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The Growth of Breadfruit (*Artocarpus altilis* Forst) Root Cuttings on Various Media of Organic Matter and Concentrations of 2,4 Dichlorophenoxy Acetic Acid

Kafrawi [a*], Zahraeni Kumalawati [a] and Rafiuddin [b]

[a] *Department of Agriculture Production Technology, Pangkep State Polytechnic of Agriculture, Pangkep, Indonesia.*
[b] *Department of Agronomy, Hasanuddin University, Makassar, Indonesia.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The purpose of this study was to determine the effect of organic matter in the planting medium and a concentration of 2.4 D on the growth of breadfruit root cuttings. This experiment was carried out in the form of a factorial experiment consisting of two factors using a Completely Randomized Block Design (CRBD) with 2 treatment factors. The first treatment was utilizing media of organic materials; filter cake, sawdust and rice husk. The second treatment was adding a concentration of 2.4 D: 1.0; 1.5 ; and 2.0 mL.L^{-1} water. The experimental results showed that breadfruit root cuttings in the filter media were better for shoot height, number of leaves, leaf area and root volume compared to sawdust and rice husk media. A low concentration of 2.4 D (1.0 mL.L^{-1} water) showed

**Corresponding author: Email: kafrawidjamin@gmail.com;*

better growth of shoot height and number of leaves than higher concentrations. The interaction of filter cake media and low concentration of 2.4 D (1.0 $mL.L^{-1}$ water) had a significant effect on the sprouting rate of breadfruit root cuttings. The study therefore concluded that the interaction of filter cake media with the addition of 2.4 D concentration showed that the increase in auxin concentration was inversely proportional to the rate of sprouting rate produced by breadfruit seeds and became the best treatment combination on the parameter of sprouting rate.

Keywords: Breadfruit; root cuttings; organic matter; 2.4 D.

1. INTRODUCTION

Breadfruit (*Artocarpus altilis* Fosb) is a source of carbohydrates and is rich in nutrients so that it becomes an alternative food to replace rice in Indonesia [1]. In Latin American countries, breadfruit plants are used as reforestation plants because of their large crowns and their roots which grip the ground to reduce erosion. The breadfruit' beautiful leaves and habitus makes its trees often be used as garden elements, especially in countries in the Asia Pacific region [2]. In Indonesia, breadfruit is not cultivated commercially even though climatic conditions are classified as suitable for cultivating it [3] and does not require high inputs [4].

Generative propagation is very difficult to do in breadfruit plants because as a parthenocarpy formed fruit this plant does not produce seeds [5]. Breadfruit vegetative propagation is generally through cuttings, grafts, root shoots [6], budding, grafting [7] and using tissue culture techniques [8].

The growth of breadfruit root cuttings is relatively slow because [9] it is estimated that they will sprout only in the eighth week or so [10]. To stimulate the growth of shoots from root cuttings, plant roots are injured mechanically or by giving various Growth Regulatory Substances [11]. The growth regulator commonly used in accelerating cuttings is Auxin. Applying the auxin is very important in the entire physiological processes of plants. Auxin forms root shoots, participates in cell division, and takes part in Tropism [12]. Compound 2.4-D (dichlorophenoxy acetic acid) is a strong auxin which is often used alone to induce callus formation. Callus is a mass of undifferentiated cells and is very important for the formation of early plant organs including roots [13]. Giving exogenous growth regulators can be done to increase the content of growth hormone in root cuttings so as to accelerate root formation on cuttings [14]. The use of growth regulators substance can stimulate plant growth at the right concentration, contrary it can inhibit growth if added at excessive or insufficient concentrations [15].

