Potential of forage systems-three strata (FS-TS) management in the coconut-beef integrated farming system (Coco-Beef IFS)

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Abstract- This study aims to implement the coconut and beef cattle integration system farming through planting the forage system-three strata (FS-TS) system on coconut plantations as a superior source of forage to increase the added value of cattle and coconut farming.

The research method was carried out on farmers' land *(in situ*), with field experiments using coconut plantations land. Forage system-three strata (FS-TS) applied: Stratum 1 is grazing grass Ruzi grass (*Brachiaria ruziziensis*); Stratum 2 is cut grass dwarf elephant grass (*Pennisetum purpureum* cv. *Mott*); and Stratum 3 is tree legume Indigofera sp. (*Indigofera zollingeriana*). On the experimental soil, the application of cattle dung waste fertilizer for forage plants and coconut plants was carried out.

The results showed the production of forage system of natural pasture (FS-NP) before FS-TS on coconut land were 192,480 kg per year, and with a grass palatability of 31.2 pencent, it is 60,053.76 kg per year, only able to provide a carrying capacity of 4.7 AU/ha per year. Then, after the application of FS-TS, the potential capacity is 27.70 AU per hectares per year, which means an increase of 23 AU per hectare per year for the forage system - three strata (FS-TS) in coconut land.

Index Terms- Carrying capacity, coco-beef, fodder

I. Introduction

Coconut plantations are the mainstay of the economy of North Sulawesi, Indonesia, with the price of copra as the main coconut product decreasing drastically in 2018 by around 26.36 percent. On the other hand, beef experienced an increase in national prices by 19.4 percent, while production increasing only 2.5 percent and beef consumption tends to increase by around 6.01 percent, so that nationally imports of meat are on average 267.58 thousand tons (Kemendag 2014 and Jiuhardi 2016). There is a need to increase the production of coconut commodities in rural areas which can be integrated with other commodities to encourage an increase in rural income. The existence of large potential land and above average coconut production capabilities can capture opportunities to increase coconut production and other commodities that have the potential to be developed further (Kamarullah et al., 2022)

When there is a decline in the contribution of coconut farming, there must be other commodity farming to increase farmers' income. One alternative to farming is coconut-beef cattle integrated farming system (coco-beef IFS), which is a farm that is managed in an integrated, mutualism and ecologically oriented, so that added value is obtained and increased income for farmers. Coco-beef IFS is basically mixed farming where cattle are reared on land under coconut trees that provides farmers with a higher return per hectare. Cattle under coconuts have long been practiced in many tropical countries (Reynold 1995).

Farming systems can consist on the one hand large scale managed as corporate agri-businesses and on the other hand small-scale farms, which employ family labor and use limited external inputs. In the small systems, a closer integration of the different components, recycling and optimized use of local resources can enhance productivity (Preston 2005). Integration of different farming increases the productivity, profitability and agricultural sustainability, and to reduce the huge quantity of residues and by-products, integrated farming system can be suitable option for proper value addition (Panda et al 2022). The concept of sustainable integrated farming system with low external inputs, waste from one farm becomes input for other farms using efficient resources (Walia and Kaur 2013). The concept of man-land-livestock ecosystem is gaining momentum to maximize food production and to elevate economic status of the farmers by multifarious farm activities (Ramrao, Tiwari and Singh 2006).

IFS is capable of producing diverse social, economic and environmental benefits to the smallholder systems (Dasgupta et al 2015). In South East Asia, the integration of crops and livestock, and the use of manure as fertilizer, are traditional practices and are the basis of farming systems, especially at small-holder level (Preston 2022).

One alternative application of the concept of the integration farming system of coconut - cattle is the application of the forage system - three strata (FS-TS). Through the three strata system, it will provide added value for farmers, get an attractive level of profit and increase farmers' income.

The aim of the research is to implement integrated farming of coconut and cattle by cultivating superior forage plants with a forage system-three strata (FS-TS) in coconut plantations as a superior source of forage for cattle. These three types of forages, resistant and productive forage plant under the tree canopy, which needs to be studied through the forage system-three strata (FS-TS), in an effort to increase cattle production to support a green economy and want to reduce negative impacts on the environment and scarcity of natural resources.

II. MATERIALS AND METHODS

The research was conducted on farmers' land (*in situ*), as a field experiment on coconut land owned by farmers.

The study was conducted by applying the cultivation of superior forage crops with a three strata system on coconut plantations land to increase the production of cattle and coconut. Forage system FS-TS:

Stratum 1 Ruzi grass (*Brachiaria ruziziensis*) as grazing grass;

Stratum 2 Dwarf elephant grass (*Pennisetum purpureum* cv. Dwarf) as cut grass; and

Stratum 3 Indigofera (*Indigofera zollingeriana*) as a tree legume.

