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Analysis of sweet corn growth and yield with the use of organic cow manure fertilizer

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Abstract

Sweet corn is a horticultural crop that is widely cultivated and consumed by Indonesian people. Meeting the demand for sweet corn is still reliant on imports; therefore, increasing production by improving soil properties through proper fertilization. Cow manure with a content of N 2.33%, P 0.61%, and K 1.58% is able to add nutrients to the soil. This research aimed to obtain an optimum dose of organic fertilizer for sweet corn growth and yield. The doses of cow manure consisting of 5 levels: control, 10, 20, 30, and 40 tons ha^{-1} were assigned in the randomized complete block design with 5 replications. Data analysis deployed analysis of variance (Anova) at 5% level, and if there were significant differences, it would be proceeded to Duncan Multiple Range Test 5% and orthogonal polynomial. The results showed that a dose of 20 tons ha^{-1} was able to increase growth in plant height, stem diameter and number of leaves by 12.92%, 26.29%, and 15.67%, respectively, compared to the control. A dose of 35 tons ha^{-1} can produce a weight of cob-husk and cob without-husk per plot, respectively, 4.38 kg $plot^{-1}$ and 2.64 kg $plot^{-1}$, and a productivity of cob-husk of 5.30 tons ha^{-1}. A dose of 38 tons ha^{-1} can produce a cob without-husk productivity of 3.29 tons ha^{-1}.

INTRODUCTION

Sweet corn is a horticultural crop that is widely cultivated and consumed by Indonesian people and has a different nutritional value than regular corn. The reducing sugars (fructose and glucose), sucrose, polysaccharides, and starch are abundant in sweet corn kernels. Sweet corn kernels have a 5–6% sugar content and a 10–11% starch level. In contrast, it is only 2–3% in regular corn, meaning that the sugar concentration of regular corn is less than half that of sweet corn.

According to data from the 2020 Badan Pusat Statistika (BPS), Indonesia imported 737.2 thousand tons of sweet corn in 2018–2019, a 42.46% rise over the previous year's 517.5 thousand tons (Wulan and Bintoro, 2021). The high level of imports is caused by insufficient sweet corn production to meet the consumers' needs.

Superior quality cultivation, especially sweet corn, is heavily reliant on balanced and sufficient fertilization with nutrients. Alfisol soil has a low level of chemical fertility but has good physical properties (Hely, 2022). The total nutrient content of the research site is 0.08% (very low) for nitrogen, 29.21 mg/100g (medium) for P, 12.26 mg/100g (low) for K, 0.39% (extremely low) for organic C, and 4.84 (very low) for C/N ratio, according to the findings of the preliminary soil analysis. Alfisol soil has a low organic matter level; hence, more organic matter is required to supply nutrients for the plants and soil. Increasing fertilizer application is one way to boosting corn production, achieved through the intensified use of fertilizer. Fertilization aims to improve soil fertility and

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meet the nutrient needs in plant growth process (Su'ud et al., 2018). Nutrients that are not fully provided can disrupt plant growth and development, preventing the growth process from occurring normally and optimally (Fauzi et al., 2019).

Cow manure is an organic fertilizer that offers many benefits for soil fertility, provides nutrients to plants, and improves soil properties (Cely et al., 2015). Cow manure can provide benefits by providing macronutrients and micronutrients for plants (Efendi et al., 2017). Cow manure has a positive effect on plant growth and yield because it can improve soil structure, provide nutrients, loosen the soil, and make it easier for plants to absorb water (Damtew, 2022). While some of it passes through a nitrification process, corn plants can use this kind of ammonium to thrive. Nitrification necessitates enough aeration because it is an oxidation process (Suntoro et al. 2018). According to Wiryanta (2002) in Yulianto et al.) 2022), the nutrient content of organic cow manure fertilizer is N 2.33%, P 0.61%, and K 1.58%. The treatment dose used is based on previous research doses where the recommended dose for sweet corn is 30 tonnes/ha.

