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Best Combination of Liquid Organic Fertilizer with NPK Fertilizer for Cocoa Seedling Growth (*Theobroma cacao* L.)

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ABSTRACT

One strategy for achieving sustainable agriculture is the reduction of inorganic fertilizers. Inorganic fertilizers are reduced by substituting them with organic fertilizers. This study aimed to identify the optimal combination of LOF with NPK fertilizers to promote the growth of cocoa seedlings in polybags. The study used completely randomize design. The treatment design, namely the combination of LOF with NPK fertilizers, consisted of five distinct combinations: control, 100% LOF, 100% NPK, 75% LOF +25% NPK, 50% LOF + 50% NPK, and 25% LOF + 75% NPK. The parameters observed were plant height, stem diameter, number of leaves, total leaf area, plant dry weight, shoot dry weight, root dry weight, soil physical properties, soil water content, soil analysis, and seedling quality index. The results showed that treatment 25% LOF + 75% NPK increased the percentage of plant height by 73.47%, stem diameter by 42.13%, number of leaves by 67.36%, total leaf area by 75.30%, plant dry weight by 45.70%, shoot dry weight by 24.81%, root dry weight by 95.54%, and seedling quality index by 90.65%. LOF can reduce the use of NPK fertilizer by 25% in cocoa seedling

Keywords: Cocoa seedling, Fertilizer, NPK, LOF, Ultisol

1. INTRODUCTION

Cocoa (*Theobroma cacao* L.) is one of the most significant plantation commodities, ranking behind only oil palm and rubber in economic importance. The plant has considerable economic value and serves as a source of foreign exchange for the country. The cocoa beans produced can be utilized as raw materials for various industries, including food, pharmaceuticals, and cosmetics. According to data from the Direktorat Jenderal Perkebunan (2020), cocoa is one of the most prominent plantation commodities with significant potential for enhancing people's well-being. This is largely because most cocoa plantations are operated through smallholder plantations.

Cocoa development areas are distributed across multiple Indonesian provinces, including South Sulawesi, West Sulawesi, Southeast Sulawesi, Central Sulawesi, West Papua, East Java, Lampung, West Sumatra, and North Sumatra. Expanding productionareas has yielded tangible outcomes in increased Indonesian cocoa exportswithin the global trade landscape. Indonesia has successfully positioneditself as the second largest cocoa producer, trailing only Ghana, with a total export volume of 354,480 tons (Direktorat Jenderal Perkebunan, 2020).

The expansion of cocoa cultivation in Jambi Province between 2017 till 2021 saw an increase in area by 2,929 hectares. However, during the same period, cocoa productivity experienced a decline, with yields dropping from 585 tons per hectare in 2017 to 504 tons per hectare by 2021 (BPS, 2022). As noted by Arsensi et al. (2022), this reduction in productivity can be attributed to various factors, including pest infestations, the use of inferior seed varieties, and inadequate fertilization practices that do not adhere to recommended guidelines.

Cocoa seedlings necessitate an adequate supply of nutrients throughout their growth stages. Utilizing ultisol as a cultivation medium presents challenges due to it’s unfavorable physical and chemical characteristics. Ultisol is characterized by clumping, a clayey texture, a firm consistency, slow permeability, clay-coated aggregates, and low stability, reducing total porespace. Additionally, the chemical properties of ultisol are not conducive to plant growth, exhibiting low pH levels, low organic matter content, and insufficient micronutrient availability, particularly nitrogen, phosphorus,potassium, calcium, and magnesium.

Efforts to increase cocoa plant productivity begin with intensive seedling maintenance with good plant cultivation, one of the excellent plant cultivation activities is by maintaining plants by fertilizing which aims to add nutrients needed to produce good quality cocoa seedlings.

Fertilization is essential in supporting a plant's growth and production. Fertilization supports plants in growing and producing optimally. Proper fertilization according to the rules, both in terms of type of fertilizer and dosage can increase the plant growth rate (Dogbatse et al., 2021). Fertilizers used in cocoa nurseries can be organic and/or inorganic fertilizers.

Inorganic fertilizers are chemical fertilizers produced by factories, and plants easily absorb these fertilizers. However, behind their advantages, inorganic fertilizers have drawbacks such as high costs and being environmentally unfriendly with long-term use. Organic fertilizers are derived from organic materials or decomposed living organisms. These fertilizers are cheaper, can be made independently, and are more environmentally friendly. However, the disadvantage of using this type of fertilizer is that plants absorb it slowly.Comparing the composition of organic and inorganic fertilizers is a strategic step to accommodate the advantages and mitigate the disadvantages of bothorganic and inorganic fertilizers.

