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Integration of Cocoa and Cattle Towards Production and Creation Body Weight of Cattle

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Cocoa is one of the main plantation crops in North Kolaka, Southeast Sulawesi, and is a strategic plantation commodity that tends to be important for the national economy because it provides employment, a source of foreign exchange, and a source of income for farmers. Manure is a waste product from livestock manure, one of which is cattle, which can be used to add nutrients and improve the physical and biological properties of soil. Integrated agriculture (crop-livestock integration) is an agricultural system characterized by the interrelationship between crop and livestock components in a farming business or an area. This study was conducted to determine the effect of manure on cocoa crop production, and to find out that feed made from cocoa fruit peel waste can increase the body weight of cattle. To find out how cattle manure and cattle feed using cocoa shell waste can be integrated in increasing cocoa production and increasing body weight in cattle. Based on the results of the research conducted, it was found that the cattle manure treatment showed the best results for each parameter observed in cocoa production, while in the cattle parameter, the provision of additional cocoa peel feed gave the highest results.
Keywords: Sustainable agriculture, crop productivity, ruminants, reduced production, effort, harvesting.

INTRODUCTION

The agricultural sector plays an important role in economic activities in Indonesia because it can contribute to a fairly large gross domestic product (GDP), this can be seen from its contribution, which is around 13.28% in 2021 and is second only to the processing industry sector, which is 19.25%, including one of the sub-sectors that has a significant role, namely the plantation sub-sector (Central Statistics Agency, 2022). Cocoa (*Theobroma cacao L.*) is one of the leading plantation commodities, which is mostly cultivated by smallholder plantations. This is by statistical data showing that smallholder cocoa plantations are estimated at 1.45 million hectares or around 99.39%. With its contribution to the gross domestic product (GDP), cocoa also acts as the largest foreign exchange earner. However, it is ironic that cocoa production in Indonesia continues to decline. Cocoa is one of the plantation crops that is the main commodity in North Kolaka, Southeast Sulawesi, and is a strategic plantation commodity whose role is important for the national economy because it provides employment opportunities, a source of foreign exchange, and a source of income for farmers. Apart from that, cocoa also plays a role in encouraging the development of a region and agro-industry (Ministry of Agriculture, 2022). One effort that can be made to meet market demand for cocoa commodities is by increasing cocoa production. To increase the production of cocoa plants, it is necessary to carry out optimal handling of the plants, especially fertilization. Currently, Indonesia is experiencing a critical condition in the use of fertilizer. The availability of both subsidized and non-subsidized fertilizers greatly influences the amount of agricultural production. In plant-livestock integration technology, cocoa waste can be used as a source of animal feed, which is made from cocoa pod shells. Apart from that, crop-livestock integration technology, in the form of cattle waste, can be used as a source of organic fertilizer (solid and liquid) and biogas (Indrawanto and Atman, 2016). Integrated agriculture (crop-livestock integration) is an agricultural system characterized by close links between the plant and livestock components in a farm or in a region. The relationship between the plant and livestock components in question is characterized using diverse

