Identification of Advantages of Indigofera-Pennisetum Intercropping Under Coconut Plantation Based on Dry Matter Yield

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Identification of Advantages of *Indigofera-Pennisetum* Intercropping Under Coconut Plantation Based on Dry Matter Yield

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Abstract. The point of this exploration was to decide the benefit of intercropping *Indigofera zollingeriana* (*Iz*) and *Pennisetum purpureum* (*Pp*) under coconut manor dependent on dry matter yield. This experiment was performed using a completely randomized design (CRD) with six treatment combinations of settlement space, *Iz* with settlement space (1) 1.0 m x 0.5 m, (2) 1.0 m x 1.0 m, (3) 1.0 m x 1.5 m and *Pp* with base space (1) 1.0 m x 0.5 m, (2) 1.0 m x 0.75 m. The data were analyzed by analysis of variance (ANOVA) and continued by HSD test. Measured variables are land equivalent ratio (LER), crowding factor (K), aggressiveness (A), competition rate (CR) and actual yield loss (AYL). The results showed that the growing space treatments showed a significant difference (P < 0.01) in LER, K, A, CR and AYL as a function of dry matter yield. *Iz* was dominant in many combinations establishing intercropping patterns, *Iz* with 1.0 m x 1.0 m extension and *Pp* with 1.0 m x 0.75 m extension showed the highest LER and K based on dry matter yield. In conclusion, *Indigofera zollingeriana* dominated all the mixed growing schemes. Intercropping *Iz* with an extension of 1.0 m x 1.0 m and *Pp* with an extension of 1.0 m x 0.75 m were the most suitable LER and K depending on dry matter yield.

Keywords: Indigofera · Intercropping · Pennisetum · Planting space

1 Introduction

Intercropping is one of the typical cropping conventions practically used in sustainable agricultural systems. It plays an important role in increasing the yield of solid soils and stabilizing yields [1]. The intercropping of two or more crop species not only improves yields, but also improves biodiversity and prevents pests and diseases [2]. The main reason for using multiple cropping systems is that it involves more efficient matching of crops using space and labor. Biophysical reasons include better use of environmental factors, higher yield stability in variable environments, and soil conservation practices. Socio-economic reasons include the magnitude of inputs and outputs and their contribution to stabilizing household food supplies). The main definition of intercropping is to create superior yields on a single piece of land by optimizing processes that cannot be

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used rapidly in monocrop trading [3]. The main help of intercropping is that it makes use of existing processes quickly and increases the yield of the crop. Alternating buoys cling to the waterlogged area creating that shade, reducing the suction velocity, increasing the permeability through the humus layers, and increasing the accumulation of humus [4].

The benefits of intercropping herbs or giant trees to enhance yield ultimately depend on the spatial arrangement (intercropping pattern) of the crops involved [5]. An influential and organized blueprint for the growing diversity of agricultural systems is intercropping trading that captures the interactions between individual crops and opposite diversifications. [6]. Intercropping buoy aggregate material multifariousness nailed down the progressive planting of contradistinctive crops during corresponding opportunity [7]. Accrued nutritious comprehension in intercropping organized whole buoy eventualize spatially and temporally. Spatial nutritious comprehension buoy be accrued nailed down the increasing foundation mass, patch material superiorities in nutritious comprehension eventualize when crops in an intercropping transaction chalk up summit nutritious requires at contradistinctive times. On the other hand, any conjunction chalk up contradiction consequences on the outturn of the components underneath intercropping transaction [8].

Poor quality forage of tropical grass provided by farmers leads to low daily productivity of livestock. The problem is that the forage supply is insufficient due to space constraints for forage production and the dependence of the seasons, especially during the dry battery period. Tropical grasses are the main food source which is never enough to satisfy the nutritional quality of at least 8% crude protein [9]. *Indigofera zollingeriana* grows profusely and is available year-round, where these corner legumes for foliage can take advantage of low-quality grasses. The Indigofera species has considerable expectations as a ruminant food. It is a potential legume because it has first-class growth rate [10] with high yield [11] and nutritional value [12]. The application of this herb increased the protein content of the diet, the degradability of dry matter complications and the value of volatile fatty acids in an in vitro representative of the stomach [13].

