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Enhancing Entisols Physical Properties and Sweet Corn Agronomic Performances with Liquid Organic Fertilizer and Cow Manure

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ABSTRACT

Entisols, comprising approximately 10.6% of Indonesia's land area, are youthful soils distinguished by sandy texture, loose structure, ample aeration porosity, rapid permeability, low water retention, and diminished organic matter. This study determines the optimal dosages of liquid organic fertilizer and cow manure capable of enhancing the physical attributes of Entisols and the growth and yield of sweet corn plants. Employing a Randomized Complete Block Design (RCBD) with two factors, the research evaluates three doses of cow manure (0 tons ha^{-1}, 5 tons ha^{-1}, and 10 tons ha^{-1}) and four concentrations of liquid organic fertilizer (0 mL L^{-1}, 100 mL L^{-1}, 200 mL L^{-1}, and 300 mL L^{-1}). The findings reveal that liquid organic fertilizer significantly influenced soil wet weight and pF pressure at 0.1 atm (12.68 g^{-1}). Application of cow manure demonstrates tangible improvements in Entisols properties, with water content at 12.15%, bulk density at 0.73 g m^{-3}, permeability at 90.57 cm hour^{-1}, and soil wet weight and pF pressure at 0.1 atm (15.10 g). Furthermore, liquid organic fertilizer contributes to a plant height of 176.82 cm and husk cob weight of 8,545 kg/ha, while cow manure results in a plant height of 174.05 cm and husk cob weight of 8.044 kg ha^{-1}. The optimal combination emerged with a 300 mL L^{-1} concentration of liquid organic fertilizer or a 10 tons ha^{-1} dose of cow manure, showcasing superior enhancements in Entisols' physical properties, as well as sweet corn plant growth and yield.

Keywords : *Entisols, cow manure, liquid organic fertilizer, sweet corn*

INTRODUCTION

The Entisol soil type, constituting 10.6% of Indonesia's land, is relatively young. It exhibits limited horizons and is characterized by a high distribution of sandy texture. Entisols face challenges due to poor soil properties, including rapid permeability, moderate drainage, and susceptibility to erosion (Putra *et al*., 2022). Typically dominated by sand fractions, Entisols have low organic matter, resulting in loose soil structure with large particle spaces, facilitating rapid water and air movement to lower soil layers (Anggriawan & Tripama, 2014). Factors influencing soil water retention include soil structure, texture, and pore space. High sand fractions in Entisols reduce nutrient absorption and base cation retention, lowering soil pH (Arifin, 2011). These unfavorable soil conditions for plant growth can be addressed by incorporating organic matter into the soil.

Organic matter, a complex natural compound, plays a vital role in determining soil structure and aggregate formation. Organic fertilizers enhance soil microorganism activity, chemical processes, and physical properties, promoting favorable conditions for plant growth (Rahma *et al*., 2014). Organic inputs improve soil aeration, water retention, resilience, nutrient availability, and serve as a food source for soil microorganisms (Putinella, 2014). Natural substances like organic matter play a crucial role in binding soil particles, enhancing the stability of soil aggregates. Organic fertilizers come in two forms: solid, such as manure, and liquid.

Liquid Organic Fertilizer (LOF) results from the decomposition of natural materials and improves soil structure and quality, aids in nutrient availability, enhances crop production and quality, and is environmentally friendly when used continuously (Nur *et al*., 2016). LOF provides nutrients directly absorbable by plant roots, offering flexibility in application through foliar spraying or root watering (Kusmarwiyah & Erni, 2011).

Cattle manure, a product of natural organic decomposition, serves as a natural fertilizer, improving nutrient availability and enhancing plant production indirectly. It contains macro and micronutrients, contributing to water retention, soil structure improvement, and providing energy for soil microorganisms. Incorporating cattle manure into the soil increases water-holding capacity and benefits plant growth (Yulitonsana *et al*., 2015). The use of cattle manure enhances soil fertility by improving structure and permeability (Kuyik *et al*., 2013). Cattle manure is a valuable nutrient source, increasing soil water retention, and the microorganisms present in manure can synthesize specific compounds beneficial for plant absorption (Gole *et al*., 2019).

