ASIAN JOURNAL OF AGRICULTURE
Volume 2, Number 1, June 2018
Pages: 8-13

E-ISSN: 2580-4537
DOI: 10.13057/asianjagric/g020102

Seed emergence and growth of the shortage sugar palm (*Arenga pinnata*) as a response to seed scarification and liquid organic fertilizer application

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Manuscript received: 2 February 2018. Revision accepted: 15 May 2018.

Abstract. *Elidar Y. 2018. Seed emergence and growth of the shortage sugar palm (*Arenga pinnata*) as a response of seed scarification and liquid organic fertilizer application. Asian J Agric 2: 8-13.* This research aimed to know the effect of seed scarification and liquid organic fertilizer application on the seed emergence and growth of the shortage sugar palm (*Arenga pinnata* (Wurmb.) Merr). The research was conducted in two experiments, i.e. (i) effect of seed scarification, and (ii) effect of liquid organic fertilizer application. The first experiment was a single factor designed at Completely Randomized Design (CRD). The factor consisted of 4 scarification technique treatments i.e., s_1 = seed abaxial scarification; s_1 = seed tip scarification; s_3 = seed left and right sides scarification; s_4= seed embryo scarification. All treatments were replicated 6 times. The second experiment was arranged at a factorial (3 x 3) using Completely Randomized Design (CRD) with 6 replications. The first factor was the dose/volume of liquid organic fertilizer treatment in concentration of 3 cc L^{-1} of water (D) consisting of 3 levels i.e., d_1 = 300 mL; d_2 = 400 mL; d_3 = 500 mL, while the second treatment was the interval of liquid organic fertilizer (I) application consisting of 3 levels i.e., i_1 = 2 weeks; i_2 = 3 weeks; i_3 = 4 weeks. Seedling emergence test, germination rate, vigor index and seed germination percentage were measured and the growth parameters such as the plant height increase, plant midrib girth, number of midrib increase, and number of leaves were observed. The results showed that scarification at the embryo part (s_4) resulted in the best seed germination percentage of the shortage sugar palm at around 99.81%. Combination treatments between 500 mL dose of liquid organic fertilizer in concentration of 3 cc L^{-1} of water with the interval of 2 weeks (d_3i_1) produced the best seedling growth of the shortage sugar palm.

Keywords: *Arenga pinnata,* liquid organic fertilizer, scarification, seedling germination, shortage sugar palm

INTRODUCTION

East Kalimantan Province shows and possesses a great potential for the development and cultivation of palm commodities like sugar palm (*Arenga pinnata* (Wurmb.) Merr). The shortage sugar palm is a national superior variety that was released by the Minister of Agriculture of Indonesia in 2011, with Decree No. 3879. This plant is a native sugar palm from East Kutai regency, East Kalimantan that is fast growing and shows both harvested palm and high yield of sugar and other by-products, such as fruit and traditional drink. In 2008, the development of sugar palm in East Kalimantan reached 1.504 ha and produced brown sugar 4.21 tons ha^{-1}. In 2011, the cultivation area was decreased to 1.253 ha, and the productivity of brown sugar became 1.29 tons ha^{-1} (Plantation Agency of East Kalimantan Province 2013). Generally, the main problem in the development of sugar palm is because of the low input of cultivation technology application and the use of traditional systems in cultivation by farmers.

Currently, sugar palm is used as a producer for *nira* (the main source of brown sugar), renewable energy (bioethanol), carbohydrate (starch), a mixture of foods and drinks (palm fruit), building materials (stems), and for soil and water conservation (Martini et al. 2012; Ferita et al. 2015). With the demand for sugar palm increasing, the development of sugar palm in a large area using proper cultivation techniques in terms of cultivation aspects is required and very important.

Seed selection, seedling, and plant treatment and maintenance could significantly enhance the regeneration of sugar palm. The main obstacle in sugar palm regeneration is the long period of seed dormancy and the low percentage of seed germination. Dormancy period is time required for seeds to germinate. The dormancy period of the plant seeds is influenced by genetic, environmental, and hormonal factors (Koorneef et al. 2002; Finch-Savage and Leubner-Metzger 2006; Graeber et al. 2012). From the previous research, the sugar palm seed germination percentage was very low and varied (10-65%) as well as the time required to start germinating was long enough about 4-6 months (Mashud et al.1989).

