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The Effect of Using Green Manure *Calopogonium mucunoides* on the Growth and Crop Yields of Sweet Corn (*Zea mays* Saccharata Sturt)

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ABSTRACT

This research aiming to find the effect of green manure *Calopogonium mucunoides* on the growth and crop yields of sweet corn (*Zea mays* saccharata Sturt) has been conducted in the resident's yard at Pelton Street in Bukit Sofa, Siantar Sitalasari, Pematangsiantar on the 400 m above sea level. The used design of the experiment is Randomized Block Design (RBD) with four repetitions. The treatment is the dosage of green manure *C.mucunoides* at 5 levels that is, K0 = without green manure *C.mucunoides*, K1 = 2.25 kg per plot (5 tons per ha), K2 = 4.5 kg per plot (10 tons per plot) *C. mucunoides*, K3 = 6.75 kg per plot (15 tons per ha) *C. mucunoides*, and K4 = 9.0 kg per plot (20 tons per ha) *C. mucunoides*. The plot area for the experiment is 2 m x 3 m (6 m2). Observations were made to the plant height (cm) at the age of 3 WAP, 5 WAP, 7 WAP, the corncob length (cm), the corncob weight per plant (g), and the corncob weight per plot (kg). The data were analyzed statistically by using Analysis of Variance (ANOVA) in order to find the treatment effect on observation perimeters and were further tested in terms of average differences by using Least Significance Difference (LSD) Test at the level 5%. The results of this research show that green manure *C. Mucunoides* has a real effect on the plant height at the age of 3 WAP, 5 WAP, 7 WAP, the corncob length, the corncob weight per plant (g), and the corncob weight per plot (kg). The use of green manure with the dosage 9.0 kg per plot (20 tons per ha) results in the heaviest weight of corncobs, which is 9.95 kg per plot or about 16.58 tons per ha.

INTRODUCTION

Nowadays, most of farmers cultivate sweet corns since they have high economic values and taste sweet so that many people like them. They can be not only stewed and roasted but also processed into various dishes like cooked vegetables and snacks.

The demand of sweet corns is increasing by the advent of supermarkets, hotels, and restaurants in big cities. Besides, the prospect for overseas markets is still available. The need of sweet corns for consumption especially from urban and suburban areas is progressively increasing. In some local markets, the demand of sweet corns is increasing and it can reach between 1-1.5 ton per day. In the cities of Jakarta and Batam, the demand can even reach more than 1.5 ton per day.

Mostly, farmers in Indonesia have narrow fields and thus, the selection of planted commodities is needed in order to gain more profits so that the needs of the farmers' family can be fulfilled. Planting sweet corns can give more profits since their price is relatively high, which is about Rp 5,000 per kg, and their harvest time is short, which is 75 days.

A cultivation of plants on narrow fields should use organic inputs in order to retain the land conservation. The cultivation of plants using organic materials is also called as organic agriculture. The definition of organic agriculture is multifarious and the most recognizable one is the agricultural system that uses no fertilizers and pesticides. The organic agriculture emphasizes the use of inputs promoting the biological processes for the availability and resistance against plant-injurious organisms. It can be achieved by manipulating the natural resources in order to promote the processes of improving and preserving land productivity (Melati dan Andriyani, 2005).

Some of nutrient sources which are able to use in the system of organic agriculture are organic materials from animal manures, green manures, agricultural wastes, organic manures, and household/urban wastes. The nutrient sources which are also allowed to use in organic agriculture are minerals like lime, phosphate rocks, *biosuper* (mixture of specific rocks and microorganisms affecting the weathering and release of nutrients) (Stockdale *et al*, 2001 in Melati and Andiyani, 2005).

Organic manures added into the soil will grow several times to be humus with the help of soil microorganisms. Organic materials also have a role as the source of energy and food for soil

microbes, thereby increasing the microbes' activities for the provision of plant nutrients. Not only is it as the source of plant nutrients, the addition of organic materials is also as the source of energies and nutrients for microbes (Munanto,2013).

