Efforts to improve the growth of longan plant grafting (*Dimocarpus longan* lour.) in Indonesia with the application of fertilizer

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**Abstract.** The purpose of this research was to study the response of longan grafting plant to the application of leaf and NPK fertilizer. The experimental design was randomized block design with three factors namely varieties, leaf fertilizers and NPK fertilizers. Varieties were Kristalin, Aroma Durian, Diamond River, and Itoh. Leaf fertilizer concentration was without fertilizer, 2 g/l, and 2.5 g/l. The dosage of NPK fertilizer were without fertilizer, 40 g/pot, and 60 g/pot. The observed variables were plant height, number of leaves, number of branches, leaf area and amount of chlorophyll. The results showed that Kristalin was the most responsive to NPK fertilizer at dosage of 60 g per plant. The 2.5 g of leaf fertilizer per plant was the optimal dosage to increase the height addition. The highest plant addition was found in Kristalin was 21.72 cm. Kristalin and Durian Aroma were have highest number of leaves at 102.75 while the largest leaf area is Kristalin 3,861.54 cm$^2$. The concentration of leaf fertilizer will increase the addition of plant height and number of leave, however it will reduce number of branches and leaf area. The more dosage of NPK fertilizer will reduce the number of leaves and leaf area.

1. Introduction
The national fruit demand was reached to 19.03 million tons, and 667 thousand tons were imported. This situation was in line with the demand of longan which increase continuously. According to previous report [1], Zanzibar company is the largest producer of longan fruit in Indonesia. It has production plantation with 9,000 plants on a total area 44 ha, producing 270 tons/year. Efforts to fulfil the fruits demand can be done in such two ways, namely improving production and more imports [2]. Improving fruit production has been carried out by expanding fruit planting area including longan. Commercially, fruit plantations has been done in Indonesia, however many constraints such as availability of longan grafting with good genetic quality, limitations of the fruit production technology packaging, the seasonal to the fruit content, and the price fluctuation during harvesting season [3]. One of effort to overcome these problems is by providing longan plant grafting with good genetic quality.

According to previous study [4], production of longan fruit can be improved by provision of longan plant grafting and balanced application of leaf fertilizer. Procurement of longan plant can be done by vegetative propagation through top grafting. The success of top shoots is influenced by several factors such as: genetic of the plant, environmental, and skills. If these three factors are collaborated, then good longan plant grafting will be produced.
Growth of longan plant grafting can be stimulated by application of leaf fertilizer. Leaf fertilizer which containing macro and micro nutrients is Gandasil D. Gandasil D is formally dissolved in water. The composition of that fertilizer is 20% nitrogen (N), 15% phosphorus (P), 15% potassium (K), 1% magnesium (Mg) and was equipped with elements of manganese (Mn), boron (B), copper (Cu), cobalt (Co), zinc (Zn), as well as vitamins for plant growth such as aneurine, lactoflavine and amid v [5]. According to the previous report [6], the effect of leaf fertilizer application in longan plants, is able to fulfill plants need in one or more micro and macro nutrients, curing nutrient deficiencies, strengthen the weak or damaged plant tissue, and accelerate growth.

The use of a complete and complex fertilizers is an agricultural cultivation business, has advantage of reduce the nutrients, saving labor and fertilization time. The use of NPK and leaf fertilizers aiming to maintenance plants, usually carried out in plant nurseries to increase growth [7]. For that, the purpose of this research was to study the most responsive of longan grafting plant with the application of different dosage of leaf and NPK fertilizer.

2. Materials and methods
The research was conducted in March 2015 to September 2015 at the Pandak Village screen house, Baturaden, Banyumas, Central Java. Seedlings of longan from 4 variety at 6 month from grafting with a height of ± 75 cm. Planting media with was prepared with a mixture of soil: husk: manure at ratio of 1: 1: 1; NPK fertilizer is Mutiara Biru with a ratio 16:16:16; leaf fertilizer is Gandasil D. The design used was Complete Randomized Block Design (RCBD) with three factors, namely varieties, leaf fertilizers and NPK fertilizers. The variety consists of four types, namely V1: Longan Kristalin, V2 :Longan Aroma of Durian, V3: Longan He mond River, and V4: Longan Itoh. Leaf fertilizer consists of 3 levels, namely D0: control (without fertilzer), D1: 2 g leaf fertilize/l, and D2: 2.5 g leaf fertilizer/l. NPK fertilizer with three levels, namely N0: Control (without NPK fertilizer), N1: 40 g NPK fertilizer/plant, N2: 60 g NPK fertilizer/plant. The variables observed were additions plant height, number of leaves, number of branches, leaf area and contents of chlorophyl. F test followed with Duncan's Multiple Range Test (DMRT 5%) was employed to analysed the data.