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resources such as forage, plant residues, and organic fertilizer produced by livestock in a production process. It is hoped that the concept of crop-livestock integration can stop the impact of agricultural activities that damage land resources and reduce agricultural productivity (Harli, 2017). Farmers' lack of knowledge in utilizing cocoa shell waste results in a lot of cocoa shell waste being wasted and can cause environmental pollution. Based on surveys in the field, cocoa pod shells are simply thrown away, without anyone using them. It is usually used as feed for cattle and goats by being given directly without being fermented first. In fact, in terms of its potential, cocoa pod shells can be used as an alternative feed for livestock by fermenting them, which has excellent nutritional value for ruminant and poultry feed. One way to deal with cocoa shell waste is to use it as alternative animal feed by fermenting and drying (Kamelia and Fathurohman, 2017). The main feed for livestock is generally forage which includes legume grass and leaves. The availability of forage, especially grass, is experiencing many problems due to low levels of production and non-continuous availability as well as the availability of land for planting grass which is decreasing over time. Based on this, exploration of agricultural and plantation waste has been carried out as potential animal feed for livestock which can be used as a substitute for forage. One of the plantation wastes that can be used is waste from cocoa fruit processing in the form of cocoa pod shells (Murni, 2012). The demand for meat is always increasing, so by raising livestock you can meet the need for meat and also produce fertilizer for plants. Integrated farming reduces the risk of crop failure because dependence on a commodity can be avoided and saves production costs. According to (Siswati, 2012) an integrated crop and livestock agricultural system is an agricultural system characterized by a close relationship between plant and livestock components in a farming activity or within an area. Meanwhile, this linkage is a trigger factor in encouraging sustainable regional economic growth (Siswati, 2012). It is hoped that livestock with high productivity will convert low-quality natural resources into good-quality products. (Sodiq *et al*., 2017) reported that ruminant livestock can provide guaranteed services for the sustainability of agricultural systems. Ruminant livestock are very helpful in quickly converting biological resources originating from pastures, agricultural waste residues, and product waste into food products that are of high value for human consumption. Through ruminant livestock such as beef cattle, barren land can become fertile and productive. Likewise, manure from agricultural waste and agro-industrial waste will no longer be an environmental problem if it is used as well as possible (Sodiq *et al*., 2017). Agricultural development aims to increase production towards self-sufficiency, with the hope of expanding employment opportunities and improving people's living standards. To achieve this goal, innovations are needed to increase agricultural production. One of the main things that supports agricultural productivity is the availability of nutrients. Nutrients can be obtained through the livestock sub-sector by using livestock waste such as cow dung as organic fertilizer. Chemical fertilizers cause depletion of micro elements such as zinc, iron, copper, manganese, magnesium and boron, which can affect plants and animals as well as human health. Therefore, to prevent major impacts on sustainable agriculture, this is done by improving the level of soil fertility one way is by providing manure (Melsasail *et al*., 2019). There are two types of manure, namely solid manure and liquid manure. Manure makes the soil more fertile, loose and easy to cultivate. Manure has natural properties and does not damage the soil, where macro elements (nitrogen, phosphorus, potassium, calcium and sulfur) and micro elements (iron, zinc, boron, cobalt and molybdenum) are available in manure. Apart from that, manure also plays a role in increasing water resistance, soil microbiological activity, cation exchange capacity and improving soil structure. Manure can contribute nutrients to plant growth, because manure contains higher levels of nutrients (Arif, 2020). Manure is a waste product from domestic animals such as cattle, buffalo, goats and chickens which can be used to add nutrients and improve the physical and biological properties of the soil. The quality of manure greatly influences the plant's response. Manure is processed livestock manure given to agricultural land to improve soil fertility and structure. The nutrients contained in manure depend on the source of the raw material. Large livestock manure is rich in nitrogen and metallic minerals, such as magnesium, potassium and calcium. Thus, the main benefit of manure is maintaining the physical structure of the soil so that roots can grow well (Melsasail *et al*., 2019). Among the various types of manure, cow dung contains the highest levels of fiber such as cellulose, as evidenced by the results of measuring the C/N ratio which is quite high >40. Apart from that, cow manure also contains macro nutrients such as 0.5 N, 0.25 P_2O_5, 0.5% K_2O with a water content of 0.5%, and also other essential micro nutrients (Hafizah and Mukarramah, 2017). Based on the description above, the objectives of this study were to determine the effect of manure application on cocoa crop production, to determine whether feed with cocoa waste shell ingredients can increase cattle body weight, to determine how cattle manure and feed with cocoa waste shell ingredients integrate in increasing cocoa production.

MATERIALS AND METHODS

***Place and time*:** This research was carried out in the form of an experiment in Lasusua District, North Kolaka Regency, Southeast Sulawesi Province from October 2023 to February 2024.

***Tools and materials*:** The tools used in this research are collection buckets, meters, markers, cattle scales, analytical scales, measuring cups, dropper pipettes, burlap sacks, stir

sticks or wood, pruning shears, CCM-200 plus, glass preparations, and microscope. The materials used in this research were 4-year-old side grafted MCC-02 cocoa plants, 10 cows, cocoa shell waste for cattle feed, cow manure, cow manure, NPK Pelangi fertilizer 14:12:16:4, EM4 livestock, EM4 agriculture, clear nail polish, water, plastic bag and marker label.