Green manure is materials made of plants that are buried again in the soil and have a function to improve plant growth (Salahin *et al.*, 20130).Green manure is able to improve physical, biological, and chemical characteristics of the soil resulting in the improvement of plant growth. The long-term benefit of using green manure is the stable crop yields in dry season. According to Rinsema (1983), the advantages of using green manure are (1) the preservation of the soil structure as the ground surface is covered; (2) the soil structure is improved as there is an addition of organic materials; and (3) the soil becomes rich of nitrogen especially when the used green manure is made of leguminous plants.

According to Listyarini (2010), the used green manure is made of legumes because legumes can fixate N from the atmosphere with the help of nitrogen-fixing bacteria so that the level of N in plants relatively becomes high. The most used green manure is from cover crops easily found in large plantations in Indonesia. The cover crops commonly used as green manure are *Pueraria javanica, Pueraria phaseoloides, Centrosema pubescens, Calopogonium caeruleum, Calopogonium mucunoides* and *Mucuna bracteata* (Hashim, 2012). According to Andriani (1994 *in* Melati and Andiyani, 2005), this type of green manure has fast growth and is adaptable to acid soils as well as generates a pretty high number of forage production.

The plant *Calopogonium mucunoides* is a type of leguminous plants which is able to produce a high number of organic materials and which can improve the soil fertility since it can fixate nitrogen through nodule bacteria from plant roots. Thus, it has the potential to be green manure (Hanafiah, 2004). The average amount of nutrients in *Calopogonium mucunoides* is 3.47%Nitrogen, 0.18%Phosphorus, and1.79% Potassium (Purwanto, 2010).

Skerman (1977 *in* Fanindi and Prawiradiputra, 2014) states that *Calopogonium mucunoides* contain relatively high value of protein which is about 16% dry weight, 0.25% phosphorus, and 1% calcium. The relatively high value of protein can be the source of protein for plants. *Calopogonium*can is used as fodder especially when the season is dry season. This plant is also a cover crop which is important to plantations. As a type of green manure, *Calopogonium* can improve the soil and is the pioneer in protecting the soil surface. Besides, it can also decrease the soil temperature and improve the soil fertility.

The use of organic materials will create more pores so that the soil becomes loose. The loosen soil will be low in terms of its volume weight and *Calopogonium mucunoides* will have a real effect on the increase of the organic materials in the soil and the decrease of the soil volume weight. The more green manures mean that the more organic materials and the more ground spaces will be (Arsyad, 2009).

It is further explained by Anas (1989) that the addition of organic materials like Kalopo (*Calopogonium mucunoides*) toward physical characteristics such as improving the soil structure, making the soil light to process and penetrable for roots. The vertical circulation or infiltration of water can be improved and the soil can absorb water more quickly so that the surface flow and erosion can be minimized. Likewise, the soil aeration can be improved since the space of the soil pores becomes more due to the aggregate formation. The organic nitrogen increase in the soil means the fertility improvement and the possibility of improving humus.

The use of *Calopogonium mucunoides* is done to increase the use of existing natural resources. Fortunately, Kalopo is an easily found plant so that the use of inorganic fertilizers can be minimized. Besides, nutrients in the soil and the soil fertility can also be preserved (Damanik, 2009).

The research results of Marsuni, Subaedah and Koes (2013) about corn crops show that the use of green manure *Calopogonium mucunoides* generates tallest plants, most leaves, widest leaves, and the highest amount of chlorophyll than the use of *Calopogonium juncea* or without the use of green manure. The research about sweet corns shows that the use of green manure with the dosage 15 tons per ha give the highest result on the observed parameter of plant-growth rate (g per day), root canopy ratio (g), plant dry weight (g), the time for male flower's appearance (hst), time to harvest (hst), weight per corncob without cornhusk (g), and corncob production per plot (kg). The corncob weight in the use of 15 tons per ha is 136.78 kg. It has no significant difference with the use of 10 tons per h, which is 128.11 kg but it has a significant difference with the use of 5 tons per ha and without the use green manures, which are respectively 113.43 kg and 105.73 kg (Kalyubi, 2011).