It is believed that competition among mixtures is the main aspect affecting yield compared to single grain cultivation. Species or cultivar selection, seeding rate, and ability to compete in mixes can influence the growth of species used in intercropping systems in areas with high rainfall [14]. Several indicators such as land parity ratio, relative population density, competitive rate, real yield loss, monetary advantage and intercropping advantage have been proposed to describe competition in agriculture. Industrial and economic benefits of intercropping systems [15]. The aim of this study was to determine the best of planting space of intercropping combination of *Indigofera zollingeriana* (*Iz*) and *Pennisetum purpureum* (*Pp*) under coconut palms based on nutritional potential.

2 Materials and Methods

2.1 Experimental Site

The study was carried out at the North Sulawesi Institute of Agricultural Technology Assessment (AIAT) observation site, 12 km from the town of Manado, North Sulawesi, Indonesia (Fig. 1). The observed situation allows an average rainfall of 500 mm per

Fig. 1. Experiment location.

month, and all are more moderately distributed on either side of the site, with the exception of a reduced precipitation amplitude of 50,100 mm per month. The pH of the yellow, fertile litter on all sides was 6. The fluorescence transmission at 10:00 am on a sunny day while the PAR under high ripe coconuts was on average 73%. The dirty color is dark brown chocolate clay. Rainfall peaks occur in January, with high rainfall concentrations. This consideration causes an acute comparative humidity of 86%. The temperature of the atmosphere ranges from 23.1 °C to 32.7 °C.

2.2 Experimental Design

Pennisetum purpureum cv Mott (*Pp*) grass seeds were obtained from the Institute of Agricultural Technology Evaluation (AIAT), North Sulawesi. Legume seeds *Indigofera zollingeriana* (*Iz*) were obtained from the Agronomy section of the Institute of Animal Science of Bogor Agricultural University. Indigofera seeds sown in the ground have been converted into a nursery. Seeds of well-developed plants were then placed in a 2.5 kg plastic bag filled with soil (one tree/plastic bag). After a two-month management process in a medium plastic bag, stocking was switched to a 3m x 4m observation situation that was clarified with 6 behavioral treatments relative to the planting site. And position of rope 1m apart. Three *Iz* planting spaces: (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 of Indigofera at the plant site, *Pp* was planted. Two *Pp* planting spaces: (i) 1.0 m x 0.50 m, and (ii) 1.0 m x 0.75 m. The intercrops had six combinations and each combination was planted in three plots. The combinations of plots are: I1 = 1.0 m x 0.5 m *Iz* and 1.0 m x 0.50 m *Pp*; I2 = 1.0 m x 0.5 m *Iz* and 1.0 m x 0.75 m *Pp*; I3 = 1.0 m x 1.0 m *Iz* and 1.0 m x 0.50 m *Pp*; I4 = 1.0 m x 1.0 m *Iz* and 1.0 m x 0.75 m *Pp*; I5 = 1.0 m x 1.5 m *Iz* and 1.0 m x 0.50 m *Pp*; and I6 = 1.0 m x 1.5 m *Iz* and 0.75 m x 1.0 m *Pp* (Fig. 2).

Indigofera were harvested 90 days after planting. Indigofera has deciduous at level 100 cm on the ground. Pennisetum has been decolished at 10 cm above the ground. The sample representation has been dried at 60 °C for 48 h. Samples are analyzed for dry matter, crude protein and raw fibers after the Association of official analytical chemical processes.