Organic fertilizers can currently be found in liquid form, one of the liquid organic fertilizers (LOF) that can increase thegrowth of cocoa plants is TOP G2 LOF. TOP G2 LOF is a LOF that has quality and quantity with sustainable results. TOP G2 LOF is made from selected organic materials from animals and plants so that it does not contain microbes that are harmful to health and most importantly, is environmentally friendly. TOP G2 LOF is a high quality LOF made from selected organic materials from animals and plants, not from household waste, so it does not contain toxins or microbes thatare harmful to plant health and is environmentally friendly. TOP G2 LOF contains growth regulating hormones such as zeatin, gibberellin and 14 essential nutrients, both macro and micronutrients and 17 forms of amino acids, vitamins, and various micro flora can increase plant growth (Rahmawati et al., 2015). The content and composition of LOF TOP G2 nutrients are C-org (6%), N (5%), P_2O_5 (5%), K_2O (5.8%), CaO (0.4%), MgO (0.4%), $S0_4$ (0.38%), C/N ratio (1.28%), amino acids and bioactive compounds (Brosur TOP G2, 2013).

Using inorganic fertilizers also plays an important role in supporting the growth of cocoa seedlings. According to Romiyadi and Sufiadi (2017), provisioning organic fertilizers combined with inorganic fertilizers can increase plant productivity and fertilizer use efficiency in the long term. Combining organic and inorganic fertilizers can gradually reduce the use of chemical fertilizers to achieve completely organic farming. In addition to using LOF, efforts to increase productivity need to be combined with other fertilizers that will encourage better cocoa plant yields by providing compound fertilizers or NPK fertilizers.

NPK fertilizer has a balanced nutrient composition and can dissolve slowly until the end of growth. The content of NPK fertilizer is 16% N, 16% P_2O_5. and 16% K_2O. Giving NPK fertilizer can increase nutrient absorption and vegetative and generative growth (Yeboah, 2023). According to Victoria & Aggangan (2023), the advantage of NPK compound fertilizer is that N, P, and K nutrient composition can be adjusted to plant needs, making it more effective and efficient than single fertilizers. NPK fertilizer is the most well-known fast-available compound fertilizer today.

Fadli & and Safnidar's research (2019) showed that the TOP G2 LOF treatment significantly affected the height of Areca nut seedlings at 30, 60, and 90 days after planting. The results of Setiadi et al.'s research (2021), the interaction of the treatment of NPK 16:16:16 fertilizer and cow dung fertilizer on cocoa plants in the K_3N_3 treatment (cow dung as much as 375 g/polybag and NPK 16:16:16 fertilizer as much as 15 g/polybag) with the number of leaves, the best treatment was with the number of leaves 18.33 blade, and the wet weight parameter of the plant was 24.82 g.

In their 2019 study, Fadli and Safnidar tested the TOP G2 LOF based exclusively on LOF. In their 2021 study, Setiadi and colleagues combined organic fertilizer derived from animal manure with NPK fertilizer. However, they did not assess the proportion of inorganic fertilizer that could replace organic fertilizer. The objective of this study is to ascertain the percentage of inorganic fertilizer (NPK) that can be substituted with organic fertilizer (LOF TOP G2) in order to ascertain the benefits of both types of fertilizer in supporting the growth of cocoa seedlings.

The combination of LOF with NPK is anticipated to balance the use of organic and inorganic fertilizers. The comparison in percentage form is anticipated to facilitate the adjustment of LOF concentration and NPK dosage. To address this question, a study was conducted to identify the optimal combination of LOF and NPK fertilizer for promoting the growth of cocoa seedlings.

2. MATERIAL AND METHODS

This research was conducted in the Kasang Pudak Village, Kumpeh Ulu District, Muaro Jambi Regency over three months, from October to December 2023. The location coordinates are S-1o36.035. E10.40.553 with an elevation of 42 meters above sea level. The materials used in this study were F1 Hybrid cocoa seedlings obtained from the Plantation Agency at Muaro Jambi Regency was three months old and exhibited uniform growth with physical characteristics including the same number of leaves and height. The soil media used consisted of topsoil ultisol, TOP G2 LOF, NPK Mutiara fertilizer in a 16:16:16 ratio, and polybags size 15 x 30 cm. The tools utilized in this research included writing instruments, soil analysis equipment, tools for soil processing, 40% shade netting, plastic ties, a leaf area meter, a camera, a measuring tape, a ruler, calipers, an analytical balance, a beaker glass, a hand sprayer, anelectric oven, and other supporting equipment.

The research design used was a completely randomized design with one factor, namely a combination of LOF with NPK fertilizer consisting of 5 treatment levels, namely control, 100% LOF (10 ml L^{-1} water), 100% NPK (10 g), 75% LOF (7.5 ml L^{-1} water) + 25% NPK (2.5 g), 50% LOF (5 ml L^{-1} water) + 50% NPK (5 g), and 25% LOF (2.5 ml L^{-1} water) + 75% NPK (7.5 g). Each treatment was repeated 3 times so that there were 18 experimental plots. Each plot consisted of 10 plants so there were 180 plants. The number of samples per plot was 8 plants. The implementation of the research is presented in the following flow diagram:

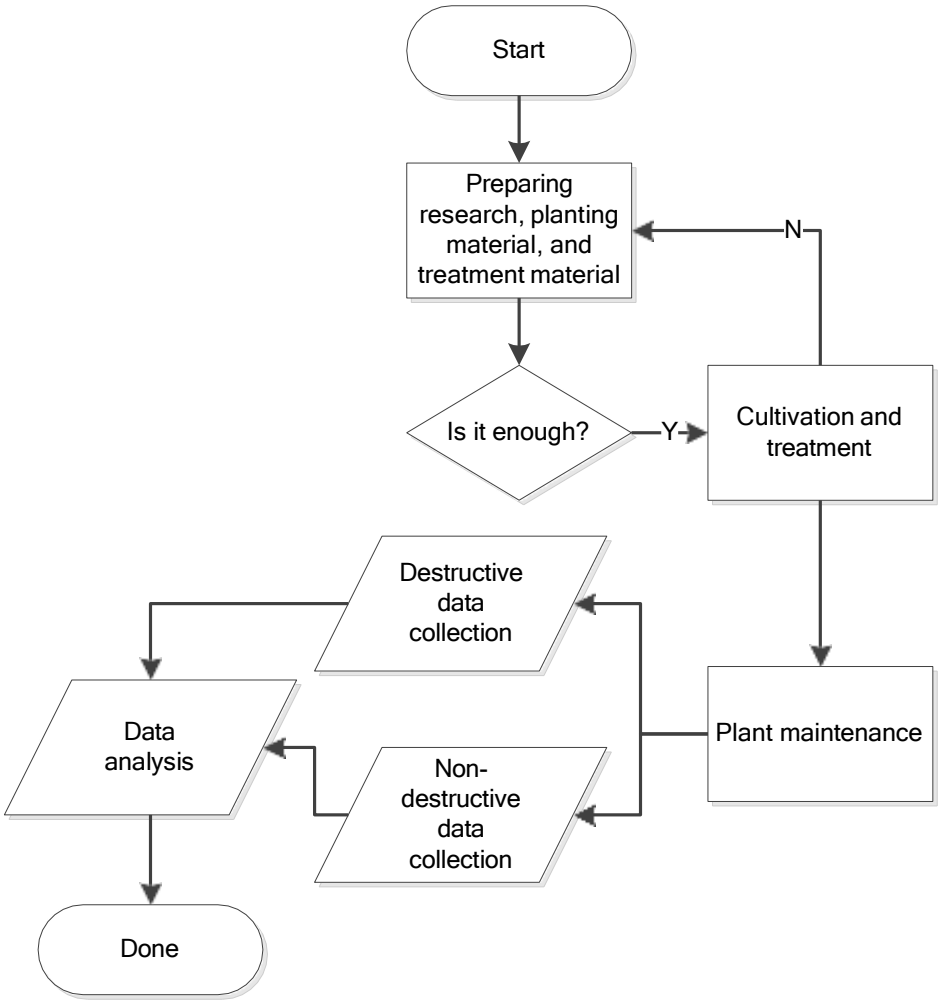

Figure 1. Research flow chart

The planting medium used is ultisol type soil in the topsoil layer. The topsoil is taken to a depth of 20 cm, then the soil is cleaned and loosened. Put 3 kg of soil into a prepared polybag size15 x 30 cm. Initial soil analysis showed that the soil used in the research was not fertile, the results of the analysis were as follows: C-organic 3.74%, total N 0.07%, available P 20.50 ppm, available K 29.71 cmol/kg, CEC 18.71 cmol/kg, and C/N ratio 54.86.

The planting material used in this research was 3 month old cocoa seedlings of the F1 Hybrid type. Uniform seedling growth is indicated by plant height and number of leaves. Seedlings are also free from pest and disease attacks. The planting medium for the cocoa seedlings is removed and the roots are cleaned and replaced with new planting medium according to the treatment.

Liquid organic fertilizer is first dissolved according to the treatment concentration in each experiment in 1 liter of water. The LOF solution was applied by pouring it directly onto the surface of the soil around the plant evenly as much as 200 mL for each seedling. For NPK fertilizer, the fertilizer was applied after LOF was given by sprinkling it evenly around the plant as much as the dosethat had been determined for each experiment, to avoid evaporation, The NPK fertilizer is covered directly with the planting medium.

Liquid organic fertilizer treatment was given 10 days after planting (DAP) with an interval of 14 days. During the research period, there were 6 fertilizer applications. For NPK fertilizer, the application was only once, namely at the beginning of fertilizer application or 10 DAP. Fertilizer application was carried out in the afternoon, at 17.00 WIB.

Efforts to maintain plant growth are carried out by controlling weeds in the planting medium and in the research area. Water needs are met by watering once a day, namely in the morning with a volume of 150 mL for each polybag.

Data collection was carried out in the 12th week after planting. The parameters observed in were:

1. Soil Analysis. Conducted at the beginning of the study, this soil analysis aims to determine the chemical properties of the soil as a planting medium. The chemical properties of the soil to be analyzed consist of the nutrients N, P, K, C/N, C-organic, pH and CEC. Soil analysis is carried out by drying the soil, crushing it to make it smoother, stirring it evenly, and sifting it with a 0.5 x 0.5 cm sieve. Soil analysis was carried out at the Bureau of Agricultural Instrument Standardization (BSIP) Jambi Province.

