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# CONTRIBUTION OF NEW TROPICAL TREE LEGUMES SPECIES TO ENHANCE CARRYING CAPACITY OF KORONIVIA GRASS PASTURE IN COCONUT BASED FARMING SYSTEM

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***Abstract***

*Indonesia is one of the larger producer copra in the world, so coconut still economic backbone of society. A tropical grass namely koronivia grass well adapted under mature coconuts, crude protein content lower than minimum requirement in the ruminant diet, carrying capacity able to provide only the needs of total digestible nutrient for cattle with bodyweight no exceed to 250 Kg. Needs inorganic nitrogen fertilizer application but costly and occurred negative impacts on the environment. Herbaceous legume integrated as mixed pasture failed to persist due to the aggressiveness of this koronivia grass. This research aims to study the ability of tree legume Indigofera zollingeriana as a source of protein and dry matter to enhance the carrying capacity. Koronivia grass solely could provide dry matter, crude protein and TDN for cattle with body weight 250 Kg, and I. zollingeriana as well, but the latter provides crude protein more, almost double than koronivia. Both species altogether in the same space and management could provide feeds to fulfil the requirement of cattle more than 250 kg body weight.*

***Key words**: capacity, coconut, enhance, I. zollingeriana, koronivia.*

## INTRODUCTION

Indonesia is currently the largest copra producer in the world (FAO, 2009) therefore coconut commodity is still one of the economic backbone of society. Integrated land with industrial plantations include coconut that can be used for the development of forage crops (Anis et al., 2015) still a model farming systems applied in North Sulawesi eastern part of Indonesia. However, this kind of integration is faced with competition for nutrients, water, and sunlight.

Ruminant productivity in Indonesia is determined by forages availability throughout the year. Mostly of forage fed to animals is derived from local grasses species which is low quality contains only around 5% of crude protein (CP) lower than ideal protein content on ruminant diet. A kind of tropical grass namely *koronivia* well adapted under mature coconuts, persist under free-grazing as practice by the farmers, drought resistant and good performance as tropical pasture but crude protein content fluctuated, and in some case that content lower than minimum requirement in ruminant diet. Furthermore, carrying capacity pasture based on *koronivia* in coconut plantation able to provide only the needs of total digestible nutrient for cattle with bodyweight no exceed to 250 kg. Therefore, to increase crude protein content needs nitrogen fertilizer application but costly and in some circumstance occurred negative impacts on the environment. Herbaceous legume integrated as mixed pasture failed to persist due to the aggressiveness of this grass. On the other hand, there are some kinds of tree legumes available in Indonesia i.e., *Indigofera zollingeriana*, highly relished by the ruminant. This kind of tree legume alternate to replace *Leucaena leucocephala* which is susceptible to psyllid (Heteropsylla cubana) as kind of insect pests has been attack *Leucaena* all over the world. However, this *Indigofera* as single plant is widely studied in full sun environment, while growth and performance of this plant in shade conditions such as underneath mature coconut area has been reported yet, both in single plant or in mixed pasture with any tropical grasses.

Plant morphology can be seen and measured in several parameters including plant height, stem diameter, leaf number, branching, and root development. Morphological development is

observed both as a growth indicator and as a parameter used to measure environmental influences or treatments applied. Thus plant growth is an increase in size that can be known by the increase in length, stem diameter, plant-covered area, volume or biomass, wet and dry weight of plants (Abdullah, 2010). This type of legume contains relatively higher crude protein ranging from 22-29% compared to other tree legumes, and fiber content (NDF) is low between 22-46% (Abdullah & Suharlina, 2010), and has been used in improving diets of fattening goats (Anis et al., 2020).
The limited land for forage planting is a common problem in the development of ruminant animals (Sumolang et al., 2020; Rumokoy & Toar, 2014). Along with the increase of human population, participation in the availability of land for the development of extensive forage fodder is decreasing, because it is used for the development of food agriculture and other infrastructure. Therefore, there needs to be an effort to provide land for growing forage since the efficiency of land use in producing nutrition for animals becomes an important issue in a populated region. Evaluation of rows pacing is needed to find an appropriate row spacing for planting *Indigofera* over existing *koronivia* pasture to produce the highest forage yield and quality. There is needs to elaborate from animal nutrition aspect studied on dry matter intake, total digestible nutrients (TDN) and predicted carrying capacity.