Corn (*Zea mays* L.) requires ample water during its growth, with sweet corn being a favored commodity in Indonesia for its taste and nutritional content. Despite a 22% annual increase in corn consumption from 2008 to 2013, production decreased by 14.72%. Nutrient deficiency, including soil nutrient availability, is a limiting factor in sweet corn growth. Natural compost from animal waste plays a crucial role in soil physical improvement and nutrient availability, making organic fertilizers a sustainable choice for agriculture (Kuyik *et al*., 2013).

This research aims to determine the appropriate doses of liquid organic fertilizer and cattle manure to improve several physical properties of Entisols and assess their impact on the growth and yield of sweet corn plants.

MATERIALS AND METHODS

This research was conducted from October 2022 to February 2023 in Beringin Raya Subdistrict, Muara Bangkahulu District, and the analysis of soil physical properties was carried out at the Soil Science Laboratory, Faculty of Agriculture, University of Bengkulu. The study design employed a Complete Randomized Block Design (CRBD) with two factors. The first factor was cow manure, consisting of three doses (H_0 = 0 tons ha^{-1} or control, H_1 = 5 tons ha^{-1}, and H_2 = 10 tons ha^{-1}). The second factor was liquid organic fertilizer, comprising four concentrations (P_0 = 0 mL L^{-1} or control, P_1 = 100 mL L^{-1}, P_2 = 200 mL L^{-1}, P_3 = 300 mL L^{-1}). The treatments were replicated three times, resulting in a total of 36 experimental units (3 x 4 x 3).

The main material for producing Liquid Organic Fertilizer (LOF) was organic waste from households, such as vegetable residues weighing 10 kg, which were then chopped into 3-5 cm pieces to expedite the decomposition process. The chopped vegetables were placed in a composting tool made from a water drum with holes on the left and right sides for air circulation. A tap at the bottom of the drum facilitated the drainage of LOF. EM4, diluted with water, was added according to the prescribed dose into the drum containing chopped vegetables as an activator to expedite decomposition. Composting was carried out for approximately 4 to 5 weeks until maturity, characterized by dark brown LOF with no unpleasant odor. Subsequently, the LOF was filtered and ready for application to plants.

Each plot was created with dimensions of 2 m x 2.5 m and a spacing of 30 cm between plots. The land was minimally cultivated using a hoe to loosen the soil, remove weeds, and create plots. Cattle manure was applied according to the predetermined doses for each plot: H_0 = 0 tons ha^{-1} (control), H_1 = 5 tons ha^{-1}, and H_2 = 10 tons ha^{-1}. Cattle manure was applied once during plot creation and incubated for 14 days before planting.

Planting was done manually with dibbling, placing two corn seeds in each hole at a depth of 2-3 cm and a spacing of 25 cm x 75 cm. Basal fertilizer, comprising 50% of the recommended Urea, SP-36, and KCl, was applied. Urea was applied twice, first at 15 days after planting (DAP) with Urea and SP-36, and the second at 35 DAP with Urea and KCl.

Liquid organic fertilizer was applied when the corn was two weeks old by spraying it evenly on the entire plant. The application of LOF followed the concentrations assigned to each plot: without LOF (P_0 = 0 mL L^{-1}, control), LOF dose P_1 = 100 mL L^{-1}, LOF dose P_2 = 200 mL L^{-1}, and LOF dose P_3 = 300 mL L^{-1}, applied weekly from 08:00 to 10:00 AM until the 6th week of the corn's vegetative period.

