

ONLINE ISSN : 2548-5148
PRINT ISSN : 2548-5121

AGROTECH JOURNAL

Volume 4, No. 1, June 2019



Published by USN Scientific Journal Group, Indonesia
<http://www.usnsj.com/>

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AgroTech Journal (ATJ)

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Plant Growth Analysis of Jack Bean (*Canavalia ensiformis* L.) at Different Spacing to Determine the Application Time of Cutback Technology

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ARTICLE INFO

e-ISSN: 2548-5148
p-ISSN: 2548-5121
Vol. 4, No. 1, June 2019
URL : <http://dx.doi.org/10.31327/atj.v4i1.907>

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Abstract

The growth of jack bean (*Canavalia ensiformis* L.) is affected by genetic and environmental factors. One of the environmental factors involved is growing space. Growing space related to each plant of areas occupied is stated by the distance between plants. A Research has been conducted as long three months in dry season with average daily temperature of 25 to 31°C on altitude of 25 to 500 meter, to determine the timing of the application of cutback technology based on an analysis of growth of jack bean plants (*Canavalia ensiformis* L.) in different growth spaces. The research was conducted in the trial form using a randomized block design. Variables of plants growth analysis observed is leaf area index (LAI), leaf area is computed by gravimetric method; net assimilation rate (NAR), and relative growth rate (RGR) is determined based on the dry weight of plants; in all three rooms grew, namely 75 cm x 100 cm (control), 75 cm x 75 cm and 75 cm x 50 cm, each repeated three times. The result shows that the trend of leaf area index increased at net assimilation rate (g-1.cm-2.week-1) and relative growth rate (g-1.g-1.minggu-1) decreasing at the time the plant to the age 8 weeks after planting. The best time for the application of reduction technology to jack bean plants (*Canavalia ensiformis* L.) in all tested growing spaces, is recommended when plants are between 7 and 8 weeks after planting

Keywords : Jack bean, LAI, NAR, RGR

A. Introduction

The growth of jack bean (*Canavalia ensiformis*) is affected by genetic and environmental factors. One of the environmental factors involved is growing space. Growing space related to each plant of areas occupied is stated by the plant between distances. The closer a plant between distances, the higher density at leaves between and the less light reaching the leaf below layer (Sitompul & Guritno, 1995). The shade can decrease the number of stomata and wide porous stomata on the leaf surface, but not to the length of stomata porous top surface and the bottom and width of the surface porous bottom of plant leaves *zephyranthes rosea* Lind (Haryanti, 2010). The ginseng plants not experienced shade has leaves that are thicker and the number and bigger of stomata density the underside of leaves compared to that experienced shade (Afa & Wahyu, 2014).

Plants growing in low light intensity environments has deeper roots are small, few and composed of thin-walled cells. It happens due to the translocation inhibition of photosynthesis from the root. Internode is longer composed of thin-walled cells, a bigger space between cells, the less a carrier and barrier tissue. The leaves are larger, thinner and larger size of the stomata epidermal cells is thin but the number of leaves less space between cells more (Haryanti, 2010). The results of his research that planting distance between rows of sweet corns in a cropping system effect on plant height, diameter base of the stem, long cob, and weight cob. The growth and the best result obtained at the use of plant spacing 100 cm x 30 cm (Ainun. M., Jumini & Jamilah, 2010), also concluded that the real effect on the spacing of higher plants, the highest obtained at the use of a spacing of 20 cm x30 cm. Similarly, the results a spacing of 40 x 25 cm is significantly higher than the spacing of 40 cm x 40 cm (Pakaya, M.S., Pembengo, W. & Zakaria, F., 2013).

In the early phases of plant growth, leaf area increased will happen to continue with increasing age of the plant until a specific time. Leaf area is not with respect to time but decreased by increasing the age of plant (Gardner. F.P., Pearce, R.B. & Mitchell. R.L., 1991). The effectiveness of a plant leaf area can be detected by calculating the value of leaf area index.

Leaf area index (LAI) is a variable that shows the relationship between leaf area and areas extensive covered (Risdiyanto & Setiawan, 2007). The value of the leaf area index (LAI), which increased the growth of early phase still give net results increased assimilate.

The increase in the net assimilation rate (NAR) will result in an increase in the speed of plant growth. The net assimilation rate had a positive correlation and large direct effect on yield. Net assimilation rate among of rice genotypes ranged between 0, 40 to 0, 86 g-1.m-2.hari-1. Another character that has a close relationship with the result is a dry grain weight per hill amount of grain per panicle (Ratnasari, D., Hidayat, P., Sunarto. & Agung D. H. T., 2010). The resulting research indicated that the plant buncis highest net assimilation rate obtained in the age range 35 to 42 days after planting and the lowest obtained in the age range 28 to 35 days after planting (Duaja, M. D., Mukhsin. & Sijabat, R., 2013).

However, the leaves of growth will cover each other which is the upper leaves will cover the below it leaf thus reducing the net result assimilates (Susanto, 1994). The net assimilation rate (NAR) soybeans plant increase until the 43 days after planting (DAP) and decline after that age (Hartawan, 2013). LAB decline in value caused soybean leaves cover each other until the lower leaves only a little sunlight and the leaves are as parasites. Fotosintat amount produced is not balanced with the leaf area growth ultimately decreased LAB, indicates that the shade of reducing the weight of dry Stover per soybean plant (Chairudin, Efendi & Sabaruddin., 2015).

Based on this information it needed a time of application of technology research cutback based on based on the analysis of growth in order to jack bean (*Canavalia ensiformis*) be able to grow and produce optimally.

B. Methodology

The experiment was arranged by a randomized block design (RBD) with three treatments growing space of 75 cm x 100 cm (control), 75 cm x 75 cm and 75 cm x 50 cm were applied respectively in three groups in order to obtain 9 experimental units. Jack Bean of seeds used is a local seed derived from farmers in Enrekang district. The seed is planted using a dibble stick

and stuffed of one to two seeds each planting hole after soaked seeds, then after seeds grow the reduction to sustain one crop. Plant growth analysis observed variable is leaf area index (LAI), leaf area is computed by the gravimetric method; net assimilation rate (NAR) and relative growth rate (RGR) is determined based on the dry weight of plants. Observation is made of 7-day interval until the plant to concern generative phase.

Analysis of variance conducted at each growth analysis variable, if the treatment gives the effect of significant then it will continue Duncan test to see between treatments differences (Akib, 2013).

C. Result and Discussion

Leaf Area Index (LAI): Leaf area reflects the widest part of the photosynthesis, while LAI reflects the light interception by plants. Although part of the stem also light intercept but more happens effectively on the leaves. LAI increases with increasing intensity light until the optimum limit the plant light intercept (Duaja *et al.*, 2012).

That leaf area index (LAI) has an important role determining the speed of photosynthesis/degree of assimilation net and production, which value depends on the light conditions and forms of the canopy plant (Indonesian center for agricultural library and technology dissemination, 2013). LAI in the optimal range also the maximum production obtained. Management pruning or shade is one attempt to maintain the planting conditions in order to be at optimal LAI that is if more than 95 % of the leaf area receives sunlight.

Leaf area index of a plant community is not only determined by the morphology of plants related to the distribution of light, and the leaves nature but also by the leaves of density, so that that leaf area (LD) or leaf area ratio (NDL) parameters will not be sufficient to explain the differences between plant communities leaves unit price (HSD). The leaves of density are closely related to the plant population or growing space (plant spacing). The closer the plant between distances, the higher the leaves of density and the fewer quanta of radiation (light) that reached lower leaf layer (Suggu., A. G., Ahmed, E., Himayatullah, H., Ayaz, M., Ahmad, H. K. & Hannan, A., 2010).

LAI value in figure 1, show that the treatment to grow space the narrow resulted plants more reach quickly LAI > 1, this case give an information that in this condition happen the leaves between shade to affect the decreasing of productivity in the photosynthesis process to produce assimilates. The higher plant density the number of plants per unit area more and more, so that the plant inter canopy cover each other in the effort to get light (Suryadi., Setyobudi. L. & Soelistyono, R., 2013). A similar result was obtained in sorghum plant (*Sorghum bicolor* (L))(Puspitasari., N. G., Kastono, D. & Waluyo, S., 2012) and caisim plant (*Brassica juncea* L) (Abas, M. Z., Zakaria, F. & Pembengo, W., 2014).

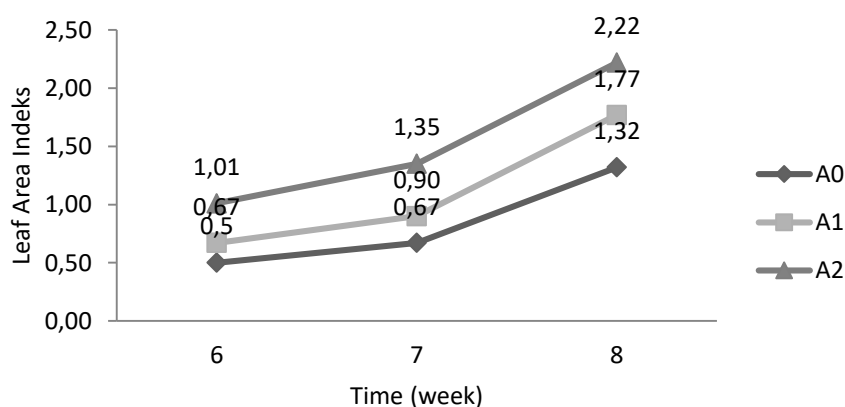


Figure 1. The average LAI of Jack Bean (*Canavalia ensiformis*) at treatment spaces growth different (A0, 75 cm x 100 cm; A1, 75 cm x 75 cm; A2, 75 cm x 50 cm)

The price LAI > 1 describes the existence of mutual the leaves among shading which resulted in leaves in shade on the bottom layer canopy received light to be less and can, therefore, behave a lower rate of photosynthesis from the leaves that are not shaded. When the leaf area exceeds that area the growing space, then there protected leaves. Protected leaves ineffective because as it cannot perform photosynthesis (Herlina, 2011).

Net Assimilation Rate (NAR): Net Assimilation Rate (NAR) is a plant's ability produce the dry ingredients of assimilation result per unit of leaf area per unit time ($\text{g}/\text{dm}^2/\text{minggu}$) (Gardner *et al.* 1991). The rate of net assimilation is affected by the amount of solar radiation, the leaves ability to photosynthesis, leaf area index, light distribution and the number of plant respiration (Kiswanto, D., Indradewa, E. T. & Susila. P., 2012). Value highest NAR at the time of plants is still small and most of the leaves are exposed to direct sunlight. NAR likely to decrease during accretion leaf area, so it is not capable of doing photosynthesis optimally (Nasaruddin, 2010).

Figure 2 shows that the highest NAR acquired during the seven-week-old plants and declined at the age of eight weeks, where the value of LAI increase to continues. LAI value on the treatment to grow wider space has reached a value greater than 1 n 7 days old plant but has not led to LAI impairment. It indicated that the need leaves shaded assimilates still afford to supply the leaf that light gets. There is a correlation between LAI value and dry matter production, which the asimotik curves follow, the curves are seen that during the plant production dry matter are not declining at a rate of greater LAI than the need for full interception radiation, then the bottom leaf canopy that protected not a parasite for the productive part (Sumarsono, 2008).

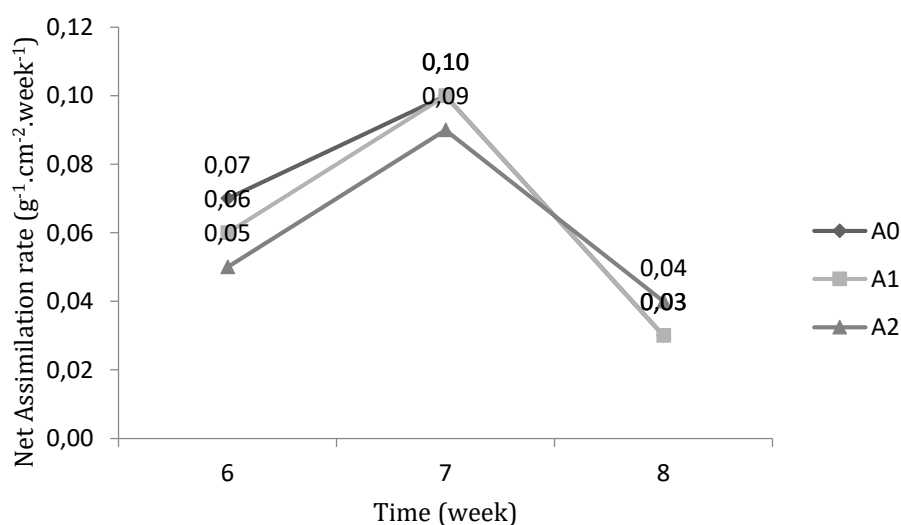


Figure 2. The average NAR of jack bean (*Canavalia ensiformis*) at treatment spaces growth different (A0, 75 cm x 100 cm; A1, 75 cm x 75 cm; A2, 75 cm x 50 cm)

The more and distantly the plant distances hence more and more captured solar energy by plants for use photosynthesis process, but in his study found to decrease on soybean dry weight with decreasing plant spacing (Pangli, 2014). The plant distance of dense affects the formation of chlorophyll and enzymes, the photosynthesis process will be disturbed when chlorophyll formed is not perfect, and so if the light deficiency, then enzyme formation is also disturbed (Herlina, 2011). Enzymes that are disturbed will disturb the photosynthesis process and eventually diminished photosynthesis is formed.

Relative Growth Rate (RGR): Relative growth rate indicates dry weight an increase in time intervals, in relation to the origin weight⁶. The relative growth rate (RGR) is the dry weight increase per unit dry weight that has been assimilating into the plant (Nasaruddin, 2010). The growing analytical variables that are closely related to the production of seed and 1000 grain

weight of seed is the relative growth rate (Hartawan, 2013). The protein content of seeds is the main variables that affect the quality of seed viability and vigor in storage.

The phenomenon of relative growth rate in figure 3 shows a decrease in dry weight addition plant of planting line with decrease value net of assimilation rate (NAR) at the time the plant reaches age 8 WAP where continue increase of LAI. This indicated that the shaded leaves organ has become parasitic to plants. The leaves a lack of sunlight receives will reduce photosynthesis and eventually reduce fotosintat which is useful for growth (Herlina, 2011).

