these elements have an important physiological role and are needed by plants. Physiologically, the function of the element Fe is as a catalyst for the formation of chlorophyll, an activator of the enzymes catalase, peroxidase and cytochrome oxidase, as well as an electron carrier in photosynthetic and respiration processes[13]. Therefore, if these elements (macro and micro) are provided for the plants, then the growth process of the plant will run normally, leading to the high total dry weight of plants produced (Table 5).

Furthermore, when viewed from the effect of application time on various sources of organic matter, it was found that for concurrent application time, the total dry weight of the plants produced was not significantly different for all organic material sources. This is due to the high C/N value possessed by the three sources of organic matter, so an earlier application time is required. However, for the application time of one and two months before planting, a higher total plant dry weight was obtained in urban waste compost, compared to Azolla compost. This is because the urban waste compost has a lower C/N value, which is 24.62, compared to Azolla compost which reaches a value of 32.14. At high C/N values, it takes a longer time for the decomposition process to take place immediately and this can be proven by the high nutrient content and C-organic content in the second soil analysis of Azolla compost and goat manure (Table 7). This is in line with the opinion of Wang *et al.*[13] which stated that in the long term, the application of organic matter can increase the total soil organic carbon, increase soil fertility through significant changes in the physicochemical properties and soil microbial community. The higher nutrient content in the two sources of organic matter reflects that these nutrients have not been optimally utilized for the previous growth process. As a result, the plant growth rate is disrupted and results in a lower total dry weight produced (Table 5).

Statistically, there was a significant interaction between the source and application time of organic compost to the tuber fresh weight ha^{-1} (Table 6). In all organic compost sources, a higher tuber fresh weight ha^{-1} was obtained at the time of application two months before planting, each amounting to 5.66, 5.84 and 8.26 t ha^{-1}, rather than organic matter application done at the same time planting with a yield of 3.93, 3.88 and amounted to 4.42 t ha^{-1}, respectively for goat manure compost, composted Azolla and urban waste compost. The higher yield (Urban waste compost) is closely related to the higher total plant dry weight produced in the treatment (Table 5). This is because the total dry weight of the plant is a reflection of the assimilate, while the assimilate is energy and part of that energy will be stored in the sink in the form of an economic yield, namely tubers. Therefore the weight of the tubers formed will be greatly influenced by how much assimilation is formed and its partition to the tuber part. The results of the research showed that there was no significant effect of the source of organic matter on the harvest index value. However, there is a tendency that a higher value, namely 0.37, was obtained at the time of application 2 months before planting, while at the same time of planting and one month before planting, respectively 0.23 and 0.11. The harvest index is the ratio between total assimilate and its economic yield[2] and the value achieved from the three treatments is still below normal, generally above 0.50. Therefore, in general, the tuber weight ha^{-1} produced is still below its potential production (Fig. 1) and the potential production reach the range of 10-20 t ha^{-1}.

Meanwhile, when viewed from the effect of application time on various sources of organic compost, for an organic compost that was applied during planting, the fresh weight of tubers ha^{-1} produced was not significantly different for the three sources of organic compost used. This is because the three sources of organic compost are included in the slow decomposition group with a C/N value>16. This is in line with the opinion of BulluckIII *et al.*[10] which states that a low C/N value will spur the decomposition process earlier. However, for application time 1 and 2 months before planting, the highest yield was obtained for urban waste compost. This is closely related to the lower C/N value of urban waste compost (24.62) compared to 2 other sources of organic matter, namely Azolla compost and goat manure compost, which are 32.28 and 32.14 respectively. As a result, the decomposition process starts earlier so that it has an impact on improving the physical and chemical properties of the soil earlier (Table 7). Changes in physical properties have an impact on the wider leaf area produced by this treatment (urban waste compost) due to the wider penetration of plant roots. Roots that develop normally will be able to absorb water and nutrients according to the level of need, which in turn will have an impact on increasing plant growth rates and the resulting fresh weight of tubers. However, based on the results of the regression analysis showed a quadratic relationship between C/N (X) with tuber fresh weight ha^{-1} (Y), through an equation:

$$Y = -0.3.24\ X^2 + 181.44\ X - 2437.7;\ R^2 = 1$$

Based on the above equation, it can be determined the optimum C/N value, which is 28 and the maximum fresh weight of the tubers, which is 10.25 t ha^{-1}.

CONCLUSION

Based on the results of the study, it can be concluded that for various organic compost sources, the application time of 2 months before planting resulted in growth, tuber fresh weight ha^{-1}, as well as changes in the physical, chemical and biological properties of the soil better than the application at planting. Based on the various times of application, plant growth, tuber fresh weight ha^{-1}, as well as improvements in physical, chemical and biological properties of soil that are better found in the use of urban waste compost.

SIGNIFICANCE STATEMENT

This study discovers the Effect of source and application time of organic matter on the growth and yield of beetroot (*Beta vulgaris* L.) in Jatikerto dry land, Indonesia, so that it can be used as a guideline in the management of red beetroot plants in a dry land. This study will help researchers to uncover the need for organic compost, both in terms of the source and time application of organic compost in red beetroot plants in the dry land. Thus, the discovery of the source and time application of organic compost will be able to assist and facilitate the management of red beet plants in dry land to increase the quantity and quality of red beet tubers in dry land.

ACKNOWLEDGMENT

The author would like to thank all laboratory managers in the Department of Agriculture's Cultivation, Faculty of Agriculture, Brawijaya University who have provided facilities where the authors conduct analysis, measurement and borrowing equipment to support research activities. The author is also grateful to the lab assistant, as well as the Jatikerto field staff who helped us in conducting this research.

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