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Evaluation of Intercropping *Indigofera* and *Pennisetum* underneath mature coconuts Based on Yield and Carrying Capacity

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Abstract

Intercropping can increase crop growth and yield due to resources use efficiently. *The purpose of this research was determines the land equivalent ratio in coconut plantation of intercropping tree legume Indigofera zollingeriana (IZ) and tropical grass Pennisetum purpureum cv. Mott .* The aims of this research was to determines the land equivalent ratio (LER) of this intercropping based on nutrient content and carrying capacity underneath coconut plantation. This experiment was conducted using Completely Randomized Design (CRD) with six treatment combination of planting space as follows: *Iz* with planting space at 1.0m x 0.5m, 1.0m x 1.0m and 1.0m x 1.5m, combined with *Pp* planting space 1.0m x 0.75m, 1.0m x 1.0m. Data were analyzed using analysis of variance and HSD test. The variables measured were Land Equivalent Ratio (LER) based on carrying capacity measure for dry matter and crude protein. The results showed that treatment were significant different ($P < 0.01$) on LER in term of carrying capacity based on crude protein and crude fiber content, but were non significant different ($P > 0.05$) on LER based on dry matter and ash content. The HSD test showed that intercropping *Iz* with planting space at 1.0m x 1.0m and *Pp* with planting space at 1.0m x 1.0m have highest LER for crude protein and lowest LER for crude fiber content. It conclusion that intercropping *Iz* with planting space at 1.0m x 1.0m and *Pp* with planting space at 1.0m x 0.75m have most suitable LER based on nutrient content.

Key words : crude protein, dry matter, LER , planting space

Introduction

Intercropping is advanced as one of the integrated soil fertility management practices consisting of cultivating two or more crops in the same space at the same time, which have been practiced in past decades and achieved the goals of agriculture. Also, intercropping systems are beneficial to the smallholder farmers in the low-input and/or high-risk environment of the tropics, where intercropping of cereals and legumes is widespread among smallholder farmers due to the ability of the legume to contribute to addressing the problem of declining levels of soil fertility (Matusso et al 2012).

The main purpose of intercropping is to produce a greater yield on a land by optimizing resources that cannot be utilized in a monocropping system efficiently (Moradi et al 2014). The main advantage of intercropping is helps in utilizing the available resources efficiently and increases the productivity of the crops. Intercropping can conserve soil water by providing shade, reducing wind speed, increasing infiltration with mulch layers, and improving soil structure (Mobasser et al 2014). The success of intercropping systems and performance of component crops are governed mainly by the availability of and the competition between the components for the environmental resources (Telleng et al 2016). However, some combinations have negative effects on the yield of the components under intercropping system (Matusso et al 2012). An important tool for the study and evaluation of intercropping systems is the Land Equivalent Ratio (LER). LER providing that all other things being equal measure of the yield advantage obtained by growing two or more crops or varieties as an intercrop compared to growing the same crops or varieties as a collection of separate monocultures (Yancey and Cecil 1994).

Materials and Methods

Experimental Site

The study was conducted in the experimental station of Asasement Institute of Agriculture Technology (AIAT) of North Sulawesi, located 12 km from Manado City. Experimental site received an average rainfall of 500 mm, and fairly distributed even around location, except for the period of lower rainfall of 50-100 mm monthly, occurred from July to September 2020. The pH of the fertile, sandy loam soil was around 6. Light transmission at 10.00 a.m on a sunny day as PAR underneath mature tall coconuts was averaging of 73 percents. The soil color was dark brown clay. Precipitation peaks took place in January, with high rainfall intensity This condition caused high relative humidity of 86 percents. Air temperature ranged from 23.1 °C to 32.7 °C.