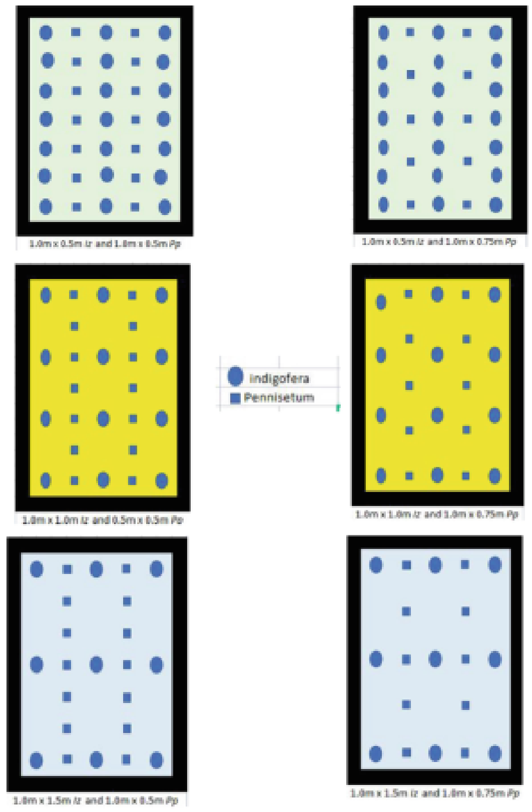

Fig. 2. Combination of planting space.

Data has been analyzed using analysis of varians (Anova) with minitab (version 16). Honest significant difference (HSD) was applied to study the effects of differences around treatments. Significant differences are accepted if $p < 0.05$.

2.3 Advantage Ratio

(1) The land equivalent ratio, LER, which indicates the possible yield benefit of inter-cropping from the potential yield at each harvest day is calculated as follows: LER = (Y_{IP}/Y_I) $(Y_{PI})/Y_P)$ where Y_I and Y_P are the potential dry matter yields for crops 1 and 2 grown in single cropping and YI_P and YP_I are yields from intercropping crops. The LER value was 1, indicating no yield difference between intercropping and monoculture. Any value greater than 1 indicates a yield advantage when intercropping [16].

(2) The relative participation coefficient (K) is a measure of the relative dominance of one species over another in a mix. K calculated as formulas: K = $(K_P \times K_I)$, where.

$$K_P = Y_{PI} \times Z_{IP}/((Y_P - Y_{PI}) \times Z_{PI}), \text{ and}$$
$$K_I = Y_{IP} \times Z_{PI}/((Y_I - Y_{IP}) \times Z_{IP}) \quad (1)$$

where Y_P and Y_I are the yields of *Pp* and *Iz* as the main crop, respectively, and Y_{PI} and Y_{IP} are *Pp* and *Iz* yields, respectively. Z_{PI} and Z_{IP} are the *Pp* and *Iz* ratios in the mixture, respectively. When the value of K is greater than 1, there is an output advantage; when K equals 1, there is no yield advantage; and, when it is less than 1.00, there is a disadvantage [17].

(3) Aggression (A) is often used to determine the rate of competition between two crops used in polyculture. Aggression has been formulated [17] as follows:

$$A_I = (Y_{IP}/Y_I \times Z_{IP}) - (Y_{PI}/Y_P \times Z_{PI}), \text{ and}$$
$$A_P = (Y_{PI}/Y_P \times Z_{PI}) - (Y_{IP}/Y_I \times Z_{IP}) \quad (2)$$

where Y_P and Y_I are the yields of *Pp* and *Iz* as the main crop, respectively, and Y_{PI} and Y_{IP} are the yields of *Pp* and *Iz*, respectively. Z_{PI} and Z_{IP} are the ratios of *Pp* and *Iz* in the mixture, respectively.

(4) The rate of competition (CR) is another way to assess competition between different species. CR confers more desirable competitiveness for crops and is also beneficial as an indicator compared with K and AYL [17]. CR simply represents the individual LER ratios of the 2 component crops and takes into account the ratio of crops in which they were originally sown. Then, the CR index is calculated using the following formula:

$$CR_{Pennisetm} = (LER_P/LER_I)(Z_{IP}/Z_{PI}), \text{ and}$$
$$CR_{Indigofera} = (LER_I/LER_P)(Z_{PI}/Z_{IP}) \quad (3)$$

where $LER_P = (Y_{PI}/Y_P)$ and $LER_I = Y_{IP} / Y_I$, where Y_P and Y_I are the yields of *Pp* and *Iz* are pure cultures, respectively, and Y_{PI} and Y_{IP} are the *Pp* and *Iz* yields, respectively. *Iz* are cultural buffers.

