Impact of *Mucuna bracteata* Addition in Biofertilizer with Various NPK Doses on Sweet Corn (*Zea mays saccharata* Sturt.) Growth and Production

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Abstract. The effectiveness of bacteria in biofertilizers when applied to soil is essential to ensure optimal nutrient availability for plants. This research aims to determine the best combination of oil palm compost sludge and biofertilizer enriched with *M. bracteata* to enhance the growth and yield of sweet corn plants while reducing the use of inorganic NPK fertilizers that negatively impact the environment. The study was conducted using a non-factorial completely randomized design (CRD) with 8 treatments and 3 replications, resulting in 24 experimental units. Each unit included different concentrations of *M. bracteata* (0%, 5%, 7.5%, and 10%) combined with various NPK doses (100%, 75%, and 50%). The results indicated that biofertilizer combined with 10% *M. bracteata* significantly increased plant height, cob weight without husks, and cob length without husks in sweet corn and reduced NPK fertilizer usage by 50%. The novelty of this research lies in its potential for eco-friendly farming practices, offering dual benefits of enhanced crop yields and reduced environmental impact.

1 Introduction

Sweet corn (*Zea Mays saccharata* Sturt.) is a type of plant that originates from America and has been known and developed in Indonesia for quite a long time. Need corn sweet in every Riau Province the year increase along with increasing amount resident. Statistic of Indonesia reported that amount resident Riau Province in 2020 reached 6,394,087, in 2021 it will reach 6,493,603, and in 2022 it will reach 6,614,384 [1]. Efforts to meet corn needs, farmers generally still rely on inorganic fertilizers to increase sweet corn production.

Continuous use of inorganic fertilizers will have a negative impact on the environment and will reduce plant productivity. Fang et al found that excessive application of inorganic fertilizer without balance with the use of organic fertilizer can cause soil degradation results in changes in the physical properties of the soil such as compaction of the soil, changes in soil structure, a decrease in the number of soil organisms that are useful for decomposing organic matter, and a decrease in the nutrient content in the soil [2]. One way

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to reduce the use of inorganic fertilizer is by combining inorganic fertilizer and organic fertilizer. Replacing some inorganic fertilizers with organic fertilizers will certainly reduce the risk of soil damage while creating environmentally friendly corn cultivation.

Giving fertilizer organic in system agriculture aim for repair fertility physical, chemical, and biology land as well as streamline use fertilizer inorganic [3]. Organic material that can become potential organic fertilizer is sludge originating from palm oil processing. The amount of this waste is quite large in Riau so it has the potential to help the availability of organic fertilizer to support plant cultivation in Riau.

The use of sludge form oil palm as fertilizer really requires the help of decomposing bacteria so that the use of sludge form oil palm as organic fertilizer can be maximized. In this research, we used six bacteria consisting of two bacteria from rice straw (*Bacillus cereus* JP6 and *B. cereus* JP7), two bacteria from empty oil palm fruit bunches (*Proteus mirabilis* TKKS3 and *P. mirabilis* TKKS7) and two bacteria from acacia litter (*Providencia vermicola* SA1 and *B. cereus* SA6) [4]. The application of these bacteria will not only be limited to the sludge from oil palm composting process, but will also be provided directly in the form of biofertilizer. This is because *B. cereus* produces the IAA hormone [5], as a phosphate solubilization [6], *P. vermicola* is able to produce the IAA hormone [7], as a phosphate solubilization [8], and *P. mirabilis* produces IAA [9], as a phosphate solubilization [10]. The application of this bacterial consortium biofertilizer has been tested on several plants including rice [11, 12], chili plants [13-15], oil palm plantations [16, 17], corn [18]. The results of the research showed that by administering the bacterial consortium biofertilizer to the rice washing liquid media, it was able to provide the same growth and production as applying inorganic fertilizer alone without organic fertilizer. However, efforts need to be made to increase the effectiveness of bacteria in the soil by providing organic material as a carrier for these bacteria. One organic material that is also quite abundant is *M. bracteata* leaves. Utilization of *M. bracteata* leaf flour will also provide opportunities for bacterial storage material as biofertilizer. Therefore, the aim of this research is to obtain the best combination of sludge from oil palm compost and biofertilizer added to *M. bracteata* to increase the growth and production of sweet corn plants, as well as to reduce the use of inorganic NPK fertilizer which has a negative impact on the environment so that it will be profitable for sustainable farmers.