Experimental Design

Grass of *Pennisetum purpureum* cv Mott (*Pp*) were obtained from Asasement Institute of Agriculture Technology (AIAT) of North Sulawesi. Legume seeds of *Indigofera zollingeriana* (*Iz*) were obtained from the Agrostology Laboratory of the Faculty of Animal Science, Bogor Agricultural University. *Indigofera* seeds sown on land had been processed as a nursery. Plant seeds that had grown well were then moved into the 2.5 kg plastic bag already filled with soil (one plant/plastic bag). After growing of two months in a medium plastic bag, the plant was then transferred in to experimental site in a plot size of 3 m x 4 m that had been processed with 6 treatments of planting spacing (PS) with row spacing of 1 m apart. Three planting space *Iz* : (i) 1.0 m x 0.5 m, (ii) 1.0 m x 1.0 m, and (iii) 1.0 m x 1.5 m. After two months *Indigofera* grown in experimental plots, *Pp* was planted. Two Planting space *Pp* : (i) 1 m x 0.5 m, and (ii) 1 m x 0.75 m. Intercropping having six combination and each was planted in three plot. The plot combination were: $I_1 = 1 \text{ m} \times 0.5 \text{ m } Iz \ \& \ 1 \text{ m} \times 0.75 \text{ m } Pp$; $I_2 = 1 \text{ m} \times 0.5 \text{ m } Iz \ \& \ 1 \text{ m} \times 1 \text{ m } Pp$; $I_3 = 1 \text{ m} \times 1 \text{ m } Iz \ \& \ 1 \text{ m} \times 0.75 \text{ m } Pp$; $I_4 = 1 \text{ m} \times 1 \text{ m } Iz \ \& \ 1 \text{ m} \times 1 \text{ m } Pp$; $I_5 = 1 \text{ m} \times 1.5 \text{ m } Iz \ \& \ 1.0 \text{ m} \times 0.75 \text{ m } Pp$; $I_6 = 1 \text{ m} \times 1.5 \text{ m } Iz \ \& \ 1 \text{ m} \times 1 \text{ m } Pp$.

Data were then statistically analyzed by using analysis of variance (ANOVA) by means of MINITAB (Version 16). Honestly Significance Difference (HSD) was applied to determine the difference among treatments. Differences were considered at $p < 0.05$.

Variable Observations

Harvesting *Indigofera* was done + 90 days after planting, defoliated at 100 cm above ground level. *Pennisetum* were defoliated at height level of 10 cm above ground. Samples were dried at 60 °C for about 48 hours to determine the dried weight. The samples were analyzed for dry matter, crude protein, and crude fiber according to the standard procedure of Association of Official Analytical Chemists (2005).

The variables include potential dry weight yield (ton/ha) and crude protein yield (ton/ha), land equivalent ratio (LER) based on carrying capacity for dry matter and protein production. Dry matter yield of each plot was calculated through the value of green forage production and dry-weight percentage. Combining the dry matter yield with crude protein data allowed us to calculate the mean crude protein yield. Carrying capacity was determined by the information obtained from the forage harvested; it was collected from productivity estimation of each plot and converted to one ha. Available forage was calculated based on 70% of the total used as factor. It is assumed that animal consumes 6.29 kg DM of forage/day/head (Indonesian

condition). The amount of dry matter required to provide 6.29 kg of digestible nutrients based on available forage (70% of the total used as factor) was 9.0 kg.

Land Equivalent Ratio

Land equivalent ratio (LER) is the most common index adopted in intercropping to measure the land productivity. It is often used as an indicator to determine the efficacy of intercropping (Brintha and Seran 2009). The LER is a standardized index that is defined as the relative area required by sole crops to produce the same yield as intercrops (Mead and Willey 1980). The LER is the ratio of land required by pure (sole) crop to produce the same yield as that of intercrop was determined according to the following formula:

$$LER = \frac{Y_{iz} \text{ in mixed stand}}{Y_{iz} \text{ in pure stand}} + \frac{Y_{pp} \text{ in mixed stand}}{Y_{pp} \text{ in pure stand}}$$

Where : LER = Land equivalent ratio,

Y_{iz} = nutrient content of *Indigofera zollingeriana*,

Y_{pp} = nutrient content of *Pennisetum purpureum*

Results

Potential Yield

Intercropping improve the soil's micro-environment (Salau et al., 2011). Soil microorganisms have an important role in maintaining soil function and involving in mineralization and mobilization of nutrients required for plant growth. Due to differential rhizodeposition, the microbial community structure in the rhizosphere may vary with plant species, nutritional status of the plant, manganese availability, soil type, and mycorrhizal colonization. Increasing N in the soil is the most efficient method to increase the yield of plant dry matter. Dantata (2014) suggests that intercropping affects vegetative growth of component crops depending on the adaptation of planting pattern and selection of compatible crops. Intercropping with legume is a desirable agronomic practice to boost crop production. Planting space affects plant growth stage. Decreasing plant density with increasing spacing causes plants to have a longer chance to develop their roots and accumulate photosynthetic (Telleng et al 2020). It is well shown in Table 1 that intercropping at different spacing had highly significant effects on dry matter and crude protein yield.