(5) Actual Yield Loss Index (AYL), which provides more accurate information on competition than other indicators between and within constituent crops and on the behavior of individual species in the intercropping. This system, because it is based on yield per plant [18]. AYL is the yield loss or gain of the intercrops to their respective single crops, i.e., it takes into account the actual sown ratio of the component crops to its single crops. In addition, an AYL_I or AYL_P fraction represents the respective yield loss or gain of each species under intercropping, compared with its single plantation yield [17]. AYL is calculated as follow formulas: $AYL = AYL_I + AYL_P$, where.

$$AYL_I = ((Y_{IP}/X_{IP})/(Y_I/X_I)) - 1$$
$$AYL_P = ((Y_{PI}/X_{IP})/(Y_P/X_P)) - 1 \quad (4)$$

where X_{IP} and X_{PI} represent the sown proportion of intercrop *Indigofera* with *Pennisetum*, and *Pennisetum* with *Indigofera*, respectively.

3 Results and Discussion

3.1 Results

3.1.1 Implication of Land Equivalent Ratio and Relative Crowding Coefficient

Statistical analysis of the data showed that the combination of intercropping systems had significant consequences on LER and RC based on potential dry matter yield. An LER based on a potential dry matter yield of approximately 1,58 to 1,685 indicates that intercropping media will have 5.8% to 68.5% higher dry matter content than the corresponding media grown in pure media or single parent. In general, partial LER_*Indigofera*

Table 1. The Land equivalent ratio (LER) and Relative crowding (K) of intercropping *I. zollingeriana* and *P. purpureum* cv Mott based on dry matter potential yield

Planting space		Variable					
Indigofera	*Pennisetum*	LER Values			K		
		Pennisetum	*Indigofera*	Total	*Pennisetum*	*Indigofera*	Total
1.0 m x 0.5 m	1.0 m x 0.50 m	0.700	0.848^{b}	1.548^{b}	0.565	1.375^{c}	0.773^{c}
	1.0 m x 0.75 m	0.708	0.865^{b}	1.570^{b}	0.583	1.668^{c}	0.820^{c}
1.0 m x 1.0 m	1.0 m x 0.50 m	0.700	0.933^{a}	1.633^{a}	0.588	3.528^{bc}	2.105^{bc}
	1.0 m x 0.75 m	0.720	0.9630^{a}	1.685^{a}	0.643	6.400^{ab}	4.110^{a}
1.0 m x 1.5 m	1.0 m x 0.50 m	0.660	0.973^{a}	1.630^{a}	0.463	8.958^{a}	4.093^{a}
	1.0 m x 0.75 m	0.698	0.953^{a}	1.653^{a}	0.590	5.728^{ab}	3.245^{ab}
P value		0.521	<0.01	<0.01	0.475	<0.01	<0.01
SE Mean		0.022	0.014	0.013	0.061	0.860	0.398

^{a,b} Means in the same column with different letters show differences ($p<0.05$). SE: standard error

zollingeriana was highest in combination planting space 1.0 m × 1.0 m *Iz* and 1.0 m × 0.5 m *Pp* and LER_*Pennisetum purpureum* was highest in combination planting space 1.0 m × 1.0 m *Iz* and 1.0 m × 0.75 m *Pp* and LER_Total was highest in combination planting space 1.0 m × 1.0 m *Iz* and 1.0m × 0.5 m *Pp* (Table 1).

The K based on dry matter potential yield have about 0.773 to 4.110 indicates that an environment cropped an intercrop would have higher 54.8% to 68.5% dry matter content more than dry matter content as the corresponding environment cropped in sole crop or monoculture. In general, partial LER_*Indigofera zollingeriana* was highest in combination planting space 1.0 m × 1.0 m *Iz* and 1.0 m × 0.5 m *Pp* and LER_*Pennisetum purpureum* was highest in combination planting space 1.0 m × 1.0 m *Iz* and 1.0 m × 0.75 m *Pp* and LER_Total was highest in combination planting space 1.0 m × 1.0 m *Iz* and 1.0 m × 0.5 m *Pp* (Table 1).

