



The Seedlings Growth Performance of Areca Nut Palm (*Areca catechu* L.) under Different Types of Organic Mulching

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Abstract

Seedlings is the initial part of seed plant's growth and development including areca nut palm which germination is an essential part of it. Organic mulching is one of the utmost sustainable practices, therefore, it has been employed to enhance areca nut seedlings growth. The study aims to evaluate the effect of several types of organic mulch on areca nut seedlings shoot-root growth. The 3-month long experiment was conducted according to completely randomized design, with four treatments, namely no mulching (control) (M0), gliricidia (*Gliricidia sepium*) mulching (M1), imperata (*Imperata cylindrica*) mulching (M2) and lamtoro (*Leucaena leucocephala*) mulching (M3). The treatments were repeated 5 times with 20 experimental units. The findings revealed that no significant differences ($p < 0.05$) were found on the application of different organic mulching among all of the parameters. The treatment covered by imperata mulch tended to score the highest compared to other mulches on germination time, seedling height and shoot fresh weight while the minimum yield was recorded in M1 where gliricidia mulch was used. Application of organic mulch displayed better results for most of the parameters than that of the control resulting from an optimal growing environment for areca nut seedlings growth.

Keywords: mulch; seed germination; sustainable farming

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INTRODUCTION

Areca nut palm (*Areca catechu* L.) is a slim monoecious palm belonging to the Arecaceae family (Coppola et al., 2016) and areca nut or commonly referred as betel nut is the seed of *A. catechu*. The plant can be found in many regions including East Africa, the Arabian Peninsula, the tropical regions of Asia and Indonesia, as well as the Central Pacific and New Guinea (Nair, 2021). It is one of the most popular tropical plants in Southeast Asia, has been

denoted and classified as a promising commodity for its commercial cultivation. Areca nut is needed in events such as in traditional ceremonies and for household purposes (Garg et al., 2014). Other parts of the *A. catechu* are useful as construction materials, ornamental plants, foodstuffs and industrial raw materials such as cloth dyes and traditional medicines (Joo et al., 2020; Irwanto and Irsyam, 2021).

Advances in science and technology have been developed, resulting in the utilization of areca nuts for pharmaceutical and industrial purposes

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(Ansari et al., 2021). As a multipurpose crop in the international market, it can be exported in the form of seeds or whole fruit. Areca nut is generally grown on the small scale yards or gardens with very limited cultivation practices such as in India (Gangaiah and Abbubaker, 2019) and other parts of Southeast Asia countries (Staples and Bevacqua, 2006).

In Indonesia, in almost all cultivation areas and despite it is being largely used, this commodity has not been considered as commercial commodity which is in turn need to be cultivated on a large scale with export projections (Ansari et al., 2021). In Papua, areca nut chewing is the most habitual consumption, not only among local people but for other inhabitants as well. Unlike other parts of Indonesia where areca nut chewing is mostly taken by elder people, it is consumed by children, teenager, adult people as well as elders (Kameubun et al., 2020). Therefore, it has been grown widely for subsistence and commercial purposes (Joo et al., 2020).

One of the obstacles in commercial cultivation of areca nut is seed germination rate, germination percentage and growing seeds (Dinarti et al., 2021). Generally, in order to obtain high quality areca seedlings, especially in the number of leaves, it takes approximately 12 to 18 months after germination. It is caused by a dormancy period in which seeds germination takes 2 to 3 months after sowing (Staples and Bevacqua, 2006). In addition, fresh areca nuts contain 60 to 80% husk fiber of the nuts' weight (Rajan et al., 2005). The large husk fiber content will become a barrier in the germination process; further, the content of lignin, suberin and cutin found on the outside of the areca seed allowing the nuts become dormant (Rahmah et al., 2018; Ansari et al., 2021).

Environmental manipulation, such as mulching, is one way to increase the success of cash crops germination process (Chandra and Govind, 2001; Shirish et al., 2013; Li et al., 2016). Mulch is defined as a coating material spread over the soil surface (Kasirajan and Ngouajio, 2012). Mulching is the technique of covering of the soil surface around the plants with an organic or synthetic mulch to create favorable conditions for the plant growth and proficient crop production (Ilyas et al., 2021). Accordingly, there are two types of mulches: inorganic mainly made of

plastic-based materials and organic materials such as crop residues (Hussain et al., 2001; Sharma and Sharma, 2003; Kasirajan and Ngouajio, 2012; Shirish et al., 2013; Nzeyimana et al., 2017; Ilyas et al., 2021).