Dry matter yield of intercropping have about 30.9 ton/ha/year until 50.1 ton/ha/year. Dry matter yield was highly significant effects, there was that intercropping at different spacing had highly significant effects on dry matter yield. Combination planting space 1mx0.5m *Iz* and 1mx0.75m *Pp* have highest dry matter yield. It is well shown in Table 1.

Crude protein yield of intercropping have about 5.91 kg/ha/harvest until 9.75 kg/ha/harvest. Crude protein yield was highly significant effects, there was that intercropping at different planting space had highly significant effects on crude protein yield. Combination planting space 1mx0.5m *Iz* and 1mx0.75m *Pp* have highest dry matter yield. It is well shown in Table 1.

Table 1. Land Equivalent Ratio of Intercropping *I. zollingeriana* dan *P. purpureum* cv Mott Based on Carying Capacity.

Planting Spacing	Intecrop Potential Yield	Land Equivalent Ratio
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		(ton/ha/year)		(based carrying capacity)	
<i>I. zollingeriana</i>	<i>P. purpureum</i>	Dry Matter	Protein	Dry Matter	Protein
1m x 0.5m	1m x 0.75m	50.1 ^a	9.75 ^a	1.55 ^b	1.44 ^c
	1m x 1m	47.2 ^{ab}	9.6 ^{ab}	1.57 ^b	1.57 ^b
1m x 1m	1m x 0.75m	42.7 ^{bc}	7.99 ^{bc}	1.63 ^a	1.66 ^a
	1m x 1m	41.1 ^{bc}	7.96 ^c	1.69 ^a	1.65 ^a
1m x 1.5m	1m x 0.75m	39.4 ^c	7.23 ^{cd}	1.63 ^a	1.63 ^{ab}
	1m x 1m	30.9 ^d	5.91 ^d	1.65 ^a	1.65 ^a
P Value		<0.001	<0.001	<0.001	<0.001
MSE		1.41	0.367	0.0125	0.0156

^{a,b} Means in the same row with different letters show differences ($p < 0.05$).

Land Equivalent Ratio

The LER with value greater than 1 indicates that intercropping is advantageous while the LER less than 1 shows that intercropping is disadvantageous (Mohammed 2011). For instance, a LER 1.25 indicates that an area planted sole crop or monoculture, would require 25% more land to produce the same yield as the same area planted in an intercrop (Dariush et al 2006). Statistical analysis of the data showed that combination of intercropping systems had significant effects on LER based on crude protein and crude fiber content, but had non significant effects on LER based dry matter and ash content (Table 1).

A LER based on carrying capacity of dry matter have about 1.55 to 1.69 indicates that an area planted an intercrop would have higher 55% to 69% carrying capacity of dry matter more than carrying capacity of dry matter as the same area planted in sole crop or monoculture. A LER based on carrying capacity of dry matter highly significant effects, there was that intercropping at different spacing had highly significant effects on carrying capacity of dry matter.

Combination planting space 1mx1m *Iz* and 1mx1m *Pp* have highest carrying capacity of dry matter. It is well shown in Table 1.

A LER based on carrying capacity of crude protein have about 1.44 to 1.66 indicates that an area planted an intercrop would have higher 44% to 66% carrying capacity of crude protein more than carrying capacity of crude protein as the same area planted in sole crop or monoculture. A LER based on carrying capacity of crude protein highly significant effects, there was that intercropping at different spacing had highly significant effects on carrying capacity of crude protein. Combination planting space 1mx1m *Iz* and 1mx0.75m *Pp* have highest carrying capacity of dry matter. It is well shown in Table 1.

