Productivity and LER (Land Equivalent Ratio) Napier grass-based intercropping with Legume Cover Crop (LCC)

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Abstract. The aim of the study was to evaluate productivity and Land Equivalent Ratio (LER) Napier grass-based intercropping with Legume Cover Crop (LCC). The experiment conducted at Teaching Farm Faculty of Animal Science, Universitas Brawijaya. Three type of LCC (A) were *Clitoria ternatea, Centrocema pubescens* and *Pueraria javanica* and number of row of LCC (B) that nested on factor A. Each treatment repeated 4 times. One plot of experiment were 5 x 4 m (30 plants, 5 row). Parameters that observed were productivity (fresh and dry matter forage production) and LER. Data analyzed with Variance Analysis using Completely Randomized Block Nested Design. The result has shown that type of LCC had influenced on fresh and dry matter forage production while row number of LCC had not influenced. Land Equivalent Ratio Napier grass-based intercropping with two row of LCC were higher than one row of LCC, especially intercropping with *Clitoria ternatea* and *Pueraria javanica* have LER > 1, in order 1.073 and 1.028. It can be concluded that type of LCC on intercropping had influence on forage production and intercropping Napier grass with two rows of LCC are more effective to maintain forage production and sustainable animal production with high quality forage.

1 Introduction

Forage crop systems are important for animal production. Ruminant animals need forage as a sources of fibre and other nutrient such as protein, vitamin. Continuity of forage production frequently become problems, especially in dry season. There is a huge shortage of feeds and fodder in developing countries, it is projected that by 2050, 35% of cereals that produced will be used as animal feed [1]. It means that forage production management need to be concern, to fulfil animal requirement especially on quality and production. To increase biomass of forage need a good management of nutrient that needed by forage to growth especially nitrogen, phosphor and potassium. Nutrients often limit plant growth and animal performance and reduce pasture productivity as a result [2]. Forage production systems

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demand large amounts of nitrogen fertilizer. If deficiency of nitrogen, forage will stunted growth, chlorosis or yellowing the leaves, and poor production. [3] Nitrogen inputs to soil are largely dependent on prior fixation by a legume or nitrogen fertilizer that used in the land. It will influenced soil fertility and forage production. High crop yields mean greater depletion of soil nutrient supplies, which eventually must be balanced by increased nutrient input to maintain the fertile soils needed.

There are a few method that farmer usually used to maintain and increase soil fertility, e.g. 1. Use fertilizer (organic or an-organic or bio-fertilizer or combination), 2. Crop rotation, 3. Intercropping with legume. Fertilizer application produced a forage yield advantage of up 2000 kg / ha forage DM in 2017 over control, indicating that fertilizer application can be used to bring the productivity of a stand back, without the expense of re-seeding. Using fertilizer has potential to substantially increase forage yield and quality, and to improve condition of forage stand [4]. Nitrogen fertilizer application has significantly contributed to forage productivity in tropical regions [5]. Integration of legumes on forage production systems also help smallholder farmers to produce more forage biomass and increase quality of fodder production [6]. By legume intercropping, environmental resources such as water, light and nutrient are more efficiently utilize than sole cropping systems [7]. Therefore, grass-legume forage intercropping can help to increase productivity of land and feedstuffs of livestock especially green forage like grasses.

Napier grass is a perennial C4 grass species with a lot of superiority such as be adapted in a wide range of soil conditions, strong resistance to dry spells [8]; tall and high yielding capability and also mainly used for cut and carry feeding systems for livestock [9-10]. On average nutritive value of Napier grass contain 9 % CP, 20 % DM, 70 % NDF, 50 % ADF, 9 % ash and 6 % lignin with age 10 – 15 weeks [11-12].

Legume cover crop (LCC) are ground cover plants used for protecting the soil from erosion and preventing loss of nutrients, furthermore they can improve soil quality physically, chemically, and biologically, such as *Centrosema pubescens, Pueraria javanica, Mucuna bracteata and Calopogonium mucunoides* [13]. LCC also used to fix atmospheric nitrogen (N), produce biomass and add organic matter to the soil and attract beneficial insects.