Based on the research of Hakim *et al.* (1986), the burying of *Calopogonium mucunoides* really affects the availability of organic materials in the soil, the soil volume weight, and the total space of the soil pores. The burying of *Calopogonium mucunoides* with the use of 10

tons per ha can provide the highest organic materials in the soil. The more dosage of green manures means that the more available organic materials in the soil. Organic materials are decomposed to tie ground grains, thereby losing the density of the soil. In this case, the soil becomes loose and granulated so that there is a decrease in the soil volume weight. With the high level of organic materials, the soil usually has lower volume weight.

Melatidan Andriyani (2005) conducting a comparative research about the dosage of *Calopogonium mucunoides* as the green manure toward the growth and production of soybeans and the early harvest shows that the use of 15 tons per ha generates tallest plants at the age of 4, 5, 6, and 7 MST in which the most leaves are on 5 and 6 MST. Meanwhile, the dry weight per plant, the dry weight of root nodule per plant, the number of seed pods per plant, the number of empty seed pods per plant, the wet weight of seed pods per plant, the weight of empty seed pods per plant, the weight of seed pods per 12.5 m^2, the dry weight of seed pods, the weight of empty seed pods per plant, and the dry weight of 100 granules are not affected by the dosage of green manure *Calopogonium mucunoides* (0, 7.5 tons per ha, 15 tons per ha, and 30 tons per ha)

MATERIALS AND METHODS

This research was conducted in the field of a farmer in the resident's yard at Pelton Street in Bukit Sofa, Siantar Sitalasari, Pematangsiantar on the 400 m above sea level.

Materials used in this research are seeds of sweet corns bonanza, green manure *Calopogonium mucunoides*, urea fertilizers, SP-36, KCI. The dosage determination guides the use of organic manure or compost in general, which is 15 tons per ha. Green manure was buried in the soil for 2 weeks before planting. Before burying it in the soil, the green manure was chopped in order to get smaller pieces so that the decomposition process becomes easier. The burying of them was done in parallel to the 20-cm row cropping. Urea fertilizers, SP-36, and KCl were used twice when the age of plants was 3 weeks (each of plants had 2/3 portion) and 8 weeks (each of plants had 1/3 portion). Each of fertilizer dosages was urea fertilizer: 200 kg per ha, SP-36: 140 kg per ha, and KCl: 70 kg per ha.

The used design of experiment is Randomized Block Design (RBD) with four repetitions. The treatment is the dosage of green manure *C. mucunoides* at 5 levels i.e., K_0 without green manure *C. mucunoides*, K_1 = 2.25 kg per plot (5 tons per ha), K_2 = 4.5 kg per plot (10 tons per plot) *C. mucunoides*, K_3 = 6.75 kg per plot (15 tons per ha) *C. mucunoides*, and K_4 = 9.0

kg per plot (20 tons per ha) *C. mucunoides*.The plot area for the experiment is 2 m x 3 m (6 m^2).

Observations were made to the plant height (cm) at the age of 3 WAP, 5 WAP, 7 WAP, the corncob length (cm), the corncob weight per plant (g), and the corncob weight per plot (kg). The data were analyzed statistically by using ANOVA in order to find the treatment effect on the observation perimeter and were further tested in terms of average differences by using LSD Test at the level 5%.