3. Results and discussions
Longan varieties have a significant effect in all observed variables. The treatment of leaf fertilizer dosage has significant effect on all variables except the chlorophyll content. The treatment of NPK fertilizer dosage was found has significant effect on the number of leaves and leaf area variables. Moreover, the interaction between longan varieties and leaf fertilizer dosage showed significant effect only on plant height. The interaction between longan varieties and NPK fertilizer dosage significantly affected to the chlorophyll contents variable. The interaction between leaf fertilizer dosage and NPK fertilizer dosage did not show any effect. Then, the interaction between longan plant varieties, leaf fertilizer dosage and NPK fertilizer dose show a significant effect on plant height.
Table 1. The average number of statistical analyzes of variety responses and growth of longan to leaf fertilizer dosage and NPK fertilizer dosage

| Treatment                  | HP (cm) | LF       | NB    | LA (cm²) | CC (nm) |
|----------------------------|---------|----------|-------|----------|---------|
| Varieties                  |         |          |       |          |         |
| V1                         | 21.72 a | 102.75 a | 1.39 a| 3861.54 a| 41.99 a |
| V2                         | 8.49 b  | 102.75 a | 1.68 a| 1320.10 b| 42.57 a |
| V3                         | 12.33 b | 41.05 b  | 2.40 a| 2444.60 ab| 43.49 a |
| V4                         | 11.85 b | 42.62 b  | 1.35 a| 1642.95 b| 43.39 b |
| F count                    | 44.91   | 28.49    | 9.27  | 31.37    | 6.43    |
| F table                    | 2.74    | 2.74     | 2.74  | 2.74     | 2.74    |
| Leaf fertilizer dosage     |         |          |       |          |         |
| D0                         | 9.84 a  | 39.51 a  | 2.152 b| 2317.30 a| 42.71   |
| D1                         | 14.18 b | 69.00 b  | 1.50 a| 1486.73 b| 43.58   |
| D2                         | 16.75 c | 70.95 b  | 1.47 a| 2186.23 b| 43.91   |
| F count                    | 22.66   | 13.92    | 7.65  | 15.23    | 1.36    |
| F table                    | 3.13    | 3.13     | 3.13  | 3.13     | 3.13    |
| NPK fertilizer dosage      |         |          |       |          |         |
| NO                         | 14.16   | 71.80 b  | 1.53  | 2762.24 b| 42.67   |
| N1                         | 14.22   | 66.43 b  | 1.82  | 2561.17 b| 44.24   |
| N2                         | 12.39   | 41.23 a  | 1.78  | 1628.49 a| 43.29   |
| F count                    | 2.00    | 11.95    | 1.28  | 11.92    | 2.21    |
| F table                    | 3.13    | 3.13     | 3.13  | 3.13     | 3.13    |

Means followed by the same letter along the column are statistically similar (DMRT, 5%). V1: Kristalin, V2: Aroma Durian, V3: Diamond River, V4: Itoh, D0: control (without leaf fertilizer), D1: 2 g leaf fertilizer/ plant, D2: 2.5 leaf fertilizer g/plant, N0: Control (without NPK fertilizer), N1: 40 g NPK fertilizer/ plant, N2: 60 g NPK fertilizer/plant; PH: Plant height, LF: Number of leaf, NB: Number of branches, LA: Leaf area; CC: Contents of chlorophyll.

3.1. Plant height
The results showed that the interaction between longan variety, leaf fertilizer dosage and NPK fertilizer dosage have significant effect on plant height. Figure 1 shows that the NPK fertilizer dosage increases the plant height of Kristalin along with the increase in leaf fertilizer dosage. The NPK 40 g fertilizer dose gives the highest increase in plant height compared to other NPK fertilizer doses. This shows that the dose of NPK fertilizer 40 g is the most suitable dose for the growth of Kristalin variety.
Kristalin variety has the highest increase in plant height in 40 NPK fertilizer along with the increase in leaf fertilizer. This shows that in this combination Kristalin variety have fulfilled their daily needs. NPK fertilizer is the source of macro nutrients, while micro elements can be supplied from the given leaf fertilizer. The leaves of the Kristalin variety have length of 17.1-20.6 cm and width of 4.8-7.2 cm, the shape of leaves was elongated and dark green [8]. The leaves size will increase in line with light absorption and CO₂ in the leaves, thus the rate of photosynthesis in plants will improve. Photosynthetic properties will be transferred (commonly in the form of sucrose) from the leaves to the holding organs which function for cell division and enlargement, and tissue formation, one of which is for the formation of shoots [9].