Harvesting was conducted when the corn reached the harvest age of 72 DAP, characterized by 70-80% of the cob husks turning yellow, yellowing leaves, brownish tassel hairs, fully filled cobs, and a milky liquid when pressed from the kernels. Plant height measurements were taken from 2 days after planting (DAP) until the end of the vegetative period (6 WAP) using a meter, measuring from the base of the stem to the tip of the highest leaf in centimeters (cm). Cob weights were measured with an analytical balance. Soil moisture content was measured using the Gravimetric method (Chairani *et al*., 2015) with the formula:

$$\text{SMC (\%)} = \frac{BB-BK}{BK} \times 100\%$$

Where:
SMC = soil moisture content
BB = wet weight of air-dried soil sample
BK = dry weight of oven-dried soil sample
Bulk density (BV) was analyzed using the Gravimetric method (Nurhartanto *et al*., 2022) with the formula: BV = (dry weight of soil (g))/(soil volume (cm^3))

Capillary potential (pF) indicates the soil's water retention energy. The pF analysis method used a pressure plate apparatus (Rusman *et al*., 2015). Plant height was measured using a meter from the base of the stem to the tip of the highest leaf. Plant height was routinely measured every week from 2 WAP until the end of the corn's vegetative period. Corn cobs were weighed with their husks using an analytical balance. Supporting data observed included the analysis of liquid organic fertilizer content, including Organic Carbon, N, P, K, analysis of cattle manure content, rainfall (mm), air temperature (°C), and air humidity (%) obtained from the Meteorology, Climatology, and Geophysics Agency.

Soil permeability was analyzed using the constant head permeameter method (Putri, 2019) with the formula:

$$K = \frac{Q \times L}{t \times h \times A}$$

Where:
K = permeability (cm $hour^{-1}$)
Q = amount of water flowing per measurement (mL)
L = thickness of the soil sample (cm)
t = measurement time (hours)
h = water head, height of the water surface from the soil sample surface (cm)
A = surface area of the soil sample (cm^2)

The research data were analyzed using Analysis of Variance (ANOVA) with a significance level of 5%. If a significant difference was observed, it was followed by the Least Significant Difference (LSD) test at a 5% level of significance.

RESULTS AND DISCUSSION

The research was conducted from October to December 2022 in the Beringin Raya Village, Muara Bangkahulu Subdistrict, Bengkulu City, on Entisols soil type. The treatment involved various concentrations of liquid organic fertilizer from household waste, sprayed on the leaves of sweet corn plants, and various doses of cow manure fertilizer. Initial soil laboratory analysis showed organic C content of 0.112%, moisture content of 11.11%, bulk density of 0.95 g cm^{-3}, a saturation difference of 8.3, and soil permeability of 139.27 cm $hour^{-1}$. Cow manure fertilizer contains N 0.4-1%, P 0.2-0.5%, K 0.1-1.5%, and moisture content of 85-92% (Mading *et al.*, 2021). Meanwhile, vegetable residue POC has C-organic content of 3.189%, total N 5.740%, total P 0.285%, and total K 0.48%.

Based on climate data from the Pulai Baai-Bengkulu Climatology Station, the climate conditions during the study from October to December 2022 had an average rainfall of 353.6 mm $month^{-1}$ to 652.2 mm $month^{-1}$, average temperature of 26.20°C to 26.70°C, and average humidity of 82.6% to 86.9%. Corn plants require more sunlight, ideal rainfall between 85 mm $month^{-1}$ to 200 mm $month^{-1}$, and a temperature range of 23 °C to 30 °C (Paski *et al.*, 2017).

Corn plants (*Zea mays* L.) were attacked by armyworms at 24 days old, and at 43 days old, they were attacked by armyworms and grasshoppers, causing some leaves to be perforated and torn. Control measures included killing the caterpillars and spraying with the insecticide DuPont Lannate, with an active ingredient of 25% methomyl, at a dose of 1 -1.5 g L^{-1} of water. Control measures were continued until signs of infestation disappeared.

Table 1. Summary of variance analysis results

Observed variables	F-value		
	Cow manure	LOF	Interaction
Soil moisture content#	5.75*	0.29^{ns}	0.75^{ns}
Bulk volume	22.85*	0.67^{ns}	0.93^{ns}
Permeability	43.12*	1.08^{ns}	0.52^{ns}
pF	125.74*	4.36*	0.75^{ns}
Plant height	7.29*	8.24*	0.94^{ns}
Ear weight	3.57*	4.29*	0.52^{ns}

Note: * = significant effect, ns = no significant effect, # = transformation of data X^5

Observation data were analyzed using Analysis of Variance (ANOVA) at a significance level of α 5%. The summary of the data analysis results can be seen in Table 1.