The soybean plant is shaded at 50 %, increasing the leaf area index, the decrease net assimilation rate; decrease the Relative Growth Rate, lowering the total dry weight of the plant and pods weight (Merita & Qadir, 2011). Similarly, the results tomato plants that shade obtains 70 % (Baharuddin, R., Chozin, M. A. & Syukur, M., 2014). The diminished light on shade treatment caused leads to stacks of nitrate (NO_3). The nitrate increase caused to diminish of energy required by the enzyme nitrate reductase to reduce nitrate to nitrite (NO_2). The energy comes from the reaction of photosynthesis through the supply of carbohydrates. Inhibition of photosynthesis and nitrate pile, in turn, decreases the production of biomass plant is shaded (Sirait, 2008). The 75 % shade treatment nitrate reductase activity is also quite high. This is probably caused by the plant efficiently light capture by increasing the surface area of leaves (Latifa & Anggawulan, 2009). The increase in the rate of photosynthesis followed by increased respiration which will produce energy to reduce NO_3^- to NO_2^- .

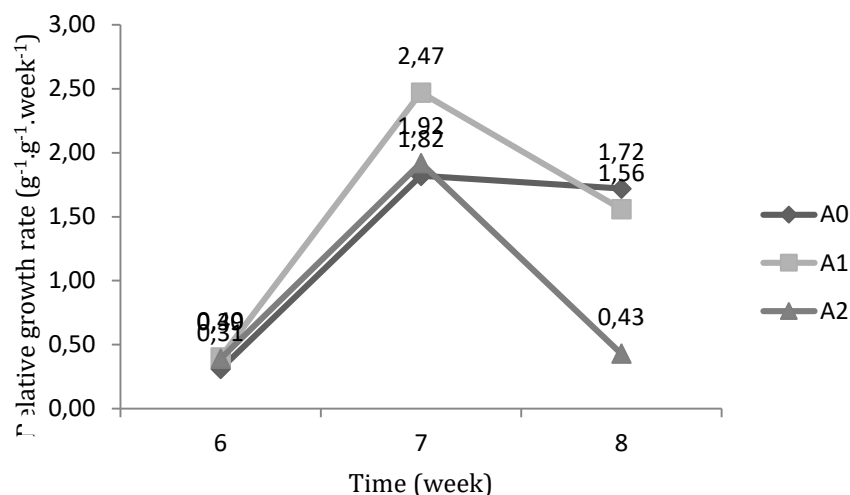


Figure 3. The average RGR of jack bean (*Canavalia ensiformis*) at treatment spaces growth different (A0, 75 cm x 100 cm; A1, 75 cm x 75 cm; A2, 75 cm x 50 cm)

In addition to the buildup of nitrate in the shaded plant, also an increase of proline and ascorbic acid compounds. The plant cells exposed to environmental conditions that are less suitable for example shade will produce a proline to maintain osmotic balance of cells. Setting the osmotic pressure on the stress condition or known as osmotic adjustment will produce a soluble compound that accumulated during the osmotic adjustment process such as sugar compounds and proline acid. Increased content of proline and the shaded chili is the mechanism of osmotic adjustment to the lack of light intensity due to the of shade treatment. Further, explain that the condition shade of acid ascorbic content continued to decline of the observation initial until the last day. This is according to the ascorbic acid function of the plant as a co-factor for violaxanthin deoxidase on xanthophyll cycle. This process plays a role in the protection of the release of light absorption in the form of temperature and can be measured as nonphotochemical quenching of fluorescence of chlorophyll. Ascorbic acid as antioxidant compounds can interact with the plasma membrane and electrons donated to the radical x-tocopheroxyl and activity-trans-plasma membrane oxidoreductase. Recycling x-tocopheroxyl can help protect the plasma membrane from peroxidation (Kloiri, 2010).

Information concerning the influence application of the catback technology on the growth and crop production sword koro bean plant will be written in another article.

D. Conclusion

A good time for technology cutback application on jack bean plant in all three growing space is recommended when the plants reach the age of 7 to 8 weeks after planting.

E. Acknowledgements

Thanks for the Ministry of Research Technology and Higher Education that has funded this research through competitive grants.

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Increasing The Production of Thai Eggplant (*Solanum melongena* L.) Grown at Altitude of 2 Masl Using Mycorrhizal Biofertilizer

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ARTICLE INFO

e-ISSN: 2548-5148
p-ISSN: 2548-5121
Vol. 4, No. 1, June 2019
URL : <http://dx.doi.org/10.31327/atj.v4i1.908>

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Abstract

This study was aimed to increase the production of Thai eggplant (*Solanum melongena* L) grown at altitude of 2 masl using myccohirzal biofertilizer. The study was conducted in Experimental Farm of Agricultural Faculty of Campus II University of Cokroaminoto Palopo, Batu Pasi Sub-district, Wara Utara District, Palopo City. This research applied the method of Randomized Block Design with four replicants and five treatments; P0 = Without treatment (control), P1 = Mycorrhizal fertilizer of 5 gr/plant, P2 = Mycorrhizal fertilizer of 10 gr/plant, P3 = Mycorrhizal fertilizer of 15 gr/plant, and P4 = Mycorrhizal fertilizer of 20 gr/plant. Research of this study showed that one treatment significantly affected the root length of eggplant, namely P2 with root length of 39.42 cm. In general, application of mycorrhizal fertilizer did not significantly affect the growth and production of eggplant, but several doses resulted in better outcome. Treatment of P3 obtained the best plant height of 9.22 cm, while the best average flowering age was found in P2 and P4 of 31.8 days after planting. Moreover, P3 and P4 produced the most number of flower, namely 3.83 flowers, while the most number of fruits was obtained by P4 of 3.53 fruits. At last, P3 produced the heaviest fresh weight of fruit of 221.13 gram

Keywords: production, mycorrhizal biofertilizer, thai, eggplant

A. Introduction

Eggplant (*Solanum melongena* L.) is one of horticultural plants widely distributed in Indonesia. Eggplant is originated from Sri Lanka and India. Its fruits have a variety of colors, namely purple, green, and white. In Indonesia, eggplant is often served in many kinds of dishes, from vegetable soup to lalap (raw vegetable). Similar to other vegetables, eggplant also provides health benefit to the body as it contains many nutrients. Rukmana (1994), mentioned that eggplant is rich of vitamin C, K, B6, thiamin, niacin, magnesium, phosphorus, copper, fiber, folate acid, potassium, and manganese. However, eggplant production in Indonesia is still considered low despite its abundant nutrient content.

According to Badan Pusat Statistik Kota Palopo (2016), eggplant productivity in Palopo City decreased for the last five years. The production was 248.60 ton in 2011 but drastically declined to 77.40 ton in 2012. Later, there was significant increase of 105.70 ton in 2013, but then again it felt drastically in 2014 (83.10 ton) and 2015 (69.70 ton). Decreasing eggplant production was due to small eggplant farming area and farmers who still considered eggplant cultivation as secondary farming culture thus it was not intensively performed. Furthermore, low production was also caused by inappropriate farming technic and non-optimal eggplant growth, both in the vegetative and generative phases.

One effort to increase eggplant growth and production is conducted by improving root function to absorb nutrient and water available in soil. Improving root function can be done by stimulating or inducing roots with the help of fungi or bioagents that are able to penetrate to plant roots, such as mycorrhizal fungi and bioagents like *Trichoderma* sp., *Pseudomonas Fluorescent Indofit* sp., and *Bacillus Subtilis* sp. Those microorganisms can be obtained in the form of fertilizer for ease of application. One of fertilizers providing microorganisms to improve plant root function is mycorrhizal fertilizer, that is powder fertilizer containing Mycorrhizal fungi, *Trichoderma* sp., *Pseudomonas Fluorescent Indofit* sp., and *Bacillus Subtilis* sp. that are able to improve water transportation to root, transform the form of available nutrient for plant, increase phosphorus availability, and suppress the growth of pathogen.

Imas, T., Hadioetomo, R. S., Gunawan, A. W. & Setiadi, Y. (1989), said that mycorrhiza was also found to increase the production of growth hormone such as auxin, cytokinin, and gibberellin of host plants. Auxin has function to slow the aging process in root, thus root function to nutrient and water will last longer.

Prasasti, O. H., Purwani, K. I. & Nurhatika, S. (2013), reported that mycorrhizal treatment affected plant height, root dry weight, and canopy dry weight of peanut plant (Domba variety) infected with pathogenic *Sclerotium rolfsii*. Treatment of mycorrhiza at dose of 50 gram resulted in the highest effect on vegetative growth of peanut plant, both the height and dry weight of plant. According to those findings, the objective of this study was to investigate production increase of Thai eggplant (*Solanum melongena* L) grown at altitude of 2 masl and treated with mycorrhizal biofertilizer.

B. Methodology

1. Research Design

The study was conducted in Experimental Farm of Agricultural Faculty of Campus 2 University of Cokroaminoto Palopo, Jln. Lamaranginang, Batupasi Sub-district, Wara Utara District, Palopo City.

The materials used in this study were seeds of Thai eggplant, plastic, basic fertilizer, and Mycorrhizal Fertilizer. Tools used in this research included hoe, scale, bamboo, container or bucket, stationery, and camera.

2. Experimental Methods

The mycorrhizal dose treatment applied was :

P0 : Without treatment (control)

P1 : 5 gram/plant

P2 : 10 gram/plant

P3 : 15 gram/plant

P4 : 20 gram/plant

Data of observation were analyzed by ANOVA (Analysis of Variance). Any significant results were further analyzed using Tukey's Honest Significant Difference test at level of 5%.

3. Application Methods

a. Land Preparation

Land preparation was conducted 1-2 weeks before seed transplanting. Preparation was carried out by cleaning the land, loosening the soil, and creating planting beds (*bedengan*) at length of 1 meter, width of 40 cm, and height of 15-30 cm. Land preparation was followed by spreading of basic fertilizer, that was chicken manure amounted to 1.5 sacks for 3x7 meter of planting area.

b. Seed Sowing, Preparation of Planting Hole, and Planting

Planting media used for eggplant seedling in this study was soil mixed with husk charcoal. After seeds reached the age of 1-1.5 months or had 4 leaves, they were ready to be transplanted.

Preparation of planting hole was done using *tugal* (traditional planting tool), then planting holes were made at planting distance of 30x40 cm and depth of 3-5 cm (adjusted to the length of seed roots) with planting beds length of 1 meter and width of 40 cm. The seeds used were of 1-1.5 months old or had 4 leaves. Seeds were further put into the hole following the rule of 1 seed/planting hole. Moreover, seed roots (*collum*) had to be completely planted and seed covering was further performed to prevent stress in plants due to direct exposure of sunlight. Later, plants were watered to moisture the soil.

c. Application of Mycorrhizal Fertilizer

Mycorrhizal fertilizer was firstly applied in Thai eggplant at the age of 7 Days After Planting (DAP). The next application was done after flowering at the age of 35 Days After Planting (DAP). Mycorrhizal fertilizer application was conducted by digging the soil around plant stem until plant roots were seen. Mycorrhizal fertilizer was spread around plant roots. The amount of mycorrhizal fertilizer applied in this study was 1,120 gram.

d. Harvest

The first harvest of eggplant was conducted in about 63 DAP or 15-18 DAP after flowering. Eggplant is harvested when the fruit flesh is still tender, the fruit color is shiny, and the fruit size is not too big or too small.

e. Observation

Observation of plant height (cm), number of leaves (leaf), and stem diameter (cm) was done 1 WAA (Week After Application), that was in the morning. Later, observation was conducted once a week until the first flower bloomed. The next observation process that was performed after the eggplant fully bloomed included flowering age (DAP), number of flower (flower), number of fruit (fruit), and harvest to determine the fresh weight of fruit, root length and root diameter of plant.

f. Parameter of Observation

The parameter observed in this study included: Plant height (cm), Flowering age (day), Number of flower (flower), Number of fruit (fruit), Fresh weight of fruit (gr), and Root length (cm).

C. Results and Discussion

1. Findings

a. Plant Height (cm)

The diagram below shows that the height of eggplant plants given mycorrhizal fertilizer 15 grams / plant (P3) shows the best plant height of all existing treatments with an average plant height of 9.22 cm while the lowest plant height is found in plants given mycorrhizal fertilizer 10 gram / plant (P2) with plant height of 8.82 cm.

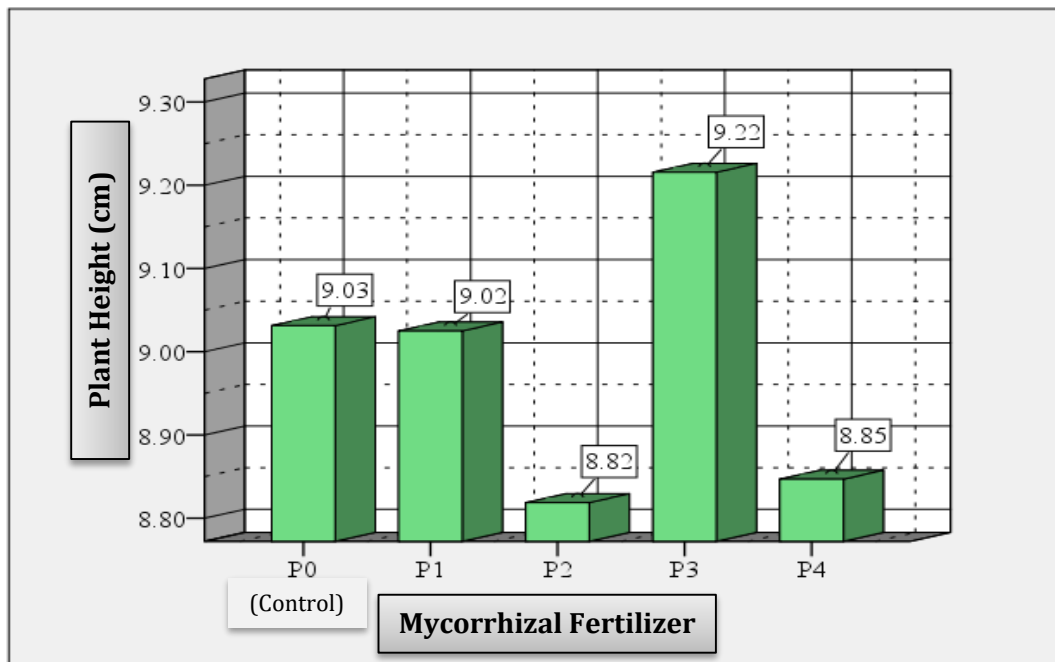


Figure 1.Measurement of Thai eggplant height at the age of 4 Weeks After Planting

b. Flowering Age (Day)

The picture below shows a difference in flowering time for each plant given or not given mycorrhizal fertilizer, where there are two treatments that show the same flowering time fast compared to other treatments, namely in plants given 10 grams of mycorrhizal fertilizer / plant (P2) and 20 gram / plant (P4) with flowering age which is 31.8 days after planting (HST) while plants without mycorrhizal fertilizer / control (P0) are plants with the longest flowering time among all treatments with flowering age which is 35 days after planting (HST).