There are a lot of advantanges implementing Napier grass- legumes intercropping which are improve the nutritive value of Napier grass [14-15], maximaze yield and quality in forage production [16] because legumes are good sources of protein. Intercropping legumes with grasses significantly reduced neutral detergent fiber and acid detergent fiber content and increase digestibility of the forage [17]. Napier grass intercropped with lablab and cowpea at planting density of 24 plant m^2 was better choice for high yield and forage quality [17]. Incorporating N2-fixing legumes with grasses has been suggested as one of the best alternatives to enhancing the income in grass-fed livestock operations [2], thus minimising the dependence of farmers on synthetic N fertiliser. Research of intercropping usually use legume to decrease N fertilizer on pasture/ field [18-19], improve and sustain great yield [18-21] increase profitability [19-20] and sustain soil quality [19-21].

However, challenges to the increase in acreage that are needed to produce substantial quantity of high-quality feed along with global food security still largely remain unaddressed. Considering the above merits of Napier grass and LCC, evaluating the effect of intercropping Napier grass with different type of LCC and different row of LCC will be of great importance. The aim of the study was to evaluate productivity and Land Equivalent Ratio (LER) Napier grass-based intercropping with LCC (*Clitoria ternatea, Centrosema pubescens* and *Pueraria javanica*) that planted with different row of LCC, ie., one row LCC per plot (R1) and two row LCC per plot (R2).

2 Material and Method

The research conducted from July to November 2022, at Teaching Farm Faculty of Animal Science, Universitas Brawijaya for planting the forage. The planting of Napier Grass and all legume cover crop was done on 7^{th}August, 2022 with different pattern and then harvested on 5^{th} November, 2022. The experimental design used was Randomized Completely Block Nested Design with three type of Legume Cover Crop (LCC) were planted intercropping with Napier grass which are *Clitoria ternatea, Centrosema pubescens* and *Pueraria javanica* as a factor A and number of row of LCC (R) as a factor B that nested on factor A. Each treatment repeated 4 times. One plot of experiment was 5m x 4 m, consist of 30 plants and 5 rows of plants. All part of plant (stem and leaves) in each plot harvested at 90 days, than weighed to produce fresh production (kg/20m^2). Fresh forage samples for each treatment carried to Animal Nutrition Laboratory at Faculty of Animal Science, Universitas Brawijaya, Malang for proximate analysis. Parameters that observed in this study were productivity (fresh and dry matter production) of forage and LER.

Monocropping

Fresh forage production = all fresh forage after harvested than weighed (kg/20m^2)
Dry matter forage production = % dry matter x Fresh forage production (kg/20m^2)

Intercropping (Napier grass and Legume)

Fresh forage production = all fresh forage (Napier Grass and legume) after harvested than weighed (kg/20m^2)
Dry matter forage production (kg/20m^2)
= ((% dry matter Napier grass x Fresh napier grass production) + (% dry matter legume x Fresh legume production))

Land Equivalent Ratio (LER)

The LER is calculated using the formula LER= $\sum$ (Ypi/Ymi), where Yp is the yield of each crop or variety in the intercrop or polyculture, and Ym is the yield of each crop or variety in the sole crop or monoculture [22, 23].

2.1 Data analysis

Data were collected then analyzed with Variance Analysis using Completely Randomized Block Nested Design if there any significant or highly significant influence of variables will be continue with Duncan's Multiple Range Test (DMRT).

3 Results

The result indicated that type of LCC were significantly give influence ($P<0.05$) to average of fresh and dry forage production on intercropping based Napier grass and number of Legume cover crop (LCC) row were not significant effect ($P>0.05$) to average of fresh and dry forage production on intercropping based Napier grass. Average of fresh and dry matter production on intercropping of Napier grass with various LCC are show on Table 1, 2 and 3. Average of LER is shown on Table 4.