The dormancy of palm seeds can be fractured mechanically by damaging the tissue of its testa (seed coat) through scarification/sanding (Saleh 2004; Abu Bakar and Maimuna 2013; Silalahi 2017). The aim of the scarification/sanding is to reduce the lignin layer in testa (seed coat). Lignin thin layer in testa (seed coat) will increase the permeability of water to facilitate the entry of water into the embryo. Scarification treatment on the sugar palm seed has been done by Silalahi (2017) using a sanding width of 1/4, 2/4, 3/4 and all parts of the seed coat. The results showed that the seeds sanded more than half of the seed coat, were the quickest to germinate.

Liquid organic fertilizer has multipurpose function for all kinds of food crops (rice and cereals), horticultural crops (vegetable, fruit, ornamental plants) and perennial crops (cocoa, palm oil, rubber, etc.) as well as for livestock/poultry and fish/shrimp. The micronutrient content of one-liter liquid organic fertilizer has a function equivalent to the micronutrient content of 1 ton of manure. The use of liquid organic fertilizer can save Nitrogen (N), Phosphorus (P) and Potassium (K) use as much as 12.5 - 25%. The fertilizer also contains complete macro and microelements for plant growth. To support the seedling growth of sugar palm, the use of liquid organic fertilizer is a good alternative to substitute the an-organic fertilizer application because it provides complete nutrients, improves soil conditions, and contains the plant growth hormones such as auxin, gibberellin, and cytokines (Anonymous 2015). The humic and fulvic contents in liquid organic fertilizer have a role in improving the consistency (friability) of hard soil and dissolving SP-36 (Phosphorus fertilizer) quickly. Liquid organic fertilizer will also trigger the multiplication of the formation of polyphenols compounds to improve the plant resistance against diseases (Anonymous 2015). Therefore, it is important to examine the effect of seed scarification (sanding) on germination, and the dose and interval time of liquid organic fertilizer application to the seedling growth of the shortage sugar palm.

MATERIALS AND METHODS

Plant materials

The plant materials used in this study were the shortage sugar palm seeds, harvested from several mature plants and fruits of shortage sugar palm cultivated in Kandolo village, East Kutai (Kutai Timur). The physiologically ripe seeds (characterized by tawny fruit skin) were put into a porous plastic bag and watered every day for a month. After the fruit pulp became soft, the seed was separated and rinsed with water selected for the homogenous size and quality.

Growing media, seed preparation, and maintenance

Sand used as the main seedling medium was put in a media box made from wood planks in a rectangle form with size 3 m x 1.8 m. The media box was placed on the *para-para* (nursery place) with a shading percentage around 60 % and as high as 1 m, to facilitate the seeds for seedling. The physiological ripe sugar palm fruit (characterized by tawny fruit skin) was put into the porous plastic bag and watered every day for a month. After the fruit flesh became soft and the seed was separated, then the seeds were rinsed. The point of an embryo was determined by soaking the seeds in water, and the white-shadow seeds were marked as an embryo point. All seeds were treated with Fungicide (Dithane M-45) solution to prevent disease infection, especially from fungi. The seeds used in this experiment were approximately similar/homogenous in size and color. The sanding/scarification was done by scrubbing the seeds using sand on the abaxial side, seed tip, embryo, and both seed sides determined as follows: Scarification/sanding of the shortage sugar palm seeds consisted of 4 levels, in the part of: s_1 = abaxial; s_2 = tip; s_3 = left and right side; s_4 = embryo. Seeds were then disseminated in moist and watered top-soil media. Seeds that begin to germinate, were marked by the appearance of epicotyl at the growing point. The epicotyl begins to prolong and form shoot, on the other hand, the radix will grow downward to form the plant roots. The plumule was formed by the growth of embryo axis in the upward direction. Prolongation of the plant roots and the formation of leaves were initiated and formed from the plumule. After two weeks, the hypocotyl had reached a length of 2 cm.