The analysis results indicate that the treatments given did not have interactions on the observation variables. Data transformation was performed on the moisture content variable using the Box-Cox method. The application of POC significantly affected the difference in saturated weight and pF pressure of 0.1 atm, plant height, and ear weight but had no significant effect on moisture content and bulk volume variables. This is likely due to the nutrient content in liquid organic fertilizer, ensuring that the plant's needs for development, growth, and health are met (Chasanah *et al.*, 2018).

The application of organic materials such as cow manure significantly affected soil moisture, bulk volume, permeability, pF, plant height, and ear weight. Cow manure plays a role in improving the physical properties of the soil, consistent with the findings of Muyassir *et al.* (2012), stating that organic matter can improve the chemical, physical, and biological properties of the soil.

The application of liquid organic fertilizer had no significant effect on soil physical properties. The process of making liquid organic fertilizer utilizes extracts of composted organic materials. Liquid organic fertilizer can be applied directly to plant leaves, and nutrient absorption can occur directly. However, the application of different concentrations of liquid organic fertilizer had no significant effect on soil moisture content, bulk volume, and permeability. The application of liquid organic fertilizer to the leaves did not directly affect the soil because it did not come into direct contact with the soil. Nevertheless, the concentration of 300 mL L^{-1} of liquid organic fertilizer yielded the highest value for soil moisture content, while bulk volume and permeability had the lowest values at that concentration. In the pF variable, there was a significant difference in the difference between saturated weight and pF given a pressure of 0.1 atm.

The application of cow manure had a significant effect on soil moisture content, bulk volume, permeability, pF, plant height, and ear weight. The dose of 10 tonss/ha of cow manure produced the highest values, while the control without cow manure had the lowest values. Cow manure contributed significantly to improving the physical properties of the soil, as supported by the findings of Muyassir *et al*. (2012) and Wawo (2018).

Permeability is an important aspect of the hydrological cycle that affects the amount of water in the soil. The application of cow manure had a significant effect on soil permeability in this study. The highest average value of 136.14 cm $hour^{-1}$ was obtained with the application of 0 tons ha^{-1} of cow manure, while the lowest average value of 90.57 cm $hour^{-1}$ was found with the application of 10 tons ha^{-1} of cow manure. The decrease in permeability indicates an increase in the soil's water retention capacity. Natural or organic materials help improve sandy soil, making water and nutrients available and absorbable by plants.

The pF of the soil represents its ability to retain water. The application of 0 tons/ha of cow manure produced the lowest average value of pF, indicating a low ability to retain water. Meanwhile, the application of 10 tons ha^{-1} of cow manure produced the highest average value of pF, indicating a high ability to retain water. The ability of the soil to retain water is influenced by the availability of organic matter and microorganisms (Sisworo *et al*., 2015). The higher the pF value, the better the soil's ability to retain water, which is important for plant growth.

Plant height and ear weight were significantly affected by the application of cow manure. The dose of 10 tons ha^{-1} produced the highest values, indicating that cow manure contributes to plant growth and development. The increase in plant height and ear weight is likely due to the improved physical properties of the soil, making it more conducive to plant growth. This is consistent with the findings of Muyassir *et al*. (2012), who reported that cow manure can improve the chemical, physical, and biological properties of the soil, leading to increased plant growth and yield.

Table 2. Effect of liquid organic fertilizer application on soil physical properties.