3.1.2 Implication of Aggressivity, Competitive Ratio, and Actual Yield Loss

In the entire growing space, positive values of A Indigofera showed that I was the dominant species (Table 2). If A Indigofera = 0, two cultures compete equally, if A Indigofera is positive, the Indigofera species is dominant, if the A value of *Indigofera* is negative, the Indigofera species is weak. Indigofera intercropping had a higher Competitive Rate (CR) in *Iz* 1.0 m × 1.0 m and 1.0 m × 1.5 m varieties; however, the CR planting models were lower than *Iz* 1.0 m × 0.5 m (Table 2). In particular, AYL_*Indigofera* and AYL_*Pennisetum* have positive values in all planting options. The highest *AYL_Indigofera* value belonged to in planting patterns *Iz* 1.0mx1.0m and *Pp* 1.0 m × 0.5 m while the lowest value was in planting patterns *Iz* 1.0 m x 0.5 m and *Pp* 1.0 m × 0.75 m, while the highest AYL_*Pennisetum* value belonged to in planting patterns *Iz* 1.0 m × 0.5 m and *Pp* 1.0 m × 0.75 m while the lowest value was in planting patterns *Iz* 1.0 m ×1.5 m and *Pp* 1.0 m × 0.5 m (Table 2). Comparing 2 crops, planting patterns *Iz* 1.0 m × 1.0 m and 1.0 m × 1.5 m had the higher AYL_*Indigofera* values than AYL_*Pennisetum* (Table 2).

Table 2. The Aggressivity (A), Competitive Ratio (K), and Actual Yield Loss (AYL) of intercropping *I. zollingeriana* and *P. purpureum* cv Mott based on dry matter potential yield

Planting space		Variable						
Indigofera	*Pennisetum*	A		CR		AYL		
		Pennisetum	*Indigofera*	*Pennisetum*	*Indigofera*	*Pennisetum*	*Indigofera*	Total
1.0m x 0.5m	1.0m x 0.50m	0.230^{c}	0.230^{b}	1.240^{b}	0.808d	13.703^{c}	10.868^{a}	24.57^{a}
	1.0m x 0.75m	-0.358^{d}	0.358^{a}	1.738a	0.588^{e}	13.853^{c}	7.630^{a}	21.49^{b}
1.0m x 1.0m	1.0m x 0.50m	-0.053^{ab}	0.053^{c}	0.645^{cd}	1.555^{b}	$7.405b^{c}$	12.060^{b}	19.47^{c}
	1.0m x 0.75m	-0.198^{c}	0.198^{b}	0.90^{0c}	1.113^{c}	7.658^{ab}	8.625^{b}	16.28^{d}
1.0m x 1.5m	1.0m x 0.50m	0.020^{a}	-0.020^{d}	0.43^{8d}	2.298^{a}	4.930^{a}	12.598^{c}	17.53^{e}
	1.0m x 0.75m	-0.085^{ab}	0.085^{c}	0.66^{0cd}	1.520^{b}	5.292^{ab}	8.530^{c}	13.82^{f}
P value		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	P < 0.01
SE Mean		0.017	0.017	0.071	0.039	0.388	0.163	0.726

[a,b] Means in the same column with different letters show differences ($p < 0.05$). SE: standard error

3.2 Discussion

LERs with an outlay greater than 1.0 indicate that intercropping is a fixable patch, LERs less than 1.0 indicate that intercropping is harmful [19]. For a LER of 1.25 indicates that a medium grown in single harvest or monoculture, will have 25% more soil to produce the corresponding result than the corresponding medium grown in intercropping [16]. The land equivalent ratio (LER) is a comparative pointer that scientifically speaks to the economic reliability of an intercrop, contrasting the results as self-determining. It can be calculated on the basis of the yield of each component in the intercropping and in its pure state; if abnormal 1.00, intercropping is recommended as economically viable [20]. LER greater than 1 for crude protein content can often be attributed to better nitrogen uptake and fixation in intercropping crops [21].