RESULTS AND DISCUSSION

1. Plant height (cm)

The dosage treatment of green manure *Calopogonium Mucunoides* has a real effect on the plant height at the age of 3 WAP, 5 WAP, and 7 WAP. The further test results with BNT in table 1 indicate that the use of green manure *C. Mucunoides*with the dosage 9.0 kg per plot (20 tons per ha) results in the plant height 85.21 cm at the age of 3 WAP, 120.11 cm at the age of 5 WAP, and 191.79 cm at the age of 7 WAP which are significantly different with the use of green manure *C.Mucunoides* with the dosage 6.75 kg per plot (15 tons per ha), 4.5 kg per plot (10 tonsper plot), 2.25 kg per plot (15 tons per ha) and without the use of green manure

Table 1: Plant height (cm) Sweet Corn at the age 3 WAP, 5 WAP, and 7 WAP at treatment Green Manure *C. mucunoides*

Green manure *C. mucunoides* (ton per ha)	Plant height (cm)		
	3 WAP	5 WAP	7 WAP
(0)	60.92 e	84.77 e	152.80 e
(5)	68.55 d	90.35 d	164.88 d
(10)	75.29 c	96.83 c	172.84 c
(15)	80.42 b	111.12 b	182.14 b
(20)	85.21 a	120.11 a	191.79 a

Remark: Means followed by same letter in same column do not differ significantly at the level 5%

Based on table 1, it can be seen that the tallest plants are shown by the highest dosage

treatment of green manure *C. Mucunoides*, which is 20 tons per ha. The addition of green manure dosage will add the number of nutrients in the soil especially nitrogen and potassium. *C. Mucunoides*is a leguminous plant which is able to produce a high number of organic materials and which can improve the soil fertility since it can fixate nitrogen when the green manure has been decomposed (Hanafiah, 2004). The average amount of nutrients in this green manure is N 3.47%, P 0.18%, and K 1.79%.

Nitrogen is the important constituent of amino acid, amide, nucleotides, and nucleoproteins. It is also essential for cell division and cell enlargement for growth (Gardner *et al*, 1991). Marschne (1986) states that the addition of nitrogen will increase the height of plants and the width of leaves.

Epstein (1978) states that nitrogen is the fourth biggest element following C, H, and O. Protein contains more or less 18% nitrogen. Nitrogen is the constituent of acid amino, nucleotides, and coenzyme. About 70% of the total nitrogen in leaves is in chloroplast. Chloroplast is an organelle cell where there is a process of photosynthesis. Nitrogen in chloroplast becomes the constituent of enzyme formation which has a function in the dark reaction of photosynthesis to form glucose.

Protein is a polymer made of 20 amino acids amalgamated by a lot of combinations of peptide bond producing heavy molecules. Amino acids have N adhering to alpha carbon and also have N in its ring like tryptophan. Glutamine has N in a group of amide and adenine is purine base with N in its ring. Adenine is a part of many nucleotides and nucleoproteins like DNA and RNA.

Potassium especially has a function as enzyme activator or converter of about 46 enzymes (Evan and Sorger, 1966 *in* Gardner *et al*, 1991).Potassium also helps plants maintain their osmotic potential and water retrieval. Plants with enough K only lose a little water because K improves their osmotic potential and has a positive effect on stomata closure (Gardner *et al*, 1991). Not only is it as enzyme activator, K also has a function to synthesize protein. The speed of protein synthesis by ribosome in cells will increase if K is at its optimum concentration. It is suspected that K has a role in the translation step including the amalgamation of RNA and ribosome (Marschner, 1986).

The N element is one of constituents in chlorophyll which is very important for the photosynthesis of plants. The addition of N in plants will add the amount of chlorophylls so

that the energy captured from the sun can be more. The energy addition from the sun into the reaction center will increase energies in the form of ATP and NADPH which have a function to combine CO_2 and water forming glucose. K also has a role in photosynthesis. In most plants, K is responsible for changing the turgor of guard cells. The increase of K concentration in the guard cells will improve water absorption from the cells around it as well as increase the pressure of the turgor of the guard cells, thereby opening the stomata. Stomata are the pathway of CO_2 from the atmosphere into leaves used as raw materials of photosynthesis. The more open stomata mean that the more CO_2 will be taken for the increase of the photosynthesis speed.

In order to know the use of green manure *Calopogonium mucunoides* toward the height growth of sweet corns can be seen in figure 1.