***Research methods*:** This research was carried out in the form of an experiment structured based on a Randomized group design (RGD) pattern with 3 groups, to help reduce the influence of environmental factors that may occur during the research. Treatment consists of 4 levels, namely:

K0= No manure or control
K1= Providing 2.5 kg of manure/tree
K2 = Providing 5 kg of manure/tree
K3 = Providing 7.5 kg of manure/tree

Thus, there are 4 treatment combinations, namely K0, K1, K2, K3. Each group consisted of 3 units of side-grafted MCC-02 cocoa plants that were more than 4 years old and were repeated 3 times so that 36 experimental units were used. Meanwhile, treatment for cows consists of 2 levels, namely:

S0= Without feeding or control (5 animals)
S1= Feeding cocoa shell waste 2 kg/head (5 heads)

Research implementation

***Manure making*:**

1. Prepare various ingredients including EM4, brown sugar, water, and cow dung. Next, prepare the various tools used, including hoes, buckets, shovels, and burlap sacks.
2. Next, make manure by mixing about 100 ml of EM4, and water with 1 kg of sugar, and stir until evenly distributed, to produce microbes that are useful for decomposing manure. After stirring, leave the solution for 15 days in a closed condition.
3. Mix the dry cow dung with the EM4 solution which has been left for 15 days by stirring until evenly mixed.
4. The dough that has been mixed evenly is covered with a burlap sack so that the fermentation process takes place optimally, this process lasts for 15 days.
5. Stir the mixture above every two days so that the fermentation process takes place optimally.
6. On the 16th day the manure can be stored or used immediately.

***Feed making*:**

1. Chop the cocoa pod skin on a wooden base using a machete. The purpose of chopping is to speed up withering and remove theobromine sap because this sap can cause digestive disorders in livestock if consumed in excess.
2. After chopping, air-dry the fruit skin for approximately 4 hours.
3. After that, the fruit peel is ready to be given to livestock with the addition of livestock EM4 according to the recommended dosage on the packaging. Fruit peels can still be given to livestock for up to 3-4 days.

***Application of manure to cocoa plants*:** Make it look like a disc on the cocoa plant, then manure is applied according to the predetermined treatment levels, following the disc that has been made. The dose of manure per plant is 2.5 kg, 5 kg, and 7.5 kg.

***Feeding cocoa husk waste to cows*:** Cocoa shell waste is given to cattle as additional feed after withering at 2kg/head 3 times per week to cattle that have been stalled for 30 days. Cocoa pod skin processing has been carried out previously to increase nutrients and reduce anti-nutritional compounds from cocoa pod skin.

***Maintenance*:** Carrying out maintenance by carrying out weeding. Weeding is carried out if there are weeds growing around the cocoa plants by pulling out the weeds, sanitizing rotten and diseased cocoa pods, and pruning water shoots and orthotrop that grow around the primary stem after treatment. Meanwhile, cattle maintenance is carried out on cattle that are treated with cocoa shell waste by providing food in the morning and evening.

***Harvest*:** Cocoa harvesting is carried out in stages starting from early January 2023 to February 2024.

***Observation of cattle body weight*:** The body weight of cattle was carried out twice, with an initial weighing in January 2024 and a final weighing in February 2024.

Observation parameters

***Cocoa plant observation parameters*:** The number of harvested fruits was carried out at the end of the research. Harvesting of ripe fruit is done in stages because the maturity of the cocoa fruit does not occur at the same time, so harvesting is done at any time when the fruit is ripe.

Weight of 100 dry seeds (g)
Production per tree (kg)
Production per hectare (ton)

Cattle observation parameters

***Increase in Body Weight of Cattle*:**

$$Increase\ in\ Body\ Weight\ of\ Cattle = \frac{w2 - w1}{t2 - t1}$$

Question: t1= Starting time of weighing (days)
t2= Maintenance time (days)
w1= Initial body weight (kg)
w2= Final body weight (kg)

Source: (Ratna, 2014).