LOF (mL L-1)	Average value			
	Moisture content	Bulk volume	Permeabiliy	Difference between saturated weight and pF pressure 0.1 atm
	(%)	(g cm^{-3})	(cm $hour^{-1}$)	(g)
0	11.52	0.88	118.98	11.10b
100	11.53	0.85	114.44	11.23b
200	11.66	0.83	114.67	11.58b
300	11.81	0.83	108.82	12.68a

Note: Numbers followed by the same letter in the same column are not significantly different according to Tukey's Honestly Significant Difference (HSD) test at a 5% significance level

Table 3. Effect of cow manure application on soil physical properties and plant growth

Cow manure (tons ha-1)	Average value			
	Moisture content	Bulk volume	Permeabiliy	Difference between saturated weight and pF pressure 0.1 atm
	(%)	(g cm^{-3})	(cm hr^{-1})	(g)
0	11.11b	0.95a	136.14a	8.40c
5	11.63ab	0.86b	115.97b	11.46b
10	12.15a	0.74c	90.57c	15.10a

Note: Numbers followed by the same letter in the same column are not significantly different according to Tukey's Honestly Significant Difference (HSD) test at a 5% significance level

The influence of liquid organic fertilizer on the growth and yield of sweet corn.

Liquid organic fertilizer sprayed on leaves can affect the variables of sweet corn plant height. Liquid organic fertilizer at a concentration of 300 mL L^{-1} shows no significant difference compared to concentrations of 100 mL L^{-1} and 200 mL L^{-1} but significantly differs from the concentration of 0 mL L^{-1} or no treatment. This is likely because liquid organic fertilizer is easily absorbed by plants, so the application of organic fertilizer with different concentrations can influence the growth of sweet corn plants. The changes in plant height each week indicate the influence of manure treatment and POC concentration. The bar chart of sweet corn plant height from age 2 to 7 WAP under the treatment of liquid organic fertilizer and cow manure can be seen in Figure 1.

Based on the bar chart, the height of sweet corn plants showed an increasing trend from the first week of measurement to the fifth week. The plant height is influenced by the nitrogen content in the organic fertilizer absorbed by the plants, ensuring the nutritional needs for the vegetative growth phase are met. This aligns with the findings of Nanda *et al.* (2017), who emphasized the necessity of nitrogen for the formation of compounds supporting plant growth, such as nucleic acids, chlorophyll, and enzymes. Insufficient nitrogen uptake by plants is identified as one of the hindrances to plant growth. Rizqiani *et al.* (2007) also highlighted that increasing the concentration of liquid fertilizer correlates with the increased absorption of nutrients by plants.

According to the data analysis, the application of liquid organic fertilizer significantly influenced the weight of the cobbled ears, indicating that the treatment contributed to an increase in cobbled ear weight in sweet corn plants. The highest value was observed in the treatment with a concentration of 300 mL L^{-1} of liquid organic fertilizer, reaching 8.545 kg ha^{-1}.

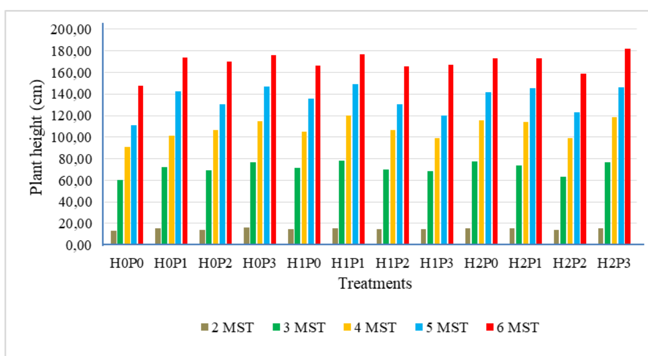

Figure 1. Bar chart of the growth in height of sweet corn plants against various doses of cow manure (H) and concentrations of liquid organic fertilizer (P)

The lowest weight of cobbled ears was recorded in the treatment with a concentration of 0 mL L^{-1}

of liquid organic fertilizer, amounting to 6.267 kg ha^{-1}. The enhancement in cobbled ear weight is attributed to the phosphorus nutrients present in the liquid organic fertilizer, leading to the development of well-filled corn cobs. Phosphorus deficiency can result in small and abnormal corn cob sizes, as suggested by Galu *et al*. (2017), emphasizing the impact of nutrient availability on the length, diameter, and weight of sweet corn cobs.