2. Plant height. Measurements using a measuring tape and carried out from the root neck to the growing point.

3. Stem Diameter. Measured at a height of 2 cm from the ground surface, stem diameter measurements can use a caliper.

4. Number of Leaves. Done by counting the number of leaves that have developed (opened) perfectly on each sample.

5. Total Leaf Area. Measurements using a leaf area meter. This tool is equipped with a rotating transparent plate and is connected to a shadow area recording device resulting from placing the leaves on the transparent plate. The detected or recorded shadow area recorder can be programmed in total or partially for each measurement.

6. Plant Dry Weight. Observations were made at the end of the study. Plant samples were removed from the planting medium and then cleaned from soil attached to the roots. Plants were separated from the crown and roots, placed in a labeled paper envelope, and oven-dried at 105°C for 48 hours. The samples were placed in a desiccator until cool and then weighed with an analytical scale until a constant weight wasobtained.

7. Shoot Dry Weight. The dry weight of the crown is weighed simultaneously with the dry weight of the plant using the calculation of the dry weight of the crown.

8. Root Dry Weight. The dry weight of the root is weighed simultaneously with the dry weight of the crown using the calculation of the dry weight of the root.

9. Physical and Chemical Properties of Soil. Observations of soil properties consist of soil pH, texture and soil structure. The pH of the soil in the media is measured at the beginning of planting and the end of the study using a pH meter by inserting the tip of the pH meter into the planting media and waiting a few moments until the pH meter is stable on the screen. The texture and structure of the soil are observed after the study. Observations of soil texture are carriedout by inserting a soil sample into a bottleof as much as 500 g, then mixing 500 ml of water then shaking the bottle so thatthe soil sample mixes with water and thensettles for 1 x 24 hours, after settling each soil component such as sand, clay, and dust is measured using a ruler and then calculated using the soil texture calculation formula.

10. Soil Water Content. Determination of soil water content using the gravimetric method. The steps taken to determine the water content are as follows: The empty container is weighed to find out the empty weight of the container, after the weightof the container is obtained, insert 10 g of soil sample, the wet weight of the soilsample is the same for all samples then ovened at a temperature of 105 °C for 24hours. Then removed from the oven and cooled, and the dry weight. After that the soil is removed from the container andcleaned. Next, the water content is determined and can be calculated using the formula:

$$Water\ content = \frac{M2 - M3}{M2 - M1} \times 100\%$$

Description: M1= cup weight; M2= cup weight + soil sample weight before oven; M3= cup weight +soil sample weight after oven

11. Seedling Quality Index. Calculated at the end of the study using data on shoot dry weight, root dry weight, plant height and stem diameter with the following formula:

$$QI = \frac{Shoot\ DW - Root\ DW}{\frac{Plant\ height}{Stem\ diamter} - \frac{Shoot\ DW}{Root\ DW}}$$

The minimum seedling quality value as a requirement for seedlings when transferred to the field is 0.09, and it is indicated that the seedlings will get better if the seedling quality value continues to increase.

The observation data were tabulated and analyzed to determine the effect of the treatment. The tools used were MS Excel Windows 11 and SPSS version 24. If the analysis of variance shows that the treatment has a significant effect, then accept H_1 and reject H0 and vice versa. If the H_1 hypothesis is selected, a further DNMRT test is carried out at the α level of 5%.

3. RESULT AND DISCUSSION

Initial soil analysis showed that the available N nutrients in the soil were very low so that it was unlikely to support plant growth quickly and properly so that the combination treatment of LOF with NPK fertilizer became important. The results of the initial soil chemical analysis are presented in the following Table 1.

Based on the results of laboratory tests on the planting media, the C-organic content is classified as moderate with a value of 3.74%. The N content is classified as low with a value of 0.07%. The available P content is classified as high with a value of 20.50 ppm. The K content is classified as high with a 29.71 cmol/kg value. The CEC value isclassified as moderate with a value of 18.71 cmol/kg. The C/N ratio value is classified as high, which is 54.86. Thecause of the high C/N ratio value is the limited amount of available nitrogen and the greater carbon value that binds

N, and the pH of the soil in theresearch area is classified as acidic witha value of 5. The physical properties of the soil observed are soil texture. After being treated, the texture is granular and slightly sticky due to the presence of a small mixture of clay. Soil texture is presented in Table 2.