The nutrients in cow manure are complete and reasonably accessible to plants. This is because, in a short amount of time, the food item has undergone a complete metamorphosis. Some of the solids in manure are composed of organic substances that are similar to the food the animal has consumed, such as cellulose, sugar, and starch, hemicellulose, and lignin, which are present in humus's ligno-protein of humus (Mutegi et al. 2012). Fertilizing with organic fertilizer requires careful attention to the type and dosage of fertilizer used. Based on this, there needs to be a study regarding the use of organic fertilizer types and what the best dose is for sweet corn plants. This research aimed to determine the optimum dose of cow manure for the growth and yield of sweet corn.

MATERIALS AND METHODS

The research was conducted in June–September 2023 at the Faculty of Agriculture, Universitas Sebelas Maret (UNS). The tools and materials needed in this research were digital scales type RESHY High Precision, heating ovens FD 240 I merk binder, digital caliper, SPAD 502Plus Konica Minolta, a lux meter type LX1330B, RHS Color Chart color categories by UPOV, sweet corn seeds (Bonanza F1), cow manure fertilizer, and NPK Mutiara fertilizer. The research used a randomized complete block design (RCBD) with one factor, which was the dose of cow manure, with 5 levels of treatment: control, 10, 20, 30, and 40 tons ha^{-1}, and repeated 5 times, making it 25 experimental units in total. There were 25 experimental plots, each measuring 375 cm × 175 cm, with a planting distance of 75 cm × 25 cm, resulting in 35 plants per plot. The data were obtained by observing 3 sample plants and 3 destructive plants in each experimental plot, resulting in 75 sample plants and 75 destructive plants.

The research implementation consisted of land preparation, processing cow manure, planting, maintenance and harvesting. Organic fertilizer treatment was applied as basic fertilization method, carried out 1 week before planting. The fertilizer was sprinkled and evenly distributed across each plot according to the treatment. The corn plants were maintained by providing additional fertilizer, watering, and controlling pests. Additional fertilization was provided to corn plants using NPK Mutiara (16:16:16) fertilizer at the age of 2 days after plant and 7 days after plant, each amounting to 468 kg ha^{-1} or 8.77 grams per plant, by immersing it near the plant.

The variables observed were plant height, stem diameter, number of leaves, greenness of leaves, fresh weight, dry weight, weight of cobs with husks and without husks, diameter of cobs with husks and without husks, length of cobs with husks and without husks, number of seeds, and seed color. Data were analyzed with Anova at 5% level, and we continued with Duncan Multiple Range Test at the 5% level if there is significantly and orthogonal polynomials.

RESULTS AND DISCUSSION

Plant height

According to the data analysis, sweet corn plant height at 11 weeks after planting (WAP) was significantly impacted by the amount of cow manure applied. As the amount of cow manure applied to the plants increases, the height of the corn also increases. The plant height of 160.81 cm was produced by the 40 tons ha^{-1}, significantly higher than the control, which was 140.70 cm (Table 1). Low plant height is caused by a lack of nutrient uptake in plants. Lack of essential nutrients in plants can disrupt the cell division process, which results in stunted corn plant growth, characterized

by slow development and reduced plant size (Sofyan et al., 2019). Although it is not different substantially from the dose of 10 tons ha^{-1}, the cow manure dose of 40 tons ha^{-1} has the highest average plant height. Cow manure may make the soil more ideal in both physical and biological aspects, ensuring that nutrients are available for plants to use during growth, and provide the vital nutrients that sweet corn require in order to grow. The macro and micronutrients found in cow dung contribute to the vegetative growth of plants, particularly the height of maize plants (Setiono and Azwarta 2020).

Stem diameter

The data analysis showed that the dose of cow manure had a significant effect on the stem diameter of sweet corn at 11 Week after planting (WAP). A dose of 30 tons ha^{-1} was able to produce stem diameter of 23.26 mm, and was significantly different from the control, which was 17.91 mm (Table 1). Plants that are not given cow manure produce suboptimal diameter due to the lack of nutrients available in the soil. Providing cow manure to the soil can support the availability of nutrients that function to support the growth of plant stem diameter (Setiono and Azwarta, 2020). Cow manure has an effect on increasing the diameter of the stems diameter of sweet corn because it contains the nutrient NPK, which is needed by plants to stimulate the enlargement of stem diameter.