The research was carried out on land owned by coconut farmers (in situ), where the research was carried out in 3 phases, carried out one phase every year. Phase 1 has conducted research on the application of FS-TS planting with the application of beef cattle manure on forage and coconut plantations. On the experimental soil, the application of cattle dung waste fertilizer for forage plants and coconut plants was carried out.

III. RESULTS AND DISCUSSION

Prior to the application of FS-TS planting, an evaluation of the production measurement of the forage system - natural pasture (FS-NP) was carried out. The results of the evaluation of the production measurement of forage system - natural pastures (FS-NP) on coconut land before the application of the forage system - three strata (FS-TS), can be seen in **Table 1**.

Table 1 The forage system - natural pastures (FS-NP) on coconut land

Sample	Grasses	Legumes	Fern	Bush	Amount
	gram				
1	574	43	364	295	1.276
2	409	19	78	1.514	2.020
3	570	40	75	685	1.370
4	350	57	200	856	1.463
5	600	56	250	986	1.892
Total	2.503	215	967	4336	8.021
Average	500.6	43	193.4	867.2	1.604
Stdev.s	113,09	15,41	122,15	445,31	330,99

Note: Samples are 1 x 1 m

Table 1 shows the average forage production is 1,604 gr/m^2 in it consists of grass 500.6 grams or 31.2% palatability, while other forages 68.8% low edible is not eaten by cattle. With rotation grazing once a month, the potential forage is 1,604 gr x 10,000 m^2 x 12 grazing times = 192,480 kg per year. With a forage palatability of 31.2% x192,480 kg per year, it is only able to provide forages of natural pastures of 60,053.76 kg per year on 1 hectare of coconut land.

Assuming that 1 AU (animal unit) with body weight (BW) or local cattle an average of 350 kg, the need for fresh forage is 10% BW per day so that it takes 35 kg / day or 12,775 kg per AU per year. Thus, natural pasture forage production is only able to provide carrying capacity (CC) for the number of livestock that can be kept per unit area of 60,053.76:12.775 = 4.7 AU/ha per year.

The need to increase production, not only productivity but also resource efficiency or sustainable intensification, is now becoming important for agriculture, including forage production. It is also necessary to keep pace with higher production requirements for ruminants, as well as to respond to and adapt to climate change (Leuscher et al 2014). Fodder forage production faces competition from land requirements, competition between food and feed production, bioenergy needs and the need to conserve biodiversity and maintain ecosystem services (Thornton 2010). Through the integrated system of crops and livestock, the competition between food and feed production can be transformed into mutualism to increase integrated production.

One of the transformation efforts into mutualism between food and feed production is through the integration system farming of coconut and beef (coco-beef) with a forage system - three strata (FS-TS) on coconut plantations as a source of superior forage forage to increase added value (technical and economic added) coconut and cattle farming.

FS-TS is the management of forage production by planting three types of fodder crops consisting of grazing grass, cut grass and tree legumes. Tree legume forage plants need to be planted, mainly serving as a source of protein-rich forage feed, as a land fence and barrier to the pasture. Tree legumes are also used to absorb and store carbon in the air and reduce methane gas emissions by using grass for animal feed (Osak, Anis and Rumambi 2020).

On a coconut plantation area of 10,000 m^2, there are parts that cannot be planted forage system of three strata (FS-TS), where the number of circles with a radius of 2 m of coconut roots area (CRA), where is the area of each circle CRA = πr^2 = 3.14x2m^2 = 12.56 m^2 per coconut tree, with a total of 123 coconut trees on 10,000 m^2 land, then the area of land that cannot be planted with forage is 123x12,56 m^2=1,544.88 m^2. While the land that can be planted with forage systems - three strata (FS-TS) = 10.000 - 1,544.88 m^2 which is as wide as 8.430 m^2.

Thus the land that can be planted with the forage system - three strata (FS-TS) covering an area of 8,430 m2, then divided into 3 strata, namely stratum 1 is the core stratum (primary stratum) planted with Ruzi grass (*Brachiaria ruziziensis*) area of 6,000 m^2 function as grazing grass, stratum 2 is the supporting stratum

(secondary stratum) planted with elephant grass cultivar dwarf (*Pennisetum purpureum* cv. *Mott*) area of 2.000 m^2 functions as cut grass, and the remaining stratum 3 is the complementary stratum (tertiary stratum) planted tree legume *Indigofera zollingeriana* area of 430 m^2 serves as a source of forage rich in protein, rich in nitrogen and calcium.