Mulching crop residues are reported to improve soil fertility, structure and groundwater reserves, inhibits weed growth, buffers the soil temperature and attract soil biota (such as earthworms) because of the high soil moisture (Nouri et al., 2019) and the availability of organic matter as earthworm food which is in turn will help in improving soil structure (Kader et al., 2019). Moreover, organic mulch obtained from natural materials such as plant debris are easily biodegradable biomass i.e. stalk straw, gliricidia, imperata, lamtoro, etc. which are found easily, economical and more importantly, environmentally-friendly (Shirish et al., 2013; Syahrudin et al., 2020), which is in turn promoting sustainable farming.

The latest studies have shown that the application of organic mulching could significantly conserve soil moisture (Teame, 2017), alleviate water scarcity (Nouri et al., 2019), improve soil properties (Li et al., 2016), reduce water soil erosion (Prosdocimi et al., 2016; Nzeyimana et al., 2017), enhance yields, water and nitrogen use efficiencies (Qin et al., 2015). The beneficial effects of organic mulching are known on different tested crops, soils and agronomy practices performed by Brar (2018); which concluded that organic mulches helped in regulating soil temperature as well as growth and oil productivity of Japanese mint. It is further reported that paddy straw mulch is beneficial for germination and emergence of suckers as it increases soil temperature during early growth stages; while later during hot summers, it helps in lowering down soil temperature up to 1 to 2°C as well as in enhancing herbage yield when coupled with weed control. USDA (2009) reported that the straw mulch application in strawberry field helps to control weeds, reduce soil erosion and retain soil moisture. Mulumba and Lal (2008) also reported crop residues mulching effects of silt loam soil on soil physical properties. Aforementioned statement was elaborated that mulch application increased total porosity, available water capacity, soil aggregation and moisture content at field moisture capacity.

Hussain et al. (2019) found that mulching with dried leaves or straw markedly increased the germination growth and fresh rhizomes yield of ginger. Khaskheli et al. (2021) also suggested that rice straw mulching increased germination and decreased seedling rot and wilt incidence compared to control where no mulch was used. Information on the organic mulches influence on the performance of seedlings of areca nut palm, however, is less available. The aim of this research was to determine the effect of application of different types of organic mulch on areca seedlings growth; it is expected to bring benefit as factual information especially for the seedling and nursery aspects.

MATERIALS AND METHOD

The experiment was conducted in 2018. Areca nuts were grown for three months from September to December in the Screen House of Soil Laboratory, Faculty of Agriculture, University of Papua, West Papua Province, Indonesia. The study area is situated around 100 meter above sea level and the coordinate positions are 0°50'18.7"S and 134°04'04.2"E. During the period where seeds were sowed in the screen house, the reported minimum temperature 24.8°C, maximum temperature 31.37°C, precipitation 10.02 mm, relative humidity 82.89% and light intensity 35.11 watt m⁻².

Organic mulching materials comprised of four treatments i.e no mulching (M0), gliricidia (*Gliricidia sepium*) mulching (M1), imperata (*Imperata cylindrica*) mulching (M2) and lamtoro (*Leucaena leucocephala*) mulching (M3). Gliricidia, imperata and lamtoro mulching are organic mulching applied to areca nut seedlings aiming to create proper environment surrounding the seedlings. The materials were collected from the nearest surrounding area of the experimental facility.

The experiment was arranged in a completely randomized design (CRD) with four treatments and five replicates each consisting of 20 experimental units where one seed for each experimental unit.

Seeds were taken from ripen areca nuts, with the criteria of a yellowish skin color and sourced from the identical parental tree. Before planting, the seeds were hulled by separating the yellow outer shell and leaving the husk fiber only. Stripping was done carefully to get

rid of damaging the embryo of the betel nut. The mixture of 3 kg of growing media used were soil and chicken manure with 2 to 1 in volumetric ratio. The soil derived from the topsoil, the soil then was sieved using 4-inch sieve (equal to 101.66 mm) to separate the dirt and remains of other plant roots. Meanwhile, steady-used manure was obtained from the Experimental Station, Faculty of Animal Husbandry, The University of Papua. Steady-used manure means that the manure has reached its decomposition state and ready to use. Subsequently, the manure was crushed to obtain a smoother texture. The composition of soil and manure was 2 kg of soil and 1 kg of manure. The mulch of gliricidia, imperata and lamtoro were freshly picked just before being applied. Gliricidia leaves were separated from the petiole and cut into small pieces, the lamtoro leaves were separated directly from the petioles without being cut into pieces, while the imperata leaves are cut 2 to 3 cm in size. Mulches were applied over the planting medium with a thickness of 3 cm from the surface of growing media or approximately 200 g in weight. Areca seeds were planted in a horizontal position in the growing media before applying mulch. Other cultural practices were uniformly practiced such as watering once per day.