Table 4. The effects of LOF application on plant height and ear weight

LOF (mL L^{-1})	Average value	
	Plant height (cm)	Ear weight (kg ha^{-1})
0	150.97b	6.267b
100	168.84a	7.901ab
200	170.50a	7.931ab
300	176.82a	8.545a

Note: Numbers followed by the same letter in the same column are not significantly different according to Tukey's Honestly Significant Difference (HSD) test at a 5% significance level

Influence of Cow Manure Fertilizer on the Growth Yield of Sweet Corn

Cow manure fertilizer contains all essential nutrients required by plants. According to Mulyadi (2007), the incorporation of organic fertilizers, such as cow manure, into the soil can significantly impact the increase in soil nutrient levels. The application of cow manure fertilizer showed a significant difference between untreated and treated plant heights. The highest value was observed with 10 tons ha^{-1} of cow manure fertilizer, reaching 174.05 cm, but no significant difference was noted with the application of 5 tons/ha of cow manure fertilizer. The lowest value was recorded in the control group with 0 tons/ha of cow manure, amounting to 156.68 cm. In line with Adrinoviarini *et al*. (2014), cow manure fertilizer added to the soil influences plant height differently each week. The application of 10 tons ha^{-1} of cow manure enhances plant growth the most compared to different doses of cow dung. A similar pattern occurred approximately fourteen days after planting, also evident in the second, third, fourth, and fifth weeks after planting, where the highest plant growth was achieved with the treatment of 10 tons ha^{-1} of cow manure compost.

The introduction of high-dose cow manure fertilizer to the soil aids in improving the physical, chemical, and biological properties of the soil, facilitating nutrient absorption by the roots. The results indicate a significant difference in cobbled ear weight due to cow manure fertilizer. The dose of 10 tons ha^{-1} of cow manure fertilizer produced the highest value, amounting to 8.164 kg ha^{-1}, and showed no significant difference from the 5 tons ha^{-1} dose. The smallest value was recorded in the 0 tons/ha cow manure fertilizer dose, at 6.773 kg ha^{-1}. The growth of sweet corn plants is closely related to the availability of nutrients, as it significantly influences sweet corn production. One essential nutrient is phosphorus (P), crucial for corn plant development and cob formation. Sweet corn is highly influenced by soil, particularly phosphorus availability, with 85% of the sweet corn weight being affected by this variable. Furthermore, an increase in cobbled ear weight is influenced by the photosynthates allocated to the cob. Consistent with Sari's statement (2018), an increase in fresh cob weight is associated with the plant's photosynthetic process, where the products of photosynthesis are directed to the corn cob, affecting the increase in the weight of sweet corn cobs.

Table 5. Effect of cow manure application on plant height and ear weight.

Cow manure (tons ha^{-1})	Average values	
	Plant height (cm)	Ear weight (kg ha-1)
0	156.68b	6.773b
5	169.61a	8.046a
10	174.05a	8.164a

Note: Numbers followed by the same letter in the same column are not significantly different according to Tukey's Honestly Significant Difference (HSD) test at a 5% significance level

CONCLUSION

Based on the results of the research, the following conclusions can be drawn:

The application of liquid organic fertilizer significantly influences the difference in soil saturation weight and pF pressure at 0.1 atm, with a value of 12.68 g^{-1}. Cow manure fertilizer also has a significant impact and proves to be an effective soil conditioner for Entisols, resulting in a moisture content of 12.15%, bulk density of 0.73 g m^{-3}, permeability of 90.57 cm hour^{-1}, and a difference in wet soil weight and pF pressure at 0.1 atm of 15.10 g.

The application of liquid organic fertilizer results in a plant height of 176.82 cm and cob weight of 213.63 g plant^{-1}. Cow manure fertilizer shows a plant height of 174.05 cm and cob weight of 204.11 g plant^{-1}.

The application of liquid organic fertilizer with a concentration of 300 mL L^{-1} or cow manure fertilizer at a dose of 10 tons ha^{-1} is deemed the most effective in improving the physical properties of Entisols, as well as the growth and yield of sweet corn plants.

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