If environmental conditions are neglected, the use of growth regulators substance will still not support the roots of the cuttings emerge. The most important environmental factor in the growth of seedlings is the growing medium that provides nutrients, moisture and a place for roots to grow. Many media can be used to seed cuttings, as long as they are loose and smooth, so that new roots don't hinder their growth. Organic materials (natural fertilizers) include all materials made from the remains of metabolism or living organs that contain nutrients needed by plants. The use of organic matter is very important to maintain the life of soil organisms in addition to provide nutrients for plants [16]. Apart from sand and humus soil, cuttings seedling media can also be mixed with organic materials such as filter cake (sugarcane waste) [17], rice husks [18], sawdust [19]. There has never been research on the interaction between organic media and 2.4 D in breadfruit root cuttings, so in-depth research is needed on this matter.

2. MATERIALS AND METHODS

2.1 Experimental Site

This experiment was conducted in a screen house at experimental farm laboratory department of Agricultural Production Technology, Pangkep State Polytechnic of Agriculture, Mandalle Pangkep Regency from July 2022 to November 2022. It is located on latitude 4°33’59"S and longitude 119°35’50”E, 57 m above sea level.

2.2 Planting Material

The material of the breadfruit cutting roots is taken from the parent breadfruit tree of the *Bone* variety, which has a characteristic yellowish fruit skin with a distinctive aroma that cannot be found anywhere else. The parent tree was chosen to be 5 years old, healthy and bearing fruit and not affected by pests and diseases. Roots for cuttings were cut into pieces with a length of 20 cm. The root cuttings were then divided into diameter classifications, namely 1.0 – 1.7 mm, 1.8 – 2.5 mm, and 2.6 – 3.3 mm with the intention of placing them in different groups in the experiment.

2.3 Experimental Design and Layout

This experiment was carried out in the form of a factorial experiment consisting of two factors using a Completely Randomized Block Design (CRBD). The first factor is the organic matter media (S) which consists of 3 types, namely: Soil + filter cake (S1), Soil + Sawdust (S2), and Soil + Rice Husk (S3). The second factor is the concentration of 2.4 Dichlorophenoxy Acetic Acid (2.4 D) in technical form (H) which consists of 3 levels, namely: 1.0 mL.L^{-1} water (H_1), 1.5 mL.L^{-1} water (H_2), and 2.0 mL.L^{-1} water (H_3). Each treatment was combined so that there were 9 treatment combinations which were repeated three times. Data analysis will use Duncan's Multiple Range Test (DMRT) if the ANOVA shows a significantly or very significantly different response.

3. RESULTS AND DISCUSSION

The interaction between the organic matter media with a concentration of 2.4 D had a significant effect on sprouting promptness but had no significant effect on shoot height, number of leaves, leaf area and root volume.

The results of DMRT in Table 1 showed that the treatment of filter cake media with a concentration of 2.4 D 1.0 mL.L^{-1} water (S_1H_1) showed a faster germination time and was not significantly different from sawdust media (S_2H_1) and rice husk media (S_3H_1). In filter cake media with a concentration of 2.4 D 1.0 mL.L^{-1} water (S_1H_1) was not significantly different from a concentration of 1.5 mL.L^{-1} water (S_1H_2) but significantly different from a concentration of 2 mL.L^{-1} water (S_1H_3). At a concentration of 2.4 D 1.5 mL.L^{-1} water treated with rice husk media (S_3H_2) showed the slowest average germination rate and significantly different from filter cake media (S_1H_2) but not significantly different from sawdust (S_2H_2), while the treatment of filter cake media (S_1H_2) was not significantly different from sawdust media.

The experimental results showed that the fastest germination time was obtained in the interaction between the filter cake media and a concentration of 2.4 D 1.0 mL.L^{-1} water. This was due to the filter cake media being able to create porous media conditions so that the water holding capacity was high which was useful for maintaining media moisture around the cuttings roots. Filter cake had properties that support the improvement of soil chemical, biological and physical properties, including high water holding capacity, low unit weight, porous and high CEC of soil compression, saturated soil moisture content and field capacity [20,21].