***Analysis of soil fertility after application of cattle manure*:** The observation parameters for soil fertility analysis can be described as follows.

Table 1. Soil fertility indicators.

No.	Parameter	Unit symbol	Method
1	pH		Hydrometer
2	C-Organic	%	NH4OAc pH 7
3	KTK	cmol (+) kg-1	Walkey and Black
4	Ratio C/N		
5	Nitrogen (N)Total	%	Kjeldahl
6	Fosfor (P) available	ppm	Olsen
7	Kalium (K) available	cmol (+) kg-1	Ekstrak HCl 20%

Source: (Hasibuan and Santoso, 2005)Soil Research Institute (2005).

***Data Analysis*:** Plant observation data will be analyzed by Variance Analysis (ANOVA) at the 95% confidence level. If there is a significant effect, it will be further tested using the Least Significant Difference (BNT) test of 0.05. The data of cattle body weight observation will be analyzed using paired t test.

RESULTS

Based on the results of research that has been carried out, the following are obtained:

Observation parameters of cocoa plants

***Number of harvested fruits*:** The various results of the average observation of the number of harvested fruit showed that the manure dose treatment had a very significant effect on the number of harvested fruit.

***Weight of 100 dry seeds*:** A variety of results from the average observation of the weight of 100 dry seeds showed that the treatment dose of manure had a very significant effect on the weight of 100 dry seeds.

***Production per tree (kg)*:** The analysis of the variation in the average results of observations of production per tree shows that the treatment dose of manure has a very significant effect on production per tree.

***Production per hectare (ton)*:** The analysis of the variation in the average results of observations of production per hectare shows that the treatment of manure doses has a very significant effect on production per hectare.

Table 2 shows that the K2 manure treatment (5kg/tree) gave the highest average number of fruit harvests, namely 22.67, and was significantly different from K0 (control), and significantly different from the K1 (2.5kg/tree) and K3 (control) treatments. 7.5kg/tree).

Table 3 shows that the K2 manure treatment (5kg/tree) gave the highest average weight of 100 dry seeds, namely 184.36(gr), and was not significantly different from the K3 manure treatment (7.5kg/tree), while the treatment without fertilizer K0 cage (control) gave the lowest yield, namely 159.46(gr), and was not significantly different from K1 manure treatment (2.5kg/tree).

Table 4 shows that the K2 manure treatment (5kg/tree) gave the highest average yield per tree, namely 7011.72(g), while the treatment without K0 manure (control) gave the lowest yield, namely 251.33(g), and was significantly different. with other treatments.

Table 2. The average number of harvested fruit (fruit) at various doses of livestock manure cattle.

Manure Treatment	Cocoa Plant Group			Total Treatment	Average
	Deuteronomy I	Deuteronomy II	Deuteronomy III		
K0 (control)	4.00	5.00	4.00	13.00	4.3c
K1 (2,5kg/tree)	5.00	5.00	6.00	16.00	5.33bc
K2 (5kg/tree)	8.00	9.00	10.00	27.00	9.00a
K3 (7,5kg/tree)	7.00	7.00	7.00	21.00	7.00b
Total Group of Cocoa Plants	24.00	26.00	27.00	77.00	6.42

Question: Numbers followed by the same letter are not significantly different in the BNT0.05 test.

Table 3. The average weight of 100 dry seeds (g) at various doses of cattle manure.

Manure Treatment	Cocoa Plant Group			Total Treatment	Average
	Deuteronomy I	Deuteronomy II	Deuteronomy III		
K0 (control)	155.55	162.54	160.29	478.38	159.46 b
K1 (2,5kg/tree)	167.59	163.51	151.42	482.52	160.84 b
K2 (5kg/tree)	182.94	181.79	188.35	553.09	184.36 a
K3 (7,5kg/tree)	168.37	169.91	172.96	511.24	170.41ab
Total Group of Cocoa Plants	674.45	677.76	673.03	2025.24	168.77

Numbers followed by the same letter are not significantly different in the BNT0.05 test.