Observed parameters include time to germination (day), seedling height (cm), fresh shoot weight (g), total root number, root weight (g) and total root length (cm). All these parameters were recorded with due course of time at 3 months after seeds planting.

Collected data were analyzed statistically according to One-way analysis of variance (ANOVA) techniques according to the Equation 1.

$$Y_{ij} = \mu + T_i + \text{random error} \quad (1)$$

where Y_{ij} being any observation for which $X_1 = i$ (i and j denote the level of the factor and the replication within the level of the factor, respectively); μ (or mu) is the general location parameter and T_i is the effect of having treatment level i (Bathke and Brunner, 2003).

Shall the treatment gave statistically significant effect ($p < 0.05$), means of different sources of variation were compared using Tukey's honestly significant difference (HSD) test (Salkind, 2012).

RESULTS AND DISCUSSION

The analysis of variance revealed that the application of different types of organic mulch were not significantly affected the observed

parameters; which were time to germination, seedling height, fresh shoot weight, number of roots, root weight and root length. The mean of parameters are displayed on Table 1.

Table 1. Effect of different types of mulching on seedling growth characteristics of *A. catechu* L.

Treatment	Mean	Standard deviation	Treatment	Mean	Standard deviation
	Germination time (day)			Total number of root	
M0	25.40	1.52	M0	4.40	0.55
M1	26.25	2.06	M1	4.75	0.50
M2	26.40	2.41	M2	5.00	0.71
M3	24.00	0.00	M3	5.25	0.50
	Seedling height (cm)			Root weight (g)	
M0	16.18	3.88	M0	0.56	0.12
M1	13.98	2.94	M1	0.50	0.11
M2	17.24	2.00	M2	0.58	0.20
M3	16.95	1.61	M3	0.72	0.19
	Shoot fresh weight (g)			Root length (cm)	
M0	2.00	0.19	M0	12.28	0.74
M1	1.59	0.27	M1	10.69	1.25
M2	1.97	0.48	M2	11.12	2.37
M3	1.91	0.04	M3	11.53	1.30

Note: M0 = No mulching; M1 = *Gliricidia* mulching; M2 = *Imperata* mulching; M3 = *Lamtoro* mulching

Shoot growth components

Figure 1 represents the comparison between treatments on shoot growth parameters. Referring to Figure 1, in terms of germination time, it showed that areca nut seeds with *lamtoro* mulch (M3) germinate faster (24 days) than that of the other 3 treatments; while *imperata* mulch treatment (M2) seeds tends to germinate slower (26.4 days). The results revealed that the seeds with *imperata* mulch

(M2) expressed the highest seedling height of 17.24 cm; while the treatment without mulch (M0) expressed the lowest seedling height (16.18 cm). The figure indicated that *imperata* mulch provides higher fresh shoot weight than other types of organic mulch. Optimum plant growth will produce an optimum number of leaves and stem, subsequently the fresh shoot weight will also increase (Franco et al., 2006).

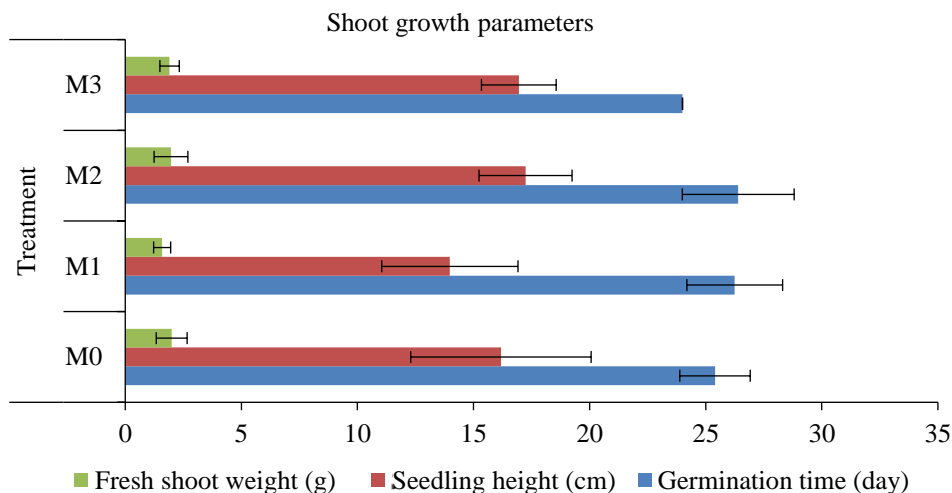


Figure 1. The shoot growth parameters of areca nut seedlings under different organic mulch application (horizontal error bars indicate \pm SE)