Porous media conditions will greatly assist the movement of the roots to occupy the pore space while providing more water for the growth of the cuttings. Moreover, the filter cake media was combined with a low concentration of 2.4 D, namely 1.0 mL. L^{-1} of water, low *auxin* will stimulate the absorption of water as a medium for dissolving nutrients that are needed in the growth of cuttings. The presence of auxin will increase the diffusion of water entering the cell so that auxin directly supports the increased permeability of water entering the cell. Water is a solvent for the nutrients contained in the planting medium so that these nutrients are easily absorbed by plant roots [22]. Shoot growth will be accelerated if nitrogen and water are available [23].

Table 1. Average Germination Speed of Breadfruit Root Cuttings (days) in Various Organic Material Media and Concentrations of 2.4 D

Organic Matter Media	Concentration 2.4 D (mL.L^{-1} water)			CV DMRT 0.05
	1.0 (H_1)	1.5 (H_2)	2.0 (H_3)	
Filter cake (S_1)	31.17^{b}_{x}	32.50^{b}_{y}	48.33^{a}_{x}	
Saw dust (S_2)	43.33^{a}_{x}	41.83^{a}_{xy}	37.50^{a}_{x}	13.11
Rice husk (S_3)	31.67^{b}_{x}	47.17^{a}_{x}	47.50^{a}_{x}	13.76

Remark: Numbers followed by the same letters in rows (a,b) and columns (x,y) are not significantly different at the test level α = 0.05

Auxin group growth regulators such as NAA, IAA, IBA, and 2,4-D function in increasing osmotic pressure, cell permeability, reducing pressure on the cell wall, increasing plasticity and developing cell walls, and increasing protein synthesis. In addition, auxin plays a role in stimulating cell elongation and enlargement. In conjunction with cell permeability, auxin increases the diffusion of water entering the cell. Growth regulator 2,4-D is an auxin which has strong activity, but at low concentrations it can induce callus [24].

The results of statistical analysis on the interaction of the filter cake media with the addition of 2.4 D concentration showed that the increase in auxin concentration was inversely proportional to the rate of germination by breadfruit seeds. The concentration gradually increased from 1.0 $mL.L^{-1}$ water, 1.5 mL. L^{-1} water to 2.0 $mL.L^{-1}$ water. The filter media turned out to have a negative effect on the germination time which showed a slower germination time. Growth regulators at high concentrations can inhibit the action of endogenous hormones thereby disrupting cell growth and development [25]. High auxin concentrations inhibit the growth of buds [26]. The same trend was also shown by the interaction of rice husk media with a concentration of 2.4 D, namely the increase in auxin concentration was inversely proportional to the results of the sprouting speed. However, in the interaction of sawdust media with a concentration of 2.4 D, the opposite occurred, namely an increase in auxin concentration was also followed by an increase in the speed of sprouting. This was because sawdust as a growing medium tends to stick to plant roots so that at the beginning of the growth of breadfruit cuttings there was direct contact between the area under the cuttings and the sawdust so that moist conditions are created in the area under the cuttings because it easily binds water. Sawdust planting media is able to increase the water retention of the growing media [19].

The results of DMRT in Table 2 show that the filter cake media (S_1) showed the highest mean shoots and was significantly different with sawdust (S_2) and rice husk (S_3) media, but sawdust media (S_2) was not significantly different from rice husk media (S_3). The concentration of 2.4 D 1.0 $mL.L^{-1}$ water (H_1) showed the highest shoots and was significantly different from the concentrations of 1.5 $mL.L^{-1}$ water (H_2) and 2 $mL.L^{-1}$ water (H_3). But the concentration of 2.4 D 1.5 $mL.L^{-1}$ water (H_2) was not significantly different from the concentration of 2 $mL.L^{-1}$ water (H_3).