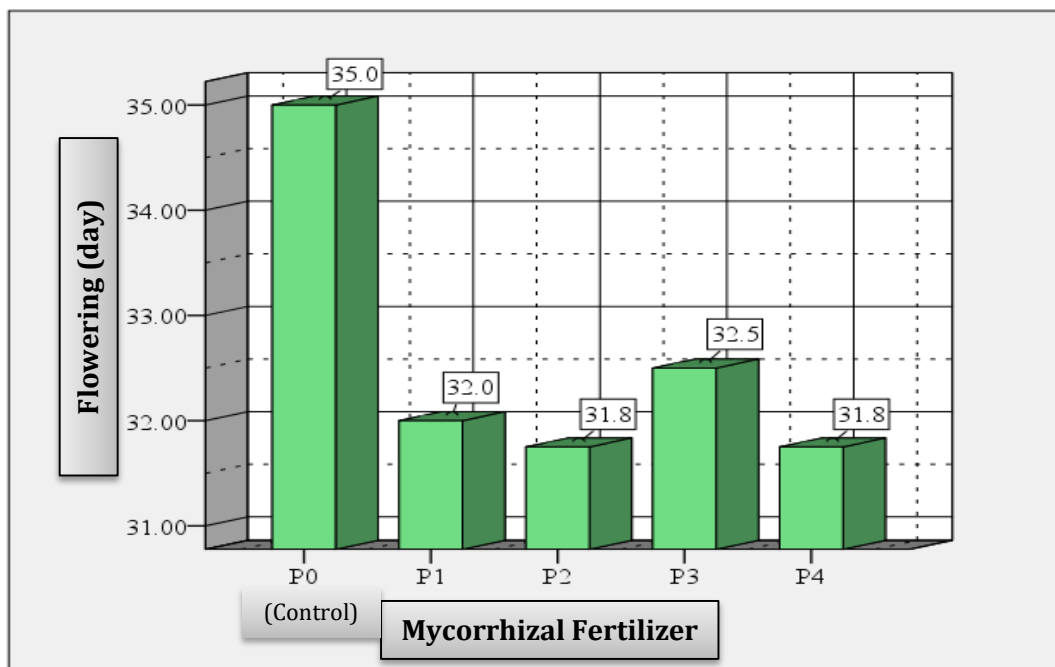


Figure 2. Diagram of eggplant flowering age

c. Number of Flower (Flowers)

The diagram above shows the number of round green eggplant plant flowers with the treatment of mycorrhizal fertilizer gives better results than round green eggplant plants without the application of mycorrhizal fertilizer / control (P0), where the results of the analysis of variance shown in figure above show that there are two treatments that have the highest number of flowers with the same value, namely P3 and P4 with the number of flowers as much as 3.83 while plants that have the lowest amount of flowers from all plants are found

in plants that are not given mycorrhizal / control fertilizer (P0) with the amount of interest 2.78 pieces.

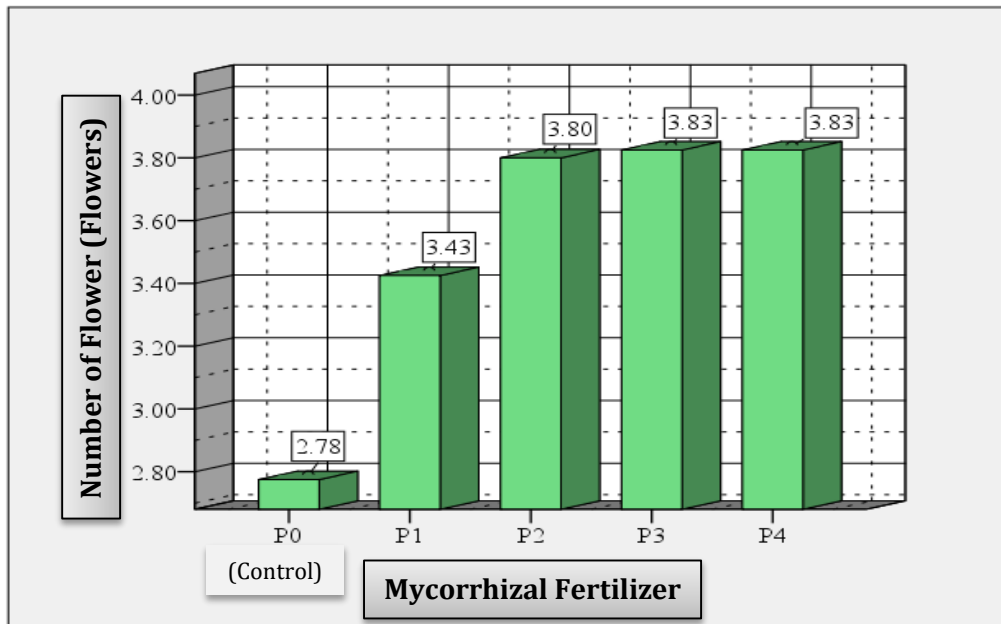


Figure 3. Diagram of flower number of Thai eggplant at the age of 5-9 WAP.

d. *Number of Fruit (Fruits)*

The average number of round green eggplant fruit plants shown in the diagram shows differences in the number of fruits between plants given mycorrhizal fertilizers and plants that were not given mycorrhizal fertilizers, where analysis of variance showed that plants were given 20 grams of mycorrhizal fertilizer / plant (P4) has the highest number of fruit, which is 3.53 while plants that are not given mycorrhizal / control fertilizer (P0) are plants that have the lowest number of fruits of all plants with a number of fruits which is 1.94 fruits.

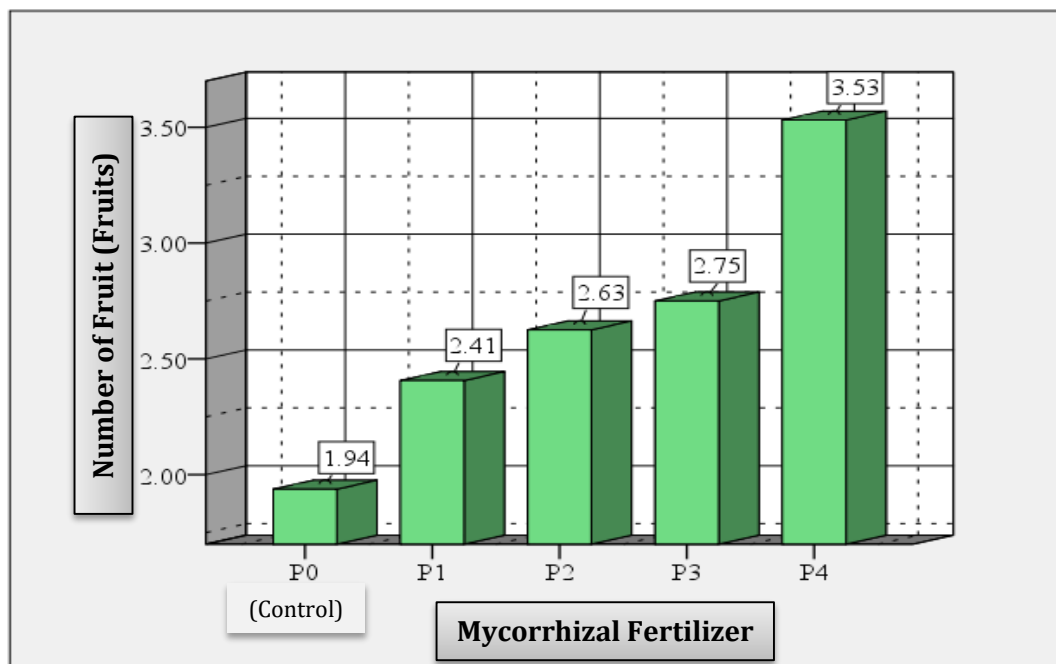


Figure 4. Diagram of fruit number of Thai eggplant at the age of 6-9 WAP

e. *Fruit Fresh Weight (gr)*

The picture below shows that the treatment of mycorrhizal fertilizer on round green eggplant plants shows the best fresh weight of fruit found in the treatment of mycorrhizae with a dose of 15 grams / plant (P3) that is 221.13 grams while the plants with the lowest fresh

weight are found in plants that are given mycorrhizal fertilizer with dose of 5 grams / plant with an average fresh fruit weight of 150.75 grams.

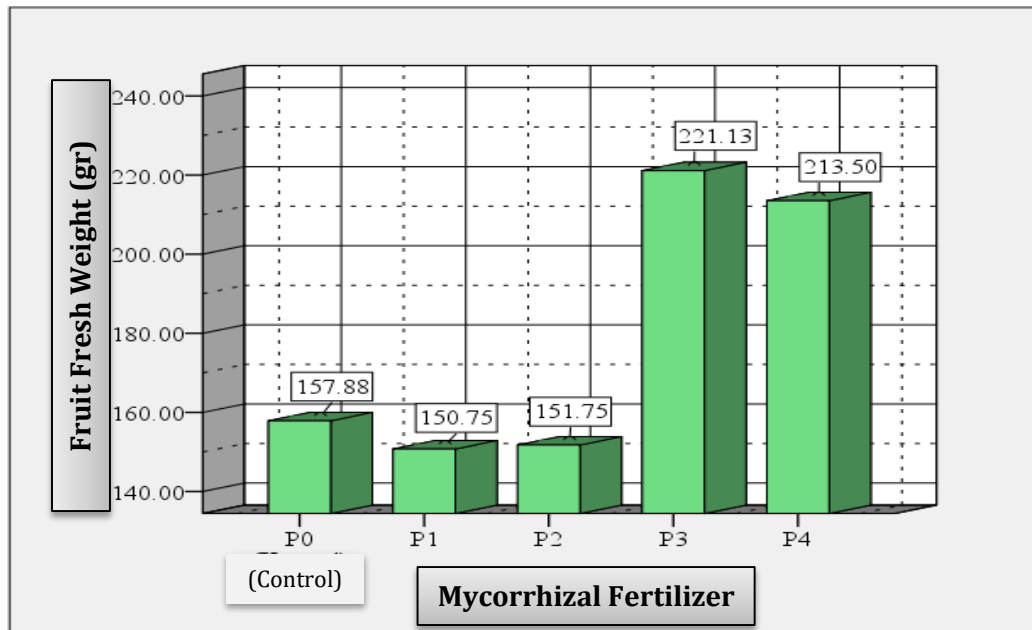


Figure 5. Diagram of fruit fresh weight measurement (gr) of Thai eggplant

f. Root Length (cm)

The root length of the round green eggplant plant shown in the diagram shows that round green eggplant plants with mycorrhizal fertilizer treatment gave better results than round green eggplant plants without treatment / control, (P0) eggplant plants were given 10 grams of mycorrhizal fertilizer / plant (P2) shows the highest value of the root length of the round green eggplant plant is 39.42 cm while the treatment shows the lowest value of all treatments, namely in plants without the application of mycorrhizal fertilizer / control (P0) with a root length value of 28.18 cm.

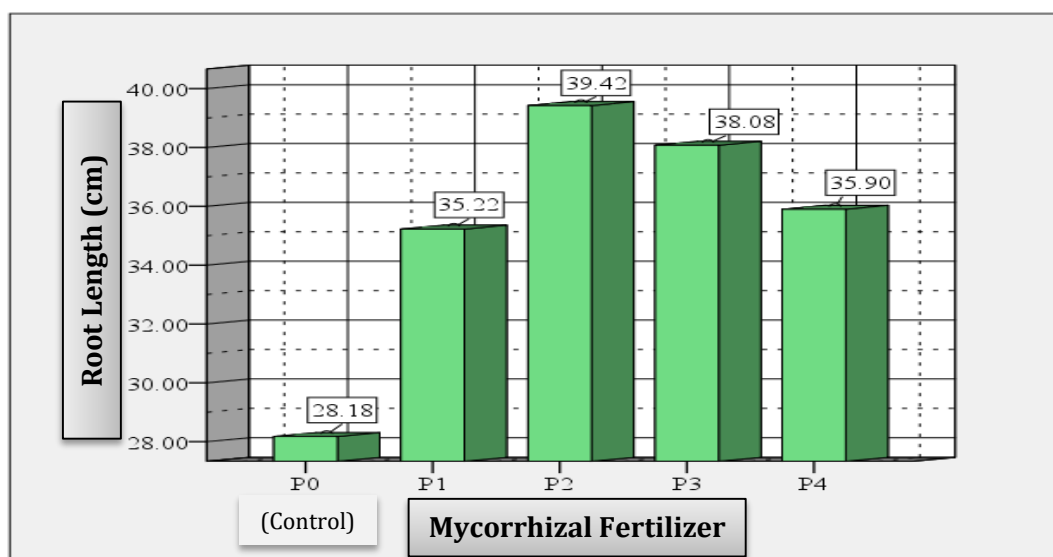


Figure 6. Diagram of root length (cm) of Thai eggplant

2. Discussion

Application of mycorrhizal fertilizer in eggplant did not significantly affect several parameters of observation since significant result was only found in root length, that was treatment at dose of 10 gram/plant (P2) which resulted in root length of 39.42 cm. There are several doses that show better results, treatment of P3 obtained the best eggplant height of 9.22 cm, while the best average flowering age of 31.8 Days After Planting (DAP) was found in P2 and P4. Moreover, both P3 and P4 produced the most flower of 3.83 flowers, and the most

fruits of 3.53 fruits was found in P4. Treatment P3 resulted in the best fruit fresh weight of 221.13 gram.

The role of mycorrhizal fertilizer in plant height, flowering age, number of flower, number of fruit, and fruit fresh weight of eggplant did not show an optimal result. However, it indicated a good result in root length of plant. Mutual relationship between eggplant roots and mycorrhizal fungi will lead to a positive impact on root growth, in which mycorrhizal fungi that associate with eggplant root will facilitate roots absorbing nutrient, particularly nutrients required by eggplant roots, such as phosphorus (Khan, 2005).

Mycorrhizal fungi are able to break down P element bound in soil to be absorbed by plants. Moreover, high phosphorus absorption by plant infected with mycorrhizal fungi is caused by phosphatase enzyme produced by mycorrhizal fungal hyphae, thus P in soil will be dissolved and available for plants. The hyphae of mycorrhizal fungi in soil absorb phosphorus and transport it to colonized roots where phosphorus is transferred to the host plant. Furthermore, the performance of mycorrhizal fungal hyphae could go beyond the distance reached by the root hair of host plant. Thus, when phosphorus around the root hair is depleted, hyphae will help the process by absorbing phosphorus in areas unreached by root hair (Musfal, 2010).