2 Materials and Methods

This research was carried out in Langsat Permai Village, Bunga Raya District, Siak Sri Indrapura Regency, Riau Province. The type of soil used is acid mineral soil. Sweet corn seeds used in this research was the Bonanza F1 variety. The fertilizer used in this research consisted of several fertilizers including NPK Mutiara 16:16:16 fertilizer, sludge from oil palm compost and biofertilizer with the addition of *M. bracteata* leaves. Bacteria used in making sludge from oil palm compost and biofertilizer consists from 6 isolates bacteria cellulolytic. This research was carried out experimentally with use design random complete (RAL) with eight treatment be repeated three times. His treatment namely P1 = 100% NPK fertilizer (300 kg.ha^{-1}), P2 = 75% NPK fertilizer (225 kg.ha^{-1}) + sludge from oil palm compost (20 t.ha^{-1}) + biofertilizer (30 mL) (without *M. bracteata*), P3 = 75% NPK fertilizer (225 kg.ha^{-1}) + sludge from oil palm compost (20 t.ha^{-1}) + biofertilizer (30 mL) (10% *M. bracteata*), P4 = 75% NPK fertilizer (225 kg.ha^{-1}) + sludge from oil palm compost (20 t.ha^{-1}) + biofertilizer (30 mL) (7.5% *M. bracteata*), P5 = 75% NPK fertilizer (225 kg.ha^{-1}) + sludge from oil palm compost (20 t.ha^{-1}) + biofertilizer (30 mL) (5% *M. bracteata*), P6 = 50% NPK fertilizer (150 kg.ha^{-1}) + sludge from oil palm compost (20 t.ha^{-1}) + biofertilizer (30 mL) (10% *M. bracteata*),P7 = 50% NPK fertilizer (150 kg.ha^{-1}) + sludge from oil palm compost (20 t.ha^{-1}) + biofertilizer (30 mL) (7.5% *M. bracteata*), P8 = 50% NPK fertilizer

(150 kg.ha^{-1}) + sludge from oil palm compost (20 t.ha^{-1}) + biofertilizer (30 mL) (5% *M. bracteata*). *M. bracteata* was chosen as a nutrient source for microorganisms because it has the advantages of high N fixation and high biomass production. Analysis of variance data that had a significant effect and no significant effect were further tested using Duncan's New Multiple Range Test (DNMRT) at the 5% level. Variance detection and subsequent testing were conducted using SAS application version 9.1 (developed by SAS Institute, USA).

2.1 Sludge palm oil

Making sludge from oil palm compost by rejuvenating 3 ml of bacterial consortium which is available in the laboratory, refreshing it again in 30 ml of sterile nutrient broth (NB) media and incubating for 1×24 hours at room temperature. Weigh the material that will be used for sludge from oil palm composting, 0.025 $MgSO_4.7H_2O$, 0.0375 NH_4SO_4, 0.125 KH_2PO_4, 0.0625 K_2HPO_4, 0.0025 $FeSO_4.7H_2O$, 0.005 $CaCl_7.2H_2O$, 0.25 *Yeast extract*. After that, put the ingredients into an Erlenmeyer flask and add 300 ml of distilled water, dissolve using *a hot plate* . The solution is then stored in the incubation box for 1×24 hours. A total of 30 ml of bacterial culture was refreshed on NB media, then inoculated again into 300 ml of liquid media containing 1% sludge from oil palm, then incubated for 3×24 hours at room temperature. The consortium culture of cellulolytic bacteria that has grown in liquid sludge from oil palm media is mixed into 150 liters of rice washing water and added with 600 g of granulated sugar, left for 3 hours before composting. The bacterial inoculum starter that has been mixed with rice washing water can be used directly to decompose 150 kg of sludge from oil palm. Next, add 1.5 kg of lime to the sludge from oil palm to be composted. Cover sludge from oil palm that have been given cellulolytic bacterial starter with dark colored plastic or tarpaulin to maintain a temperature of 38-50° C. Turning and watering is done once a week. After three weeks the compost is ready to use.