Root formation is a major problem of vegetative propagation, especially for cuttings. If this problem has been solved, the method of propagation by cuttings of breadfruit will be the best, practical and economical method of propagation. The experimental results showed that the filter media showed the highest average yield of shoot height, number of leaves, leaf area and root volume compared to sawdust and rice husk media. This is due to the fact that filter cake is able to create better pore space in the media so that it supports the growth of breadfruit roots, in this case root penetration into the media is not hindered. The position of the pore space is very important because plant growth and the physical and chemical processes that occur in the soil occur in and through the root pore space. Plant roots develop through the pore spaces. Likewise where water is stored, the movement of water and the movement of nutrients [27].

Duncan's Multiple Range Test results in Table 3 show that the filter media (S_1) showed the highest average number of leaves and was very significantly different from the sawdust media (S_2) and rice husk media (S_3), while the sawdust media (S_2) did not differ significantly with rice husk media (S_3). The concentration of 2.4 D 1.0 mL.L-1 water (H1) showed the most leaves and was significantly different from the concentration of 2 mL.L-1 water (H_3), but not significantly different from the concentration of 1.5 mL.L-1 water (H_2) . The concentration of 2.4 D 1.5 mL.L-1 water (H_2) was not significantly different from the concentration of 2 mL.L-1 water (H_3).

Table 2. Average shoot height of breadfruit root cuttings (cm) in various organic matter media and concentrations of 2.4 D at the end of the experiment

Organic Matter Media	Concentration 2.4 D ($mL.L^{-1}$ water)			Average	CV DMRT 0.01
	1.0 (H_1)	**1.5 (H_2)**	**2.0 (H_3)**		
Filter Cake (S_1)	33.57	24.77	24.90	27.75^a	
Saw Dust (S_2)	24.17	22.33	13.77	20.06^b	6.90
Rice Husk (S_3)	23.55	12.80	13.67	16.67^b	7.25
Average	27.10^a	19.93^b	17.45^b		

Remark: Numbers followed by the same letters in rows (a,b) and columns are not significantly different at the test level α = 0.01

Table 3. Average number of leaves of breadfruit root cuttings (strands) in various organic matter media and concentrations of 2.4 D at the end of the experiment

Organic Matter Media	Concentration 2.4 D (mL.L^{-1} water)			Average	CV DMRT 0.01
	1.0 (H_1)	1.5 (H_2)	2.0 (H_3)		
Filter Cake (S_1)	6.50	6.33	5.33	6.05^a	
Saw Dust (S_2)	5.17	4.50	3.17	4.28^b	1.30
Rice Husk (S_3)	4.83	2.83	4.00	3.89^b	1.37
Average	5.50	4.55	4.00		
CV DMRT 0.05	0.95^a	1.00^b	4.16^b		

Remark: Numbers followed by the same letters in rows (a,b) and columns are not significantly different at the test level α = 0.05

The water concentration of 2.4 D 1.0 mL.L^{-1} showed the best average shoot height and number of leaves followed by concentrations of 1.5 mL.L^{-1} water and 2.0 mL.L^{-1} water. It seems that these results follow a quadratic curve, that is, the lower the auxin concentration, the higher the shoots and the number of leaves produced. This is possible because the low concentration of auxin given can increase the content of growth substances present in plants which in turn will stimulate cell activity in the form of elongation, cell division and lead to tissue formation. One of the roles of auxin is to stimulate cell elongation in shoots and significantly affect the growth of shoots and leaves [27].

On the other hand, filter cake media stabilized soil structure better than sawdust and rice husk media with a better ability to hold/hold more water so that the media moisture could be maintained. Wet filter cake had a moisture content of 50-70% [20]. The number of leaves was also influenced by genetic and environmental factors. For example, leaf growth will be encouraged if there is enough water in the growing medium [23]. In addition, the easily weathered nature of filter cake was able to provide nutrients compared to sawdust and rice husk media which were needed for the growth of breadfruit cuttings because they contained high nitrogen and little phosphorus and potassium. The total nitrogen content of filter cake after 2 months of fermentation was 1.23%, while phosphorus and potassium were 1.26% and 0.38% respectively [28].