The average of the best root length with a dose of 10 grams of mycorrhizal / plant shown in P2 with a value of 39.42 cm and the lowest root length at P0 (control) with a root length of 28.8 cm This is due to the symbiosis between the mycorrhizal fungus and the root of the eggplant plant which results in the effective addition of root length. Muzar (2006), states that the high and low percentage of CMA infection in plant roots is influenced by the amount of CMA given. Application of mycorrhizal fertilizer in eggplant indicated the lowest average result in which plant did not administered with mycorrhizal fertilizer/control (P0) resulted in the lowest measurement of root length (28.18 cm), root diameter (1.27 cm), flowering age (35 days longer), number of flower (2.78 flowers), and number of fruit (1.94 fruits). Application of mycorrhizal fertilizer at dose of 5 gram/plant (P1) obtained the lowest result in fresh weight of fruit (150.75 gr).

The lowest value obtained due to the application of mycorrhizal fertilizer in eggplant is because mycorrhizal fungi no longer properly associate with eggplant root, thus hinder nutrient absorption benefits for the growth and production of eggplant. Performance of mycorrhizal fungi in absorbing nutrient in soil will lead to optimal result if nutrient requirement for fungi is fulfilled. Therefore, the existence of mycorrhizal fungi in eggplant roots depends on mutual relationship between plants and mycorrhizal fungi as well as nutrient availability for mycorrhizal fungi obtained from its host. If nutrient availability for mycorrhizal is fulfilled by the host plant, mycorrhizal will continuously exist in plant roots. Mycorrhizal fungi need carbohydrate in the form of simple sugars, e.g. glucose and carbon (C) from plant/host as nutrient. Furthermore, through the external hyphae, mycorrhizal fungi will distribute water, mineral, and nutrients in soil to facilitate metabolism activity of the host plant. This situation is in line with Nusantara (2008), who mentioned the life and association of mycorrhizal fungi depend on passive carbon flow from host plants that provide nutrient for mycorrhizal fungi.

D. Conclusion

1. Application of mycorrhizal fertilizer in to the growth and production of green eggplant plants gave a significant effect, namely root length through the administration of mycorrhizal fertilizer at dose of 10 gram/plant (P2) which resulted in the best root length of 39.42 cm.
2. The average result showed that plant given treatment of mycorrhizal fertilizer of 10 gram/plant was able to provide the best result of flowering age (31.8 DAP). Moreover, plant given mycorrhizal fertilizer of 15 gram/plant (P3) showed best result in plant height (9.22 cm), number of flower (3.83 flowers), and fresh weight of fruit (221.13 gram). In addition, plant administered with mycorrhizal fertilizer of 20 gram/plant (P4) obtained the best result in number of flower (3.83 flowers) and number of eggplant fruit (3.53 fruits).

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Mechanism of Toxicity and Tolerance in Plants Against Aluminum Stress

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ARTICLE INFO

e-ISSN: 2548-5148
p-ISSN: 2548-5121
Vol. 4, No. 1, June 2019
URL : <http://dx.doi.org/10.31327/atj.v4i1.910>

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Abstract

Aluminum (Al^{3+}) is rhizotoxic ions in the soil (mineral) acid. Al activities increases with increasing soil acidity, below pH 5.5 the solubility of Al^{3+} cations will increase. High level of soluble can cause interference with metabolic processes and plant physiology. Cumulatively, the physiology of metabolic disorders and initially looked at the root system. The tip of the root and lateral roots become thickened and hair and roots become lower, causing a decrease in root length and root tissue enlargement thus inhibiting the growth of roots, the absorption of nutrients and water, will further lower the growth, production and productivity of crops. Although Al disrupt metabolism and suppress the growth of the plant, until a certain threshold of adverse effects in Al still be tolerated, depending on the type of plant and the level of activity of Al. Tolerance of crops to Al can be expressed through two mechanisms, namely: external tolerance mechanism and internal tolerance mechanism. The main difference between the two mechanisms is in the area of detoxification Al whether in symplast (internal) or apoplast (exclusion). The ability of plants to be able to adapt to drought stress Al, depends on the ability of plants to produce organic acid in an amount sufficient for eliminating the toxic influence of stress Al. Root exudates of plants capable of producing such an organic acid that plays an important role in adaptation strategies. The high production of organic acids is associated with the formation of specific enzymes, as a response to stress Al. Allegedly the sensitive strain, the synthesis of organic acids is not adequate to chelate Al

Keywords: Al stress, organic acids, soil acidity, tolerance mechanism

A. Introduction

Aluminum (Al^{3+}) is rhizotoxic ion that inhibits the growth and productivity of plants in acidic (mineral) soil (Huang J.W., Pellet D.M., Papernik L.A. & Kochian L.V., 1996). Indonesia has approximately 47.6 million hectares of Red-Yellow Podzolic soil (RYP) or 32.4 % of its total land area (Karama & Abdurrachman, 1993). Acidic (mineral) soil leads to major problems in plant growth, such as: (1) increasing concentration of H^+ , toxicity of H^+ ; (2) increasing concentration of Al, toxicity of Al; (3) increasing concentration of Mn, toxicity of Mn; (4) decreasing concentration of macro nutrient (cation), deficiency of Ca^{2+} , Mg^{2+} , and K^+ ; (5) decreasing solubility of P and Mo (deficiency); and (6) inhibition in root growth and water absorption, nutrient deficiency, drought, and increase in nutrient leaching (Sopandie, 2013). Previous studies also found that the major obstacles in farming, particularly food crop farming, in acidic soil include harmful effect of Aluminum (Al) toxicity and low phosphorus availability (Otani & Ae, 1996; Fageria & Baligar, 1997; Schaffert R.E., Sorgo E.M.E, Alves V.M.C., Parentoni S.N. & Raghothama K.G., 2000) that could inhibit root growth as well as nutrient and water absorption, result in declining plant growth and production (Foy, 1983; Taylor, 1988; Sivaguru & Paliwal, 1993; Marschner, 1995; Ma, 2000; Sopandie D., Jusuf M. & Setyono T.D., 2000).

Activity of Al increases along with the increasing soil acidity, at pH below 5.5, solubility of Al^{3+} cation will increase (Marschner, 1995). Moreover, the absorption of P, Ca, Mg, and K was also found to significantly decrease at high concentration of Al (Matsumo H., Yamamoto Y. & Kasai M., 1992) and there was decrease in H^+ -ATP-ase activity (Marschner, 1995). High solubility of Al might hinder metabolic and physiological processes in plants.

Cumulatively, this metabolic and physiological disruption is firstly found in root system (Picton S.J., Richards K.D. & Gardner R.C., 1991). Root tip and lateral roots become thickened and root hairs are suppressed (Wright, 1989) resulting in decreasing root length (Basu U, Good A.G., Aung T., Slaski J.J., Basu A., Briggs K.G. & Taylor G.J., 1999). Therefore, parameter of root length is mainly applied to assess plant resistance to Al toxicity (Delhaiz & Ryan, 1995). There are different responses in soybean genotype to aluminum stress. Bushamuka & Zobel (1998) compared the basal and apical root development of several maize and soybean varieties given lime and no-lime treatment. Sensitive varieties were found to suffer from disruption of root development, while tolerant varieties were not affected by the existence of Al. Sanzonowicz C., Smyth T.J. & Israil D.W. (1998), added that high saturated Al will inhibit lateral root elongation of soybean. Michelle R., Frederic G., David E.E. & Martin J.H. (2003), also applied the model of root growth to examine the resistance of *Picea abies* to Al toxicity. Inhibition in root growth has been reported many times such as in rice (Nasution & Suhartini, 1992), wheat (Delhaiz E., Craig S., Beaton C.D, Bennet R.J., Jagadish V.C., & Randall P.J., 1993), maize (Sivaguru M., Fransitisk B., Dieter V., Huber H.F. & Walter J.H., 1999), and soybean (Soepandi, *et al.*, 2000).

Even though Al disrupts metabolism and suppresses plant growth, adverse effect of Al is still tolerated until certain threshold, depends plant types and the level of Al activity. Tolerant characteristic of plant to Al can be expressed hypothetically through two mechanisms, namely: Mechanism of external/exclusion tolerance and Mechanism of internal tolerance (Taylor, 1988; Kochian, 1995).

B. Methodology

1. Aluminum Acidity and Nutrient Absorption

In acidic soil with high mineral content, Al toxicity becomes the main limiting factor in plant growth. When investigating Al stress, difficulties related to processes occur in soil are often found due to its complexity. The forms of Al in soil are affected by pH. At $\text{pH} < 4.0$, soil is dominated by Al^{3+} , Aluminum hydroxide such as $\text{Al}(\text{OH})^{+2}$ and $\text{Al}(\text{OH})_2^+$ are formed at $\text{pH} 4-5.5$, while Al^{3+} content is ignored at $\text{pH} > 5.5$. However, result of study conducted by Ma Z. & Miyasaka S.C. (1998), proved that more than 95% of Al is in the form of Al^{3+} that is extremely toxic to plants at $\text{pH} 4.3$; $\text{pH} < 4.5$, 2007); $\text{pH} < 5$ (Kochian, 1995). Hence, Al^{3+} is the most toxic aluminum form to plants (Marschner, 1995; Kochian, 1995; Miyasaka S.C., Bute J.G., Howel R.K. & Foy C.D., 1991).

In both soil and plants, the monomer of Al cation may form bonds with: various organic and inorganic ligands, such as PO_4^{3-} , SO_4^{2-} , non-toxic F⁻, organic acid, protein, and fat. Similar to other ions, Al is absorbed by plants either via diffusion or mass flow in free space that includes interspace in root tissue and dead tissue; cell wall, and xylem element. There is carboxylate group (RCOO^-) within this area that has function as cation exchanger. The primary cell wall is a tissue consists of cellulose and hemicellulose including pectin. In this tissue, pectin is formed by polygalacturonic acid, particularly in the middle lamella that functions as a place where cations (Al) are exchanged or rejected. Furthermore, casparian strip in endodermis will prevent the movement of Al to *stele*.

Normally, nutrient availability in acidic soil is low in amount. Moreover, plant ability to absorb nutrient is limited by high Al content. According to several studies, the absorption of P, Ca, Mg, and K by plants was found to significantly decrease in soil with high Al content, while Mn element is significantly absorbed. Deficiency of P is caused by the formation of Al-phosphate complex. Al directly interacts with P, both in soil solution and plant tissue, thus results in unavailable P for plants (Marschner, 1995; Takenaga, 1995). Similarly, the absorption of K element in roots is inhibited, while it increases in shoot. Increasing K absorption in shoot is possibly caused by the increasing role of K in maintaining ionic balance since K determines the osmotic potential in plants. In case of barley planted in media contained Al, it was found that Ca^{2+} and K^+ content was only a half of the initial amount compared to control (Matsumoto, *et al.*, 1992). In *Fagus sylvatica*, the content of Ca, Mg, and Zn drastically decreased at the lowest Al concentration (0.1 mM AlCl_3) (Balsberg-Pahlson, 1990), due to competition between cations on binding site in root surface.

2. Aluminum Toxicity and Its Effect on Plants

Al toxicity is the major environmental stress that limits productivity in acidic soils. One of Al toxicity mechanisms involves the interaction between Al and ion transport system that has function in root plasma membrane. The role of this interaction between transport of Al/Ca^{2+} in Al toxicity mechanism has raised concern since Ca^{2+} plays important role in the regulation of several cellular processes in plant (Hepler & Wayne, 1985).

According to Marschner (1995), inhibition may occur in cell wall since Al replaces the position of Ca^{2+} in the middle lamella despite the essential role of Ca^{2+} in ion transport through plasma membrane as Ca^{2+} is the second messenger in H^+ -ATP-ase activity with the help of calmodulin regulator protein. Replacement of Ca^{2+} bound to calmodulin will result in changes in enzyme activity. Later, Al and carboxyl group will form strong bond to prevent cell to grow bigger. Moreover, Al also interacts with bilayer lipid membrane of cell that may result in membrane structure damage since Ca^{2+} is replaced by Al^{3+} which eventually affects nutrient absorption. Furthermore, at the cellular level, Al ion affects permeability and transport activity of plasma membrane.

Inhibition by Al on Ca^{2+} influx into plant cells quickly occurs and is reversible as Al blocks Ca^{2+} channel on the surface of outer membrane of root cell plasma membrane or through Al transport into cell via Ca^{2+} channel. This Ca^{2+} influx blocking by Al starts the phenomenon commonly appears due to Al toxicity (Huang, *et al.*, 1996). The biochemistry mechanism of phytotoxicity proposed in the last review assumed that Al is not only required to enter the cell, but it has to be active inside cell.

There have been many reports of studies that mentioned root plant as the target tissue of Al toxicity. Root tip is the main target of Al toxicity and the decreasing in root length can be detected in just several minutes after the addition of Al. The first one is interference on root cap (calyptra) that modulates Al signal and has function as the detector of gravity and mechanical resistance. In turn, there will be decrease in mucigel secretion of root cap where the cells play role as the source of endogenous growth regulator. The next phenomenon is the inhibition of root growth that includes shortening and enlargement of root tissue, water loss, and the absence of healthy lateral roots (Delhaize & Ryan, 1995; Sopandie, 1999; Sopandie, *et al.*, 2000; Sopandie, 2013). The effect of Al toxicity on root tip is seemingly caused by cell division disturbance. First, cells become binucleate (cells have two nuclei) and if Al penetrates to the

nucleus, it will be deposited due to compound that contains P thus hindering enzyme activity that controls cell wall polysaccharides deposition. Besides, Al strand in pectin will also harden the cell wall. Changes in growth pattern will disrupt the absorption and transport of essential nutrients such as Ca, Mg, P, and K (Marschner, 1995; Takenaga, 1995).

As mentioned by Ma (2000), Al concentration of 20 μM was found to inhibit maize root elongation up to 70%, yet this problem can be solved through the addition of silicic acid. Based on the result of this study, concentration of toxic Al^{3+} significantly decreased with the addition of silicic acid. In fact, the addition of higher amount of silicic acid successfully decreased the concentration of Al^{3+} . The decreasing Al^{3+} was parallel with the declining level of root elongation. It is expectedly due to the complex formation of Al and silicic acid. This study also reported that the complex of Al-Si was dissolved in water. Silicon (Si) is the second most abundant element found in Earth's crust. Normally, Si is found together with Al in soil solution in the form of monosilicic acid. The mechanism responsible for this decreasing Al toxicity by silicic acid is probably caused by include solution effect, declining Al activity outside plants, and effects in cytoplasm as well as enzyme activity.