The second experiment was designed at a factorial Completely Randomized Design with eight replications. The first factor was the dose of liquid organic fertilizer (D) in concentration of 3 cc per liter of water, consisted of 3 levels 1.e. d_1 = 300 mL; d_2 = 400 mL; d_3 = 500 mL. The second factor, was the interval of liquid organic fertilizer application (I) consisted of 3 levels, i.e., i_1 = 2 weeks; i_2 = 3 weeks; i_3 = 4 weeks. The treatment combination consisted of 9 treatments and was repeated 8 times. Each treatment consisted of 4 seedlings, so that the number of seedlings used was as much as 144 seedlings.

Seedling growth and maintenance

The polybag of 20 cm x 30 cm size was filled with the mixture of top-soil: sand: chicken manure fertilizer in the ratio of 2 : 1 : 1. Seedlings were transferred from the seedling box to the polybags 60 days after sowing. The seedlings were planted in polybags and maintained until the age of 6 months. They were then treated with liquid organic fertilizer according to the dose and interval treatments as determined in the experiment. The seedlings were maintenance by watering every morning and afternoon. Weeding was conducted to remove weeds growing among the plants.

Data collection and analysis

Seedling emergence time (days), germination time (days), vigor index (%), and the percentage of seedlings (%) were observed for the scarification and germination experiment of the shortage sugar palm. Moreover, the increase of pant height (cm), stem girth (cm), and number of leaf number at the plant age of 30, 60, 90 and 120 days after treatments were measured for the second experiment. The data were analyzed using analysis of variance (ANOVA) and the Least Significant Difference (LSD) at 5% level were used to test the mean value differences.

RESULTS AND DISCUSSION

Effect of scarification on seed germination of the shortage sugar palm

Seedling emergence time (days)

Based on the variance analysis, scarification treatment gave significant effect to the seedling emergence test. The fastest seedling emergence time was reached by the treatment of s_4, (Scarification at embryo part of seed) which was 16.73 days, while the slowest was in the treatment of

s_1 (scarification at the abaxial side of the seed) which was 42.42 days (Figure 1).

Scarification treatment at the embryo part (s_4) gave the best results, presumably, it increases and accelerates the process of water imbibition into the seed and stimulates the seed to germinate. Imbibition process is an initial process of germination. Therefore, it could activate enzymes and hormones for seed germination. According to Flach and Rumawas (1996), sugar palm seeds scrapped around the embryo, besides facilitating the entry of water and air, it also helped root primordia to emerge out from the part of growing point, and as a result, the appearance of plumule was more rapid than without treatment. The scarified seeds will lose lignin layer in the seed coat, and it makes the endosperm of the seed will open, therefore water could enter easily headed to the embryo. Water in the embryo will trigger hormones and enzymes to activate germination (Delouche 1985).

The scarification at both sides of the seed showed the lowest results, it was assumed because the scarification treatments in the right and left side of the seeds were far from the embryo position, so the imbibition process was less influence on the germination process. The appropriate position of an embryo in the technique of sanding scarification was very effective in helping the process of sugar palm for seed germination. Usually, the location of the sugar palm embryo was in the right abaxial or left abaxial, but sometimes is also located in the middle of the seed.

Germination rate

Based on the variance analysis, the sanding scarification treatment resulted in a significant effect on the germination time. Based on the results of LSD test at the level of 5%, the treatment of (s_1) showed no significant difference with the treatment of (s_2) but showed significant difference with the treatment of $s_{4.}$ The treatment of s_2 was significant different from the treatment of $s_{3.}$ The best result of germination time was in the treatment of s_4 with 18.35 days, whereas the lowest was in the treatment of $s_{1,}$ with 32.58 days (Figure 2).

The treatment from s_4 gave the best result on germination time parameters. This germination time value showed and represented the vigor condition. The lower the value of germination time, the higher the seed vigor, and the seed germination became faster. Sanding scarification treatment at the embryo part, made the seed become permeable to gas and water. While on the treatment of s_3, the seed was still impermeable to water and gas. Impermeability of the seed coat to water was due to water was prevented by thick-walled of the seed coat cell which was covered externally by a hard wax layer. The fission of this layer was immediately allowed water into the seed, and thus germination started (Adiguno 2000).