Table 1. Initial soil chemical analysis

No	Sample Code	C organic %	N Total	P HCl 25% (mg P_2O_5 100 g^{-1})	K HCl 25% (mg K_2O 100 g^{-1})	CEC Cmol (+) kg^{-1}	C/N
1	Ultisols	3.74	0.07	20.50	29.71	18.71	54.86

Source: Soil analysis by the BSIP Laboratory, Jambi Province (2024)

Table 2. Soil texture of cocoa plant growing media with various combinations of LOF and NPK fertilizer treatments

Code	Treatment	Sand (%)	Clay (%)	Dust (%)	Remarks
P_0=	Control	61.54	30.76	7.70	Sandy clay loam
P_1=	100% LOF (10 ml L^{-1} water)	71.43	21.43	7.14	Sandy clay loam
P_2=	100% NPK (10 g)	76.92	15.38	7.70	Sandy loam
P_3=	75% LOF (7.5 ml L^{-1} water) + 25% NPK (2.5 g)	66.67	26.67	6.66	Sandy clay loam
P_4=	50% LOF (5 ml L^{-1} water) + 50% NPK (5 g)	66.67	25.00	8.33	Sandy clay loam
P_5=	25% LOF (2.5 ml L^{-1} water) + 75% NPK (7.5 g)	57.14	35.72	7.14	Sandy clay loam

From the data in Table 2, it can be concluded that the texture of the planting media after treatment tends to be sandy clay loam. The following formula determines soil texture:

$$P = \frac{P}{P + L + D} x\ 100\%$$

Notes: P: Sand; D: Dust; L: Loam

The combination of LOF with NPK Fertilizer indirectly affects the soil structure. The structure of the planting medium changes from lumpy to loose (granular), and the color becomes thicker and darker due to the activity of microorganisms in the soil. The loose soil structure allows plant roots to absorb nutrients in the soil. The combination treatment of LOF with NPK Fertilizer also slightly affects soil acidity. The initial pHof the planting medium soil was 5. which is categorized as acidic soil, but after being treated, there was an increase in soil pH, especially in the P_1 treatment thehighest value treatment, which was 6.60. The increase in soil pH occurred becausethe K and Mg elements were sufficient in the soil due to the LOF treatment. The results of the analysis of variance in pH and soil water content showed that the combination of LOF with NPK fertilizer had no significant effect on the pH and water content of the cocoa seedling planting medium. Further DNMRT tests at α level 5% for each treatment can be seen in Table 3.

Table 3 shows treatment P_1 has the highest soil pH value, 6.60. significantly different from treatment P_2. Treatment P_2 has the lowest soil pH value of 6.40 but significantly differs from other treatments. There is an increase in the pH value of the soil of the cocoa plant growing medium by 3.13% when P_1 is compared to P_2. The initial soil pH value is 5.

Table 3 shows that P_2 has the highest soil water content value of 25.40% but is not significantly differentfrom other treatments. Treatment P_0 has the lowest soil water content value of 23.38% but is not significantly different from other treatments. There is an increase in the soil water content of the cocoa plant growing medium by 8.64%when P_2 is compared to P_0.

Table 3. Average pH and water content of the soil in cocoa planting media with various combinations of LOF and NPK fertilizer treatments

Code	Treatment	Average Value			
		Soil pH		Soil Water Content (%)	
P_5=	25%LOF (2.5 ml L^{-1} water) + 75% NPK (7.5 g)	6.50±0.06	ab	24.78±0.47	a
P_4=	50% LOF (5 ml L^{-1} water) + 50% NPK (5 g)	6.49±0.07	ab	24.91±0.21	a
P_3=	75% LOF (7.5 ml L^{-1} water) + 25% NPK (2.5 g)	6.51±0.17	ab	23.41±0.99	a
P_2=	100% NPK (10 g)	6.40±0.17	b	25.40±0.15	a
P_1=	100% LOF (10 ml L^{-1} water)	6.60±0.08	a	23.97±0.25	a
P_0=	Control	6.48±0.08	ab	23.38±0.32	a

Notes: Numbers followed by the same lowercase letter are not significantly different in the DNMRT follow-up test at the 5% α level.

The lowest water content value was obtained in treatment P_0. which was 23.38%, not significantly different from the highest treatment, which was in treatment P_2. which was 25.40%. This is due to the same soil texture in all treatments. The nature of sandy clay loam soil is classified as good soil for plant cultivation and has good water binding ability.

The combination of LOF with NPK frertilizer in the P_5 treatment (25% LOF (2.5 ml L^{-1} water) + 75% NPK (7.5 g)) showed the highest average plant growth compared to other treatments. In this case, the combination of LOF with NPK Fertilizer in the P_5 treatment (25% LOF (2.5 ml L^{-1} water) + 75% NPK (7.5 g)) can still be responded well by cocoa plants. The combination of LOF through leaves and NPK fertilizer through roots can accelerate the absorption of nutrients by plants and improve the soil's physical, biological, and chemical properties. Liquid organic fertilizer also adds nitrogento the soil so that sufficient nitrogen in thesoil can accelerate plant growth. The nutrients N, P, and K and micronutrients (Fe, Cu, Mn, Zn, B, Mo, Ca) will be released slowly through the mineralization process to support plant growth. Pakpahan & Yoseva (2015) explained that the plant growth process is preceded by cell division, an increase in the number of cells and cell size. Thedivision process requires protein synthesis, which is achieved by obtaining raw materials from the environment such as organic materials.