Production management application of the forage system - three strata (FS-TS) in coconut land begins with tillage and clearing the land under coconut plants from grass, weeds and wild bushes including natural pasture forage, which has measured the capacity of cattle capacity as shown in Table 1.

After the land is clean and then loosened, then add cow manure in the amount of 1-1.5 kg/m^2. After that the land in the stratum 1 area was planted with Ruzi grass (*Brachiaria ruziziensis*) with spacing 30x50 cm, the stratum 2 area is planted with elephant grass cv. dwarf (*Pennisetum purpureum* cv. *Mott*) with a spacing of 50x50 cm, while the stratum 3 area is planted with tree legume *Indigofera zollingeriana* with a spacing of 1x1 m. After planting, forage was cut at 90 days after planting (DAP) for measurement of forage production in coconut fields with the FS-TS system. Production of forage fodder on coconut land with the FS-TS system can be seen in **Table 2**.

Table 2 Production of forage fodder on coconut fields FS-TS system

Sample	*Brachiaria ruziziensis*	Sample	*Pennisetum purpureum* cv. *Mott*	Sample	*Indigofera zollingeriana* *)	Amount
	gram					
1	3.893	1	6.024	1	3.687	9.917
2	4.028	2	6.212	2	3.900	10.240
3	3.987	3	5.869	3	4.186	14.042
4	3.976	4	6.105	4	3.898	13.979
5	4.119	5	5.982	5	4.277	14.378
Total	20.003		30.192		19.948	62.556
Average	4.000,60		6.038,40		3.989,60	12.511,20
Stdev.s	82,37		129,09		239,35	82,37

Notes: Sample area of 1 x 1 m
*) Production per sample tree

Based on **Table 2** shows that the production of the FS-TS system in coconut land are in stratum 1 or the core (*primary stratum*), Ruzi grass production (*Brachiaria ruziziensis*) an average of 4,000.60 grams/m^2 or 4 kg/m^2. Based on this production, the production of Ruzi grass (*Brachiaria ruziziensis*) with 10 grazing rotations per year produces fresh forage with a planting area of 6,000 m^2 of 240,000.36 kg per year. Ruzi grasss (*Brachiaria ruziziensis*) is commonly used for pasture development and forage production. Ruzi grass is generally used for pasture development and forage production (Wangchuk et al. 2021). Ruzi grass like other Brachiaria like Brachiaria decumbens and Brachiaria brizantha native or hybrid is the most preferred grass because of its possibility for high palatability, drought tolerance, year-round biomass production, and low fertilization inputs requirement (Maass et al. 2015 and Magalhaes et al. 2017).

In stratum 2 land (*secondary stratum*), production of elephant grass cv. dwarf (*Pennisetum purpureum* cv. *Mott*) an average of 6.038,40 6 gram/m^2 or 6,04 kg/m^2 it can be projected that the production of elephant grass cultivar dwarf with an area of 2,000 m2 and 9 times trimming per year produces fresh forage of 108,691.2 kg per year. *Pennisetum purpureum* cv. *Mott* can increase the production and nutrition of animal feed on coconut plantations compared to local feed crops *Cynodon* sp. and *P. purpureum*, can also adapt under the shade of mature coconuts (Reynolds 1995).

In stratum 3 land (*tertiary stratum*), average tree legume *Indigofera zollingeriana* production of 3.989,60 gram/m^2 or 4 kg/m^2 with a planting area of 430 m^2 and 3 times trimming per year produces fresh forage 5,146.58 kg per year. In the current scenario of climate change and the need to increase food security, tree legumes are a key component for the sustainable intensification of livestock systems in warm-climate regions (Dubeux Jr et al 2017).

Thus the total production potential of FS-TS is 240.000,36 + 108.691,2 + 5.146,58 kg per year or as much as 353.873,78 kg per year per hectare of coconut land. With the animal unit (AU) of cattle weighing an average of 350 Kg, the need for forage feed weighing 10% of body weight is 35 kg per day or 12,775 kg per year, so that the potential carrying capacity of the FS-TS system for cattle on land coconut plantations as much as 27.70 AU per 1 hectare per year, when compared to the production of the forage system-natural pasture which is only 4.70 AU which means an increase of 23 AU per 1 hectare per year through the application of the FS-TS system on coconut land.

Thus, the production of the forage systems-three strata (FS-TS) in coconut plantation has the potential to increase the carrying capacity or the ability to provide forage to increase the population and productivity of cattle.

IV. CONCLUSION

The potential carrying capacity of the forage systems-three strata (FS-TS) for cattle on land coconut plantations as much as 27.70 AU per 1 hectare per year. The management of the FS-TS system in coconut plantations has the potential to increase the ability to provide forage to increase the population and productivity of cattle.

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