2.2 Manufacture biofertilizer plus *M. bracteata*

The process of manufacturing biofertilizer with *M. bracteata* was carried out by first refreshing the bacterial culture in 60 mL of nutrient broth (NB) medium, followed by incubation for 24 hours at room temperature. The grown culture was then mixed with 3 L of rice washing water and 300 g of brown sugar. The *M. bracteata* leaves were air-dried in a shaded area to avoid direct sunlight, ensuring the preservation of their chemical content. The leaves were left to dry for 4-5 days until they turned brown and wrinkled. Once dried, the leaves were blended into a fine powder. This powdered *M. bracteata* was mixed with the biofertilizer solution according to the treatment specifications: 100 g per liter for the 10% treatment, 75 g per liter for the 7.5% treatment, and 50 g per liter for the 5% treatment. The mixture was then incubated for 2 weeks at room temperature to facilitate fermentation and the formation of biofertilizer.

2.3 Land preparation

Preparation of the research land includes measuring land measuring 5.5 m x 38.5 m, then spraying herbicides and cleaning the research site from bushes, rubbish and all existing vegetation. Soil processing was carried out by chopping the soil and then creating research plots measuring 1 m x 6 m, totaling 24 plots with a distance between plots of 50 cm to obtain 20 plants per plot with a total population of 480 plants.

2.4 Providing treatment

NPK fertilizer was applied according to the prescribed dosage: 100% (300 kg/ha), 75% (225 kg/ha), and 50% (150 kg/ha). The application was divided into three stages, with 1/3 of the total amount given at 7 days after planting (DAP), 1/3 at 30 DAP, and the final 1/3 at 50 DAP. The fertilizer was mixed with the soil to enhance plant absorption. The application of oil palm compost sludge was conducted a week prior to planting, using a dosage of 20 tons/ha and distributed evenly across the prepared plots according to the treatment. Biofertilizer was directly sprinkled onto the plots, with 10 mL applied per plant at intervals of 14 DAP, 28 DAP, and 42 DAP.

2.5 Observations

Observations made in this research included plant height in plant growth and ear weight without husks, length of cobs without husks in plant yield.

3 Results And Discussion

3.1 Plant Growth

Based on research results, a combination of 75% NPK fertilizer + sludge from oil palm compost + biofertilizer with or without addition *Mucuna bracteata* and a combination of 50 % NPK fertilizer + sludge from oil palm compost + (biofertilizer + 10% *M. bracteata*) produces the plant height is relatively the same with giving 100% NPK fertilizer , however, in the combination of 50% NPK fertilizer + sludge from oil palm compost + biofertilizer with the addition of 5% and 7.5% *M. bracteata,* plant yields were not optimal (Table 1).

Table 1. Sweet corn plant height with various toppings combination of NPK fertilizer, sludge from oil palm compost and biofertilizer added *M. Bracteata*.

Combination Fertilizer	Plant Height (cm)
100% NPK fertilizer	227.66 a
75% NPK fertilizer + sludge from oil palm compost + biofertilizer (without *M. bracteata*)	224.16 abc
75% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 10% *M. bracteata*)	229.08 a
75% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 7.5% *M. bracteata*)	225.75 ab
75% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 5% *M. bracteata*)	224.75 abc
50% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 10% *M. bracteata*)	224.58 abc
50% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 7.5% *M. bracteata*)	221.50 bc
50% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 5% *M. bracteata*)	219.33 c

Note : The numbers on column that follows with letter same small different No real according to DNMRT on level 5% ; 100% NPK (300 $kg.ha^{-1}$) ; 100% sludge from oil palm compost (20 $ton.ha^{-1}$); biofertilizer (10 ml), 10% *M. bracteata* (100 $g.l^{-1}$).