Based on the combination treatment of LOF with NPK fertilizer tested, it showed that the highest cocoa plant height parameter value was found in treatment P_5 (25% LOF (2.5 ml L^{-1} water) + 75% NPK (7.5 g)). The combination treatment of LOF with NPK fertilizer at this concentration provides sufficient nutrients for cocoa plants compared to concentrations of 50% LOF + 50% NPK, 75% LOF + 25% NPK, 100% LOF, and 100% NPK. The combination of LOF and NPK fertilizer provides a balance of nutrient supply needed by plants. The results of this study are relevant when compared to the results of Yeboah's (2023) study whichfound that efforts to increase N in the soil using inorganic fertilizers Ammonium Sulfate and Potassium Nitrate with a dose of 126 mg N per pot would actually have a suppressive effect on the growthof cocoa seedlings as measured by the parameters of stem diameter, plant height, number of leaves, total leaf area, total dry matter. The results of the study by Dogbatse et al. (2021) showed that combining inorganic fertilizer with chicken manure fertilizer effectively increases cocoa seedlings' growth. However, Orisajo & Adejobi (2020) stated that manure makes cocoa seedlings susceptible to root nematode attacks. In the context of this study, when compared to the P_3 and P_4 treatments, which have less NPK content compared to P_5.

The nitrogen nutrients needed by plants will not be maximized as a result, plant heightgrowth will be slow and this can be seen directly in the control treatment (P_0) where the average plant height growth is smaller due to the low N available in the soil. The increase in the height of cocoa plants is caused by the presence of meristem tissue, whose cells are actively dividing at the top (apical) of the plant.

Table 4. Average height, stem diameter, final leaf number, and total leaf area of cocoa seedlings with various combinations of lof and NPK fertilizer treatments

Kode	Perlakuan	Avarage Value							
		Steam Height (cm)		Steam Diamater (mm)		Number of leaves (blade)		Total Leaf Area (cm^2)	
P_5=	25% LOF (2.5 ml L^{-1} water) + 75% NPK (7,5 g)	55.44±0.50	a	10.57±0.85	a	27.33±0.60	a	100.77±0.89	a
P_4=	50% LOF (5 ml L^{-1} water) + 50% NPK (5 g)	50.33±0.29	ab	9.80±0.66	ab	25.00±0.58	ab	84.73±0.32	ab
P_3=	75% LOF (7.5 ml L^{-1} water) + 25% NPK (2.5 g)	49.33±0.58	ab	9.53±0.87	ab	20.67±0.46	abc	81.97±0.31	b
P_2=	100% NPK (10 g)	46,11±0.49	ab	9.47±0.45	ab	19.67±0.30	bc	80.49±0.93	b
P_1=	100% LOF (10 ml L^{-1} water)	42.66±0.73	b	9.10±0.90	b	19.67±0.30	bc	74.88±0.96	b
P_0=	Control	31.96±0.20	c	7.43±0.45	c	16.33±0.15	c	36.61±0.34	c

Notes: Numbers followed by the same lowercase letter are not significantly different in the DNMRT follow-up test at the 5% α level.

The combination treatment of LOF with NPK fertilizer in the P_5 treatmentgave the highest value in stem diameter. The increase in stem diameter was also inseparable from cell division activity, which continued to occur as a response to the fulfillment of nutrient needs. The increase in stem diameter was caused by lateral meristem cells that divided fromthe outside to the inside. The combinationof LOF with NPK fertilizer in the P5 treatment gave the highest number of leaves. This was shown physically, wherethe average number of leaves was 27.33 in the P5 treatment, which is the highest compared to other treatments. The large number of leaves in the P_5 treatment wasinseparable from the composition of the fertilizer treatment, which provided sufficient nitrogen. According to Pangondian Sihaan et al. (2023), the function of nitrogen for cocoa plants is to make leaf growth healthy to improve the quality of plants that produce leaves.

The increase in the total leaf area of cocoa seedlings occurs because the availability of nutrients such as N, P, and K influences the leaf area. The combination of LOF with NPK fertilizer with a concentration of 25% LOF (2.5 ml L^{-1} water) + 75% NPK (7.5 g) can meet the availability of N, P, K in the soil, thus affecting the increase in the leaf area of cocoa seedlings. Lindawati et al. (2010) and Effendi et al. (2024) stated that nitrogen is needed to produce protein, fat, and other organic compounds. N nutrients are essential in forming green leaves, which are very useful in photosynthesis. Chlorophyll that is available in sufficient quantities in plant leaves will increase the ability of leaves to absorb sunlight so that the photosynthesis process will run smoothly. The photosynthate produced will be reorganized through respiration and produce the energy cells need to carryout activities such as cell division and enlargement, which causes the leaves to reach maximum length and width. The highest average dry weight of plants was obtained in the P_5 treatment, which was 26.10 g, which was not significantly different from the P_4 treatment and

significantly different from the other treatments (Table 5). These data illustrate that combining fertilizers in the P_5 treatment helped cocoa plants absorb nitrogen very well. Good nitrogen absorption by plants can encourage the growth process of cocoa seedlings.