When the value of K is greater than 1, there is an output advantage; when K equals 1, there is no yield advantage; and, when it is less than 1.00, there is a disadvantage [17]. The K value of Indigofera was higher than that of *Pennisetum*, indicating that *Indigofera* was more competitive than *Pennisetum* in grass and legume mixtures. In peanut-cereal mixtures, cereals overload the peanuts (K_{cereal} value $>$ 1). The K value can change as the density of planting space changes. When intercropping grasses and legumes are considered at a close level such as *Iz* 1.0 m $\times$0.5 m and *Pp* 1.0 m $\times$ 0.5 m or *Iz* 1.0 m $\times$ 0.5 m and *Pp* 1.0 m $\times$0.75 m, the competition between trees seemed to work against *Indigofera* while it was in favor of *Pennisetum*.

The superiority of intercropping is due to the extensive use of limited processes such as light, nutrients and water [22]. The nutritional composition of plants is influenced by the reproduction rate of the culture medium and certain factors of the organism's environment. Short distances (increased densities) increase nutrient requirements and compete with sunlight. Planting will stretch the surrounding microspheres (temperature, humidity and light) and widen the trunk to understand nutrients [23]. Because the light is provided by the plants of the sky, individuals who identify their leaves in the sky of their neighbors bless when the flying bull reprimands photosynthesis precisely and indirectly by reducing the development of these neighbors through shade [24].

The physiological supplementation can occur in polyculsures including species that use C4 and C3 photosynthesis channels and this is illustrated by the example of North Carolina, a better-adapted C factory with lips High light school. Of course, the most common example of physiological supplementation is the installation of nitrogen by legum trees, meaning soil nitrogen is available for neighboring vegetables [25]. The abundant data of the branches, as many ontegenesis characteristics for the development of vacation and will be associated with the availability of energy reserves (carbohydrates) something to regenerate animal feed [26]. Search in a shadow environment in coconut plantations, although the number of vegetable populations has increased by ha, dry weight does not increase linearly. This phenomenon is probably due to the lack of law in coconut plantation [27]. The study found inadequacy results found in the sunlight environment, thus increasing the plant population on units. This condition approximates the upper production limit linearly [28].

Experimental evidence has shown that plant interactions below ground are often more intense than those above ground, and that competition can limit plant uptake. Nutrients are often found in specific areas of the soil due to specific environmental conditions (i.e., along with these differences, and often in part in response to them, differences in the patterns of root distribution among plants and throughout the soil. The authors further note that roots can also use soil resources differently: in a way that meets nutrient needs (legumes use N, legless plants use NO_3 or NH_4. Different species may have resource requirements differently. There was a fourfold difference between species for calcium concentrations, a twofold difference for potassium and phosphate, and a threefold difference for nitrogen concentrations [25].

The discussion of coconut farming is an even more important topic in pastoral farming because the commodity is invested in the backbone of the economy at the farmer level [29]. The production of forage dry matter complications is contributed by the formation of leaves and stems, which are produced by cell division and elongation. Both physiological treatments are the site of acute metabolic activity, including the synthesis of dry matter complications nailed in the utilization of atmospheric CO_2 photosynthetic activities [30]. Indirectly, grasslands interested in mitigating changing conditions, due to the beneficial management of tropical grazing systems, can contain as much soil organic carbon (SOC) as or even higher than the amount of carbon lying under natural rain forests [31].

The most suitable for assessing how to grow under coconut trees by land equivalence ratio, relative crowding, aggresivity, competitive and actual yield loss based on dry matter yield is in an area of the same size of 1.0 m × 1.0 m *Indigofera zollingeriana* and 1.0 m × 0.75 m *Pennisetum purpureum* cv Mott.

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Authors' contributions. MT and WK conceived the original idea, SS and IU screened and summarized all obtained literatures. MT evaluated the generation of tables and schemes, as well as analysed the bias of the study. The main text was written by MT and WK. The manuscript was initially written by SS, and the improved and revised by IU. All authors read and approved the final manuscript.

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