Figure 2 shows that the dosages of 0 g and 40 g NPK fertilizers still increase the plant height of Aroma Durian variety along with the increase in leaf fertilizer dosage, while the NPK fertilizer dosage of 60 g is known to be the maximum required fertilizer fertilizer dosage of 1.2 g. Aroma Durian variety has reached the maximum dosage of leaf fertilizer at a dosage of 60 g NPK showed that the combination of fertilizer at high fertilizer nutrient dosage given exceeded the required amount. The micro nutrients that are given are thought to have reached excessive requirements derived from leaf fertilizer. Leaf fertilizers which contain micro elements cause the addition of these elements to be available in excess quantities. Micro elements in large quantities can cause poisoning in plants. Therefore, the given fertilizer is recommended to be given independently without the addition of NPK fertilizer.
Figure 2. Interaction of leaf fertilizer dose and NPK fertilizer dosage against plant height in Aroma Durian variety.

Diamond River variety has better plant height growth in the administration of leaf fertilizer independently without NPK fertilization. This shows that the Diamond River variety has been able to utilize macro nutrients from the soil. This also shows that the Diamond River variety has better nutrient uptake than other varieties. Diamond River variety requires more micro nutrients to support its growth. This is indicated by the increase in plant height increase with the increase in leaf fertilizer dosage given.

3.2. Number of leaves

Figure 3 show the number of leaves in Kristalin and Aroma Durian varieties were more than other varieties in this study. The number of leaves in Diamond River variety is 41.05 strands, whereas Itoh is 42.62 strands.

Figure 3. Difference in number of leaves four longan varieties.

The Kristalin and Aroma Durian aroma varieties have more leaves than the other two varieties. This shows that Kristalin and Durian varieties have greater potential in capturing sunlight for
photosynthesis. The high number of leaves causes the light that can be absorbed by plants also increases. This encourages the rate of photosynthesis carried out by plants. High photosynthesis rates will support the growth and development of plants.

![Figure 4. Effect of leaf fertilizer dosage on the number of leaves](image)

Figure 4 shows that increasing dosage of foliar fertilizers capable of increasing the number of leaves of the plant longan. The number of leaves increased is thought to be due to the addition of micro nutrients from the addition of leaf fertilizer. Micro nutrient is needed in small amounts, but if available in the right amount it will be able to significantly increase plant growth. Many micro nutrients play a role in metabolic processes in plants. Micro nutrients function as cofactors for various reactions that occur in plants. The number of cofactors that are quite capable of accelerating metabolic reactions thus as to spur plant growth such as the number of leaves.

![Figure 5. Effect of NPK fertilizer dosage on the number of longan leaves](image)

Figure 5 shows that increasing dosage of NPK fertilizer causes a decreased number of leaves of the plant longan. Increasing the dose of NPK fertilizer given has a negative effect on the formation of the number of longan leaves. It is suspected that the leaf growth of longan plants has been fulfilled from the nutrients available from the soil as a medium. The need for micro nutrients further spurs leaf growth because it will spur the utilization of these macro nutrients. Provision of
excessive NPK fertilizer can also have negative effects. Excess N elements will cause succulent plants, so the plants are susceptible to attack by pests and pathogens. Excess macro elements will also suppress the role of micro nutrients in spurring plant growth.

3.3. Number of branches

Figure 6 shows the most number of branches reached by Diamond River variety (2.40 pieces), followed by Aroma Durian (1.68 pieces), Kristalin (1.39 pieces) and Itoh variety (1.35 fruits). Diamond River variety have a higher number of branches than the other three varieties. The number of branches shows the potential results that can be obtained from longan plants. The more branches that are formed it is possible for many generative shoots to grow. The number of branches of plants that form also shows the balance of hormones that terdap a t on the plant. Auxin hormone affects the condition of apical dominance. Apical dominance leads to the growth of dominating plant shoots. Such conditions will cause the top of the plant to continue to elongate and will inhibit branch growth. Giberellin hormones in plants that play a role in the process of forming plant branches. The content of giberellin in plants will suppress auxin activity. This emphasis on auxin performance will stimulate the formation of new branches.

![Figure 6. Difference in number of branches longan varieties.](image)

Figure 7 shows that increasing the dose of leaf fertilizer causes a decrease in the number of branches of longan. Increasing the dose of leaf fertilizer will increase the micro nutrients that can be absorbed by plants. Excess micro nutrients can cause poisoning in plants. The form of poisoning that can occur is one of which is the inhibition of plant branch growth. Micro nutrient poisoning is thought to inhibit the growth of axillary shoots from plants. Micro nutrients are thought to inhibit also macro nutrient transport that occurs in plants. The inhibition of macro nutrient transport caused macro nutrient concentrations in axillary shoots to be low, while high macro nutrient concentrations were needed for axillary shoot growth.
Figure 7. Effect of leaf fertilizer dosage on the number of longan branches

3.4. Leaf area

Figure 8 shows that the highest leaf area reached by the Kristalin (3861.54 cm²), followed by Diamond River (2444.60 cm²), Itoh (1642.95 cm²) and Aroma Durian (1320.10 cm²).