Being considered that organic mulch treatments were not significantly affected the parameters, however, it was sufficient to indicate that seed germination was determined by the application of organic mulch. The application of organic mulch tended to accelerate the germination time as compared to control. Germination is the process of growing the embryo and the components of the seeds which have the ability to grow normally into new plants (Hadas, 2005; Han and Yang, 2015; Khaskheli et al., 2021). Seeds contain the potential needed to grow into new individuals, for example embryos, food reserves and foliage leaves where the seed covering regulates the rate of absorption of water vapor and liquid and oxygen (Han and Yang, 2015). Organic mulch improves time to germination on areca nut seeds by providing essential factors needed. It means that the germination requires sufficiency of internal and external factors. Internal factors that influence seed germination include the level of seed maturity, seed size, seed weight, food supply conditions in the seed. External factors that affect seed germination, such as temperature, water, oxygen and light (Jarvis and Moore, 2008; Lynch et al., 2012).

The application of *lamtoro* mulch tended to speed up the germination of areca nuts compared to *glicicidia* and *imperata* mulch. It is presumably due to *lamtoro* mulch could create maximum moisture for areca seed germination for imbibition. The imbibition of water by seeds before germination can be divided into three phases: rapid uptake of water (phase I), phase of enhanced water uptake (phase II) and uptake of water along with the initiation of growth (phase III) (Bareke, 2018). The initial growth of seed plants starts from seeds; where the initial process of germination is the process of imbibing water into the seeds allowing water content in the seeds reaches a percentage between 50 to 60%. This process can occur if the seed coat is permeable to water and there is enough water throughout osmotic pressure. As Taylor (2014) stated that the seeds imbibition causes activating enzymes to work within chemical processes of vegetable seeds. Previous research on 25 different species of plants reported that the initial process was strongly related to water and solutions (Wierzbicka and Obidzińska, 1998), supported by the study on selected bean varieties as well (Mwami et al., 2017).

The application of organic mulch has increased the seedling height of the areca nut at the end of the observation and it is predicted that it will continue to grow to its maximum height. As seeds absorb water more rapidly with the seed covering removed (or ruptured) than when it is intact promoting cell elongation, it reaches optimal growth height. The growth rate indicates the vigor of seed growth because fast-growing seeds are better in coping with sub optimal field conditions. Recent studies also shown that mulch application provides higher temperature and water content to support the growth after germination process on cotton (Khaskheli et al., 2021) and areca nut (Nur and Miftahorrahman, 2012).

There is a tendency that *glicicidia* and *lamtoro* mulch affected the vegetative growth of areca seeds. The result was also in agreement with a theory that seedlings height is an indicator of growth as well as a parameter used to measure and determine the effect of the treatment applied in the experiment or as an indicator to determine the effect of the environment (Moi and Mandal 2021). A study on onion by Parsottambhai and Rawat (2020) proved that the increase in seedlings height is parallel to the increase of cell division due to assimilates acceleration and affect morpho-physiological attributes.

The fresh shoot weight is the result of the utilization of energy captured from the photosynthesis process to support plant's growth and development. Growth is often defined as an increase in plant size or weight due to changes in the new structure of the growth of roots, stems and leaves which is related to cell division and elongation and the formation of meristem tissue. Brar (2018) found that the utilization of mulch on Japanese mint mostly affects soil temperature in which soil temperature affects the plant growth in several ways viz. soil micro-organisms show maximum growth and activity at optimum range of temperature, the biological processes for nutrient transformations and soil nutrient availability.

Root growth components

Figure 2 represents the comparison between treatments on root growth parameters i.e. number of roots, root weight and root length. Figure 2 shows that the highest number of roots and root weight were from the treatment of *lamtoro* mulch (M3), while the lowest root

number and weight were found in the control treatment (M0) and gliricidia mulch treatment (M1), respectively. It contrasts to the trend of

root length in which no mulching (M0) achieved the highest root length compared to other organic mulches.