Discussion

Potential Yield

The main reason for adoption of intercropping is to produce higher yield than a pure stand of same land area in a given period. intercropping as an economic method for higher production with lower levels of external inputs (Wiley 1991). This increasing use efficiency is important, especially for small-scale farmers and also in areas where growing season is short (Altieri, 1995)

and in rainfed areas (Maitra *et al.* 2001a; Maitra *et al.* 2001b). Production more in intercropping can be attributed to the higher growth rate, more biomass production and efficient use of space and resources (Telleng 2017). Moreover, in any intercropping system if there are complementary effects among the component crops, production increases due to less competition among crops (Willey 1991)

Intercropping can be a solution to diversify agroecosystems by using more leguminous crops and also applying less mineral fertilizers (Neugschwandtner and Kaul, 2015). Reasonable intercropping could increase crop growth and productivity (Cecilio *et al.*, 2011), efficient use of the resources water, nitrogen and radiation (Lithourgidis *et al.*, 2011), macronutrients (Salehi *et al.*, 2018) and micronutrients (Neugschwandtner and Kaul, 2016), yield quality (Klimek-Kopyra *et al.*, 2017) and lower the damage caused by diseases and pests (Hauggaard-Nielsen *et al.*, 2001). Advantages of intercropping legumes with non-legumes are explained by the complementary use of resources due to non-competition for the same resource niche (Bedoussac and Justes, 2010). Increased nutrient uptake in intercropping systems can occur spatially and temporally. Spatial nutrient uptake can be increased through the increasing root mass, while temporal advantages in nutrient uptake occur when crops in an intercropping system have peak nutrient demands at different times (Anders *et al.*, 1996). The improvements in digestibility were reflected in feed intake, live weight gain and feed conversion which were all improved when the tree legume leaves were a part of the diet. Combine dwarf elephant grass, *Gliricidia sepium*, *Leucaena leucocephala* and *Indigofera zollingeriana*, for all criteria, the goats fed the tree legume *Indigofera zollingeriana* recorded the best performance (Anis *et al.*, 2020).

Advantages of intercropping are attributed to a more efficient utilization of finite resources such as light, nutrients and water (Musa *et al.* 2010). The nutrient composition of plants influenced by fertility rate of the growing media and some factors of the biotic environment. Short distance (increased density) increases nutrient requirement and sunlight competition. Planting space affected micro environment (temperature, humidity and light) and expanded the root to uptake nutrient (Telleng *et al.* 2020). Because light is supplied from above plants, individuals that situate their leaves above those of neighbours benefit directly from increased photosynthetic rates and indirectly by reducing the growth of those neighbours via shade (Craine and Dybzinski 2013). Narrower row spacing of 1.0 m x 0.5 m reduced the number of branches (Kumalasari *et al.* 2017). It was likely that the great spacing between adjacent plants within rows enhanced the abilities of the plants to convert the intercepted solar radiation to leaf production (Telleng *et al.* 2015). Planting space *Indigofera zollingeriana* in coconut plantation had effect leaf protein content, leaf crude fiber content and stem crude fiber content (Telleng *et al.* 2020).

The land equivalent ratio

The land equivalent ratio (LER) is a widely used relative indicator of economic reliability of an intercrop, unlike yield as an absolute one. It is calculated on the basis of the yield of each component in an intercrop and in its pure stand; if surpassing 1.00, an intercrop is considered economically reliable. A LER greater than 1 for crude protein content can often be attributed to enhanced nitrogen fixation and nitrogen uptake in intercropping (Salehi *et al.* 2018).

The more numbers of branches, the higher the growing point for leaf development and will be related to the availability of energy reserves (carbohydrates) sustain re-growth of forages plant (Anis *et al.* 2016). Research under shading environment in coconut plantations, even though the number of plant populations increased per hectare, dry weight had not increase linearly. This phenomenon was probably due to the shortages light in coconuts plantation (Anis *et al.* 2019). Finding in study was not in line with result found in full sun light environment increasing plant population per unit area. This condition approached an upper limit of production linearly (Kumalasari *et al.* 2017).

Reduction in number of pods of okra intercropped with maize stating the reason being the effects of nutrient and light completion (Ijoyah and Jimba 2011). Shading of maize plants reduced photosynthetic capacity of cotton in mixed intercrop pattern (Metwally et al 2012). Furthermore, a reduction of common bean yield in intercropping compared with pure stand due to the effect of shading (Santalla et al 2001). Pasture based on *Brachiaria humidicola* under coconut plantation needs to enrich protein with tree legume, since integrated herbaceous or creeping legume was not able to persist in mixed pasture due to its aggressiveness of *Brachiaria* (Anis et al 2015).