Duncan's Multiple Range Test results in Table 4 show that the filter cake media (S_1) showed the largest average leaf area and was not significantly different from the sawdust media (S_2) but it was very significantly different from the rice husk media (S3), while the sawdust media (S_2) was significantly different from rice husk media (S_3).

Filter cake contains nutrient compounds that are easily weathered. The weathering process produces CO_2 H_2O and minerals [22]. Mineral nutrition and water availability affect the growth of internodes, especially by cell expansion, nitrogen, and water, needed for vegetative growth such as roots, stems and leaves. More nitrogen is available and assisted by potassium, so more protein will be produced, and leaves can grow wider [23,29].

The results of DMRT in Table 5 showed that the filter media (S_1) showed the largest root volume and was significantly different from sawdust media (S_2) and rice husk media (S_3). However, sawdust media (S_2) was not significantly different from rice husk media (S_3).

Table 4. Average leaf area of breadfruit root cuttings (cm^2) in various organic matter media and concentrations of 2.4 D at the end of the experiment

Organic Media Matter	Concentration 2.4 D (mL.L^{-1} water)			Average	CV DMRT 0.01
	1.0 (H_1)	1.5 (H_2)	2.0 (H_3)		
Filter cake (S_1)	136.20	126.25	119.64	127.36^a	
Saw dust (S_2)	106.61	94.95	80.35	93.97^{ab}	35.55
Rice husk (S_3)	96.68	79.44	84.67	86.93^b	37.37
Average	113.16	100.21	94.89		

Remark: Numbers followed by the same letters in rows (a,b) and columns are not significantly different at the test level α = 0.05

Table 5. Average volume of breadfruit root cuttings (mL) in various organic matter media and concentrations of 2.4 D at the end of the experiment

Organic Media Matter	Concentration 2.4 D (mL.L^{-1} water)			Average	CV DMRT 0.01
	1.0 (H_1)	1.5 (H_2)	2.0 (H_3)		
Filter cake (S_1)	2.49	1.86	2.10	2.15^a	
Saw dust (S_2)	1.78	1.78	1.63	1.73^b	0.38
Rice husk (S_3)	1.66	1.86	1.55	1.69^b	0.40
Average	1.98	1.83	1.76		

Remark: Numbers followed by the same letters in rows (a,b) and columns are not significantly different at the test level α = 0.05

Filter cake was a better planting medium than sawdust and rice husk because it created good porosity for breadfruit root development. Abnormal root development due to obstacles in penetrating the soil, nutrients that were dissolved in water and were far below the reach of root suction would not be absorbed. If the roots were unable to penetrate the soil, the roots would become short and all the branches of the roots and main roots would grow thick hairy roots [30]. Rice husk media showed the lowest root volume. This condition was caused by the pore space formed by the rice husk media which was not as good as filter cake and sawdust. It was suspected that the porosity of the rice husk media was too loose resulting in lower water holding capacity so that water was easily lost due to evaporation or by the movement of water down to deeper areas of the media surface.

4. CONCLUSION

Based on the experimental results it can be concluded:

1. The interaction of filter cake media with the addition of 2.4 D concentration showed that the increase in auxin concentration was inversely proportional to the rate of sprouting rate produced by breadfruit seeds and became the best treatment combination on the parameter of sprouting rate. Although not optimal, the same trend was valid to rice husk media.
2. In contrast, the interactions of sawdust media with a concentration of 2.4 D, showed an increase in auxin concentration was also followed by an increase in the speed of sprouting or germination.
3. The filter media revealed a better effect on shoot height, number of leaves, leaf area, and root volume.
4. The concentration of 2.4 D 1.0 mL.L^{-1} of water had a better effect on shoot height and number of leaves of breadfruit root cuttings.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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