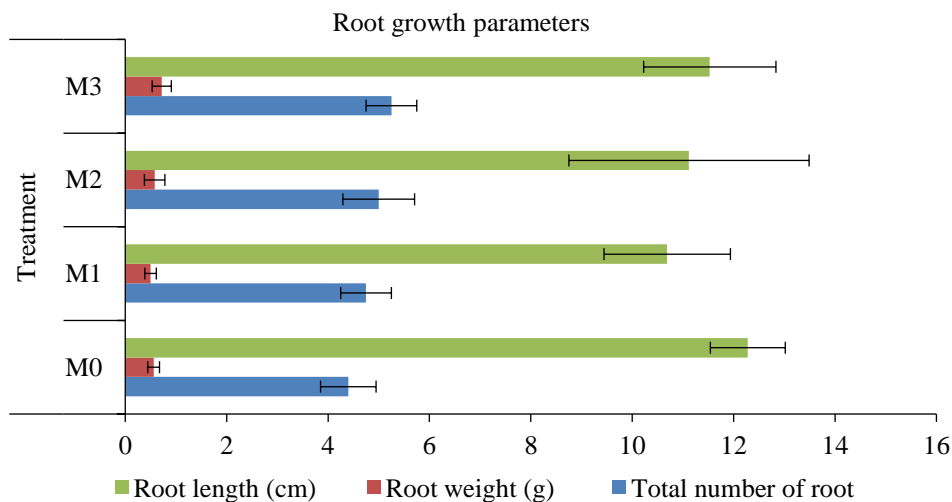


Figure 2. The root growth parameters of areca nut seedlings under different organic mulch application (horizontal error bars indicate \pm SE)

Based on the results, the growth in the number of roots was not affected by the planting medium (external factors) since the growth in the number of roots is thought to be more determined by cell division in the meristem area (internal factors). However, root traits are under genetic control resulting in substantial phenotypic variation within and among species. Lynch et al. (2012) suggested that root phenotypes may change in response to environmental conditions, either as an adaptation or simply because of external growth constraints. It is true that the porosity and aeration properties of the soil and the application of organic mulch led to the same effect on the average number of roots. The number of roots, the length of the roots and the presence of root hairs affect the area of absorption. The wider the absorption area, the more water and property elements will be absorbed (Chavarria and dos Santos, 2012), thus it will affect the wet and dry weight of the plant. The sufficient availability of water and nutrients will support the vegetative growth of plants i.e. areca nut (Sutariati et al., 2021) and potato (Wang et al., 2019).

Root weight is the wet weight of the roots after harvesting without any drying process first. The measurement of the fresh root weight is to find out how much water is contained in the root. The plant root system is pretty much

controlled by the genetic characteristics of the respective plant, soil conditions or the growing medium. Organic mulch can create environmental conditions with optimal soil moisture content for areca root growth. It means that mulch helps the areca nut plant to retain soil moisture and provides essential nutrients to facilitate its growth and yield. Proper seed germination and vigor establishment depend strongly on the environmental conditions (moisture, thermal and aeration regimes in the soil, light). Shall favorable environmental conditions prevail, other factors may determine the success or failure of seed germination and vigor establishment (seed-development processes on the parental plants), seed dispersion and depth of seed burial (Bareke, 2018). It is in line with the study on areca nut conducted by Li et al. (2018) and Zeng et al. (2020), which concluded the factors that influence the distribution pattern of roots, including: mechanical barriers, soil temperature, aeration, availability of nutrients and water.

Organic mulch treatment has the similar effect on root length, because the growing roots have the same absorption capacity to get water and nutrients from the soil (Shirish et al., 2013). However, there was a tendency that gliricidia mulch recorded the highest root length compared to other treatments. This is closely

related to the soil conditions where areca nuts are grown. Chemical properties such as acidity and others. Sufficient oxygen can also speed up rooting. Irwanto and Irsyam (2021) reported that the texture and aeration of the growing media of *A. catechu* affects the rooting process more when compared to its chemical properties such as acidity and others in which sufficient oxygen can also speed up rooting.

CONCLUSIONS

The present study indicated that the application of organic mulch did not show statistically different response for all the observed parameters. While imperata mulch tended to perform the highest compared to other mulches on the shoot growth parameters: germination time, seedling height and shoot fresh weight. *Lamtoro* mulch provided the highest root growth parameters. Overall, the application of organic mulch gave better results for almost all parameters than the control to create an optimal growing environment for the growth of areca nut seedlings. For further research, it is necessary to put more attention on the decomposition level of organic mulch.

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