The highest dry weight of the cacao plant canopy was obtained in the P_5 treatment with a value of 23.45 g. According to Ramadhan et al. (2024) and Salman et al. (2024), this occurs because nitrogen plays a role in the composition of all protein compounds, fats, and various other organic compounds and affects the use of carbohydrates in plants. N nutrients directly affect carbohydrate synthesis in plant cells, subsequently affecting plant vigor and increasing vegetative growth.

The highest root dry weight parameter data was obtained in the P_5 treatment, which was 5.97 g. This occurs because the combination of LOF with NPK fertilizer at this concentration can increase the availability of nutrients in the soil so that the nutrients needed by plantsfor the growth process are sufficient.

The combination treatment of LOF with NPK fertilizer gave a quality index value of 1.07-3.11. This value shows results above the standard plant quality index value of 0.09. Hendromono (1989) and Irawan (2017) explained that seedlings with a minimum quality index value of 0.09 will survive high when moved to the field. In this study, all combinations of LOF with NPK fertilizer showed a seedling quality index value of more than 0.09. The results of this study indicate that cocoa seedlings are ready tobe moved to the field.

Table 5. Average dry weight of shoots, dry weight of roots, total dry weight, and quality index of cocoa seedlings with various combinations of LOF and NPK fertilizer treatments

Code	Treatment	Avarage Value							
		Shoot Dry Weight (g)		Root Dry Weight (g)		Total Dry Weight (g)		Quality Index	
P_5=	25% LOF (2.5 ml L^{-1} water) + 75% NPK (7.5 g)	23.45±0.23	a	5.97±0.11	a	29.42±0.23	a	3.11±0.01	a
P_4=	50% LOF (5 ml L^{-1} water) + 50% NPK (5 g)	20.39±0.68	a	5.62±0.16	a	26.10±0.25	a	3.02±0.09	a
P_3=	75% LOF (7.5 ml L^{-1} water) + 25% NPK (2,5 g)	11.69±0.13	b	4.58±0.90	ab	16.27±0.21	b	2.10±0.03	b
P_2=	100% NPK (10 g)	11.19±0.19	b	3.90±0.64	b	15.09±0.19	b	2.00±0.05	b
P_1=	100% LOF (10 ml L^{-1} water)	10.46±0.49	b	3.27±0.69	bc	13.73±0.62	b	1.73±0.04	b
P_0=	Control	5.52±0.50	c	2.02±0.70	c	7.54±0.47	c	1.07±0.01	c

Notes: Numbers followed by the same lowercase letter are not significantly different in the DNMRT follow-up test at the 5% α level.

Table 5 shows that the P_4 treatment has the highest seedling quality index value of 3.11. which is not significantly different from the P_5 treatment, but significantly different from the other treatments. The P_0 treatment has the lowest seedling quality index value of 1.07 but significantly differs from the other treatments. There is anincrease in the cocoa seedling quality index value of 190.65% when P_4 is compared to P_0.

In the P_5 treatment, the combination of 25% LOF with 75% NPK fertilizer has the highest value for all parameters measured. The P_5 treatment is higher than the 50% LOF + 50% NPK, 75% LOF + 25% NPK, 100% LOF, and 100% NPK treatments as shown in Figure 2.

Figure 2. Cocoa seedling growth in various combinations of LOF and NPK fertilizer

The results of this study indicate that NPK fertilizer is the leading actor in supporting the growth of cocoa seedlings, and LOF plays a role in reducing the use of NPK fertilizer by 25%. The mainreason that can be stated as to why the P_5 treatment is better than other treatments is that the nutrients from NPK absorbed by the roots with the LOF nutrients received by the leaves are balanced in supporting the growth of cocoa seedlings.

4. CONCLUSION

Based on the research results, it can be concluded that:

1. The combination treatment of LOF with NPK fertilizer significantly affectsplant height, stem diameter, number of leaves, total leaf area, plantdry weight, shoot dry weight, root dry weight, and seedling quality index.
2. The combination P_5 treatment (25% LOF (2.5 ml L^{-1} water) + 75% NPK (7.5 g)) showed the highest average value in the observed parameters and increased the percentage of plant height values by 73.47%, stem diameter by 42.13%, increase in the number of leaves by 67.36%, total leaf area by 75.30%, plant dry weight by 45.70%, shoot dry weight by 24.81%, root dry weight by 95.54%, and seedling quality index by 90.65%.
3. Liquid organic fertilizer can reduce the use of NPK fertilizer by 25% in cocoa nurseries.

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REFERENCES

Arsensi, I., Boy, M. Y. Y., & Nugrahini, T. (2022). Pengaruh pupuk NPK dan bokashi daun gamal terhadap pertumbuhan bibit kakao (*Theobroma cacao* L). *Agrifor, 21*(1), 65. https://doi.org/10.31293/agrifor.v21i1.5846

Badan Pusat Statistik. (2023). *Jambi dalam angka*. Biro Pusat Statistik Provinsi Jambi.