Number of leaves

Based on the data analysis, the quantity of leaves was significantly impacted by the cow manure dosage. The average number of leaves produced by a dose of 30 tons ha^{-1} was 11.13, which was significantly more than the control, which had 9.57 leaves (Table 1). Cow manure is a good source of nutrients, which are important for plant vegetative growth and development, such as the number of leaves (Eleduma et al., 2020). The availability of nutrients such as N, P, and K in the soil will affect the process of corn leaf emergence, where low availability of these nutrients will inhibit the leaf growth process (Berutu et al., 2019). The nutrients contained in cow manure and high levels of organic material are used by plants for the growth and development of plant organs, such as leaf formation. The N element produced from the mineralization of cow manure plays an important role in the formation of leaves (Suntoro, 2018).

Shade of green

The results of the data analysis showed that the amount of cow manure strongly influenced how green the sweet corn leaves were at 8 WAP. As the amount of cow manure applied was increased, so did the degree of leaf greenness. The average leaf greenness of the 40 ton ha^{-1} dose was 44.89, which was substantially different from the control and the 10 ton ha^{-1} cow manure dose (Table 1). The difference in the level of green in sweet corn plant leaves is affected by the nutrient content available to the corn plant. According to Dharmadewi (2020), the greener the color of a leaf, the higher the chlorophyll content. The level of greenness of the leaves is affected by the nitrogen content absorbed by the plant (Pangaribuan et al., 2022). Cow manure is able to provide nitrogen elements for plants. Cow manure provides N function used for leaf growth, makes corn leaves wider and greener, and is also used by plants in the formation of chlorophyll in leaves (Anang et al., 2019).

Table 1. Differences in doses of cow manure affect plant height, stem diameter, number of leaves, greenness of leaves, and dry weight

Cow manure dosage (tons ha^{-1})	Growth variable				
	Plant height 9 WAP (cm)	Stem diameter 8 WAP (mm)	Number of leaves 8 WAP (sheet)	Greenness of leaves 11 WAP	Dry weight 11 WAP (g)
0	140.70 a	17.91 a	9.57 a	41.83 a	59.56 a
10	151.39 ab	20.23 ab	9.87 ab	42.30 ab	76.91 a
20	158.85 b	22.62 b	11.07 c	43.45 bc	99.86 b
30	160.33 b	23.26 b	11.13 c	43.55 bc	118.60 b
40	160.81 b	22.86 b	10.60 bc	44.89 c	122.86 b

Remarks: Means sharing the same letters within the same column exhibit no significant difference at a 5% level of DMRT. WAP: Week After Plant.

Dry weight

The dry weight of corn plants at 11 WAP varied greatly depending on the amount of cow manure treated. The total amount of biomass a plant contains can be determined by measuring the dry weight of its roots and branches. In comparison to a cow manure dose of 10 tons ha^{-1} and the control, a dose of 40 produced a dry plant weight of 122.86 grams (Table 1). According to Prawinata et al. (2002) in Tarigan and Nelvia (2020), the availability of sufficient nutrients will encourage good plant growth, thereby increasing the plant dry matter formed. According to Sarif et al. (2015), healthy metabolism processes like photosynthesis are linked to plants' increasing dry weight; the higher the dry weight, the more effectively the photosynthesis occurs in plants, and the faster the tissue cells grow and generate. A strong root system will maximize nutrient uptake, which will subsequently be dispersed throughout the plant to develop its organs (Augustien and Suhardjono, 2017).

Weight of cobs per plant

The weight of sweet corn husk cobs had been significantly affected by the amount of cow manure, according to the data analysis. In contrast to a dose of 10 tons ha^{-1} and the control, a dose of 40 resulted in a mean weight of cobs per plant of 256.33 grams (Table 2). The availability of nutrients and nutrient uptake in plants will affect the cob weight of sweet corn plants (Sa'adah et al., 2022). Because nitrogen is involved in protein formation, phosphorus in fruit and seed development, and potassium element in carbohydrate formation, which in turn influences corn cob production, the NPK element found in cow manure has an impact on the weight of sweet corn cobs (Huvat 2020). The formation of sweet corn cobs is affected by nutrient uptake in plants, where the unavailability of nutrients for sweet corn plants will cause suboptimal cob weight (Alatas et al. 2019). The organic components and important minerals included in cow manure can improve yields of maize and plant uptake of nutrients. (Kiran et al. 2017).