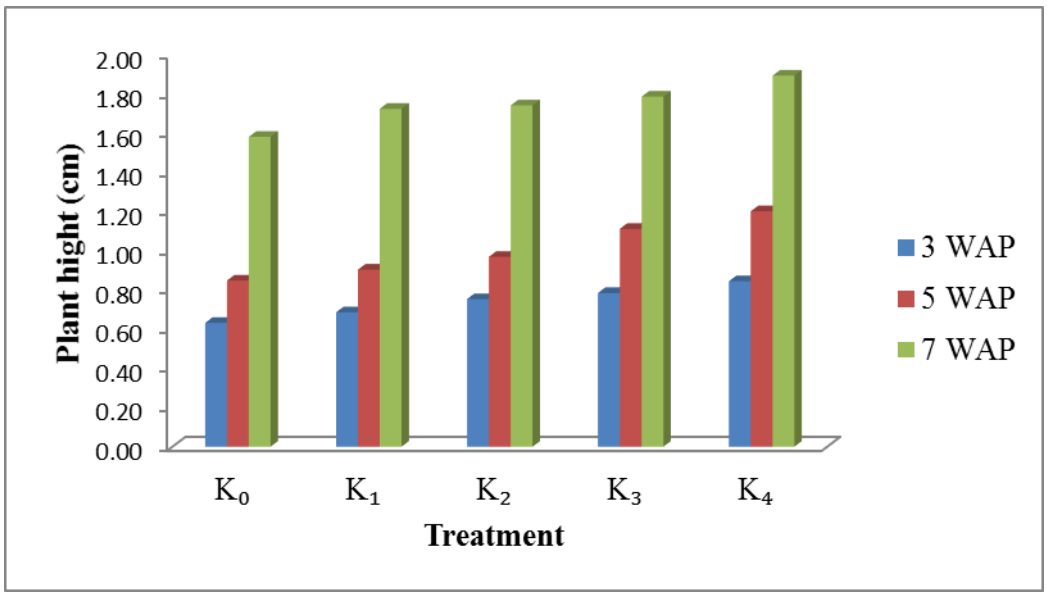

Figure 1: Histogram The effect of Green Manure *Callopogonium mucunoides* toward the height growth of sweet corns at the age of 3 WAP, 5 WAP, and 7 WAP

2. Corncob Length (cm)

The treatment of green manure *Calopogonium mucunoides* has a real effect on the length of corncobs. In table 2, it can be seen that the treatment in the dosage 9 kg per plot (20 tons per ha) generates the longest corncob, which is 21.29 cm. It is significantly different from the other treatments.

Table 2: Corncob Length (cm), Corncob Weight per plant (g), Corncob Weight per plot (kg) at treatment Green Manure *C. mucunoides*

Green manure *C. mucunoides* (ton per ha)	**Corncob Length (cm)**	**Corncob Weight per Plant (g)**	**Corncob Weight per Plot (kg)**
(0)	19.71 e	39.,25 e	8.81 e
(5)	20.32 d	404.25 d	9.02 d
(10)	20.88 c	414.75 c	9.21 c
(15)	21.03 b	425.50 b	9.75 b
(20)	21.91 a	437.25 a	9.95 a

Remark: Means followed by same letter in same column do not differ significantly at the level 5%

The vegetative growth of plants will influence their generative growth. Generally, it can be said that there is a positive correlation between vegetative and generative growths in plants. In this research, the vegetative growth is represented by the longest length of plants occurred in green manure with the dosage 9 kg per plot (20 tons per ha). The better vegetative growth in plants will improve the speed of photosynthesis which is then transited to generative-growth organs such as flowers, fruits, and seeds.

Mimbar (1990) states that the addition of N results in the increase of corncob length in corns. The fulfillment of nutrient, light, and water makes the photosynthesis well formed. The generated photosynthesis will be transferred and stored in seeds when there is seed replenishment. It is induced by nutrients absorbed by plants and then used for forming protein and fat. Eventually, they are stored in the seeds.