TOP G2. (2013). *Brosur produk TOP G2*.

Direktorat Jendral Perkebunan. (2020). *Statistik perkebunan unggulan nasional 2020-2022* (pp. 1–572). Sekretariat Direktorat Jendral Perkebunan.

Dogbatse, J. A., Arthur, A., Awudzi, G. K., Quaye, A. K., Konlan, S., & Amaning, A. A. (2021). Effects of organic and inorganic fertilizers on growth and nutrient uptake by young cacao (*Theobroma cacao* L.). *International Journal of Agronomy, 2021*. https://doi.org/10.1155/2021/5516928

Effendi, A. R., Ariani, E., & Yudiandani, Y. (2024). The effect of biological fertilizers and inorganic fertilizers on upland rice plants (*Oryza sativa* L.) growth and production. *Jurnal Agronomi Tanaman Tropika (Juatika),6*(2). https://doi.org/10.36378/juatika.v6i2.3597

Fadli, R., & Safnidar, N. (2019). Pengaruh pemberian pupuk organik kascing dan pupuk organik Cwater TOP G2 terhadap pertumbuhan bibit pinang. *Agrosamudra, 6*(2), 83–88. https://doi.org/10.33059/jupas.v6i2.1770

Hendromono. (1989). Effect of medium type, NPK fertilizer, and watering frequency to the growth and quality index of *Delbargia fusca* seeding. *Duta Rimba, XV*(105–106), 31–40.

Irawan. (2017). Pengaruh naungan terhadap pertumbuhan dan mutu bibit cempaka. *Forda Badan Litbang Kehutanan, 3*, 24.

Lindawati, N., Izhar, L., & Syafria. (2010). Pengaruh pemupukan nitrogen dan interval pemotongan terhadap produktivitas dan kualitas rumput

lokal kumpai pada tanah podzolik merah kuning. *JPPTP, 2*(2), 130–113.

Orisajo, S. B., & Adejobi, K. B. (2020). Fertilizer application enhances establishment of cacao seedlings in plant-parasitic nematode infected soil. *Acta Agriculturae Slovenica, 115*(2), 417–428. https://doi.org/10.14720/aas.2020.115.2.1136

Pangondian Sihaan, H., Wawan, W., & Khoiri, M. A. (2023). Intensity of soil treatment and frequency of inorganic fertilizer application on nutrient levels and growth of palm oil (*Elaeis guineensis* Jacq.) at the replanting stage. *Jurnal Agronomi Tanaman Tropika (Juatika), 5*(1). https://doi.org/10.36378/juatika.v5i1.2833

Ramadhan, R., Fajriah, Hartawan, R., Hayata, & Marwan, E. (2024). Pertumbuhan bibit kakao (*Theobroma cacao* L.) pada berbagai kombinasi pupuk anorganik NPK dan pupuk hayati Bioneensis di polibag. *Jurnal Media Pertanian, 9*(1), 19–28. https://doi.org/10.33087/jagro.v9i1.227

Romiyadi, R., & Sufiadi, E. (2017). Pengaruh konsentrasi water rendaman sabut kelapa dan dosis pupuk NPK terhadap pertumbuhan dan hasil tanaman melon varietas Action 434. *Paspalum: Jurnal Ilmiah Pertanian, 3*(1), 39. https://doi.org/10.35138/paspalum.v3i1.12

Salman, S., Sabli, T. E., Mulyani, S., & Alfiqri, M. (2024). The application of liquid organic fertilizer from banana peels and NPK Phonska on purple eggplants (*Solanum melongena* L.) production. *Jurnal Agronomi Tanaman Tropika (Juatika), 6*(2), 254–266. https://doi.org/10.36378/juatika.v6i2.3580

Setiadi, H., Wahyudi, & Marlina, G. (2021). Pengaruh pemberian pupuk kotoran sapi dan pupuk NPK Mutiara (16:16:16) terhadap pertumbuhan bibit kakao (*Theobroma cacao* L.). *Jurnal Green Swarnadwipa, 10*(2), 185–198.

Swatop Pakpahan, S., & Yoseva, S. (2015). Pemanfaatan kompos solid dan mikroorganisme selulolitik dalam media tanam PMK pada bibit kelapa sawit (*Elaeis guineensis* Jacq.) di pembibitan utama. *JOM Faperta, 2*(2), 5–14.

Victoria, K. S., & Aggangan, N. S. (2023). Effects of bio-and chemical fertilizers on growth and soil microbial population of cacao (*Theobroma cacao* L.) seedlings. *Philippine Journal of Science, 152*(4), 1495–1505. https://doi.org/10.56899/152.04.18

Yeboah, S. (2023). Response of cocoa (*Theobroma cacao* L.) seedlings to folia fertilizer application and fertigation [Kwame Nkrumah niversity of Science and Technology]. https://cgspace.cgiar.org/items/73f11b69-a7b3-4469-b52f-d361b4eec64f