![Leaf area chart]

Figure 8. Difference in leaf area four longan varieties.

The leaf area of the longan plant also shows the ability of plants to receive sunlight. The leaf area of Kristalin variety has a wider leaf area than the other varieties. This also shows the ability of Kristalin variety which is higher in capturing sunlight. Therefore the potential growth rate of Kristalin variety is also better than other varieties. However, it is not always the wide leaf area that is in harmony with the growth of the plant. This depends on the effectiveness of catching the sun's rays. The area of plant leaves that are too wide will cause the leaves to shade each other, so that the effectiveness of sunlight absorption will also decrease.
Figure 9. Effect of leaf fertilizer dosage on the area of longan leaves.

Figure 9 shows that increasing the dose of leaf fertilizer causes a decrease in leaf area of longan plants. Increasing the dosage of leaf fertilizer caused a decrease in leaf area due to the administration of micro elements through the fertilizer which had a greater role in increasing the number of leaves compared to the leaf area. This can be seen from the number of leaves which increases with the increase in leaf fertilizer dosage, while the leaf area decreases. Excess micro nutrients are also thought to be less capable of causing leaf expansion. The leaf area of the plant is hampered by the presence of excess micro nutrients.

Figure 10 shows that increasing doses of foliar fertilizer plant leaf area causes decreased longan. Increasing the dose of NPK fertilizer is not able to increase the leaf area of the plant because longan plants have been able to utilize macro elements from the soil. Decreasing plant leaf area is also thought to be a form of plant adaptation to maintain the effectiveness of leaves in absorbing sunlight. The area of the leaf that is too wide will cause the leaves to shade each other thus will harm the plant itself.

Figure 10. Effect of NPK fertilizer dosage on the leaf area.
3.5. Chlorophyll content

Figure 11 shows that the dosage of NPK fertilizer increases the chlorophyll content of Kristalin and Diamond River. Durian and Itoh varieties have chlorophyll content which decreases with increasing dosage of NPK fertilizer given. Kristalin and Diamond River have higher chlorophyll content with an increase in NPK fertilizer dosage because of the low chlorophyll content without NPK fertilization. This situation causes better utilization of macro nutrients in the formation of chlorophyll by administering NPK fertilizer. Kristalin and Diamond River varieties still need macro elements from NPK fertilizer for chlorophyll formation. Durian and Itoh Aroma varieties have high chlorophyll content even without NPK fertilizer. This condition causes excess macro nutrients if given additional NPK fertilizer.

![Figure 11. Interaction of varieties and dosages of NPK fertilizer against chlorophyll content.](image)

Anchomanes difformis showed that a mixed medium of soil and cocopeat (1:1) together with a fertilizer application equivalent to 100 kg/ha NPK (15% N, 15% P2O5, 15% K2O) was the best of the tested treatments not only for plant growth and rhizome yield but also for increasing saponin content of the rhizomes [10]. Green manures and NPK fertilizer increased okra mineral and vitamin C contents compared with the control [1]. The NPK fertilizer increased the leaf, stem diameter, number of leaves and nutrient contents (N, P, K, Ca and Mg) of the soil. The use of NPK fertilizer at application range between 400 and 450 NPK/ha is therefore recommended for growing of C. Moscata and improvement of the soil nutrients level [11]. Application of fertilizer at dose of 135 kg N/ha + 66 kg P2O5 per ha with the application of Crotalaria resulting in yield of maize as many as 7.234 tons ha⁻¹ while fertilizing at the same dose without the application of crotalaria obtained the yield as many as 6.172 tons per ha [12].

4. Conclusions

The results showed that variety of Kritalin was the most responsive variety in the provision of NPK fertilizer at a dosage of 60 g per plant. The dosage of 2.5 g of leaf fertilizer per plant was the most optimal dosage to increase the height addition of longan plant grafting. The highest plant height addition in Varieties Kristalin is 21.72 cm compared with Diamond River 12.33 cm, Itoh 11.85 cm and Durian 8.49 cm. Kristalin and Durian Aroma have the highest number of leaves at 102.75 compared to Itoh 42.62 and Diamond River 41.05. The largest leaf area was found in Kristalin variety 3,861.54 cm² when compared to Diamond River 2,444.60 cm², Itoh 1,642.95 cm², and Durian Aroma 1,320.1 cm². Increasing the concentration of leaf fertilizer will increase
the plant height addition and number of leaves, but will reduce the number of branches and leaf area. Therefore increasing dosage of NPK fertilizer will reduce the number of leaves and leaf area.

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