## MATERIALS AND METHODS

The study was conducted in the experimental station of Assessment Institute Agricultural Technology (AIAT) of North Sulawesi, located 12 km from Manado City. Experimental site receives an average rainfall of 2700 mm, and the distribution fairly even, except for the period of lower rainfall by 100-150 mm monthly, from July to September. The pH of the fertile sandy loam soil is around 6. Light transmission at 10.00 am on a sunny day as PAR underneath mature tall coconuts averaged 73%. This research consists of two experiments separately, from agronomic traits and animal nutrition aspect. *Indigofera* seeds sown on land that has been processed as a nursery. Seedling that has grown well are then moved into a 2.5 kg plastic bag that has already been filled with soil, one plant / plastic bag. After growing for 2 months in a plastic bag medium, the plant was then transferred to an experimental site. Treatments were different in plant spacing configurations of *I. zollingeriana* on pasture-based on *koronivia* grass. Three treatments of planting spacing (PS) namely PS1: 1.0 m x 0.5 m, PS2: 1.0 m x 1.0 m, and PS3: 1.0 m x 1.5 m corresponding to the number of plants of 21, 12 and 9 plants per plot respectively, placed randomly to the experimental sites in a plot size of 3x4 meter and distribute into 18 plots to accommodate those treatments, thereby 252 plants population has been used. Variable measured were forages yield and quality. Harvesting *I. zollingeriana* was done by cutting the plant sample one meter above ground level, then the leaves and stems are separated. Sample of *koronivia* was taken the plants in a square of 0.5 x 1.0 meter in the middle of each experimental plot. Five hundred grams of samples of both species were then dried in an oven at a temperature of $105^0$C for 24 hours to get dry weight. For these morphological traits, data analysis used a Completely Randomized Design consisting of 3 treatments of planting distance and 6 replications. Data were then statistically analyzed by using analysis of variance (ANOVA) utilizing MINITAB (Version 16). Honestly, Significance Difference (HSD) was applied to determine the difference among treatments. Differences were considered at $P<0.05$. From animal nutrition aspect studied has been done on dry matter intake, total digestible nutrients (TDN) and predicted carrying capacity. Forages material used for biological value evaluations the only take from the treatment planting spacing PS3 which have higher forages yield production. This value obtained from the apparent digestible coefficient (ADC) of nutrients and finally total digestible nutrient (TDN). Total digestible collection methods have been used to determine the ADC of dry matter, crude protein, crude fiber, ether extract, and nitrogen-free extract. This trial has been done in two periods of time, where 7 days as preliminary periods for adaptation the animals to the new rations and to stay individual in metabolic cages. The second period of 5 days as feces and intake data collecting. Total feeds on-offered and refused was measured each day during collecting periods, and drinking water for animal was available freely. At the present step of this research just only to study the contribution of *I. zollingeriana* to increase the carrying capacity of pasture-based on *koronivia* grass pasture.

***Experimental site***

The study was conducted in the experimental station of Assessment Institute Agricultural Technology (AIAT) of North Sulawesi, located 12 km from Manado City. Experimental site receives an average rainfall of 2700 mm, and the distribution fairly even, except for the period of lower rainfall by 100-150 mm monthly, from July to September 2018. The pH of the fertile, sandy loam soil is around 6. Light transmission at 10.00 a.m on a sunny day as PAR underneath mature tall coconuts averaged 73%. The soil color was dark brown clay. Precipitation peaks took place in January, with high rainfall intensity. This caused high relative humidity (80%). Air temperature ranged from $25^0$C to $37^0$C.

***Experimental design***

**Experiment 1**

Legume seeds *I. zollingeriana* were obtained from the Agrostology Laboratory of the Faculty of Animal Science, Bogor Agricultural University. *Indigofera* seeds sown on land that has been processed as a nursery. Plant seeds that have grown well are then moved into a 2.5 kg plastic bag that has already been filled with soil (one plant/plastic bag). After growing for 2 months in a plastic bag medium, the plant was then transferred to experimental site in a plot size of 3 m x 4 m that had been processed and divided into 18plots to accommodate the 3 treatments of planting spacing (PS) with row spacing 1 m apart and planting spacing varied from 0.5 to 1.5 m, namely PS1: 1.0 m x 0.5 m, PS2: 1.0 m x 1.0 m, and PS3: 1.0 m x 1.5 m, corresponding to the population densities of 21 plants/plot (1.75 plant/$m^2$), 12 plants/plot (1 plant/$m^2$), and 9 plants/plot (0.75 plant/$m^2$), corresponding 5714 plant/ha, 10.000 plant/ha and 13.333 plant/ha respectively. Each plot of, treatment had a size of 3 x 4 m (12 $m^2$) was then placed individually. Since the distance between plots of treatments were 1 meter apart, caused the space of land utilized of each plot enlarge up to 4 x 5 m (20 $m^2$) in each 10 x 10 m of square pattern planting of coconuts. Thereby the number of plots of treatments in each space of coconut of 100 $m^2$ were then 5 plots. The variables measured were: leaf dry weight (DW), wood DW, total DW (kg/ha), and leaf/wood ratio. Harvesting was done by cutting the plant canopy, then the leaves and stems are separated. Samples of 500 g were then dried in an oven at a temperature of $105^0$C for 24 hours to get dry weight. This study used a Completely Randomized Design consisting of 3 treatments of planting spacing and 6 replications. Data were then statistically analyzed by using analysis of variance (ANOVA) utilizing MINITAB (Version 16). Honestly, Significance Difference (HSD) was applied to determine the difference among treatments. Differences were considered at $P<0.05$.

