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EFFECTIVENESS OF GIVING NPK FERTILIZER AND CHITOSAN FOR THE GROWTH OF SUNAN CANDLENUT PLANT ON MARGINAL LAND

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Abstract: *Sunan Candlenut (Reutealis trisperma (Blanco) Airy Shaw) is a type of vegetable oil producing plant that has great potential as a source of raw material for biodiesel. To develop Sunan Candlenut plants on marginal land, it is necessary to achieve innovation in their cultivation, specifically by providing NPK fertilizer and nutrition with plant supplements using chitosan. In an effort to increase the effect of chitosan on plant growth, it is necessary to add gibberellins (GA_3). There was no interaction between NPK fertilizer application at various doses and chitosan administration on all vegetative growth parameters of the Sunan Candlenut plants which were observed. The results showed that the dose of NPK fertilizer had the same effect on all parameters. Chitosan plus (chitosan 30 ml/l + GA_3) gives a better effect on all parameters observed. Plants treated with chitosan had a higher number of secondary branches and leaf canopy width than those without chitosan.*

Key words: *Sunan Candlenut, NPK fertilizer, chitosan, marginal land*

1. Introduction

Indonesia has various types of plants that can be used as sources of vegetable oil as a substitute for fossils, one of which is Sunan Candlenut (*Reutealis trisperma* (Blanco) Airy Shaw). Sunan Candlenut seeds are one of the ingredients with high potential for use as biodiesel because the seed core has a high enough crude oil content that is equal to 43.3% [6]. The fatty acid content of Sunan Candlenut oil consists of stearic acid, oleic acid, linoleic acid, and ear-eleostearic acid. This oil contains poisons so it cannot be consumed, because α-eleostearic acid in the oil is a compound that causes toxicity in Sunan Candlenut oil, so it can be used as a mixture of ingredients for vegetable pesticides [17].

Sunan Candlenut has a very broad

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adaptability to various agroecosystems in Indonesia. This plant can function as a conservation plant to reclaim marginal lands so that its development does not use productive land for food. Sunan Candlenut plants which are the object of research are found in the Energy Garden, a demonstration garden of vegetable energy sources located in Gunung Kelir Hamlet, Pleret Village, Pleret District, Bantul Regency, Yogyakarta Special Region Province, a land that is categorized as marginal land where water and nutrient availability is very limited and the soil is thin [15]. Thus, to support the growth of Sunan Candlenut plants, cultivation activities need to be done so that the plants get enough nutrients during their growth, which is done by fertilizing. The balance in the use of inorganic and organic fertilizers is the key to proper fertilization. That is because inorganic and organic fertilizers have their respective advantages. In this research, inorganic (N, P, and K) and organic (chitosan) fertilizers were applied.

Nitrogen (N), Phosphor (P), and Potassium (K) are macro nutrients that plants need in large quantities. Nutrient N in plants functions in forming leaf green matter (chlorophyll) and as a protein forming element. Nutrient P, which helps in energy storage and transfer, is an important component in nucleic acids, coenzymes, nucleotides, phosphoproteins, phospholipids, and phosphate sugars. Nutrient K functions in the formation of starch, it activates enzymes and photosynthesis storage catalysts. The use of fertilizer for Sunan Candlenut plants is 4.5 years old with a dose of fertilizer per plant of Urea 200g, SP36 120g, and KCl 120g [7].

Chitosan is an organic nutrient obtained from processing skin waste or shrimp shells, crabs, molds, and others whose solutions contain macro and micro nutrients, and plant hormones, and is able to increase plant antibodies. Chitosan has an environmentally friendly nature and is easily degraded [14]. Based on test quality, chitosan contains 6.74% C-organic, 0.05% N, 0.01% P_2O_5, and 0.01% K_2O. The levels of micro elements such as Fe, Cu, Zn, and B are 8 ppm, 0.8 ppm, 7 ppm, and 1 ppm respectively. The content of growth hormone per chitosan solution such as auxin (IAA), cytokinin (zeatin), and gibberellins (GA_3) is 319.11 ppm, 18.46 ppm, and 252.48 ppm respectively [3].