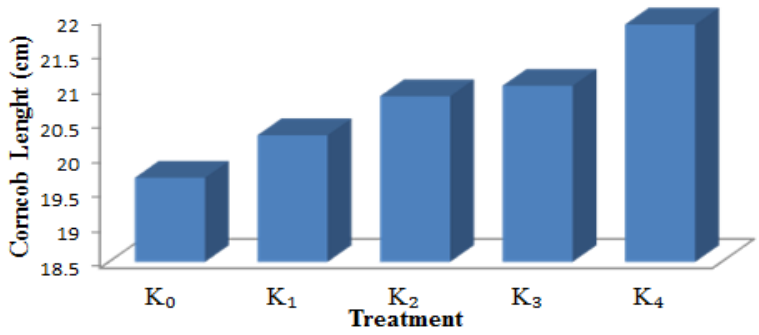

Figure 2: Histogram The effect of Green Manure *Callopogonium mucunoides* toward the Corncob Length (cm) of sweet corns at the age of 3 WAP, 5 WAP, and 7 WAP

3. Corncob Weight per Plant (g)

The treatment of green manure *C. mucunoides*has a real effect on corncob weight per plant. In table 2, it can be seen that the treatment with the dosage 9 kg per plot (20 tons per ha) generates 437.25 g corncob weight per plant which is significantly different from the other treatments.

The better vegetative growth of plants in the use of 9 kg green manure per plot (20 tons per ha) will improve the speed of plant photosynthesis, thereby increasing the carbohydrate stored as a stockpile for the formation of fruits and seeds of sweet corns. When the plants are in the generative phase, then the carbohydrate deposit in the vegetative plants will be transited to the generative parts in order to form fruits and seeds.

According to Salisbury dan Ross (1995), the transit of nitrogen from the vegetative into generative parts is quite high, especially for the cereal plants. This high diversion from vegetative organs to flowers and seeds is followed by the decreased speed of nitrogen uptake from the soil. Lack of nitrogen during the period of flowering increases the number of falling flowers and pushes the growth of seeds at the same time. The use of nitrogen during the period of flowering and seed growth effectively decreases the falling flowers and pods from soybean crops. Marschner (1986) states that nitrogen is very needed for the formation of seeds. Seeds in their growth compete with leaves to get nitrogen. The formation of seeds and seed growth till its formation of perfect seeds is basically limited by the amount of nitrogen in the organs of vegetative plants.

Prawiranata *et al* (1989) state that endosperms contain some nitrogen compounds like protein, free amino acid, amide, and nucleate acid. The compounds provide nitrogen as the nutrition for embryo and other structures of the growing seeds. The total nitrogen in the embryo and endosperms increases along with the growth of corn seeds.