**Experiment 2**

From animal nutrition aspect studied has been done on dry matter intake, total digestible nutrients (TDN) and predicted carrying capacity. Forages material used for biological value evaluations the only take from the treatment planting spacing PS3 which have higher forages yield production. This value obtained from the apparent digestible coefficient (ADC) of nutrients and finally total digestible nutrient (TDN). Total digestible collection methods have been used to determine the ADC of dry matter, crude protein, crude fiber, ether extract, and nitrogen-free extract. This trial has been done in two periods of time, where 7 days as preliminary periods for adaptation the animals to the new rations and to stay individual in metabolic cages. The second period of 5 days as feces and intake data collecting. Total feeds on-offered and refused was measured each day during collecting periods, and drinking water for animal was available freely. At the present step of this research just only to study the contribution of *I. zollingeriana* to increase the carrying capacity potential of pasture-based on *koronivia*, thereby the feeding trial has been done separately between grass and legume leaves. Eight male goats with average body weight $\pm$ 15 kg has been used. Two treatments were arranged in 4 x 4 Latin Square Block design. Data were analyzed statistically with Analysis of Variance Test (ANOVA).

## RESULTS AND DISCUSSIONS

Table 1 below presented data on the effects of treatments on biomass dry weight production based on population density or number of plants per hectare. Actually, this data come from our initial activity in this experiment with the treatments of population densities of 21 plants/plot (1.75 plant/m²), 12 plants/plot (1 plant/m²), and 9 plants/plot (0.75 plant/m²). Those populations in hectare were 5,710 plants, 10,000 plants, and 13,333 plants, corresponding to PS1, PS2, and PS3, respectively. Leaf dry weight of treatment PS2 and PS3 were significant (P<0.05) higher than treatment PS1, but both treatments were not different significantly. The wider spacing of PS2 and PS3 showed plant height, stem diameter and number of branches were significantly superior compared to narrower spacing PS1. The increase in plant height in spacing (PS2) is probably due to the high rate of stem elongation. Stem elongation is related to the light competition among plants in narrow planting spacing (Widodo et al., 2016), followed by a taller plant compared to those in wider spacing (Crain & Dybzinki, 2013).

Table 1. Leaf (L), wood (W), L/W ratio and DW yield of *I. zollingeriana* under difference planting spacing in the coconuts plantation area

| Items | Treatments groups Number plant ($ha^{-1}$) | | |
|---|---|---|---|
| | PS1 (5,710) | PS2 (10,000) | PS3 (13,333) |
| Leaf DW ($kg/ha^{-1}$) | $13.6^{b}$ | $16.59^{a}$ | $15.75^{a}$ |
| Wood DW ($kg/ha^{-1}$) | $7.54^{b}$ | $9.31^{a}$ | $9.14^{a}$ |
| Leaf/Wood ratio | 1.81 | 1.78 | 1.72 |
| Total.DW($kg/ha^{-1}$) | $21.2^{b}$ | $24.1^{a}$ | $24.9^{a}$ |

[a, b]Means in the same row with different letters show differences(P<0.05)