Chitosan applications have a wide range of uses: it has high affinity, it is not toxic, it is easily degraded and a raw material derived from nature. Chitosan regulates the plant's immune system and causes the excretion of combative enzymes. What is more, chitosan not only activates cells, but also increases the defence ability against diseases and insects. Chitosan acts as a carbon source for microbes in the soil, accelerates the process of transformation of organic compounds into inorganic compounds, and helps the root system of plants to absorb more nutrients from the soil. Chitosan is absorbed by the roots after being broken down by bacteria in the soil [8]. Based on the research results of [9], the 30 ml/l concentration of chitosan had a greater influence on the parameters of the number of leaves and the width of the canopy of leaves of Sunan Candlenut.

In an effort to increase the influence of chitosan on the growth of Sunan Candlenut plants, it is necessary to add gibberellins. Gibberellins are growth regulators that stimulate cell division or cell elongation and are known as gibberellic acid (GA_3). Gibberellins are

related to the physiological processes of plants, including plant growth, flowering, germination, dormancy, sexual expression, senescence, parthenocarpy, and fruit sex [2]. Gibberellins support the formation of proteolytic enzymes that release trypthophan as the original form of auxin. This means that gibberellins can increase auxin content [1].

Improvements in the cultivation system, especially in the application of fertilization, are expected to spur plant growth. The purpose of this study is to determine the effect of NPK fertilizer application at various doses and of the administration of chitosan on the vegetative growth of Sunan Candlenut plants. The results of the study are expected to be beneficial for plant maintenance so that the Sunan Candlenut plants soon enter their generative phase.

2. Materials and Research Methods

The study was conducted in an energy garden located in Gunung Kelir, Pleret Village, Pleret Subdistrict, Bantul Regency, Special Region of Yogyakarta. The investigation consisted in field research, taking place between April and July 2019. The research location was at an altitude of about ± 99m asl. The plants studied were ± 4.5 years old. The experiment used a two-factor complete randomized block design. The first factor was the dose of Urea + SP36 + KCl fertilizer, consisting of 3 levels which were: D1 = 150g + 90g + 90 g, D2 = 200g + 120g + 120g, D3 = 250g + 150g + 150g. The second factor was the provision of chitosan, consisting of 3 levels which were: K1 = chitosan concentration of 30ml/l (the best concentration of research in the year I [9], K2: chitosan 30ml/l + GA_3 (100 ppm) per plant, K3: without chitosan. In order to obtain 9 treatment combinations, each treatment combination was repeated 3 times, and each treatment combination consisted of 3 plants, so that the total is 81 plants.

The plants in the field with a spacing of 8 x 8m, which were used as the object of research were selected randomly. The selected plants were measured for their agronomic characteristics in the initial stage of observation. All the plants were given cow manure at a dose of 6 kg/plant. Urea, SP36, and KCl fertilizers were given by inserting them into a hole made to encircle the plant at a distance of 5 cm from the stem. Chitosan application was done by splashing it into the roots of the Sunan Candlenut plants.

The observations of the agronomic characteristics for the vegetative growth of the Sunan Candlenut plants were conducted on the parameters of increasing plant height (cm), increasing number of leaves (strands) and increasing stem diameter (cm), number of secondary branches, and width of leaf canopy (cm).

The observed data were analyzed for diversity using analysis of variance (ANOVA) at the 5% level. To find the differences between treatments, the analysis was continued using the DMRT test (Duncan Multiple Range Test) at the level of 5%.

3. Results and Discussion

3.1. Plant Height

The results of variance showed that there were no interactions in plants that were treated with NPK fertilizer (Urea + SP36 + KCl) and chitosan administration on the initial plant height parameters and on the plant height increase at 15 days, 30 days, 45 days, and 60 days after

treatment. The mean (average is used in Table 1) plant height values at the beginning of the observation and the increase in plant height (Table 1).