3. Mechanism of plant tolerance To aluminum stress

Plants that are tolerant to Aluminum toxicity have the ability to suppress the adverse effect of that Al toxicity. The criteria for plant tolerant to aluminum include: (1) roots are able to continuously grow and no damage is found in root tip; (2) plant could produce less acidic condition in root area; (3) translocation of Al ion to the upper part of plant is low since most of it is stored in roots; (4) due to certain mechanism, Al ion cannot inhibit the absorption of Ca, Mg, and K; and (5) plants are able to neutralize the effect of Al ion thus absorption and translocation of P is not disrupted. However, the mechanism of plant tolerance to Al toxicity is not similar in every plant. In fact, it is different in every cultivar of a species (Kochian, 1995). This variance indicates different mechanisms of tolerance in every plant to respond to Al stress.

The mechanism of tolerance to Al is more determined by the ability of plant root to prevent Al to enter cell membrane by secreting organic acids.

Mechanisms of plant tolerance to Al stress can be classified into two mechanisms, namely: External/exclusion tolerance mechanism and Internal tolerance mechanism (Taylor, 1988; Kochian, 1995). The main difference between the two mechanisms is regarding Al detoxification area, whether it is in symplast (internal) or apoplast (exclusion). The first mechanism (external mechanism or rejection) is a system of tolerance created by plant by preventing Al not to enter symplast through: (a) Al immobilization in cell wall, (b) selective permeability of plasma membrane, (c) pH barrier in rhizosphere, (d) exudation of ligands that chelate Al such as exudation of organic acids, (e) exudation of P, and (f) Al efflux. Moreover, the second mechanism; a mechanism that generates plant to have tolerant ability to accumulate Al in cells (internal tolerance mechanism) that is in the form of: (a) Al chelating by organic acid in cytosol, (b) Al compartmentation in vacuole (Matsumoto, 1991), (c) specific protein that is able to bind Al, (d) isozyme that is resistant to Al, and (e) induction of specific protein synthesis in plasma membrane that will decrease Al absorption and increase Al efflux (Taylor, 1988). According to Ryand P.R., Delhaize E. & Randall P.J. (1995), considering the possibility of tolerance mechanism to Al, it was expected that the mechanism of tolerance to Al is more determined by the ability of plant root to prevent Al to enter cell membrane by secreting organic acids.

4. Exudation of Organic Acids

One of secondary metabolites is the production of low-molecular-weight organic acid compounds. The synthesis of various organic acids from plant roots as a response to Al stress is the characteristic of plant species that is able to adapt to acidic mineral soil. The role of organic acid in chelating Al in vascular plants has been frequently reported, such as by Pellet D.M., Grunes D.L. & Kochian L.V. (1995) and Zheng S.J., Ma J.F. & Matsumoto H. (1998). Root cell and all existing components will inhibit the adverse effect of Al on root elongation as well as the absorption of nutrient and water, while outside the plant root, organic acid will chelate Al thus plant will be tolerant to Al stress (Ma, 2000). Organic acid synthesized by plants that are

tolerant to Al stress can be in the form of accumulation or exudate, either by accumulating it in symplast or exuding it to rhizosphere. The types of organic acid that are detected in plants experiencing Al stress include: citric acid, isocitric acid, fumaric acid, malic acid (Pellet, *et al.*, 1995; Otani & Ae, 1996; Sopandie, 1999), and oxalic acid (Ma & Miyasaka, 1998; Zheng, *et al.*, 1998; Swasti & Rozen, 2007). Several types of plant are able to secrete more than one type of organic acid from root tip. Indirectly, organic acid help increasing P availability by chelating Al (Marschner, 1995), thus P that is supposedly bound to Al can be made available to plants.

Result of study conducted by Swasti & Rozen (2007), showed that treatment of Al stress has stimulated the synthesis of oxalate acid. This organic acid synthesis confirms the mechanism of internal Al chelating by those organic acids in plant roots. The synthesis of organic acid due to accumulation process shows internal tolerance mechanism to prevent adverse effect of Al. As mentioned by Kochian (1995), and Ma (2000) regarding the tolerant plant. The mechanism can occur internally, that is by accumulating organic acid in root tissue. Study conducted by Sopandie (1999); Kasim (2001), proved that Al in nutrient solution successfully stimulated the synthesis of citric acid and malic acid in root tip of soybean plant grown in nutrient culture medium. Several tolerant genotypes of soybean showed increasing accumulation of citric acid and malic acid of 2-5 times higher than those of sensitive species. This high production of organic acids is related to the formation of specific enzymes as a response to Al stress (Pellet, *et al.*, 1995; Sopandie, 1999).

Organic acid plays role in Al inclusion through its release from roots and Al detoxification in symplast in which the organic acid could chelate Al and reduce or prevent plant from the effect of toxicity at a cellular level (Pellet *et al.*, 1995). Taylor (1991); Kochian (1995); and Ma (2000), reported that there is certain mechanism in tolerant plant to prevent Al to enter plants, namely the external tolerance mechanism. Ma (2000), mentioned that the external mechanism of Al chelating occurs through organic acid exudation to rhizosphere to form Al-organic acid complex. Internally, there is Al inhibition by the components of root cell such as cell wall, plasma membrane, DNA, and enzyme. If the components of root cell cannot inhibit the toxic effect of Al, there will be disruption of root elongation as well as absorption of nutrient and water.

The ability of plant to adapt to Al stress condition really depends on its ability to produce sufficient amount of organic acid to eliminate toxic effect of Al stress (Swasti & Rozen, 2007). Plant root is able to produce exudates like organic acid that plays important role in adaptation strategy (Ma & Miyasaka, 1998; Zheng, *et al.*, 1998; Ma, 2000), it is expected that organic acid synthesis in sensitive strains is not adequate to chelate Al.

C. Conclusion

Although Al disrupts metabolism and suppresses plant growth, until certain threshold, the adverse effect of Al is still tolerated, depends on the types of plant and the level of Al activity. The level of Al toxicity depends on the activity of Al^{3+} ion in the media. If Al^{3+} is in the form of chelated ion, it is less toxic to plant growth compared to ionic Al such as Al^{3+} . The mechanism of tolerance to Al is more determined by the ability of plant root to prevent Al to enter cell membrane by secreting organic acids. Synthesis of various organic acid from plant roots as a response to Al stress is a characteristic of plant species that is able to adapt to acidic mineral soil. The role of organic acid in chelating Al in vascular plants is performed through process will inhibit the adverse effect of Al on root elongation as well as the absorption of nutrient and water, while outside the plant root, organic acid will chelate Al thus plant will be tolerant to Al stress. Organic acid synthesized by plants that are tolerant to Al stress can be in the form of accumulation or exudate, either by accumulating it in symplast or exuding it to rhizosphere. The types of organic acid that are detected in plants experiencing Al stress include: citric acid, isocitric acid, fumaric acid, malic acid, and oxalic acid. The ability of plant to adapt to Al stress condition really depends on its ability to produce sufficient amount of organic acid to eliminate toxic effect of Al stress. Plant root is able to produce exudates like organic acid that plays important role in adaptation strategy.

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Enhancing the Viability of Rosella Seeds (*Hibiscus sabdariffa* L.) through Tetrazolium and Paper Media Test

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ARTICLE INFO

e-ISSN: 2548-5148
p-ISSN: 2548-5121
Vol. 4, No. 1, June 2019
URL : <http://dx.doi.org/10.31327/atj.v4i1.911>

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Abstract

This study was aimed to determine the viability rate of rosella seed, to obtain the best result of seed testing for enhancing rosella seed viability, to find the best seed invigoration method for enhancing rosella seed viability, to obtain staining pattern through tetrazolium test of rosella seed, and to determine viability and vigor of rosella seed to be further used as estimation indicator for rosella plant growth in the field. The study was conducted in the Seed Laboratory, Indonesian Sweetener and Fiber Crops Research Institute (ISFCRI), Malang, East Java during July - August 2018. The material used included accessions of rosella seed (*Hibiscus sabdariffa* L.) ACC. 1148 from the year 2015 and collection of ISFCRI, 100 ml of Tetrazolium solution (40 ml KH_2PO_4 , 60 ml Na_2HPO_4 and 1 gr of Tetrazolium powder). This research applied Completely Randomized Design (CRD) consisted of seed treatments of control (no immersion/0 hour), immersion for 5 hours, immersion for 10 hours, and scarification, each with 4 replications. Result of this study showed that the use of tetrazolium salt was found to be better in enhancing the viability of rosella seeds. Viable seeds was found to have bright red embryonic axis and bright red cotyledon. Testing using paper media on several seed invigoration treatments resulted in significantly different effect on parameters of vigor index, germination capacity, and dry weight of normal seedling. The best parameter of germination capacity and dry weight of normal seedling was obtained by treatment immersed in water at temperature of 27°C for 10 hours

Keywords: germination, paper media, rosella, seed invigoration technic, tetrazolium, viability

A. Introduction

Indonesia is a tropical and agrarian country with rich biodiversity that can be utilized in all aspects of community life, particularly in agricultural sector. One of multifunction commodities that is able to be used both as fiber and medicine is rosella. This plant is within the genus *Hibiscus* that can produce natural fibers with species quite popular in Indonesia includes *Hibiscus cannabinus* L. and *Hibiscus sabdariffa* L. *Hibiscus sabdariffa* L. is rosella species that is potential to be utilized as the source of functional food, antioxidant, anti-bacteria, natural dyes, and also in health aspect (Abdallah 2015; Chang, H.C., Peng, C.H., Yeh, D.M., Kao, E.S. & Wang, C.J. (2014); Lin, H.H., Chen, J.H., Kuo, W.H. & Wang, C.J. (2007). In term of plant morphology, parts of this plant are able to be used, particularly the flower petals (Christian, K.R., Nair, M.G. & Jackson, J.C., 2006; Kao, E.S., Hsu, J.D., Wang, C.J., Yang, S.H., Cheng, S.Y. & Lee, H.J., 2009; Zhen, J, Villani, T.S., Guo, Y., Qi, Y., Chin, K., Hsiung Pan, M., Ho, C.T., Simon, J.E. & Wu, Q., 2016), due to the potential of natural phytochemical content includes phenolic compound, alkaloid, tannin, flavonoid, saponin, organic acid, anthocyanin, and polysaccharides in leaves, stems, and flowers of rosella (Mungole & Charturvedi 2011; Da-Costa-Rocha, I., Bonnlaender, B., Sievers, H., Pischell & Heinrich, M., 2014).

Normally, this plant has multipurpose function. Besides being consumed, flower petal (calyx) of this plant is also able to be processed into domestic and industrial product that positively affects the country's economy. Dried calyx has a high market potential, both to be sold locally and exported. Moreover, the stem produces fiber that can be used as replacement for ramie. In addition to calyx and stem, the plant seed contains 17% oil and can be processed into flour. The demand for rosella product tends to increase due to increased interest in natural and caffeine-free herbal product such as rosella tea. However, the demand for rosella is not yet fulfilled because of low seed quality which has impact on production and prime quality. Seed quality includes physiological quality indicating seed viability that can be investigated through testing.

Seed viability is the ability of seed to grow that is shown in various physiological and biochemical phenomena (Sadjad, 1994). Seed viability testing is conducted through physiological and biochemical test. Physiological test can be done by performing germination test, yet this test is only able to determine the percentage of seed normally germinated in optimum germination media that is mainly used like paper or sand substrate. Papers normally used as media are filter, blotter and towel (ISTA, 2010) that are imported products and relatively expensive (Purbojati & Suwarno, 2006). Therefore, there is alternative paper substrate namely rice straw paper that has been recommended to be used as substrate for seed testing in Indonesia (Sadjad, 1994).

Biochemical testing is done by 2,3,5 triphenyl tetrazolium chloride solution (Eviliani, 2016) or commonly known as Quick test. This test is considered quick in process. By applying the method of topographic staining in order to test seed viability using tetrazolium salt, cells will be dyed red, yet this color has non-toxic effect (Subantoro & Prabowo, 2013). According to Bradford (2004), tetrazolium test can be used for vigor test by adding criteria in viability test assessment. Tetrazolium test could identify damage to embryo at earliest stage and show seed deterioration that is the indicator of vigor (McDonald, 1998). Based on survey in 1976, 1982, and 1990, tetrazolium test is predicted to be the method mostly applied as vigor test (Leist, 2004).

Tetrazolium test is a test of dehydrogenase enzyme activity functions as an index of respiration rate and viability of hydrogen ion that oxidizes colorless tetrazolium salt which changes following embryonic topographical staining pattern and its intensity (Sudikno, 1984 in Subantoro & Prabowo, 2013). Location and size of stained area as well as staining intensity (topography) determine the classification, whether seed is viable or not-viable (ISTA, 2004). The basic principle of this test is to differentiate between viable and non-

viable seed according to the relative respiration rate in wet condition, thus seed viability can be figured out.

Nugraha, U.S., Rasam, S. & Wahyuni. (2003), showed that the use of rice straw paper as substrate for seed germination test succeeded to significantly produce higher result compared to the use of CD paper for rice seed var. IR 64. Dina, Widajati, E., Wirawan, B. & Ilyas, S. (2007), conducted viability and vigor test in soybean seed (*Glycine max* L. Merr) using tetrazolium and found high correlation between plant growth and yield. Hapsari & Suwarno (2008), used stencil paper to substitute rice straw paper for seed viability test by applying the method of rolled paper wrapped by plastic in standing position (UKDdp). Eviliani (2016), conducted staining pattern test using tetrazolium in chili seed (*capsicum annum*) and resulted in 4 groups of staining standard used to differentiate between seed that will grow into strong normal seedling, abnormal seedling, and ungerminated seed (dead).

This study was aimed to determine the viability rate of rosella seed, to obtain the best result of seed testing for enhancing rosella seed viability, to find the best seed invigoration method for enhancing rosella seed viability, to obtain staining pattern through tetrazolium test of rosella seed, and to determine viability and vigor of rosella seed to be further used as estimation indicator for rosella plant growth in the field.

B. Methodology

The study was conducted in the Seed Laboratory, Indonesian Sweetener and Fiber Crops Research Institute (ISFCRI), Malang, East Java during July - August 2018. The material used were accessions of rosella seed (*Hibiscus sabdariffa* L.) ACC. 1148 from the year 2015 collection of ISFCRI, working sample of rosella seed (*H. sabdariffa* L.) (20 gram, \pm 36 gram), water at normal pH (400 ml), 100 ml of Tetrazolium solution (40 ml KH_2PO_4 , 60 ml Na_2HPO_4 and 1 gr of Tetrazolium powder).