An effort should be made to break the hard seed coat dormancy of shortage sugar palm by doing mechanical scarification. With this kind scarification treatment, the mechanical resistance of the hard seed coat will be reduced, therefore it will make the sugar palm seed germinate faster. The dormancy was broken to initiate the germination by destroying the seed coat acting as a barrier of imbibition (Delouche 1985).

The water content of palm seed during the harvested time is relatively high, i.e., 25-30% (Widyawati et al. 2009). The observation by Widyawati et al. (2009) to the lignin and tannin seed level, showed that the older the palm seed, the level of these compounds is increased. If it was connected between lignin and tannin seed with water imbibition, there was a close negative correlation, meaning that the higher the lignin and tannin contents of palm seed, the lower as well its imbibition. Increase in lignin and tannin levels had a role in reducing the permeability of sugar palm seed to water.

From the observation, the most optimal result of the scarification treatment on the germination time was obtained by sanding scarification. Germination was influenced by internal factors of the seed, especially the hormone contents such as abscisic acid (ABA) and gibberellic acid (GAs) (Delouche 1985). Sanding scarification causes lots of water to infiltrate into the seed easier than slashed, because the width of the coated part became larger if its lignin was removed.

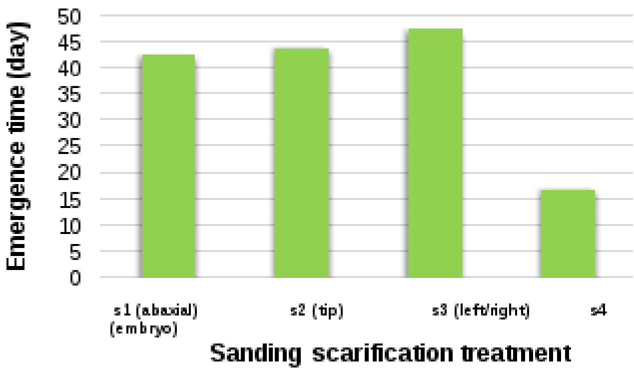

Figure 1. Effect of scarification on emergence test of shortage sugar palm

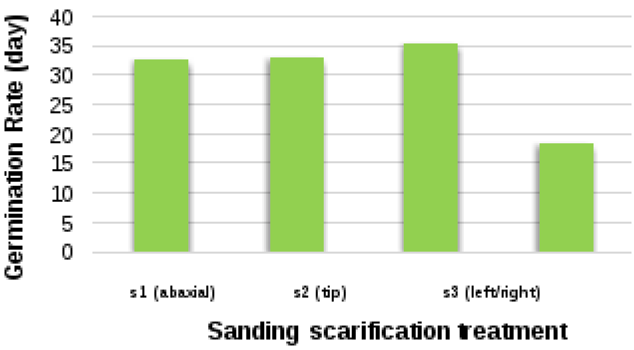

Figure 2. Sanding scarification treatment effect to germinate time

Vigor index (%)

Based on the analysis of variance, sanding scarification treatment give a significant effect on the vigor index of the shortage sugar palm seedlings. The LSD test at 5% showed that the treatment of s_1 was not significantly different from the treatment of s_2, but it showed significant differences in the treatment of s_3 and s_4. The treatment of s_2 was significantly different from the treatment of s_3. The best result of vigor index showed by the treatment of s_4, i.e., 1.41% whereas the lowest was in the treatment of s_1, i.e., 0.41% (Figure 3).

The treatment of s_4 gave the best result; it could be because the process of dormancy, breaking scarification with proper sanding at the growing point position, made easier the imbibition process of the seed. The proper scarification technique could increase the seed vigor. Seed vigor is indicated the ability of the seeds to germinate at sub-optimum conditions and related to the value of the germination rate. The value of this germination rate indicated the seed condition to possess good vigor or not. The lower the value of germination rate, the higher the seed vigor, and the seeds germinate faster.