Table 1

Average initial plant height observed and increase in plant height observed 15, 30, 45, and 60 days after treatment [cm]

Treatment	Initial observation (cm)	Plant height increase [cm]			
		15 days	30 days	45 days	60 days
Urea Dose + SP36+KCl/plant (g)					
D1 (150+90+90)	371.89 a	12.22 b	11.67 a	9.52 b	8.52 a
D2 (200+120+120)	343.74 a	23.11 a	17.00 a	14.81 a	8.89 a
D3 (250+150+150)	391.81 a	15.70 b	7.71 b	9.30 b	7.44 a
Chitosan administration/plant					
K1 (30 ml/l)	390.33 p	17.15 p	11.56 p	9.56 q	7.89 q
K2 (30 ml/l + GA_3)	368.44 p	16.74 p	12.74 p	17.56 p	10.30 p
K3 (without chitosan)	348.67 p	16.48 p	12.07 p	6.52 q	6.67 q
Interaction	(-)	(-)	(-)	(-)	(-)

Note: Average treatment between columns and rows followed by the same letter shows no significant difference in the DMRT test at the 5% level. The (-) sign indicates that there is no interaction.

In Table 1, it can be seen that the treatment dosage of NPK fertilizer (Urea + SP36 + KCl) and the administration of chitosan had no significant effect on the plant height parameters initially observed. In observations 15, 30, and 45 days after treatment, the treatment dose of fertilizer 200g Urea + 120g SP36 +120g KCL per plant showed a higher increase in plant height compared to other treatments, meaning that the more appropriate the nutrient content for plants, the better the growth and production. However, at the end of the observation, plant height increase was not significantly different between treatments. It is estimated that the increase of the plant is due to the ability of the plant to utilize the available nutrients optimally for the increase of plant height. The results of chitosan treatment on the plant height increase parameters can be seen in Figure 1. The treatment of K2 (chitosan 30 ml + GA_3) showed a higher increase in plant height compared to the treatment of K1 (chitosan 30 ml) and K3 (without chitosan). According to [15], GA_3 can stimulate stem growth, increase the enlargement and multiplication of cells in plants, so that plants can reach a maximum height. Increasing plant height affects the growth of the stem diameter of Sunan Candlenut plants. GA_3 influences the extension of plant segments by increasing the number and size of cells in these segments [16]. The addition of gibberellins causes elongation of the stem by spurring cell division and cell elongation, so the additional plant height is more significant than treatment without the addition of gibberellins.