Experimental design applied in this study was Completely Randomized Design (CRD) consisted of seed treatments of control (no immersion/0 hour), immersion for 5 hours, immersion for 10 hours, and scarification, each with 4 replications, resulted in 24 units of treatment combination. Each test unit consisted of 50 rosella seeds (*Hibiscus sabdariffa* L.). Significantly different result obtained from the analysis of variance at confidence level of 95% will be further analyzed using Duncan's Multiple Range Test.

Testing method used to enhance rosella seed viability included tetrazolium test and paper media test (Rolled Paper Wrapped by Plastic in Standing Position/UKDdp). Seed viability test was done using tetrazolium solution, namely KH_2PO_4 weighed 9 g which further dissolved in 1 liter of aquades) and Na_2HPO_4 weighed 11 g that was dissolved in 1 liter of aquades. Later, 40 ml of KH_2PO_4 and 60 ml of Na_2HPO_4 were homogenized and added with 1 g of tetrazolium powder. Seeds to be used were peeled, put into glass cup, and added with tetrazolium solution until all seeds were completely immersed. Moreover, seeds were dried in oven for 2 hours at temperature of 35° C.

Concerning UKDdp test, rice straw papers were soaked in water. Later, 50 rosella seeds (*H. sabdariffa* L.) were selected randomly and grown on rice straw paper substrate. Seeds were arranged in 5 rows where each row consisted of 10 seeds. Rice straw papers planted by seeds were covered by 2 sheets of rice straw papers that have been soaked in water. Then, rolled the paper well. Rolled paper was put inside germinator at temperature of 20-30°C in standing position where the row of seed arrangement was placed on top position. Observation was done once in 4 days to calculate the number of normal germinated seed, abnormal germinated seed, and ungerminated seed (seed was fresh, hard, attacked by fungi or decayed).

C. Result and Discussion

1. Tetrazolium Test of Rosella Seeds

Enhancing rosella seed viability from 2015 collection through tetrazolium test with application of several treatments presented in Table 1.

Table 1. Rosella seed viability through tetrazolium test

Treatment of seed invigoration	Number of seed tested		Percentage of seed tested (%)	
	Viable	Non-Viable	Viable	Non-Viable
Control	4	46	8	92
Immersion in water at temperature of 27°C for 5 hours	1	49	2	98
Immersion in water at temperature of 27°C for 10 hours	1	49	2	98
Seed cutting	0	50	0	100

Table 1 shows that control treatment (no immersion) produced the best number of viable seed for number of viable seeds and seed viability percentage. This finding indicates that pretreatment prior to tetrazolium test reduce rosella seed and viability seed was totally lose viability after cutting treatment prior to tetrazolium test.

Tetrazolium test, without any seed treatments following the test, can determine staining pattern that is able to indicate whether seed is viable or not viable. It is due to the reason that immersion in tetrazolium solution may stimulate imbibition by meristematic tissue in embryo, thus enhancing seed viability. According to Copeland & Mcdonald (1976) *in* Hasrawati, Mustari, K., & Dachlan, A. (2015), process of seed immersion in tetrazolium salt solution will lead to water imbibition by meristematic tissue in the embryo and reduction of H⁺ released from respiration process. Coker & Barton (1957), *in* Hasrawati *et al.*, (2015), mentioned that respiration in seed could increase water content when seed is immersed in tetrazolium solution.

Tetrazolium test in rosella seed resulted in embryonic staining with color intensity of bright red, pink, and, colorless (white) as presented in Figure 2. This staining pattern provides indication and can be used as a benchmark whether seed will grow into strong normal seedling or has high viability (Figure A), weak normal seedling or has low viability (Figure B), abnormal seedling, or dead seed (Figure C).



Figure 1. Tetrazolium staining pattern in rosella seed (A). Normal seedling; (B). Abnormal seedling; and (C). Dead seed.

Figure A shows high viability seed and is classified into the criteria of strong normal seedling as indicated by maximum tetrazolium staining pattern of bright red. It is because tetrazolium is chemical substancDhare that shows both oxidation and reduction properties. In term of oxidation, tetrazolium is soluble in water and easy to enter and exit

plant cells. Reduction of tetrazolium may occur for its insolubility property, hence this chemical substance still remains within the cell and provides red staining in plant cell (Subantoro & Prabowo, 2013).

Moreover, Figure C shows low viability and classified into the criteria of dead seed. It is because the unstained part of seed is actually dead tissue or necrotic. Widajati, E., murniaty, E., palupi, E.R., Kartika, T., Suhartanto, M.R. & Qadir, A. (2013), said that the area stained red is living tissue, while unstained area is dead tissue or necrotic tissue and the area where necrotic tissue is located provides information that determine the category whether seed is alive or dead.

2. Test of Paper Media

Analysis of variance presented in Table 1 shows that enhancing rosella seed viability through test of paper media for several seed invigoration treatments significantly affected the parameter of vigor index, germination capacity, and dry weight of normal seedling. Moreover, concerning the parameter of speed of germination and maximum growth potential, it is expected that several seed invigoration treatments were not able to show significantly different effect concerning the viability of rosella seed from the year 2015.

Different finding was shown by the indicator of coefficient of variance (CV) in which CV is a coefficient reflecting the precision degree of result obtained in an experiment. Parameter of maximum growth potential showed low CV of 1.47%, while parameter of dry weight of normal seedling generated higher CV of 6.86% compared to other parameter. It is expected that parameter with low CV value obtained homogeneity of observation data and higher degree of precision. Hanafiah (2010), mentioned that lower CV value indicates higher degree of precision and validity of conclusion resulted from the experiment.

Table 2. Recapitulation of analysis of variance of rosella seed (*Hibiscus sabdariffa* L.) invigoration

Parameter of observation	Treatment of seed invigoration	Coefficient of Variance (%)
Speed of germination (%KN/etmal)	0.2476 tn	2.76
Vigor index (%)	<.0001**	3.29
Germination capacity (%)	<.0001**	2.29
Maximum growth potential (%)	0.0541 tn	1.47
Dry weight of normal seedling (g)	<.0001**	6.86

Description: tn = not significant; * = significant at $\alpha=5\%$; ** = significant at $\alpha= 1\%$

Based on the result of analysis of variance in Table 1, parameter of vigor index, germination capacity, and dry weight of normal seedling had significantly different effect. Therefore, DMRT at $\alpha 5\%$ was applied to three parameters as shown in Table 2. The best parameter of vigor index was obtained by treatment of seed cutting with average of 99.5%, while significantly different result was found in treatment of immersion in water at temperature of 27°C for 5 hours with average of 62.0%.

Mechanical scarification, namely seed cutting that enables water to enter the seed, thus increasing vigor index of rosella seed. Widajati, *et al* (2013), in Noflindawati (2014); Sadjad (1994), mentioned that common technic applied in treatment of mechanical scarification is seed cutting to ease water entering the embryo as well as increasing vigor index both in optimal and sub-optimal condition.

The best parameter of germination capacity and dry weight of normal seedling was obtained in seed invigoration treatment through immersion in water at temperature of 27°C for 10 hours with average of 99.5% and 0.4849 g, respectively. Seed immersion at optimum temperature in such a long period can soften seed coat and accelerate cell division and elongation due to the existence of process where water and oxygen enter the

seed, thus increasing radical cells and further growth. Fitri (2015), mentioned that water in seed may stimulate cell division and elongation and quicken the growth of root cells since water and oxygen that enter the seed will wet the protein and colloid within the seed, hence enzyme formation and activation will lead to increasing metabolic activity, elongation of radical cell and further growth.

Table 3. Effect of invigoration treatment of rosella seed (*Hibiscus sabdariffa* L.)

Treatment of seed invigoration	Parameter of observation				
	Speed of germination (%KN/etmal)	Vigor Index (%)	Germination Capacity (%)	Maximum Growth Potential (%)	Dry weight of normal seedling (g)
Control	13.8	96.0 ^a	96.0 ^b	97.0	0.4353 ^b
Immersion in water at temperature of 27°C for 5 hours	13.5	62.0 ^b	69.5 ^c	100.0	0.3139 ^d
Immersion in water at temperature of 27°C for 10 hours	14.0	99.0 ^a	99.5 ^a	99.5	0.4849 ^a
Seed cutting	14.0	99.5 ^a	99.0 ^{ab}	99.5	0.3836 ^c

Description: Values within the same column following by different subscript letters show significantly different result in DMRT at level of 0.05

Isnaeni & Habibah (2014), found that temperature above 60°C led to ungerminated kepel seed and further dead. Lima (2012), mentioned that immersion in hot water 60°C for 10 minutes resulted in the highest percentage of germination in centro and siratro seeds. This proved that temperature may facilitate germination of hard coated seeds in a relatively short period of time.

3. Comparison between tetrazolium test and paper test

Enhancing the viability of rosella seed from the year 2015 was done through two test, namely test using tetrazolium salt solution and test using paper media as shown in Figure 2. Figure 2 presents the comparison between the two seed testing which further followed by seed invigoration treatment. According to the figure above, significantly different result was not obtained in general. However, there is only one treatment that obtained significantly different result, that is treatment of immersion in water at temperature of 27°C for 5 hours that produced average percentage of 70 % and 98 % or about 1 : 1.4 %.

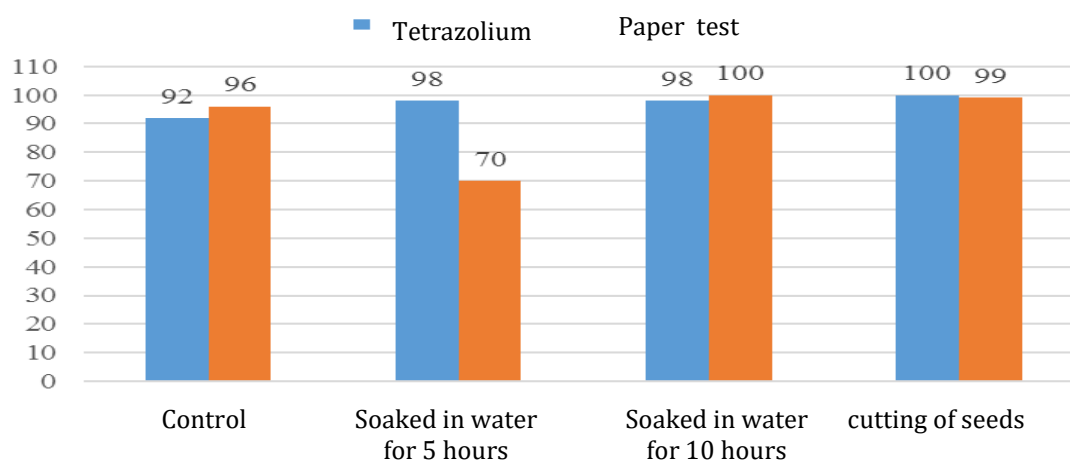


Figure 2. Comparison of rosella seed viability between tetrazolium and paper test

Seed vigor test using tetrazolium in embryonic structure may provide complete information. Seed vigor obtained from tetrazolium staining showed criteria of seed with high, moderate, and low vigor according to the indicator whether staining process of formazan precipitate was thoroughly applied or not. Budiarti (2002), performed seed testing by tetrazolium test and found that electrical conductivity and respiration could be developed to estimate seed viability and vigor.

D. Conclusion

Seed testing using tetrazolium salt solution was found to be able to enhance the viability of rosella seed from the year 2015 relatively faster compared to seed testing using paper media. Viable seeds were found to have bright red embryonic axis and bright red cotyledon. This staining provides indication or becomes a benchmark that seeds will grow into strong normal seedling or have high viability. Testing using paper media on several seed invigoration treatments resulted in significantly different effect on parameters of vigor index, germination capacity, and dry weight of normal seedling. The best seed invigoration treatment was obtained through seed cutting related to the parameter of vigor index with average of 99.5%. The best parameter of germination capacity and dry weight of normal seedling was obtained by treatment immersed in water at temperature of 27°C for 10 hours.

E. Acknowledgement

The authors would like to thank Dr. Marjani, MP for her guidance in this research stage as well as the Indonesian Sweetener and Fiber Crops Research Institute for the facility provided during the study.

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Contribution and Distribution of Farmers Income of Palm Oil (*Elaeis guineensis* Jacq.) in Pewisoa Jaya Village Tanggetada Sub-District Kolaka Regency

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ARTICLE INFO

e-ISSN: 2548-5148
p-ISSN: 2548-5121
Vol. 4, No. 1, June 2019
URL : <http://dx.doi.org/10.31327/atj.v4i1.912>

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Abstract

The objective to be achieved is to determine the contribution of oil palm farmers' income to the total income of farmers in Pewisoa Jaya Village, Tanggetada District, Kolaka Regency. To determine the income distribution of oil palm farmers in Pewisoa Jaya Village, Tanggetada District, Kolaka Regency. on the results of the study it can be concluded that the contribution and distribution of income of oil palm farmers is 25,10 % harvest season, the average income of oil palm farmers is 61,42 % per harvest year while the contribution of oil palm farming is 25.10% of the total income of oil palm farmers, and the distribution of income of oil palm farmers is 0.004. the condition is still very low or the community is less prosperous in Pewisoa Jaya Village, Tanggetada District, Kolaka Regency

Keywords: Contribution, income distribution

A. Introduction

Indonesia is an agricultural country, where agriculture plays an important role in the national economy. In 2012, the contribution of the agricultural sector to Gross Domestic Product (GDP) reached 14.44%, ranking second only to the manufacturing sector. The agricultural sector is a sector that is strong enough in facing the shock of the economic crisis and can be relied on in the recovery of the national economy. One potential agricultural sub-sector is the plantation subsector. Although its contribution to GDP is still relatively small (around 1.94%), the plantation sub-sector is a producer of industrial raw materials, absorbing labor for the majority of the population in rural areas and foreign exchange earners (BPS, 2017). The government's policy to increase production and meet CPO market demand is land expansion and plantation revitalization. In line with the enactment of the Master Plan for the Acceleration and Expansion of Indonesian Economic Development (MP3EI) in 2011. The development area of oil palm plantations is directed to become the center of growth and development of systems and sustainable plantation agribusiness businesses. The increase in the area of oil palm plantations is good compared to other commodities. As with national development, the development of plantations, including oil palm plantations, aims to equalize development and improve community welfare. According to Syahza (2013), plantation-based agricultural development in a broad sense aims to improve the welfare of people's lives so that there is a change in the life of the surrounding community. On the other hand the success of the development of oil palm plantations is expected to reduce income inequality between groups of people and regions, where the main goal is to increase community income and reduce the poor population in the countryside by empowering the people's economy. Palm oil is one of the plantation crops that has high economic value and is very prospective to be developed. This is because the market demand for palm oil products, both crude palm oil (CPO) and its processed products is very large. Palm oil (*Elaeis guineensis* Jacq.) is basically a cultivated plant that has a good response to environmental conditions. Like other cultivated plants, oil palm requires an appropriate environmental condition so that its production potential can be maximally obtained. Climate and soil conditions are the main factors besides other factors such as genetics, plant care and others (Lubis, 1992). Farming is a set of natural resources found in the place needed for agricultural production, such as sunlight, soil and water, improvements that have been made to the land with buildings that have been built on it. A farm is a unique agro ecosystem; a combination of physical and biological resources such as land forms, land, water, plants (wild plants, trees, cultivated plants) and animals (wild and maintained). Income contribution is a description of the amount of farm income contribution to total income. Income contribution is a concept that explains the amount of income received by farmers based on ownership of resources or production factors that are sacrificed to earn income.