Tree legumes such as *Indigofera* since this species has high content of protein and grown well in coconut plantation (Anis et al, 2019), increased protein content of complete ration based on tropical grass (Anis et al, 2020), and previously reported by Suharlina and Abdullah (2010) that feed efficiency was high in complete rations with utilization of this species.

Integrated *Indigofera* in pasture underneath mature coconuts was potential to enhance livestock productivity, but it had to be precisely elucidated.

Discussion about coconut plantation was still important topic in rural development since this commodity as back bone economy at farmer level (Kaligis et al 2017). Forages dry matter production was contributed by leaf and stem formation, which was affected by cell division and elongation. Both physiology processing was the sites of high metabolic activity, including dry matter accumulation through photosynthetic activity utilization of CO₂ atmospheric (Schaufele and Schnyder 2000). **Indirectly**, pasture involved to mitigate climate changes, since well managing tropical pasture systems may contain amounts of soil organic carbon (SOC) equal or even superior to those under native tropical forest (Mosquera et al 2010).

The positive effects of tree legume leaves can be ascribed to their high levels of protein and has condensed tannins content, which is known to form complexes with dietary protein helping their escape from the rumen and efficient digestion in the intestines (Preston and Leng 1987). Recent result from *in vivo* trials showed that methane production decreased up to more than 60% when the majority of diet content tree legume leaves especially leucaena, reduction rumen methane in turn result more rumen propionate followed by better glucogenic status of the diets and good animal performance (Pineiro-Varquez et al, 2019).

Conclusion

Based on the results of this study, it can be concluded that the most suitable Land Equivalent Ratio based on carrying capacity in term of dry matter was obtained combination in the size area of 1m x 1m *Indigofera zollingeriana* and 1m x 1m *Pennisetum purpureum* cv Mott and carrying capacity in term of crude protein was obtained combination in the size area of 1m x 1m *Indigofera zollingeriana* and 1m x 0.75m *Pennisetum purpureum* cv Mott as planting spacing underneath the mature coconuts.

References

- Altieri MA. 1999.** The ecological role of biodiversity in agroecosystems Agric Ecosyst Environ. 74:19–31.
- Anders, M.M., Potdar, M.V. and Francis, C.A. 1996.** The significance of Intercropping in cropping systems. In: Ito, O., Johansen, C., Adu-Gyamfi, J.J., Katayama, K., Kumar, J.V.D., Rao, K. and Rego, T.J. (Eds.). Dynamics of roots and nitrogen in cropping systems of the semi-arid tropics. Japan International Research Center for Agricultural Sciences. International Agricultural Series No. 3 Ohwashi, Tsukuba, Ibaraki 305, Japan.
- Anis S D Kaligis D A Tulung B Aryoanto 2016** Leaf quality and yields of *Gliricidia sepium*(Jacq) Steud under different population density and cutting interval in coconut plantation. J. of the Indonesian Tropical Animal Agriculture. 41(2):91-97.