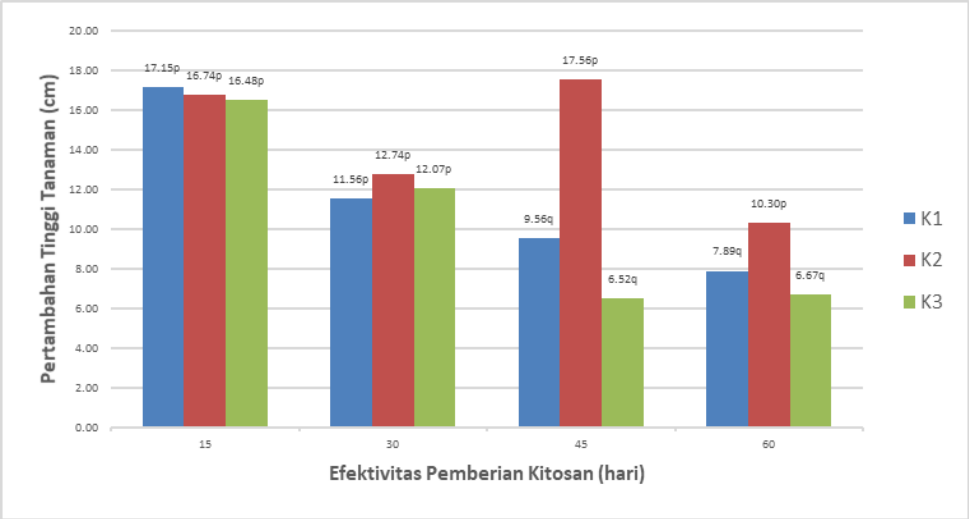

Fig. 1. *Effectiveness of chitosan administration on increasing plant height*

3.2. Number of Leaves

The results of variance showed that there were no interactions in plants to be treated with NPK fertilizer dosage (Urea + SP36 + KCl) and chitosan administration on the parameter of the number of leaves initially observed and on the increase in number of leaves on observations 15 days, 30 days, 45 days, and 60 days after treatment. The mean (average was used in Table 1) value of the number of leaves initially observed and the number of leaves added are presented in Table 2.

Table 2

The mean (average was used in Table 1) number of leaves initially observed and the number of leaves observed 15, 30, 45 d, and 60 days after treatment (strands)

Treatment	Initial observation [cm]	Increased number of leaves (strands)			
		15 days	30 days	45 days	60 days
Urea Dose + SP36 + KCl/plant (g)					
D1 (150+90+90)	313.81 a	28.59 a	20.33 a	5.15 a	6.15 a
D2 (200+120+120)	273.74 a	33.81 a	23.78 a	5.52 a	8.48 a
D3 (250+150+150)	360.56 a	30.66 a	17.04 a	6.81 a	8.22 a
Chitosan administration/tanaman					
K1 (30 ml/l)	326.93 p	31.04 p	19.22 p	5.63 pq	5.67 q
K2 (30 ml/l + GA_3)	322.00 p	33.33 p	23.44 p	8.48 p	11.37 p
K3 (without chitosan)	299.19 p	28.59 q	18.48 q	3.37 q	5.81 q
Interaction	(-)	(-)	(-)	(-)	(-)

Note: Average treatment between columns and rows followed by the same letter shows no significant difference in the DMRT test at the 5% level. The (-) sign indicates there is no interaction.

In Table 2, it can be seen that the treatment dosage of NPK fertilizer (Urea + SP36 + KCl) and the administration of chitosan did not significantly affect the initial leaf count parameters observed. Until the end of the observation, the NPK fertilizer dosage treatment did not have a different effect on increasing the number of leaves. It is estimated that the increase of the plant is due to the ability to utilize the available nutrients optimally to increase the number of leaves. The existence of NPK fertilizer as an inorganic fertilizer is very quickly absorbed by plants, especially the nitrogen elements compared to elements P and K. According to [10], the role of nitrogen for plants is to stimulate overall growth, especially stems, branches and leaves, and encourage the formation of chlorophyll so the leaves turn green, which is useful for photosynthesis.

The treatment of K2 (chitosan 30ml + GA_3) showed an increase in the number of leaves to a greater extent than the treatment of K1 (chitosan 30ml) and K3 (without chitosan). The results of chitosan treatment on the parameters of increasing the number of leaves can be seen in Figure 2.

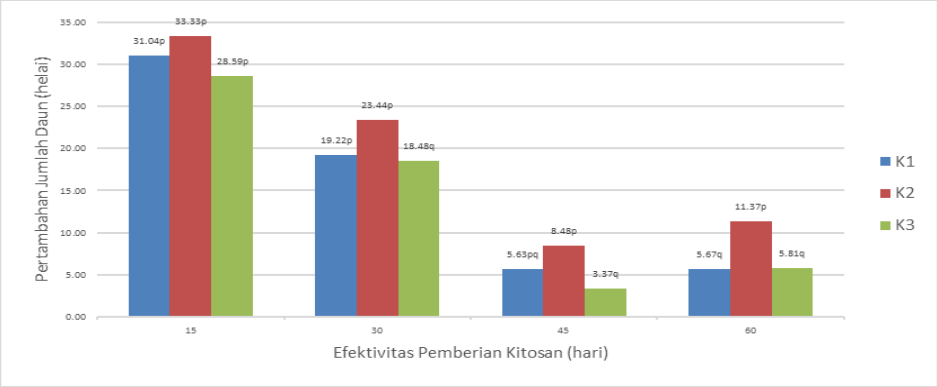

Fig. 2. *Effectiveness of chitosan administration on increasing the number of leaves*