Providing sludge from oil palm compost and biofertilizer with added *Mucuna bracteata* which can support the growth of sweet corn plants. sludge from oil palm compost and biofertilizer function to improve the physical properties of the soil, thereby providing good drainage and making it easier for air to enter the soil pores, which is then useful for root penetration so that the range of nutrient and water uptake becomes wider. Providing compost to the soil can improve soil structure, enrich the nutrients that plants really need, provide food for decomposing microbes, loosen the soil and reduce environmental pollution [20].

Good soil conditions will be utilized by the microbes contained in biofertilizer to grow well in the soil. The presence of microorganisms in the soil can improve the biological properties of the soil by increasing the number and activity of soil microorganisms in carrying out their function as decomposers. The results of the decomposition of organic material are useful for improving soil structure, as a result the soil becomes loose which makes it easier for roots to penetrate. The use of biofertilizer can increase the absorption of nutrients, water and soil productivity in intensive agricultural systems [21].

From the research results (Table 1) it can be seen that plant height will increase along with increasing doses of *M. bracteata* in the biofertilizer given. One of the microbial consortia in biofertilizer comes from the genus Bacillus. This type of bacteria has the ability to bind N from the air [9]. Nitrogen is the main nutrient for the growth of plant organs during the vegetative period because it is a constituent of amino acids, amides and nucleoproteins which are important elements for cell division. The availability of N is assisted by the addition of *M. bracteata* to biofertilizer. *M. bracteata* has an N content of up to 4.42% [22].

3.2 Crop Production

Table 2 shows that combination 75 % NPK fertilizer + sludge from oil palm compost + (biofertilizer + 10% *M. bracteata*) and a combination of 50 % NPK fertilizer + sludge from oil palm compost + (biofertilizer + 10% *M. bracteata*) produces cob weight without husk and the length of the cob without husks is relatively the same with giving 100% NPK fertilizer. However, the combination of 75% and 50% NPK fertilizer + sludge from oil palm compost + biofertilizer with the addition of *M. bracteata* (5% and 7.5%) or without the addition of *M. bracteata* was not able to produce the same weight of cob without husk and length of cob without husk by providing 100% NPK.

3.2.1 Cob Weight without Lobs and Cob Length without Lobs

The combination of NPK fertilizer, sludge from oil palm compost and biofertilizer with the addition of 10% *M. bracteata* produces cob weight without husks and cob length without husks that are relatively the same as when applying 100% NPK. The increase in cob weight and length shows that NPK fertilizer, sludge from oil palm compost and biofertilizer have an important role in sweet corn production. This is related to the high availability of P in the soil (Results of soil analysis after planting) where the P element is really needed by plants in cob formation. The availability of the nutrient P which is needed for plant growth affects the yield of sweet corn plants [23]. The P content helps improve soil properties to support plant growth which ultimately has an impact on plant production results. The availability of P elements in the soil from the application of sludge from oil palm compost is utilized efficiently in the vegetative phase of plants so that plants quickly enter the generative phase [24].

Table 2. Cob weight without cornhusk and long cob without cornhusk plant sweet corn with various toppings combination of NPK fertilizer, sludge from oil palm compost and biofertilizer added *M. bracteata*.

Combination Fertilizer	Cob Weight without cornhusk (g)	Cob Length without cornhusk (g)
100% NPK fertilizer	409 a	22.74 a
75% NPK fertilizer + sludge from oil palm compost + biofertilizer (without *M. bracteata*)	400 bc	22.02 b
75% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 10% *M. bracteata*)	408.33 a	22.77 a
75% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 7,5% *M. bracteata*)	401.41 bc	22.18 b
75% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 5% *M. bracteata*)	400.33 bc	22, 16 b
50% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 10% *M. bracteata*)	405.08 ab	22.37 ab
50% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 7,5% *M. bracteata*)	397 c	21.67 c
50% NPK fertilizer + sludge from oil palm compost + (biofertilizer + 5% *M. bracteata*)	396.41 c	21.55 c

Note : The numbers on column that follows with letter same small different No real according to DNMRT on level 5% ; 100% NPK (300 kg.ha^{-1}); 100% sludge from oil palm compost (20 ton.ha^{-1}); biofertilizer (10 ml), 10% *M. bracteata* (100 gl $^{-1}$).