Table 4. Average production per tree (g) at various doses of cattle manure.

Manure Treatment	Cocoa Plant Group			Total Treatment	Average
	Deuteronomy I	Deuteronomy II	Deuteronomy III		
K0 (control)	217.77	292.58	243.65	753.99	251.33 c
K1 (2,5kg/tree)	293.29	307.94	336.16	937.39	312.46 bc
K2 (5kg/tree)	624.45	670.82	809.91	2105.17	701.72 a
K3 (7,5kg/tree)	459.65	455.93	427.79	1343.37	447.79 b
Total Group of Cocoa Plants	1595.15	1727.27	1817.50	5139.92	428.33

Numbers followed by the same letter are not significantly different in the BNT0.05 test.

Table 5. Average production per hectare (ton) at various doses of cattle manure.

Manure Treatment	Cocoa Plant Group			Total Treatment	Average
	Deuteronomy I	Deuteronomy II	Deuteronomy III		
K0 (control)	0.24	0.33	0.27	0.84	0.28 c
K1 (2,5kg/tree)	0.33	0.34	0.37	1.04	0.35 bc
K2 (5kg/tree)	0.69	0.75	0.90	2.34	0.78 a
K3 (7,5kg/tree)	0.51	0.51	0.48	1.49	0.50 b
Total Group of Cocoa Plants	1.77	1.92	2.02	5.71	0.48

Numbers followed by the same letter are not significantly different in the BNT0.05 test.

Table 5 shows that the K2 manure treatment (5kg/tree) gave the highest average yield per hectare, namely 0.78(ton/ha), while the treatment without K0 manure (control) gave the lowest yield, namely 0.28(ton/ha) and significantly different from other treatments.

Parameters for observing cattle

***Increase in body weight of cattle*:** Observation of the increase in body weight of cattle using the t-test which includes the increase in body weight of cattle with additional feeding of cocoa pod shells and without additional feeding.

Table 6. Average daily gain of cattle (ADG).

	Additional Feeding (cocoa pod shell)	Without Additional Feeding (control)
	1.10	0.40
	0.70	0.30
	1.20	0.20
	1.40	0.20
	0.80	0.20
Average	1.00	0.26

Source: Primary data processed, (2024)

Table 6 shows that cattle with additional feeding of cocoa waste shells have the highest average daily gain of cattle(ADG) value, namely 1.0kg, while cattle without additional feeding have the lowest average daily gain of cattle(ADG) value, namely 0.26, and from the results of the t analysis Providing additional feed with cocoa waste shells has a very significant effect on the parameters of daily body weight gain of cows as indicated by the two tail P(T<=t) value, namely 0.05.

DISCUSSION

From some research results that have been obtained, treatment using cow manure K2 (5kg/tree) has a very significant effect on the parameters of the number of fruits harvested, weight of 100 dry seeds, production per tree, and production per hectare. In this case, it can be seen how cow manure is able to increase cocoa crop production. As we know cow manure or when used to process it into compost, is an organic material derived from livestock manure based on the results of soil analysis conducted and obtained the results of soil at the research location that has been applied cow manure has the content of C-Organic, C/N, N, P and K. This can occur because cow manure contains organic materials in the form of C-Organic, C/N, P and K which are available and needed by plants. As in previous research, it is generally known that each ton of manure contains 5 kg N, 3 kg P_2O_5, and 5 kg K_2O as well as other essential nutrients in relatively small amounts which are also needed to increase plant productivity (Roidah, 2013). Talking about productivity depends on the production results obtained. Cocoa plants require handling such as fertilization that contains nutrients such as nitrogen, phosphorus, potassium, and other essential nutrients to obtain good production results and product quality (Firmansyah, 2020) In the generative growth phase, such as the growth of fruit nipples, young or surviving fruit, and old fruit, sufficient nutrients are needed for cocoa plants. This is to prevent nutrient competition in cocoa plants in the generative phase which can affect the yield of old fruit to be harvested and is able to suppress the occurrence of nipple drop or what is known as nipple wilt (Widiancas, 2010). Treatment of K2 cow manure fertilizer (5kg/tree) can suppress the occurrence of wilted stems during the growth period, thereby reducing the occurrence of fallen stems. This is supported by the composition containing high phosphorus and is needed by cocoa plants in large quantities in the generative phase and is supported by the opinion of (Kotten *et al*., 2023) stating that the P element in the soil can be obtained from organic fertilizers, which play an important role in the process of forming flowers, fruits and seeds.