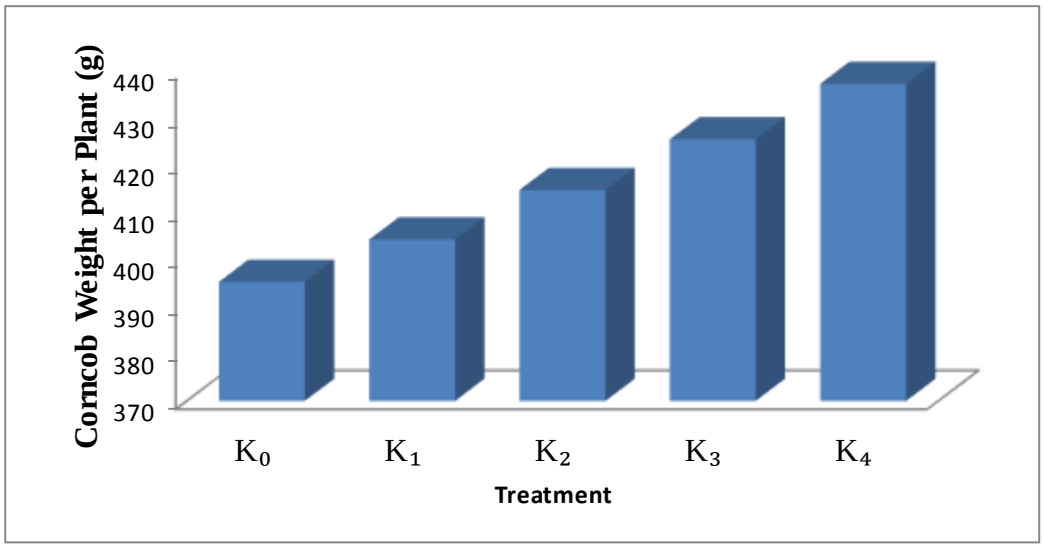

Figure 3: Histogram The effect of Green Manure *Callopogonium mucunoides* toward the Corncob Weight per Plant (g) of sweet corns at the age of 3 WAP, 5 WAP, and 7 WAP

4. Corncob Weight per Plot (kg)

The treatment of green manure *C. Mucunoides* has a real effect on corncob weight per plot. In table 2, it can be seen that the treatment with the dosage 9 kg per plot (20 tons per ha) generates the highest corncob weight per plot, which is 9.95 kg. It is significantly different from the other treatments.

Corncob weight per plot is obtained by weighing all corncobs in one trial plot. The results of this research show that the corncob weight per plant has a correlation with the corncob weight per plot where the heaviest corncob is from the dosage 9 kg per plot (20 tons per ha).

If the corncob weight per plot is converted, the result from 16.58 tons per ha will be lower than the one of sweet corn potential from 26.4 tons per ha. From the results of this research, it can be described that to improve the crop yields, the addition of green manure is needed in order to fulfill nutrients N, P, and K. Therefore, the crop yields can be equal to the ones in the data above.

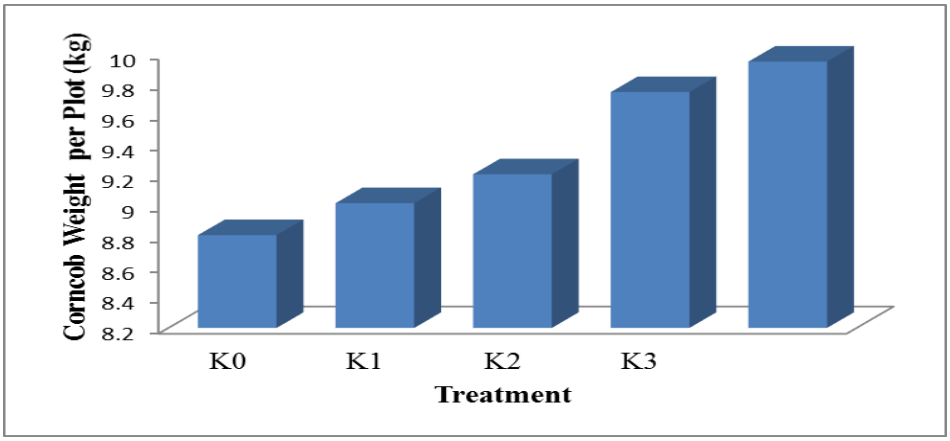

Figure 4: Histogram The effect of Green Manure *Callopogonium mucunoides* toward the Corncob Weight per Plot (kg) of sweet corns at the age of 3 WAP, 5 WAP, and 7 WAP

CONCLUSION

1. The use of green manure *Callopogonium mucunoides* has a real effect on plant height, corncob length, Corncob weight per plant Corncob weight per plot.

2. The use of green manure *Callopogonium mucunoides* with 20 tons per ha generates the tallest plants at the age of 3 WAP, 5 WAP, and 7 WAP in which each of them is (85.21 cm), (120.11 cm), and (191.79 cm) respectively, the longest corncob (21.91 cm), corncob weight per plant (437.25 g) and corncob weight per plot (9.95 kg).

SUGGESTION

It is suggested for other researchers to conduct a further research with the higher dosage from the already tested dosage

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