The percentage of germination

Based on the analysis of variance, sanding scarification treatment resulted in a highly significant effect on the percentage of germination**.** Based on the results of LSD test at 5% level, the treatment of s_1 was significantly different from the treatment of s_2, s_3, and s_4. The treatment of s_2 was significantly different from the treatment of s_4. The biggest germination percentage was shown by the treatment of s_4, i.e., 99.71%, while the smallest was by the treatment of s_1 about 46.46% (Figure 4).

The dormancy breaking techniques effectively increased the germination percentage as observed in this research. The seeds treated with scarification had been able to germinate 14 days after scarification. It was indicated by the white apical appearance. The sugar palm seeds treated by scarification techniques in the abaxial part only produced the highest germination percentage values around 50-55% (Saleh 2004). Furthermore, the sugar palm seeds scarified by sandpaper had an average germination percentage value of 74.44% (Saleh 2004). These different results were presumable because of the differences in scarification techniques, the source of seeds and germination environment conditions.

Scarification treatment with sanding at the embryo had the percentage of seed germination up to 100%. One of the factors affecting seed germination, was seed maturity level. In palm fruits, their maturity levels are not the same due to the location of palm fruits in the fruit strand/bunch. As a result, the position of palm fruits in one bunch was not uniform ripening. According to Miao et al. (2001), the sugar palm seeds obtained by picking the old fruit which is characterized by yellow-rind, do not guarantee the maturity level homogeneity. The various maturity levels of palm fruits became a factor causing the palm seed to take a longer time to germinate and show low percentage value of germination. So, even though the breaking of seed dormancy was successful, the result was usually still less satisfactory. According to Miller (1964), the palm seed germination was naturally carried by the civet, in which the civet ate a ripe palm fruit then its feces came out together with the palm seed that was ingested before and discharged in the protected and moist place. These palm seedlings can germinate faster. The research results from Morris (2000) showed that the sugar palm seed derived from the civet can germinate faster by 83%, better than the seed derived from picking the old palm fruit. According to Maliangkay (2007), to obtain the seeds with uniform and high quality, determination the harvest time of the fruit is required to be known. Determination of fruit maturity based on the fruit color, odor, hardness, the fell off fruit/seed, the rupture of fruit and others were difficult skill to be inherited or less objective. An objective benchmark for determining the seed maturity can be determined for example based on the dry weight.

Effect of the dose and interval of liquid organic fertilizer on the growth of the shortage sugar palm

The application of liquid organic fertilizer resulted in the highly significant effect to the increase of height at the age of 30, 60 and 120 days after treatment (dat) and midrib girth at the age of 30, 60, 90 and 120 dat, while the combination of the dose and interval of liquid organic fertilizer treatment did not give significant effect to midrib girth at the age of 60 and 120 dat.

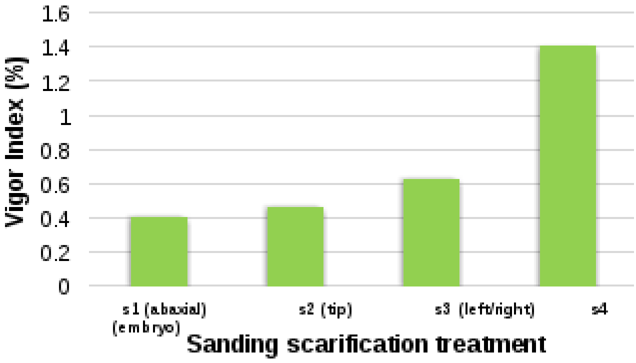

Figure 3. Sanding scarification treatment effect to the Vigor Index

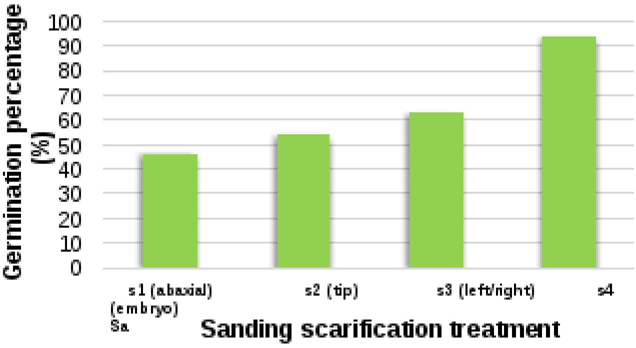

Figure 4. Sanding scarification treatment effect to the percentage of germination