Diameter of cobs per plant

The data analysis indicated that the width of sweet corn husk cobs was greatly affected by the amount of cow manure. The mean diameter of husk cobs produced by a 40 tons ha^{-1} was 47.20 mm, which was significantly greater from the control and a 10 tons ha^{-1} (Table 2). Applying cow manure to sweet corn can increase the diameter of the cob, and the wider the diameter of the corn cob, the higher the weight of the cob produced. Plants that lack nutrients will produce suboptimal results both qualitatively and quantitatively, such as a cob diameter that is not ideal. Sufficient nutrients in plants will facilitate the photosynthesis process in plants, so that the accumulated photosynthesis will increase and have an impact on the corn cob formation (Khadijah et al., 2017).

Cob yield per plot

The data analysis shows that a dose of 35.5 tons ha^{-1} is capable of producing a husky cob weight of 4.38 kg $plot^{-1}$ with a coefficient of determination of $R^2 = 0.9743$ (Figure 1). These results indicate that increasing the dose of cow manure affects the weight of husky cobs per plot by 97%. Cow manure contains N, P, and K. Jurhana et al. (2017) stated that the N element in cow manure will help in the formation of chlorophyll for plant photosynthesis, P for the formation of fruit and seeds, and the K element for accelerating the plant's metabolic rate. Plant growth

Table 2. Differences in cow manure dosage on husk cob weight, husk cob diameter, cob yield per hectare, and sweet corn seed color

Cow manure dosage (tons ha^{-1})	Weight of cobs (g)	Diameter of cobs (mm)	Seed color
0	120.73 a	34.67 a	11C (Pale yellow)
10	180.26 b	39.38 b	10C (Light yellow)
20	233.07 c	45.66 c	13B (Brilliant yellow)
30	252.47 c	45.71 c	13B (Brilliant yellow)
40	256.33 c	47.20 c	13A (Vivid yellow)

Remarks: Means sharing the same letters within the same column exhibit no significant difference at a 5% level of DMRT. WAP: Week After Plant.

and development will be more ideal if these nutrients are fulfilled. The weight of the sweet corn sample, which was 3 kg plot^{-1}, was significantly impacted by cow dung. This is demonstrated by the sweet corn sample's weight which increased to an average of 193.63 g (Ginting, 2022).

The data analysis shows that a dose of 35.5 tons ha^{-1} is capable of producing a cob weight without husk of 2.64 kg plot^{-1} with a coefficient of determination of $R^2 = 0.9286$ (Figure 2). These results indicated that increasing the dose of cow manure affects the weight of cobs without husks per plot by 92%. Jurhana et al. (2017) stated that cow manure contains microorganisms to break down organic matter so that the nutrients in the soil become available to plants. The nutrients provided by cow manure in the soil and absorbed by plants will help corn in the vegetative and generative phases. Plants will absorb nutrients, thereby increasing plant growth, and good plant growth will lead to good production results.

Productivity per hectare

The data analysis shows that a dose of 34.6 tons ha^{-1} is capable of producing a husky cob weight of 5.30 tons ha^{-1} with a coefficient of determination of $R^2 = 0.9743$ (Figure 3). These results indicate that increasing the dose of cow manure affects the productivity of sweet corn husk cobs by 97%. A form of fertilizer containing a significant amount of organic matter is cow manure. According to Maharani (2019), soil that is fertile and contains lots of organic material will help plants in their growth and development processes. Good plant growth will influence good plant results. Based on research Li et al., (2022), applying cow manure greatly increased maize yield, as well as the number of kernels per ear, ear diameter, and ear length. In comparison to a treatment control, the application of cow manure enhanced corn production by 6.0% to 28.4%. More significantly, a maximum yield of 8.14 t.ha^{-1} was attained in the treatment with a cow manure addition rate of 24 t.ha^{-1}.

The data analysis shows that a dose of 37.8 tons ha^{-1} is capable of producing a cob weight without husk of 3.29 tons ha^{-1} with a coefficient of determination of $R^2 = 0.9286$ (Figure 4). These results indicate that increasing the dose of cow manure affects the productivity of sweet corn cobs without husks by 92%. The productivity of cobs without husks per hectare showed an increase along with the additional dose given. According to Amazihono et al. (2022), organic fertilizer is able to contribute phosphorus and potassium, which plants need for cob formation. Good cob formation will influence optimal cob size and weight, so that productivity increases.