The increasing this plant height in PS2 treatment followed by increasing in stem diameter (1.18) and several branches (11.60). This founding is in agree with (Kumalasari et al., 2017) reported that narrower row spacing at 1.0 m x 0.5 m (PS1) reduces the number of branches. The greater spacing between adjacent plants within rows likely enhances the abilities of the plants to convert the intercepted solar radiation to leaf production (Telleng et al., 2016). Nevertheless, the leaf/wood ratio was not affected by all plant spacing treatments. It means that this plant could produce the same number of leaves at 12 weeks after planting for all treatments. This probably due to the age of tree legume plant at 12 weeks still in vegetative development stages which is leaves component grown dominantly (Anis et al., 2016). Plant parts that are preferred by livestock and have higher nutritional quality are leaf fractions (Kaligis et al., 2018) so that the ratio of leaves/stems becomes important. The highest dry weight production (24.1 kg/ha/harvest) resulted from the treatment of planting spacing 1.0 m x1.0 m (PS2) and 24.9 kg/ha/harvest at planting distance 1.0 m x 1.5 m (PS3), and both treatments were significantly higher (P<0.05) compared to treatment PS1 (21.2 kg/ha/harvest). This research has been done under shading environment in coconut plantations. Even though the number of plant populations increased per hectare but dry weight has not increased linearly. Total dry weight, as well as leaves and wood dry weight, increased up to the treatment PS2, and then almost reached plateau at PS3. This phenomenon is probably due to the light of the shortage in coconuts plantation.

### Quality of Forage

Table 2 showed that the quality of both forages grown underneath coconuts plantations were varied markedly especially crude protein in *I. zolingeriana* 27.88% more than double compared to *koronivia*. Tully by 11.47%. Contrary nitrogen-free extract 45.85% higher than *I. zolingeriana* 25.39%, and slight differences in total digestible nutrients content. Pasture-based on *koronivia* under coconut plantation needs to enriched protein with tree legume, since integrated herbaceous or creeping legume not able to persist in mixed pasture due to aggressiveness of *koronivia* (Anis et al., 2015). Integrated of *Indigofera* in pasture underneath mature coconuts is the potential to enhance livestock productivity, but has to be precisely elucidated.

Table 2. Nutrient content of *I. zollingeriana* and *koronivia* grass

| Plant Species | Nutrients content (%) | | | | | |
|---|---|---|---|---|---|---|
| | CP | CF | EE | NFE | Ash | TDN |
| *Indigofera zolingeriana* | 27.88[a] | 32.73 | 1.48 | 25.39[b] | 12.51 | 66.41 |
| *Koronivia* grass | 11.47[b] | 31.16 | 1.87 | 45.85[a] | 9.65 | 62.41 |

[a,b] Means in the same columns with different letters show differences($P<0.05$)
Crude protein (CP), crude fiber (CF), ether extract (EE), nitrogen-free extract (NFE), total digestible nutrient (TDN)

**Average digestible coefficient of Forages**

Table 3 below showed that differences in both forages feed attribute were CP intake of *I. zolingeriana* 163.89 g/head/day markedly superior than *koronivia* only 71.88 g/head/day. Both forages solely could provide only the needs of cattle with bodyweight around 250 kg. In mixed pasture would be provided nutrient requirement for more bodyweight.

Table 3. Feed intake and digestible coefficient

| Variable | Components | | | | | |
|---|---|---|---|---|---|---|
| | DM | CP | CF | EE | NFE | TDN |
| ***I. zolingeriana.*** | | | | | | |
| Intake (g/head/day) | 607.64 | 163.89 | 194.24 | 9.10 | 151.75 | 66.41[a] |
| Apparent digestible coefficient (%) | 58.14 | 87.47 | 75.88 | 87.69 | 63.22 | |
| Total Digestible Nutrient /TDN (%) | - | 24.25 | 24.87 | 1.30 | 15.99 | |
| ***Koronivia* grass** | | | | | | |
| Intake (g/head/day) | 599.23 | 71.88 | 185.69 | 8.86 | 152.08 | |
| Apparent digestible coefficient (%) | 56.87 | 67.26 | 78.18 | 76.30 | 63.36 | 62.41[b] |
| Total Digestible Nutrient / TDN (%) | - | 7.71 | 24.36 | 1.42 | 28.88 | |

[a,b] Means in the same columns with different letters show differences($P<0.05$)
Dry matter (DM), Crude protein (CP), crude fiber (CF), ether extract (EE), nitrogen-free extract (NFE), total digestible nutrient (TDN). Apparent digestible coefficient (ADC).

## CONCLUSIONS

From animal feeds point of view *koronivia* solely could provide dry matter, crude protein and TDN for cattle with body weight around 250 kg, and *I. zollingeriana* as well. Moreover the latter has crude protein content almost double more than *koronivia*. Both species in mixed pastures be expected could provide feeds to fulfil the requirement of cattle more than 250 kg body weight.


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