- Anis S D Kaunang Ch L Telleng M M Kaunang W B Sumolang C I J Paputungan U 2019** Preliminary Evaluation on Morphological Response of *Indigofera zollingeriana* Tree Legume Under Different Cropping Patterns Grown at 12 Weeks After Planting Underneath Mature Coconuts. *Livestock Research for Rural Development* 31(9)
- Anis S D Kaligis D A Pangemanan S 2015** Integration of cattle and Koronivia grass pasture underneath mature coconuts in North Sulawesi, Indonesia. *J. Livestock Research for Rural Development*. 27(7):42-45.
- Bedoussac L and Justes E 2010** The efficiency of a durum wheat-winter pea intercrop to improve yield and wheat grain protein concentration depends on N availability during early growth. *Plant and Soil* 330, 19–35.
- Brintha I and Seran T H 2009** Effect of Paired Row Planting of Radish (*Raphanus sativus* L.) Intercropped with Vegetable Amaranths (*Amaranthus tricolor* L.) on Yield Components of Radish in Sandy Regosol. *J. Agric. Sci.* 4:19-28.
- Cecilio A B Rezende B L A Barbosa J C Grangeiro L C 2011** Agronomic efficiency of intercropping tomato and lettuce. *Anais da Academia Brasileira de Ciencias* 83, 1109–1119.
- Craine J M and Dybzinski R 2013** Mechanisms of plant competition for nutrients, water and light. *Funct. Ecol.* 27: 833-840. at: <https://doi.org/10.1111/1365-2435.12081>
- Dantata, I J 2014.** Effect of legume-based intercropping on crop yield: A Review. *Asian Journal of Agricultural and Food Science*. 2: 507-522.
- Dariush M Ahad M Meysam O 2006** Assessing the Land Equivalent Ratio (LER) of two corn [*Zea mays* L.] varieties intercropping at various nitrogen levels in Karaj, Iran. *Journal of Central European Agriculture* 7(2):359-364.
- Haugaard-Nielsen H Ambus P Jensen E S 2001** Interspecific competition, N use and interference with weeds in pea-barley intercropping. *Field Crops Research* 70, 101–109.
- Ijoyah M O and Jimba J 2011** Effects of planting methods, planting dates and intercropping systems on sweet potato-okra yields in Makurdi, Nigeria. *Agricultural Science Research Journal* 1(8):184-190.
- Kaligis D A Telleng M M Anis S D Waleleng P O Oroh F Dalie S 2017** Utilization of signal grass pasture to support cattle production and economic value of coconut based farming. Proceeding The 6th International Conference on sustainable Animal Agriculture for developing country. City of Batu, October 16-19, 2017
- Klimek-Kopyra A Skowera B Zajac T Kulig B 2017** Mixed cropping of linseed and legumes as a ecological way to effectively increase oil quality. *Romanian Agricultural Research* 34, 217–224.
- Kumalasari N R Wicaksono G P Abdullah L 2017** Plant Growth Pattern, Forage Yield, and Quality of *Indigofera zollingeriana* Influenced by Row Spacing. *Media Peternakan* 40(1) (2017) 14-19
- Lithourgidis A S Dordas C A Damalas C Vlachostergios D N 2011** Annual intercrops: an alternative pathway for sustainable agriculture. *Australian Journal of Crop Science* 5, 396–410.
- Matusso J M M Mugwe J N Mucheru-Muna M 2012** Potential role of cereal-legume intercropping systems in integrated soil fertility management in smallholder farming systems of subSaharan Africa Research Application Summary. Third RUFORUM Biennial Meeting 24-28 September 2012, Entebbe, Uganda.