Increase of plant height

Based on the analysis of variance, the dose of liquid organic fertilizer (D), liquid organic fertilizer interval (I) and their interactions (DI) showed highly significant effect on the parameters of increase of height at the age of 30, 60, and 120 hsp and did not give significant effect on the while increase of height at the age of 90 dat (Figure 5 and 6).

The dose and interval of application of liquid organic fertilizer resulting in the significant effect to the increase of plant height were presumably influenced by the characteristic of organic fertilizer, plant species and the availability of nutrients absorbed in the soil by plants. Liquid organic fertilizer is known as natural liquid organic fertilizer derived from the extraction of organic material waste of livestock and poultry, plant waste (compost), natural waste, and some types of certain plants and natural substances that were processed based on environmentally friendly technology with the principle of zero-emission concept. The plants absorbed all the nutrient content supplied by liquid organic fertilizer both macro and micronutrients in every week, so the plants can grow up maximally. The fertilizer was able to improve the plant height because liquid organic fertilizer contains macronutrients, micronutrients, minerals, vitamins, organic acids, and growth hormones that could stimulate plant growth. Liquid organic fertilizer contains elements of 0.12% of N, 0.03% of P_2O_5, 0.31% K, 60.4 ppm of Ca, 2.46 ppm of Mn, 12.89 ppm of Fe, 0.03 ppm of Cu, minerals, vitamins, organic acids, and growth stimulating substances such as Auxin, Gibberellin, and cytokines (Anonymous 2015). Besides that, the advantages of using these organic fertilizers were able to provide nutrients rapidly (Samad 2008).

Increase of plant midrib girth

Based on the analysis of variance the dose of liquid organic fertilizer treatment (D) and liquid organic fertilizer interval (I) increased the plant midrib girth at the age of 30, 60 and 90 dat significantly, but at 120 dat, it was not significant (Figure 7 and 8). There was an interaction between liquid organic fertilizer dose and liquid organic fertilizer interval (DI) treatment on the parameter to the increase of plant midrib girth at the age of 30 dat and 90 dat while at the age of 60 dat, no significant interaction was observed.

The dose and interval application of liquid organic fertilizer showed significant effect on the increase of plant midrib girth. This was presumably due to the type of soil which supports plant growth, especially the roots, which can affect stem diameter. Plant growth may be affected by the low availability of nutrients. Plants exposed by N element deficiency, showed the obstructed vegetative growth represented by the slow growth of branches, leaves and stems. The deficiency of P element has shown to make plants become dwarf and the deficiency of K element causes plants to have a weak and short stem (Salisbury and Ross 1995).

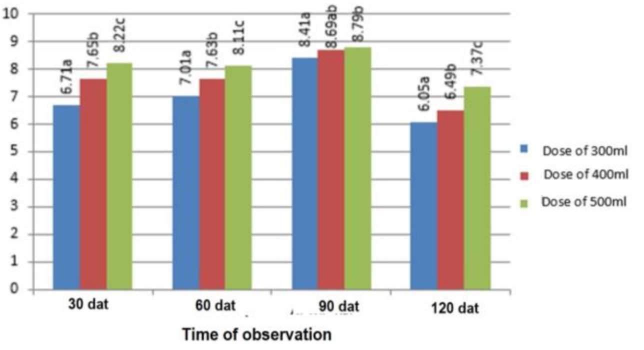

Figure 5. Increase of plant height (cm) of the shortage sugar palm as response to the dose of liquid organic fertilizer treatment