Table 1. Average of fresh forage production (kg/20m^2/90 days) intercropping of Napier grass with various Legume cover Crop (LCC)

Type of Legume cover crop	Fresh forage production (kg/20m^2/90 days)
Clitoria ternatea	92.82 ±31.0404 ^{c}
Centrosema pubescens	41.97 ±12.9582 ^{a}
Pueraria javanica	72.15 ±37.5202 ^{b}

Significant influence is shown by different superscripts on the same column (P<0.05)

Table 2. Average of fresh forage production (ton/ha/year) intercropping of Napier grass with various Legume cover crop (LCC)

Type of Legume cover crop	Fresh forage production (ton/ha/year)
Clitoria ternatea	185.64 ±62.0988 ^{c}
Centrosema pubescens	83.95 ±25.9164 ^{a}
Pueraria javanica	144.29 ±75.0404 ^{b}

Significant influence is shown by different superscripts on the same column (P<0.05)

Table 3. Average of dry matter forage production (ton/ha/year) intercropping of Napier grass with various Legume Cover crop (LCC)

Type of Legume cover crop	Dry matter forage production (ton/ha/year)
Clitoria ternatea	20.905 ±8.3213 ^{a}
Centrosema pubescens	18.885 ±10.2385 ^{a}
Pueraria javanica	43.415 ±27.3002 ^{b}

Significant influence is shown by different superscripts on the same column (P<0.05)

Table 4. Average of LER intercropping of Napier grass with various Legume cover crop (LCC)

Type of Legume cover crop	Row Number in plot	
	1	2
Clitoria ternatea	0.9315	1.0728
Centrosema pubescens	0.6033	0.7023
Pueraria javanica	0.7688	1.0284

LER > 1 is intercropping more efficient

4 Discussion

According to Table 1 and 2, average of fresh forage production on kg/20m^2/90 days and ton/ha/year, fresh forage production of intercropping Napier grass with *Clitoria ternatea* are morehigher than two other type of Legume Cover Crop (LCC), *Pueraria javanica* and *Centrosema pubescens*. This result also supported with growth of *Clitoria ternatea* is healthier than two others LCC. The results of this experiment are higher than experiments [24] which implementing intercrop Guinea grass with *Clitoria ternatea* with fresh forage production 19.10 t/ha and dry forage production 5.41 t/ha.

Average of dry matter forage production in Table 3 a little bit different with fresh forage production because average dry matter percentage mix of Napier grass and *Pueraria javanica* are higher than other mix forage. Anatomy of *Pueraria javanica*, especially leaves assumed influence the dry matter forage production. Dry matter percentage of leaves *Pueraria javanica* in this experiment around 22.93 – 25.57 %. Among two type of LCC, *Pueraria javanica* leaves are wider and thicker than *Clitoria ternatea* and *Centrosema pubescens.*

While row number of LCC on intercropping had not influenced on fresh and dry matter forage production, but there was a tendency that two row of LCC in intercropping will increase fresh and dry matter forage production. It can be seen in LER measurement in this experiment.

LER as tool to evaluate efficiency of intercropping or monocropping also conducted in this experiment. The LER principle states that producing two or more crops as an intercrop yields more than growing the same crops as separate monocultures, if all other factors are equal [22, 23]. Based on table 4, LER Napier grass-based intercropping with two rows of LCC (R2) were higher than LER Napier grass-based intercropping with one row of LCC (R1), especially intercropping with *Clitoria ternatea* and *Pueraria javanica* which have LER > 1, respectively in order, 1.073 and 1.028. According to [22-23], any value greater than 1.0 indicates a yield advantage for intercropping. It indicates that the area planted to monoculture would need to be 7,3 % and 2,8 % greater than the area planted to intercrop for the two to produce the same combined yields.

5 Conclusion

It can be concluded that type of Legume Cover Crop on intercropping had influence on forage production, and intercropping Napier grass with two rows of LCC is more effective to maintain forage production and sustainable animal production with high quality forage.

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