In the observation parameters of Average daily gain of cattle(ADG) using t analysis, it shows that the provision of additional feed from cocoa shell waste has a very significant effect on the average daily gain of cattle(ADG). Even though the average daily gain of cattle(ADG) measurement of cattle is relatively short, this can occur due to the fiber and nutrient content contained in cocoa pod shells so that significant results are obtained in the average daily gain of cattle(ADG) given additional feed. Where in the research results, the highest average daily gain of cattle(ADG) was shown in cattle that were given additional feed with cocoa pod shells at a dose of 2kg 3 times every week for 30 days. with the average daily gain of cattle(ADG) that were given treatment being 1.0kg/day, while in cattle that were not given treatment the

average daily gain of cattle(ADG) was only 0.26kg/day. This is in accordance with the opinion of (Ratna, 2014) who stated that, raising Bali cattle carried out by people's farms on dry land with a lack of quality forage to be used as cattle feed, livestock growth was only around 0.1-0.3kg/day. As stated by (Sodiq and Yuwono, 2016) that body weight gain is greatly influenced by maintenance and feed factors, the increase in body weight in Bali cattle given additional feed can reach 1.77kg. North Kolaka Regency is one of the districts that contributes the highest cocoa production in Southeast Sulawesi, based on the population recorded by the (Central Statistics Agency, 2023), North Kolaka Regency is recorded as having the number one largest cocoa plantation area in Indonesia with a total land area of both crops immature, mature plants, to old mature plants or damaged plants, namely 78,971 ha with a total production of 54,852 thousand tons/ha, from available data it can be estimated that there are around 907,712 thousand tons/ha of cocoa pod husk waste. Cocoa shells which become waste can be used as additional feed by knowing the production of dry cocoa beans. Based on existing land area data and adding up the cocoa production obtained when the integration of cocoa and cattle farming was implemented, in providing additional feed from the cocoa plantation land area in North Kolaka, ±708,015,862 million tons/year of cocoa shell waste was obtained. So, the use of cocoa pod shells as additional feed is very possible to meet the needs of 646,589 head of cattle in cocoa plantation areas, because the availability of grass and forage is very limited.

Cocoa pod husks have great potential, both in quality and quantity as a source of fiber for animal feed after processing to increase its nutritional levels. As stated (Puastuti and Susana, 2014), cocoa shells can be used as a substitute for grass, and can also be used as additional feed after processing. Fresh cocoa pod skin has high palatability due to its sweet taste and aroma. Processing cocoa pod shells is useful for increasing nutrient availability, digestibility and reducing anti-nutritional compounds contained in cocoa pod shells in the form of lignin, tannin, and theobromine.

***Conclusion*:** Based on the results of the research carried out, it can be concluded that K2 cow manure treatment showed the best results in the number of harvested fruit (9 pieces), weight of 100 dry seeds (184.36g), production per tree (701.72kg/tree), production per hectare (0.78ton /ha), and the highest average daily gain of cattle(ADG) of cattle was obtained in cattle that were given additional feed with cocoa pod shells, with an average daily gain of cattle(ADG) of 1.0kg. Manure is applied to cocoa plantations to increase dry cocoa production then cocoa shell waste is used as additional feed for cattle to meet the fiber needs of cattle contained in cocoa shell waste.

***Authors' contributions*:** M.M. Muthia, B. A. Haris, and designed, completed the experiments; R. Lellah, and R. Burhanuddin reviewed and finalized the draft.

***Conflict of Interest*:** The authors declare no conflict of interest.

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***Ethical statement*:** All relevant international, national, and/or institutional guidelines for animal care and use were observed.

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