B. Methodology

To find out how much the contribution of oil palm farming income to the total oil palm farmer households is:

$$1. \quad X = \frac{P1}{Pk} \times 100\% \dots \dots \dots (1)$$

Description:

X = Percentage of contribution of oil palm farming income to total income of oil palm farmer households (%)

P1 = Income from oil palm farming (Rp)

Pk = Total income of oil palm farmer households (Rp.)

(Soekartawi in Budiman 2014). Income distribution is a measure of the evenness of society's prosperity when economic growth occurs in a region. Usually there is a trade off between economic growth and income distribution (Sukartawi, 2002). This distribution concerns the human as an individual or household and the total income they receive. The way in which the household or individual gets the income, how much each individual or household receives it, from which the source of income, place and sector of income is not questioned (Sukartawi, 2002).

Inequality in income distribution can be measured by various methods such as pareto, logarithmic variety, coefficient of variation, Pearson skewness, gini ratio, percentage of maximum similarity, information on theil, index of EltatoFrigyes and size of Atkinson. Of these measures, the most frequently used in empirical research is gini ratio (Simatupang & Togar, 1994). To provide an assessment of the high and low inequality of income distribution, this was done with the following criteria:

- a. The gini index of less than 0.4 indicates a low income distribution imbalance;
- b. The gini index between 0.4-0.5 indicates the inequality of moderate income distribution;
- c. The gini index is greater or equal to 0.5 indicating a high inequality of income distribution.

The gini index ranges between zero and one. If the gini index is equal to zero, the distribution of income is very evenly distributed because each class of population receives the same share of income. Graphically, this is indicated by the coincidence of the Lorenz Curve with perfect evenness lines. However, if the gini index is equal to one, it indicates that there is an imbalance in perfect income distribution because all income is only enjoyed by one person. In short, the higher the gini index value, the more unequal income distribution of a population group. Conversely, the lower the value of the gini index means the more evenly distributed the income (Saptana & Rozi, 2014) Soekartawi (2002), states that income is the difference between the total revenue and the total farming costs that have been spent in the farming process. Farm income is analyzed using the formula:

$$Pd = TR - TC \dots\dots\dots (2)$$

Information:

Pd = income (Rp)

TR = Total Revenue (Rp.)

TC = Total Cost (Total Cots) (Rp)

Revenue is a selection of revenues and costs incurred during the production process. According to Hernanto (1994), it illustrates that the economic progress of farming and the success rate of a farmer compared to other farmers. To find out whether farming is said to be successful if it is able to generate revenue > 1 then farming gets income (profit) but if revenue <1 then farming is said to be a loser.

Based on the background, the purpose of this study was to determine the contribution of oil palm farmers' income to the total income of farmers in Pewisoa Jaya Village, Tanggetada District, Kolaka Regency and to determine the income distribution of oil palm farmers in Pewisoa Jaya Village, Tanggetada District, Kolaka Regency.

This research was carried out in Pewisoa Jaya Village, TanggetadaSubdistrict, Kolaka Regency. This research was carried out from March 8, 2018 to April 17, 2018. The population in this study were all farmers who cultivated oil palm plants in Pewisoa Jaya Village, Tanggetada District, Kolaka Regency which 30 families. Determination of the sample is done by census based on opinion (Sugiyono, 2014), which states that if the population is less than 100 people then all members of the population are sampled. The data used in this study are 2 types, namely primary data and secondary data. Data were obtained from respondents (farmers selected as samples), through questionnaires (questionnaires) as well as through interviews (interviews), village offices, District Offices, Education Center for Extension, and through literature studies (references) or literature

books and research reports , studies of relevant agency and service agencies. Data is analysis using formulas :

$$1. X_{ks} = \frac{P1_{ks}}{Pk_{ks}} \times 100\% \dots\dots\dots(2)$$

Description:

- Xks = Percentage of contribution of oil palm farming income to total household income of oil palm farmers(%)
- P1ks = Income from oil palm farming (Rp)
- Pkks = Total income of oil palm farmer households (Rp)

To find out the income distribution, use the formula:

$$GR = 1 - \sum_{j=1}^k \frac{Y_j + Y_{j-1}}{k} \dots\dots\dots(3)$$

Information:

- Yjks : The cumulative percentage of income received to the jth group
- Yks j-1 : The cumulative percentage of income received to previous groups
- Kks : Number of Groups (class)

C. Results and Discussion

Production is the amount or amount of yield obtained from Palm oil farming in one production process measured in kilograms (kg). The results of the research on the production of oil palm farming in Pewisoa Jaya Village are presented in Table 1, as follows:

Table 1. Palm oil production in pewisoa jaya village, tangetada district, kolaka regency 2018

No.	Production (Kg)	Number of Respondents	Percentage (%)
1	1.000 - 2.000	2	6.67
2	2.001 - 4.000	23	76.67
3	4.001 - 4.500	5	16.67
Total		30	100

Source: Primary Data After Processing in 2018

The above table can be seen that respondent farmers obtained oil palm production in the range of 1,000 kg to 4,500 kg, this can be caused by varying palm oil production because there are two possible causes including the treatment of farmers in oil palm plants especially in trimming and giving different fertilizers different, so the results obtained also vary.

1. Farming and non-farming income

Farming income is the difference between the total income received and the total production costs incurred by oil palm farmers in one farming production process. The results of research on oil palm farming income are presented in Table 2, as follows:

Table 2. Range of Number of Oil Palm Farming Revenues in Pewisoa Jaya Village, Tanggetada District, Kolaka Regency 2018

No.	Income (Rp)	Number of Respondents	Percentage (%)
1	1.000.000 - 6.000.000	2	6.67
2	6.100.000 - 10.000.000	9	30
3	10.100.000 - 15.000.000	15	50
4	15.100.000 - 35.000.000	4	13.33
Total		30	100

Source: Primary Data After Processing in 2018

The table above shows that oil palm farmers have different income, the range of income of oil palm farmers is between Rp. 1,000,000 to Rp. 35,000,000, - this is because the production obtained is also predictable, so the income earned is also different, depending on the volume of production produced by the farmer.

2. Contributions Income

An analysis of the contribution of oil palm farming will provide an overview of the size of oil palm farming income to the total income of farmers. This analysis relates to goals and hypotheses, which is assumed that oil palm income has a large contribution to farmers' income. Farming income is income from agricultural products other than oil palm crops such as clove plant income, cashew nuts and others. Non-farm income is the result of the farmer's business other than agricultural products such as the results of the workshop business, trading, livestock and others. Contributions carried out by oil palm farmers in Pewisoa Jaya Village, Tanggetada District, Kolaka Regency, in more detail can be seen in Table 3.

Table 3. Contributions Income of Respondent Farmers in Pewisoa Jaya Village, Tanggetada District, Kolaka Regency 2018

No	Source of	Contributions (Rp)	Percentage (%)
1	Pendapatan Kelapa Sawit	11.806.920	25,10
2	Pendapatan Usahatani Lain	28.882.567	61,42
3	Pendapatan Non Usahatani	6.334.733	13,39
Amount of		47.024.220	100

Source: Primary Data After Processing in 2018

Based on the analysis used above, it is obtained that the average Palm Oil farmers' income is 25.10%, while the other farm income is much greater around 61.42%, this is possible, because oil palm farmers are also pepper farmers and clove farmers and the possibility of value selling from clove and pepper commodities is far more expensive than the price of palm oil.

3. Income Distribution

The income distribution analysis will provide an overview of the level of evenness or inequality contributed by each source of income to the income distribution of palm oil farmer households. The indicators used to measure income distribution in this analysis are Gini Ratio and Loren Curve. The description of the level of inequality of oil palm farmer household income can be seen in Table

4. If the distribution of farmer household income is separated for each source of income between the sources of oil palm farming, other farming, and non-farming, it is relatively more unequal than distribution total income and income from oil palm farming and other farming.

Table 4. Gini Index of Oil Palm Farmers in Pewisoa Jaya Village District of Tanggetada, Kolaka Regency 2018.

No	Revenue Sources	GR	TK
1	Palm Oil Income	0,0044404	R
2	Total Revenues	0,0044404	R

Source: Analysis of primary data 2018

Contribution of ratio gini curve

Gape: RG = Gini Ratio

Tk = Level of inequality

Criteria = Oshima, 1976

R = Low (Gini Ratio <0.4)

S = Medium (Gini Ratio 0.4-0.5)

T = Height (Gini Ratio > 0.5)

The level of inequality of distribution of Pewisoa Jaya's oil palm farmers total income is 0.0044404. Inequalities that occur in oil palm farmers in Pewisoa Jaya Village are in the low category with values according to the gini ratio. This is because all oil palm farmers are involved in other farming and non-farming activities. The contribution given by the activity to the total income is quite significant. Besides using the gini index, the level of inequality in the distribution of income of oil palm farmers in Pewisoa Jaya Village can also be seen from the lorenz curve. The more convex curve formed from the balance line, the more uneven distribution of income of oil palm farmers. If the lorenz curve formed is near the equilibrium line, it can be interpreted that the distribution of income of oil palm farmers is more evenly distributed.

D. Conclusions

Based on the results of the study, it can be concluded that the contribution and income distribution of oil palm farmers (*Elaeis guineensis* Jacq.) is the average farmer's income of Rp. 47,024,220, the average income of oil palm is Rp. 11,806,920 while the contribution of oil palm farming amounted to 25.10% of the total income and the distribution of farmer's income of 0.004 means that in very low conditions or less affluent communities in the Jaya Village of the Tanggetada District, Kolaka District. Therefore farmer need to register it can be suggested as follows: Palm Oil Farmers in Pewisoa Jaya Village, Tanggetada District, Kolaka Regency, should carry out detailed records of the use of costs used during the production process. It is expected that the Kolaka District Government, especially in the plantation office, will pay attention to oil palm farmers in the form of counseling, so that the production and income of farmers can improve further in the future.

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Phenotypic Performance of Kanesia-10 Cotton (*Gossypium hirsutum* L.) Variety Through the Use of Liquid Organic Fertilizers in Low Land

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ARTICLE INFO

e-ISSN: 2548-5148
p-ISSN: 2548-5121
Vol. 4, No. 1, June 2019
URL : <http://dx.doi.org/10.31327/atj.v4i1.917>

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Abstract

The program of cotton variety improvement is carried out by increasing the productivity and quality of fiber in order to rise the competitiveness of cotton farming through the production of fiber quality that is in accordance with the demand of export-oriented national textile industry. This study aimed to determine the performance of the Kanesia-10 cotton phenotype cultivated using liquid organic fertilizer in the lowlands and obtain the best concentration of liquid organic fertilizer in improving Kanesia 10 cotton performance. This research was conducted in Experimental Farm of the Faculty of Agriculture of the University of Cokroaminoto Palopo from August to November 2018. The genetic material used was Kanesia 10 cotton variety for its fiber content of 27.2%, production of 2.457,2 kg cotton seed per hectare and fiber uniformity of 83,3-84,6%. This study used a randomized block design consisting of five treatments and four times. The treatment used was control (P₀), 50 ml/L POC of gamal leaves (P₁), and 100 ml/L of gamal leaves (P₂) 150 ml/L POC of gamal leaves (P₃), and 200 ml/L POC of gamal leaves (P₄), so that there were 20 experimental units. The use of liquid organic fertilizer produces heterogeneous phenotypic performance for the parameters of the number of fruits per plot with a diversity coefficient value reaching 32.93%. The treatment of liquid organic fertilizer with a concentration of 50 ml / L resulted in the performance of plant height, number of leaves, number of fruits per plot, and the best fruit weight per plot with a mean of 64.13 cm, 57.75 strands, 43.00 fruits and 7.60 g, respectively

Keyword: coefficient of diversity, concentration, gamal leaves, POC

A. Introduction

Cotton (*Gossypium hirsutum* L.) is an annual shrub that becomes one of the major plantation commodities in Indonesia. This commodity produces fiber that is widely used as raw material in textile industry and several textile products (TPT) of Indonesia. However, this industrial advance is not yet completely produced fiber processed material due to the unavailability of raw material, especially cotton fiber. Cotton has been cultivated in India since 5000 years ago and subsequently becomes more popular and the development spread rapidly to China, the Near East, and area surrounding Mediterranean regions. This commodity is intensively developed, particularly in several continents such as America and Australia.

The development of this commodity in Indonesia has not yet met the need of textile industry, thus cotton is still imported every year despite the high potential of domestic cotton to be developed. Unavailability of raw materials is caused by low production of cotton, low farmer's interest to cultivate cotton, and increasing demand of domestic cotton (Sumartini *et al.*, 2013). Until today, over 500 ton of cotton fiber (more than 99%) is still imported to meet domestic demands since cotton farming faces serious pest attack. Hence, cotton productivity and cotton farmer income is still low and continues to fluctuate (Harsanti *et al.*, 2017).

There was fluctuated cotton production in China, India and Indonesia from 2014 to 2017. In 2014, the production reached 4389.8 kg/ha, 1413.1 kg/ha, and 207.4 kg/ha, respectively. In 2015, cotton produced in each country was respectively 4467.9 kg, 1349.3 kg/ha, and 124.1 kg/ha. The production increased respectively in 2016 of 4747.8 kg/ha, 1602.5 kg/ha, and 202.6 kg/ha. In 2017, cotton seed production reached 4730.1 kg/ha, 1518.9 kg/ha, and 89.0 kg/ha, respectively. Cotton production in Indonesia fluctuated during 2014-2017, yet there was significant decrease of 113.6 kg/ha in 2016-2017, that was from 202.6 kg/ha to 89.0 kg/ha (FAO, 2018). Problem mainly occurs in cotton production is related to climate factor such as water unavailability that causes cotton production becomes not optimal. Moreover, there are other factors like low genetic and physical quality of seed used in the production and environmental condition during planting. Yield loss due to seed quality is expected to reach 30% of total loss, following by environmental factor such as pest attack and drought (Harsanti *et al.*, 2017).