The addition of gibberellins produced a fairly extensive effect. One of its main effects is to encourage leaf lengthening [11]. Gibberellins play a role in cell division and followed by cell enlargement will produce leaf primordia that develop [13]. According to [16], in addition to the extension of the stem, gibberellins also expand the leaves and affect the growth of the number of leaves. The higher the number of leaves, the more secondary branches are produced. The number of leaves is influenced by genotype and the environment. The position of leaves in plants that are controlled by genotypes also has a real influence on the rate of leaf growth and the capacity to respond to better environmental conditions, such as water availability [5].

3.3. Stem Diameter

The results of variance showed that there were no interactions in plants to be treated with NPK fertilizer dosage (Urea + SP36 + KCl) and chitosan administration on the initial stem diameter parameters of the observations and on the increase in stem diameters at 15, 30, 45, and 60 days after treatment. The mean (average was

used in Table 1) value of the initial stem diameter observed and the increase in stem diameter are presented in Table 3.

Table 3

Average initial stem diameter observed and increase in diameter rods observed 15, 30, 45, and 60 days after treatment [cm]

Treatment	Initial observation [cm]	Stem diameter increase [cm]			
		15 days	30 days	45 days	60 days
Urea Dose + SP36 + KCl/plant (g)					
D1 (150+90+90)	23.29 a	2.67 a	0.26 a	0.34 a	0.15 a
D2 (200+120+120)	22.28 a	2.45 a	0.32 a	0.23 a	0.23 a
D3 (250+150+150)	28.47 a	2.35 a	0.47 a	0.30 a	0.17 a
Chitosan administration/plant					
K1 (30 ml/l)	26.83 p	2.57 p	0.40 p	0.31 p	0.17 q
K2 (30 ml/l + GA_3)	25.13 p	2.70 p	0.46 p	0.31 p	0.23 p
K3 (without chitosan)	22.07 p	2.20 p	0.19 q	0.25 q	0.16 q
Interaction	(-)	(-)	(-)	(-)	(-)

Note: Average treatment between columns and rows followed by the same letter shows no significant difference in the DMRT test at the 5% level. The sign (-) indicates there is no interaction.

In Table 3, it can be seen that the treatment dose of NPK fertilizer (Urea + SP36 + KCl) had no significant effect on the initial stem diameter parameters of the observation. Until the end of the observation, the NPK fertilizer dosage treatment did not have a different effect on the increase in stem diameter. At the end of the observation, the response to the increase in stem diameter showed a tendency to increase in stem diameter increase (D1 to D2) and a tendency to decrease stem diameter increase (D2 to D3). It shows that with adequate doses of fertilizer given, the growth is getting better, and on the contrary, in excessive doses, the growth becomes stunted. Table 3 also shows that the treatments of K1 (chitosan 30ml) and K2 (chitosan 30ml + GA_3) at observations 30 days and 45 days after treatment showed an increase in stem diameter greater than the K3 treatment (without chitosan). According to [9], the stem is an area of accumulation of plant growth, especially in young plants. Chitosan contains Plant Growth Promoter in the form of gibberellins, IAA, and Zeatin [12]. The Plant Growth Promoter in chitosan can encourage the rate of photosynthesis in producing photosynthate, thus helping stem enlargement. At 60 days after treatment, K2 (chitosan 30ml + GA_3) produced the largest stem diameter compared to other treatments. This is because gibberellins have a synergistic effect on cambium activity and a differentiation of the transport network which causes the diameter of the trunk to become larger.