- Maitra S Samui R C Roy D K Mondal A K 2001b** Effect of cotton based intercropping system under rainfed conditions in Sundarban region of West Bengal. *Indian Agriculturist*, **45**(3-4): 157-162
- Maitra S Ghosh D C Sounda S Jana P K 2001a** Performance of inter-cropping legumes in finger millet (*Eleusine coracana*) at varying fertility levels. *Indian Journal of Agronomy*, **46**(1): 38-44.
- Mead R and Willey R W 1980** The concept of a land equivalent ratio and advantages in yields for intercropping. *Exp Agric.* 16:217–228.
- Metwally A A Shafik M M Sherief M N Abdel-Wahab T I 2012** Effect of intercropping corn on Egyptian cotton characters. *J. Cotton Sci.*, 16 (4) (2012) 210–219, U.S.A.
- Mohammed S A A 2011** Assessing the Land Equivalent Ratio (LER) of Two Leguminous Pastures (CLITORIA and SIRATRO) Intercropping at Various Cultural Practices and Fencing at ZALINGEI–Western Darfur State-Sudan. *ARPN Journal of Science and Technology* 2(11), 1074-1080.
- Moradi H Noori M Sobkhizi A Fahramand M Rigi K 2014** Effect of intercropping in agronomy. *J. Nov. Appl. Sci.* 3:315-320
- Mobasser H R Vasirimehr M R Rigi K 2014** Effect of intercropping on resources use, weed management and forage quality. *IJPAES.* 4:706-713
- Mosquera O Buurman P Ramirez B Amezquita M C 2010** Soil carbon stocks under improved tropical pasture and silvopastoral systems in Colombian Amazonia. 19th World Congress of Soil Science, Soil Solutions for Changing World. 1-6 August 2010, Brisbane, Australia
- Anis S D Kaunang Ch L Telleng M M Rumambi A 2020** Improving diets of fattening goats with leaves of fast-growing leguminous trees. *J. Livestock Research for Rural Development.* 32(8):132.
- Musa M Leitch M H Iqbal M Sahi F U H 2010** Spatial arrangement affects growth characteristics of barley-pea intercrops. *International Journal of Agriculture and Biology* 12 (2010) 685–690.
- Neuschwandtner R W and Kaul H P 2015** Nitrogen uptake, use and utilization efficiency by oat-pea intercrops. *Field Crops Research* 179, 113–119.
- Nyoki D and Ndakidemi P A 2017** Assessing the land equivalent ratio (LER) of maize (*Zea mays* L.) intercropped with Rhizobium inoculated soybean (*Glycine max* [L.] Merr.) at various P and K levels. *International Journal of Biosciences*, 10(3):275-282
- Salau A W Olanitan F O Bodunde J G Elemo K A 2011.** Effect of intercropping on soil hydro-thermal re-gime, crop performance and weed situation in casava/okra intercrop. *J. Agric. Sci. Env.* 11:38-51.
- Salehi A Mehdi B Fallah S Kaul H P Neuschwandtner R W 2018** Integrated fertilization of buckwheat-fenugreek intercrops improves productivity and nutrient use efficiency. *Nutrient Cycling in Agroecosystemes* 110:407–425.
- Santalla M Rodin˜o A P Casquero P A, de Ron A M 2001** Interactions of bush bean intercropped with field and sweet maize. *European Journal of Agronomy* 15:185–196
- Schaufele R and Schnyder H 2000** Cell growth analysis during steady and non-steady growth in leaves of perennial ryegrass (*Lolium perenne* L.) subject to defoliation. *Plant Cell Environ.* 23:185-194
- Telleng M M Wiryawan K G Karti P D M H Permana I G Abdullah L 2016** Forages Production and Nutrient Composition of Different Sorghum Varieties Cultivated with *Indigofera* in Intercropping System. *Media Peternakan* 39(3):203-20.
- Telleng M M 2017** Penyediaan Pakan Berkualitas Berbasis Sogum (*Sorghum bicolor*) dan Indigofera (*Indigofera zollingeriana*) dengan Pola Tanam Tumpangsari. Disertasi. Sekolah Pascasarjana IPB, Bogor

- Telleng M M Abdullah L Permana I G Karti P D M H Wiryawan K G 2015** Growth and Productivity of Different Sorghum Varieties Cultivated with Indigofera in Intercropping System. Proceeding of the 3rd International Seminar on Animal Industry, Bogor 17-18 September 2015.
- Telleng M M Anis S D Sumolang C I J Kaunang W B Dalie S 2020** The Effect of Planting Space on Nutrient Composition of *Indigofera zollingeriana* in Coconut Plantation. International Conference: Improving Tropical Animal Production for Food Security. IOP Conf. Series: Earth and Environmental Science 465:01201
- Willey R W 1991** Evaluation and Presentation of Intercropping Advantages. Experimental Agriculture, 21:119-123
- Yancey and Cecil Jr 1994** Covers challenge cotton chemicals. The New Farm. February 1994:20–23.
- Preston T R and Leng R A 1987** Matching Ruminant Production System with Available Resources in the Tropic and Sub Tropics. <http://www.cipav.org.co/PandL/PrestonLeng.html>
- Suharlina and Abdullah L 2010** Productivity improvement of Indigofera sp. As high quality forage using organic fertilizer: The effect of nutritional content. Proceeding of Nasional Seminar of Tropical Forages. Denpasar, 5th November 2010
- Pineira-Vazquez A, Canul-Solis J R, Guillermo OJ, Jose A A, Alfons J Cand Carlos F A 2018** Effect of condensed tannin from *Leucaena leucocephala* on rumen fermentation, methane production and population of rumen protozoain heiver fed low quality forage. Asian- Australas J. Anim Sci. Vol 31. No 11: 1738-1746

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