Increase in cotton productivity can be achieved through the use of superior variety. Availability of superior variety that is able to adapt to environmental condition in Indonesia is necessary. Thus, the use of superior cotton variety that has resistance to abiotic and biotic stress and reaches high production both in dryland and paddy field is required (Sulistyowati dan Sumartini, 2009). One of superior cotton varieties that is able to achieve high production is Kanesia-10 cotton (97023/8). The ability of this variety to adapt to dry condition or water as limiting factor is better than that of Kanesia 14 and Kanesia 15 varieties (Dewi, 2014). This variety is better compared to other clones in term of fiber content, fiber fineness, fiber length, and yield productivity.

In addition, the factors that cause a decrease in cotton production are land degradation which results in decreased soil fertility, such as decreased nutrient content, organic matter content and soil pH (Aisyah *et al.*, 2008). Giving liquid organic fertilizer is one of the ways and solutions to increase cotton crop production. Liquid organic fertilizer has the benefit of being able to improve the physical, chemical and biological properties of the soil, increasing the formation of leaf chlorophyll so that it increases the ability of plant photosynthesis and absorption of nitrogen from the air, can increase plant vigor. Thus, the plant becomes sturdy and strong, increases plant resistance to drought and weather stress, stimulates the growth of production branches and increases the formation of flowers and ovaries and can improve the quality of crop production, reduce inorganic fertilizers, and as an alternative manure replacement (Indrakusuma, 2000).

Sulistyowati and Sumartini (2009) mentioned the performance of Kanesia 10 cotton developed in several locations showed good productivity and were able to produce 1.002.5-2,287.3 kg cotton seed per ha without spraying and 1,969.6-3,025.5 kg cotton seed with spraying; the production potential of this variety was 2,97 and 19,32%, respectively, higher than that of Kanesia 7 and Kanesia 8. Peni *et al.*, (2018) said that Kanesia 10 seed variety

development was observed to obtain the best agronomic performance for 2 MST (Weeks after Planting), 4 MST, and 8 MST. However, different agronomic performance was expected to be affected by environmental condition in Palopo City. This study aimed to determine the effect of fertilization on the performance of cotton phenotypes in the low land area.

B. Methodology

This study was conducted in Experimental Farm of Agricultural Faculty of the University of Cokroaminoto Palopo from August to November 2018. The geographical location of the research location is 3°04'08 " LS and 120°14'34 " BT with altitude ranging from 0 - 500 m above sea level. The air temperature ranges from 25.5°C - 29.7°C while the rainfall varies between 500 - 1000 mm/year. Genetic material used included cotton seed of Kanesia 10 variety. This study used a randomized block design consisting of five treatments and four times, so that there were 20 experimental units.

The treatment used was control (P₀), 50 ml/L POC of gamal leaves (P₁), and 100 ml/L of gamal leaves (P₂) 150 ml/L POC of gamal leaves (P₃), and 200 ml/L POC of gamal leaves (P₄). The application of liquid organic fertilizer is given to cotton plants after 2 weeks after planting and the application of liquid organic fertilizer is done in the afternoons every 1 week until male flowers appear on cotton plants.

Determination of spacing is adjusted to soil fertility. The recommended distance for infertile soils is around 80-30 cm with a planting depth of 5 cm. planting is done directly and each plant is planted 2-3 seeds / holes. Thinning is done when the cotton plant is 7 HST. The observed and measured parameters were plant height (cm), number of leaves (strands), flowering age (HST), number of fruits / plants (fruit), fruit weight (g), and root length after harvest (cm).

C. Results and Discussions

Performance of phenotype cotton varieties Kanesia 10 were developed in the lowlands using liquid organic fertilizer for the characters that plant height, leaf number, days to flowering, number of fruit per plant, fruit weight per plant, number of fruits per plot and fruit weight per plot is presented in Table 1. Based on the results of variance, there are four parameters are significant observations of plant height, leaf number, fruit weight per plant and fruit weight per plot. While the parameters that have a significant effect are the number of fruits per plant and number of fruits per plot. However, there is one parameter of observation that has no significant effect, namely the age parameter of flowering. It is assumed that the treatment of liquid organic fertilizer used was not able to show a significant influence on the performance of the cotton phenotype of kanesia 10 variats in the lowlands. It is suspected because of the environmental influences that cause differences in the performance parameters for days to flowering.

Table 1 Recapitulation of analysis of variance of Kanesia-10 cotton (*Gossypium hirsutum* L.) Variety Through the Use of Organic Fertilizers in Low Land

Parameter of observation		Organic fertilizer treatment	Coeffecient of variance (%)
Vegetative Phase	Plant height (cm)	8.16 **	10.90
	Number of leaves (strand)	64.63 **	11.23
Generative Phase	Flowering age (HST)	1.86 ^m	8.51
Yield Component	Number of fruit per crop	3.48 *	30.75
	Fruit weight per crop (g)	10.01 **	21.20
	Number of Fruit per plot	4.25 *	32.93
	Fruit Weight per plot (g)	12.37 **	29.49

Description: tn = not significant; * = significant at $\alpha=5\%$; ** = significant at $\alpha= 1\%$.

Table 1 also presents the diversity coefficient values for each parameter is used. Parameters of plant height, number of leaves, and flowering age produced a relatively low diversity coefficient compared to other parameters. As for the parameters of the number of fruit per plot generate coefficient values are higher by 32.93% value. The coefficient of variance (KK) is a coefficient that indicates the level of accuracy of the conclusion of a trial.

The value of the coefficient of genetic diversity showed that the material used is not homogeneous and a low level of accuracy. Diwangkari et al., (2016) stated that the KK value of 10.74% can be categorized as small value, because high KK shows that the research material is not homogeneous and the greater the physical error in carrying out the experiment and parameter measurement, it can be concluded that the experiments were good. Hanafiah (2010), the value of KK is getting smaller, showing a higher degree of accuracy and the validity of the conclusions obtained from these experiments is also getting higher.

1. Vegetative Phase

Vegetative phase is a growing phase where carbohydrate resulted from photosynthesis is mostly used for root, stem, and leaf development. Vegetative phase measured and observed in this study is presented in Table 2. Table 2 shows the parameters of plant height and the number of significant leaves for the administration of liquid organic fertilizer so that further testing using BNT level 5%.

Plant height increase is one part of the growth phase. The best plant height was shown in the treatment of 50 ml/L POC with an average of 64.13 cm but not significantly different from the administration of 200 ml/L POC with an average of 63.15 cm. While, the treatment of 0 ml/L POC (control) produced the lowest plant height with an average of 52.28 cm. This is caused by the use of gamal-based liquid organic fertilizer (POC) which is capable of triggering the growth of plant height because it contains nutrients N, P and K. Nutrient content, especially nitrogen can stimulate and accelerate plant growth. Oviyanti et al., (2016) stated that the more concentration of liquid organic fertilizer made from gamal leaves, the better the condition of the plant without disrupting its growth and metabolic processes. Dhani et al., (2013), nitrogen nutrients are needed by plants for the synthesis of amino acids and proteins, especially in plant growth points so as to accelerate plant growth processes such as cell division and elongation and have an impact on increasing plant growth.

However, the growth of Kanesia 10 varieties of cotton plants cultivated in the lowlands using liquid organic fertilizer has not been able to show a significant difference when compared with the description of Kanesia 10 varieties is 110.17 cm in according with Kepts/SR.120/2/2007. It is suspected that cotton plants cultivated in the lowlands experience environmental stresses that affect the mechanism of photosynthesis and have an impact on plant growth. Sibley et al., 1999; Wollenweber et al., 2003; Wahid, 2007 states that environmental stress in the form of high temperatures and drought can influence the mechanism of photosynthesis resulting in the amount and content of assimilate.

Table 2 Performance of Kanesia 10 cotton phenotype using Liquid Organic fertilizer in the low land area for the vegetative phase

Treatment	Vegetative Phase	
	Plant Height (cm)	Number of Leaves (Strand)
Kontrol	52.28 ^{bc}	18.00 ^c
50 ml/L POC	64.13 ^a	57.75 ^a
100 ml/L POC	58.63 ^{ab}	32.75 ^b
150 ml/L POC	43.00 ^c	23.75 ^c
200 ml/L POC	63.15 ^a	37.25 ^b

Description: Values within the same column following by different subscript letters show significantly different result in BNT at level of 0.05.

The optimal number of leaves formed was shown by giving 50 ml/L POC with an average of 57.75 strands and significantly different from other treatments. However, it is different from the administration of 200 ml / L POC resulting in an average number of leaves of 37.25 strands. This is due to the concentration of a given POC different. The content-based POC *Gliricidia* leaves for the formation of the leaf that is the element N. Bungard et al., (1999), the number of leaves can be attributed to increasing vegetative growth of onion plants through the synthesis of different components of the protein needed for leaf development.

The number of leaves is also closely related to the capture of light and CO₂ more effectively so that it has an impact on increasing the rate of photosynthesis and is associated with production. Elizabeth et al., (2013), the more number of leaves produced, the better the chance to produce fresh and dry weights. Unlike the case with Nasreen et al., (2008), in several reference studies said that the discharge of excess liquid organic fertilizer tends to reduce the number of leaf plants.

2. Generative Phase

Generative phase the growth phase that accumulates most carbohydrate produced from photosynthesis process. This carbohydrate is further utilized to form flower, cotton fiber and seed, or enlargement of food storage structure in plants. Parameter of observation for generative phase consisted of flowering age as presented in Figure 1.

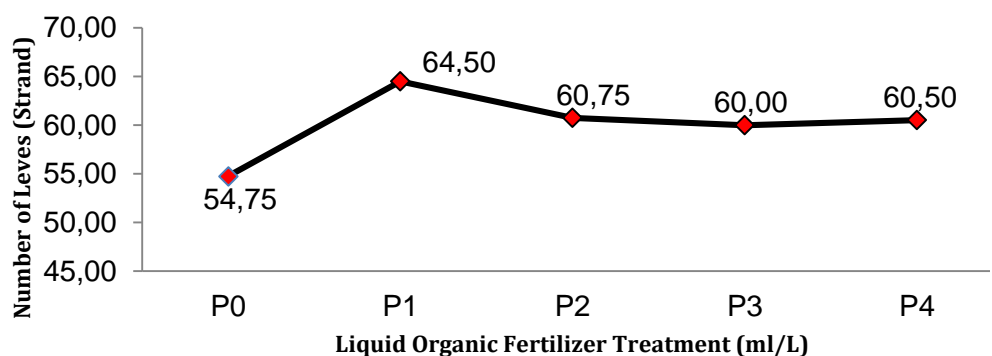


Figure 1 Performance of Kanesia 10 cotton variety for flowering age characters using liquid organic fertilizer in the low land area

In accordance with the description of the Kanesia-10 Kpts/SR.120/2/2007 variety, Kanesia-10 flowering age reaches 55 - 60 HST. Based on these descriptions, giving 150 ml/L POC results in a better flowering life compared to other treatments. Meanwhile, giving 0 ml/L POC (control) results in a faster flowering age and the administration of 50 ml/L POC results in a slower flowering age. This is due to the unavailability of effective P nutrients for flower formation. While for the administration of 150 ml/L POC, it can provide effective P nutrients for the formation of cotton flowers.

P nutrients are important components of compounds for energy transfer (ATP and other nucleoproteins), for genetic information systems (DNA and RNA), for cell membranes (phospholipids), and phosphoprotein Gardber et al., 1991; Lambers et al., 2008), sugar phosphate and specifically on energy transport and storage whose role is largely from complementary materials (Havlin et al, 2005; Gardner et al, 1991; Barker and Pilbeam, 2007).

3. Yield Component

The yield component observed included number of fruit per crop, fruit weight per crop, number of fruit per plot, and fruit weight per plot as presented in Table 3. The four components of production have a significant effect on the provision of liquid organic fertilizer. The treatment of 100 ml/L POC showed the parameters of the number of fruits per plant and fruit weight per best plant with a mean of 12.00 fruits and 1.65 g respectively, not significantly different from

the 200 ml/L POC treatment. While for the parameters of the number of fruits per plot and the best fruit weight per plot produced by the treatment of 50 ml/L POC with an average of 43.00 fruits and 7.60 g.

Table 3 Performance of Kanesia 10 cotton phenotype using Liquid Organic fertilizer in the low land area for the yield component

Treatment	Yield Component			
	Number of Fruit per Crop	Fruit Weight per Crop	Number of Fruit per Plot	Fruit Weight per Plot
Kontrol	5.00 ^b	0.58 ^b	23.50 ^b	3.13 ^b
50 ml/L POC	8.75 ^{ab}	1.40 ^a	43.00 ^a	7.60 ^a
100 ml/L POC	12.00 ^a	1.65 ^a	26.50 ^b	3.80 ^b
150 ml/L POC	8.50 ^{ab}	1.08 ^{ab}	20.00 ^b	2.33 ^b
200 ml/L POC	9.25 ^a	1.40 ^a	23.00 ^b	3.18 ^b

Description: Values within the same column following by different subscript letters show significantly different result in BNT at level of 0.05.

Addition of nutrients through fertilization can replace nutrients lost due to washing and erosion. Liquid organic fertilizer contains many macro, micro, hormone and amino acids needed for the yield component (Pangaribuan et al., 2017). Jayadi (2009), the content of gamal-based liquid organic fertilizer contained 3.15% N, 0.22% P, 2.65% K, 1.35% Ca, and 0.41% Mg.

D. Conclusion

The causes of the low production and productivity of cotton in Indonesia are one of them is conventional cultivation techniques and lack of availability of nutrients in the soil. Soil can provide sufficient nutrients for cultivated plants by adding organic fertilizer. The advantages of liquid organic fertilizer is that it is easily absorbed by plant roots. One of the plants originating from the family of leguminosae and potentially as a liquid organic fertilizer is gamal leaves. The use of liquid organic fertilizer produces heterogeneous phenotypic performance for the parameters of the number of fruits per plot with a diversity coefficient value reaching 32.93%. The treatment of gamal leaf liquid organic fertilizer significantly affected the parameters of plant height, number of leaves, number of fruits per plant, fruit weight per plant, number of fruits per plot and fruit weight per plot. The treatment of liquid organic fertilizer with a concentration of 50 ml/L resulted in the performance of plant height, number of leaves, number of fruits per plot, and the best fruit weight per plot with a mean of 64.13 cm, 57.75 strands, 43.00 fruits and 7.60 g, respectively. Giving 100 ml/L POC showed the number of fruits per plant and fruit weight per best plant with an average of 12.00 fruits and 1.65 g, respectively. Meanwhile, giving 150 ml/L POC produced the best flowering age with an average of 60.00 HST according to the description of Kanesia-10 variety (55 - 60 HST).

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