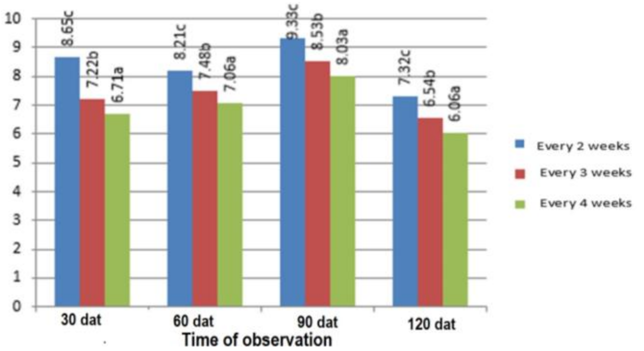

Figure 6. Increase of plant height of the shortage sugar palm as response to the interval application of the liquid organic fertilizer treatment

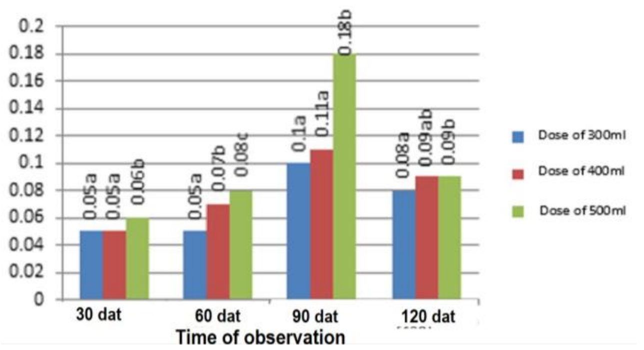

Figure 7. Increase of plant midrib girth (cm) on shortage sugar palm as response to liquid organic fertilizer dose treatment

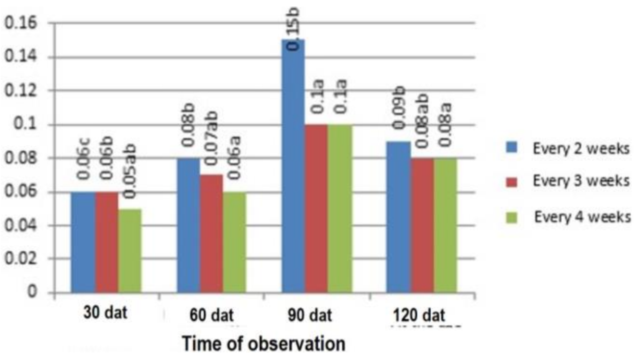

Figure 8. Increase of plant midrib girth (cm) on shortage sugar palm as response to liquid organic fertilizer interval treatment

Increase of midrib and leaves number

Based on the analysis of variance, the treatment of liquid organic fertilizer interval gave significant effect to the plant midrib number at the age of 30 and 120 dat, but it showed no significant effect at the age of 60 and 90 dat. The treatment of dose (D) and their interactions showed no significant effect on such plant parameters. On the other hand, the dose (D), liquid organic fertilizer interval (I) and the interactions of both treatments did not show significant effect for all parameters observed.

The increase of midrib number was presumably due to concentration applying of liquid organic fertilizer at the age of 30 dat had a good influence usually at the young age of plant, and the condition of rooting plants had not spread out yet. Therefore, the fertilizer must be given optimally to absorb the nutrient supply in fertilizer.

The effect of the liquid organic fertilizer interval was not significant to the midrib number. It was presumably due to the macro and micronutrients contained in the liquid organic fertilizer had not been able to be absorbed by sugar palm seeds to increase the plant midrib. According to Salisbury and Ross (1995), the formation of new shoots and leaves was associated with plant nutrients, and the absorbed nutrients can help the sustainability of plants such as the formation of new leaves.

In conclusion, scarification treatment by sanding showed a high significant effect on all parameters of seed emergence and seedling development. Sanding scarification at the embryo part gave the best result, showed in the parameters of emergence test of 16.7 days, germination percentage of 99.71%, germination rate of 18.35 days, and vigor index of 1.41. Liquid organic fertilizer dose treatment resulted in the highly significant effect of the plant height increase and midrib girth. The treatment of 500 mL doses of liquid organic fertilizer applied at interval of every 2 weeks increased the plant height and the number of midribs.

ACKNOWLEDGEMENTS

The author would like to thank people who have contributed to this research that cannot be mentioned here.

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