The results of chitosan treatment on the parameters of stem diameter increase can be seen in Figure 3.

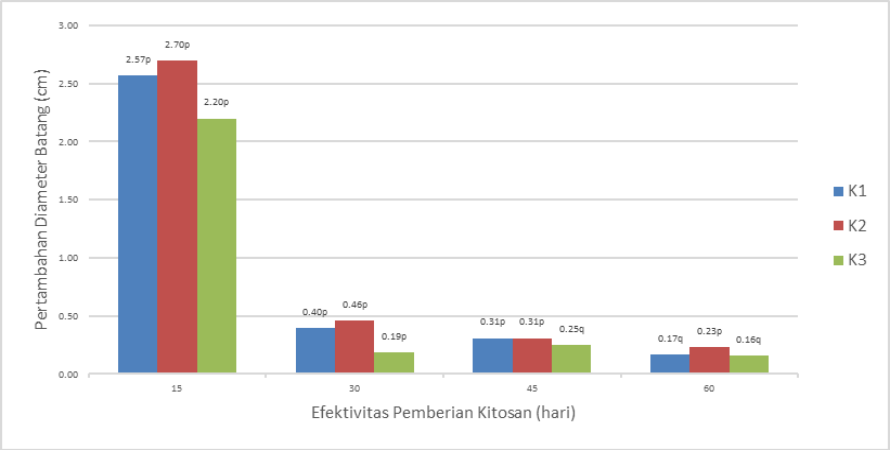

Fig. 3. *Effectiveness of chitosan administration on stem diameter increase*

3.4. Number of Secondary Branches

The results of variance showed that there were no interactions in plants to be treated with NPK fertilizer (Urea + SP36 + KCl) and chitosan administration on the parameters of the number of secondary branches initially observed and on increasing the number of secondary branches at 15, 30, 45, and 60 days after treatment. The mean (average was used in Table 1) value of the number of initial secondary branches observed and the number of secondary branches added are presented in Table 4.

Table 4

The mean of the initial secondary branches observed and the addition of the number of secondary branches observed 15, 30, 45, and 60 days after treatment (fruit)

Treatment	Initial observation [cm]	Number of secondary branches increase (fruit)			
		15 days	30 days	45 days	60 days
Urea Dose + SP36 + KCl/plant (g)					
D1 (150+90+90)	34.85 a	6.30 a	2.93 a	3.30 a	2.67 a
D2 (200+120+120)	32.63 a	6.59 a	3.30 a	4.11 a	3.22 a
D3 (250+150+150)	52.11 a	7.48 a	4.59 a	4.70 a	2.67 a
Chitosan application/plant					
K1 (30 ml/l)	46.81 p	6.48 p	3.48 p	4.15 p	3.00 p
K2 (30 ml/l + GA_3)	38.37 p	7.78 p	5.33 p	4.67 p	3.15 p
K3 (without chitosan)	34.41 p	6.11 p	2.00 q	3.30 q	2.41 q
Interaction	(-)	(-)	(-)	(-)	(-)

Note: Average treatment between columns and rows followed by the same letter shows no significant difference in the DMRT test at a 5% level. The sign (-) indicates there is no interaction.

In Table 4, it can be seen that the treatment dose of NPK fertilizer (Urea + SP36 + KCl) did not significantly affect the parameters of the number of secondary branches at the beginning of the observation. Until the end of the observation, the NPK fertilizer dosage treatment did not have a different effect on the increase in the number of secondary branches. The results of the treatment of chitosan on the parameters of increasing the number of secondary branches can be seen in Figure 4.