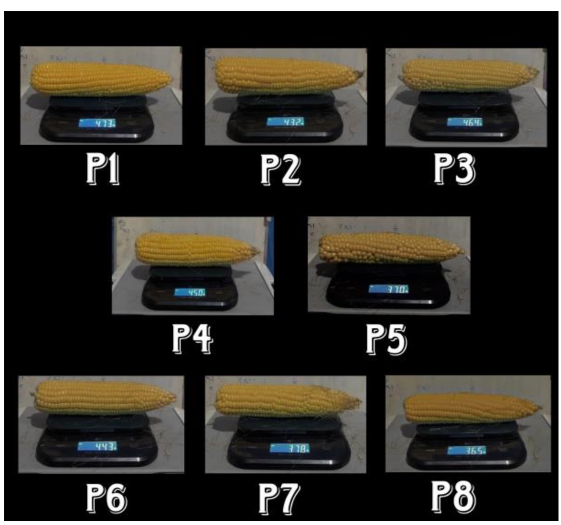

Fig. 1. Weight and cob length without cornhusk

Judging from observation data, the weight and length of sweet corn cobs are related to plant height growth. The taller the sweet corn plant, the bigger the fruit will be. This happens because the plants get maximum nutrients. The availability of nutrients is one of the factors that can influence the level of production of a plant. Plants will produce maximum production if the soil where they are planted is fertile. This causes good root penetration so that the nutrients provided by fertilization can be absorbed by the plant and will be translocated to ear formation and seed filling so that the weight of the ear without husks and the length of the cob without husks increases. Hapsoh et al. reported that plants will not produce maximum results if the necessary nutrients are not available [13].

Biofertilizers also play an important role in helping nutrient availability because they contain live microorganisms that can increase plant growth by increasing the supply of nutrients to plants. Biofertilizers contain ingredients that contain microbes that are beneficial for plant growth through colonization of plant roots and induction mechanisms that increase plant growth [14]. The presence of microorganisms in the soil can improve the biological properties of the soil by increasing the number and activity of soil microorganisms in carrying out their function as decomposers. The results of the decomposition of organic material are useful for improving soil structure, as a result the soil becomes loose which makes it easier for roots to penetrate and absorb nutrients. The microbial activity contained in biofertilizer will be maximized with the addition of *M. bracteata* . The analysis results showed that the number of microbes increased when the number of *M. bracteata* was increased. Microbes function to decompose organic material which is useful for improving soil structure, as a result the soil becomes loose which makes it easier for roots to penetrate. Reducing NPK will improve the performance of microbes in biofertilizer and sludge from oil palm compost. Our previous study revealed that organic fertilization stimulates microbial growth, changes the structure of soil microbial communities and increases enzyme activity compared with inorganic fertilization [15].

4 Conclusion

Based on the research results, it can be concluded that the application of a combination of 50% NPK fertilizer (150 kg.ha^{-1}) with sludge from oil palm compost 20 ton.ha^{-1} and biofertilizer 10 mL.L^{-1} added *M. bracteata* 10% capable increasing plant height, cob weight without husks and cob length without husks in sweet corn plants. Based on this, 50% NPK fertilizer, sludge from oil palm compost and biofertilizer added with 10% *M. bracteata* can give results best for growth And production plant sweet corn and can reduce the use of NPK fertilizer by 50%. These results show that the use of organic fertilizer can compete with the use of inorganic fertilizer, besides that the impact on the environment tends to be better than the use of inorganic fertilizer so it will help sustainable agriculture.

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