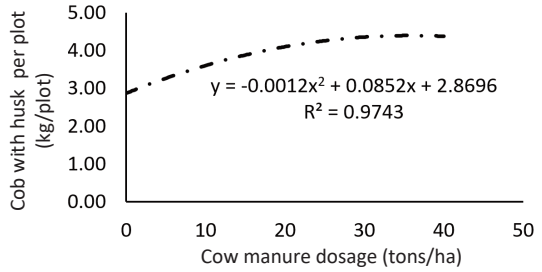

Figure 1. Weight of cob with husks per plot with different doses of cow manure at 11 WAP

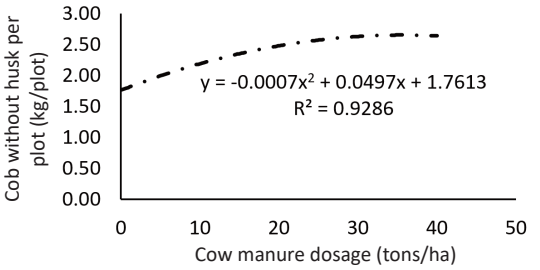

Figure 2. Weight of cob without husks per plot with different doses of cow manure at 11 WAP

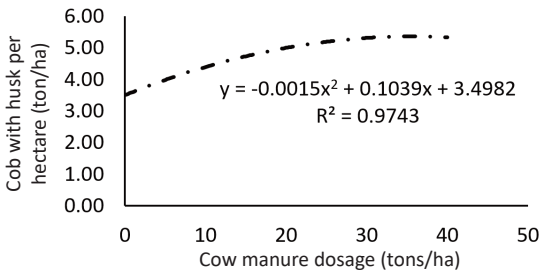

Figure 3. Productivity of cob with husks per hectare with different doses of cow manure at 11 WAP

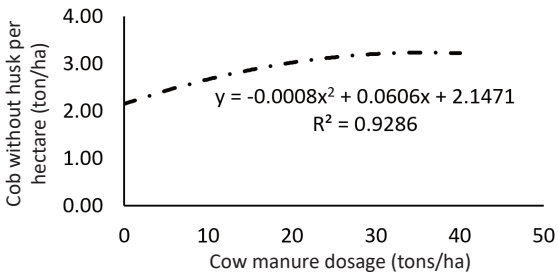

Figure 4. Productivity of cob without husks per hectare with different doses of cow manure at 11 WAP

Seed color

Based on the naming of the RHS Color Chart color categories by UPOV (International Union for the Protection of New Varieties of Plants) (2018), the color of the seeds in the control and the doses of 10 tons ha^{-1}; 20 and 30 tons ha^{-1}; as well as a dose of 40 tons ha^{-1}, were categorized as light yellow, dark yellow, and medium yellow-orange, respectively. Color can be used as an indicator of freshness and ripeness. Sweet corn plants that are ready to be harvested have several indicators (Irawan and Hidayah, 2017). Indicators that sweet corn plants are ready for harvest include the cob's hair turning blackish brown, the tip of the cob being completely filled, and the seeds turning yellow. The color of the seeds in the control and doses of 10 tons ha^{-1} was light yellow, while the dose of 20 and 30 tons ha^{-1} was dark yellow, and dose was 40 tons ha^{-1} was orange yellow. The color of the seeds is affected by the maturity of the cobs at harvest. In the control and the 10 tons ha^{-1} dose treatments, the corn cobs are still in the process of ripening, so the cob color has not yet reached dark yellow. Low availability of nutrients results in low photosynthesis processes, which can slow down the process of plant growth and development (Ernita and Yetti 2017).

CONCLUSIONS

Based on research results, a dose of 20 tons ha^{-1} with the addition of NPK Mutiara of 468 kg ha^{-1} was able to increase the growth of sweet corn in terms of plant height, stem diameter, and number of leaves, each 12.92%, 26.29%, and 15.67% respectively. A dose of 35 tons ha^{-1} was able to produce a cob weight with husk and a cob weight without husk per plot of 4.38 kg and 2.64 kg, respectively, resulting in a productivity of 5.30 tons ha^{-1} for cobs with husk. A dose of 38 tons ha^{-1} can result in cob productivity of 3.29 tons ha^{-1} without husk.

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