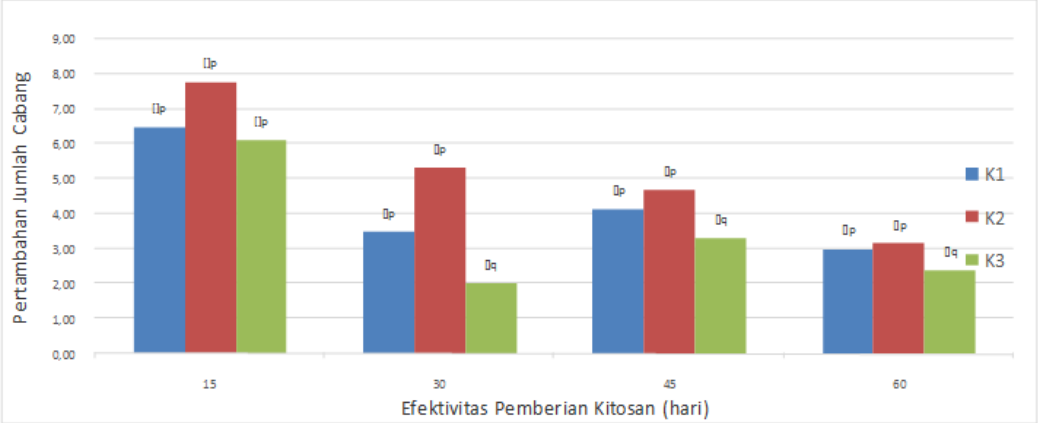

Fig. 4. *Effectiveness of chitosan administration on increasing the number of secondary branches*

The treatments of K1 (chitosan 30ml) and K2 (chitosan 30ml + GA_3) showed an increase in the number of secondary branches greater than the K3 treatment (without chitosan). The increase in the number of secondary branches in the Sunan Candlenut plants that were given chitosan (K1 and K2) showed a better growth response compared to the plants that were not given chitosan (K3). The use of chitosan can be an alternative in an effort to increase the vegetative growth of Sunan Candlenut plants. Increased plant growth due to chitosan is caused by the role of chitosan in improving plant metabolism. Chitosan is a form of polysaccharide that functions as a biological signal in cells and is able to regulate the symbiotic defenses as well as the process of plant development [4].

The addition of gibberellins to K2 tends to produce more secondary branches compared to K1, because gibberellins affect the extension of plant segments by increasing the number and size of cells in these segments. The addition of gibberellins is effective in influencing the number of productive branches, which is an increase in the number of productive branches by 5 percent compared to the case without the addition of gibberellins. This is in accordance with the opinion of [18]. The gibberellin hormones work on genes that require proper concentration in plants. The concentration of the 100 ppm gibberelline hormone can effectively increase the number of productive branches.

3.5. Leaf Canopy Width

The results of variance showed that there were no interactions in plants to be treated with NPK fertilizer dosage (Urea + SP36 + KCl) and chitosan administration on the parameters of the leaf canopy width at the beginning of the observation and on the increase of the leaf canopy width at 15, 30, 45, and 60 days after treatment. The mean values of leaf canopy width at the beginning of the observation and the increase in leaf canopy width are presented in Table 5.

In Table 5, it can be seen that the treatment dose of NPK fertilizer (Urea + SP36 + KCl) did not significantly affect the width of the leaf canopy, while the administration of chitosan had a significant effect on the parameters of the leaf canopy width increase. For the treatment of K1 (chitosan 30ml) and K2 (chitosan 30ml + GA_3), the observation 60 days after treatment showed an increase in leaf canopy width which was wider than the K3 treatment (without chitosan).

Table 5

The mean width of the leaf canopy at the beginning of the observation and the increase in the width of the leaf canopy at 15, 30, 45, and 60 days after treatment [cm]

Treatment	Initial observation [cm]	Leaf canopy width increase [cm]			
		15 days	30 days	45 days	60 days
Urea Dose + SP36 + KCl/ plant (g)					
D1 (150+90+90)	315.04 a	33.81 a	7.85 a	11.74 a	7.22 a
D2 (200+120+120)	294.19 a	25.07 a	10.37 a	11.59 a	9.41 a
D3 (250+150+150)	374.96 a	32.85 a	11.44 a	9.93 a	12.10 a
Chitosan administration /plant					
K1 (30 ml/l)	343.30 p	29.92 p	8.33 q	9.63 q	9.71 p
K2 (30 ml/l + GA_3)	329.37 p	33.96 p	13.22 p	14.63 p	11.78 p
K3 (without chitosan)	311.52 p	27.85 p	8.12 q	9.00 q	7.33 q
Interaction	(-)	(-)	(-)	(-)	(-)

Note: Average treatment between columns and rows followed by the same letter shows no significant difference in the DMRT test at a 5% level. The sign (-) indicates there is no interaction.

The results of chitosan treatment on the parameters of the leaf canopy width increase can be seen in Figure 5.

The addition of gibberellins to K2 tends to result in an increase in leaf canopy width that is wider than K1. Gibberellins are able to stimulate leaf formation well. According to Salisbury and Ross (1995), gibberellins can affect the size of plant organs through the process of cell division and enlargement. The width of the leaf canopy has to do with the number of secondary branches, because the high number of secondary branches will cause an increase in the segment where the leaves grow, so, the number of leaves tends to be higher and the leaf canopy wider.

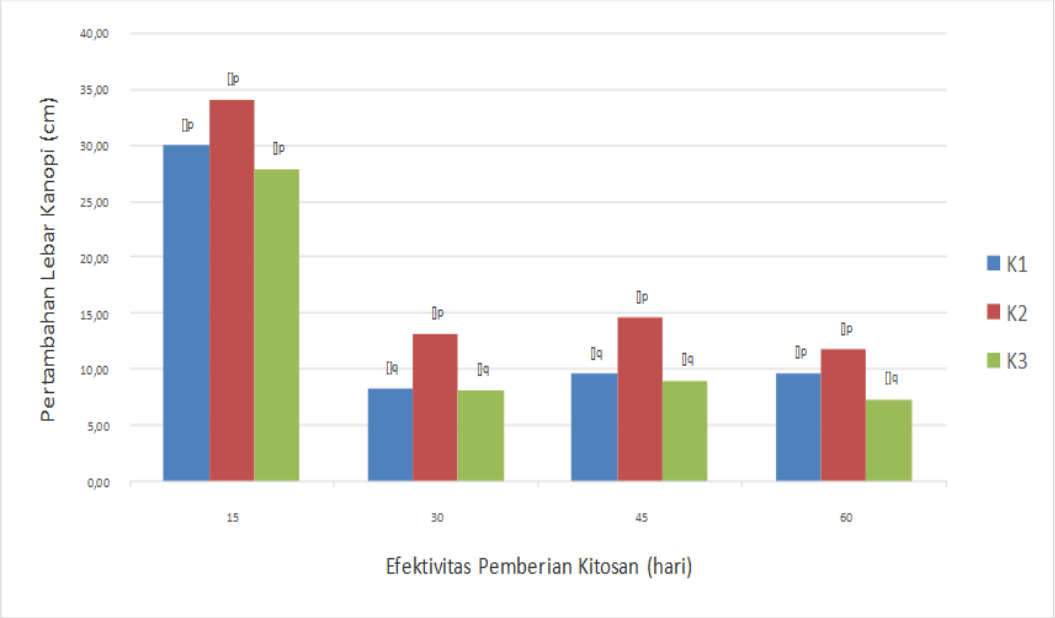

Fig. 5. *Effectiveness of chitosan administration on leaf canopy width increase*

4. Conclusions

1. There was no interaction between NPK fertilization dose treatment and chitosan administration on all vegetative growth parameters observed in Sunan Candlenut plants.
2. The dose of NPK fertilizer had the same effect on all observed parameters.
3. Applying chitosan plus (chitosan 30ml/l + GA_3) has a better effect on all parameters observed.
4. Plants treated with chitosan have a higher number of secondary branches and higher leaf canopy width than those without chitosan.

Acknowledgements

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