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Study on Interplating Density of Taros (*Colocasiaesculenta* (L.) Schott) in Acacia (*Acacia mangium* Willd) Plantation under the Agroforestry Model in Bac Kan Province

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Planting of forestry trees in Bac Kan province, Vietnam has been conducted by intercropping with annual crops at the early stage after planting of the forestry trees when they are still immature, from which an agroforestry systems (AF) that has both efficiencies of economy and protecting the ecological environment will be created. However, intercropping practices applied by the local people are spontaneous, and not advanced technical processes, therefore economic efficiency resulted from those has not been high. This study aimed to study on interplanting density of Taro plants (*Colocasia esculenta* (L.) Schott), an annual crop which can grow well under the dense canopy of the tropical forestry trees, in an existing plantation of Acacia (*Acacia mangium* Willd), an typical forestry tree grown in the province. With this regards, effects of planting density of Taro plants interpcropped in the Acacia plantation (1- 2 years old) **on** the yield of the Taro plant and the growth of Acacia trees were assessed, from which an suitable density of the Taro, which not affect to the growth of the Acacia, and also bring economic efficiency from the Taro output, was determined. The result showed that the taro plant exposed its capable for growing and developing well when intercropped with the Acacia at the first 2 years after planting. The planting density of the Taro quite remarkably affected to its yield, and the highest planting density of 24000 clusters/ ha increased the productivity of Taro by 30 %, and income from Taro output by 112 % which raised from 962.275 to 2042.275 USD/ha as compared to the control. Comparison in the yield of the Taro intercropped in the Acacia plantation between the first and the second year-old stage of the Acacia showed that the Taro yield given at the first year reached 5.9 - 7.2 tones/ha, higher than those given at the second year, which reached from 4.7 to 5.4 tones/ha. It denoted that the density of 24,000 cluster Taros/ha intercropped in the Acacia plantation at the stage of 1-2 years old brought the highest economic benefits as compared to the other in the condition of Bac Kan province. In conclusion, the density of 24,000 clusters of Taros/ha could be used for intercropping in a 1 - 2 yeas- old Acacia plantation as an agroforestry model in Bac Kan province, Vietnam.

Keywords: acacia *(Acacia mangium* Willd*),* density, economic efficiency intercropping, taro [*Colocasia esculenta* (L.) Schott].

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Introduction

Forestry production in BacKan has long been known to apply intercropping of annual crops (banana, pineapple, arrowroot, taro, etc.) with the main crop in early stages of immature plants (acacia, grease timber, pine, etc.), create agroforestry systems (AF) have both economic efficiency and protect the ecological environment (Le QuocDoanh, Nguyen Van Bo, Ha Dinh Tuan,2003).One of effective AF systems is the people commonly applied in most of the communes in the province of agricultural crops mixed forest, however applying intercropping techniques are spontaneous, yet apply advanced technical process, so economic efficiency is not high. To enhance the value of this system towards sustainability in BacKan, subjects chose acacia tree (*Acacia mangium*Willd) is one of the forest trees typical of the province to study technical intercropped with annual crops as taro plant [*Colocasiaesculenta* (L.) Schott] which adapts mixed forest canopy of the tropical forest. Problem is needed poses determine taro planting density so that economic efficiency when intercropped, adjust the density of the taro plant accordingly to provide the highest yield but little influence development and growth of acacia.

Materials and methods

Major crops: acacia (*Acacia mangium*) stages of age 1 and 2 (the first year and second year after planting); intercroppingcrops: taro varieties (*Colocasiaesculenta*), local varieties in BacKan

The study was conducted in XuatHoacommune, BacKan town, BacKanprovince, for 2 years (2013-2014).

Research methods:Test design of taro intercropped with 4 density treatmentsas follows:

Treatment1: growing taro clusters 28,000 per ha (distance: 0.6*0.6 m)

Treatment2: growing taro clusters 24,000 per ha (distance: 0.6*0.7 m)

Treatment3: growing taro clusters 20,000 per ha (distance: 0.6*0.8 m)

Treatment4 (control treatment): growing taro clusters33,000per ha (distance: 0.6*0.5 m)

Tarowereplantedbetween the rows of acacia at the age of 1 and 2; density of 2,000 acacia trees per ha, planting distance of 2.5*2 meter.The experiment was arranged in randomized complete block (RCB), 3 replicates,plot area of 300 m^2 per box.

Taro planting techniques: planting season around in early February and March calendar, harvest in octoberornovember; planting materials are tubers

level 1 or level 2 weighing 20 to 30 tubers peronekg, does not rot, many hairy coating crust; fertilizer (for 1 hectare): 10 to15 tons of manure, 345 kg of urea + 575 kg of superphosphate + 172.5 kg of potassium sulphate(Nguyen Phung Ha, 2001).

The process of cultivating, tending taro are combined prune the branches beneath acacia trees, creating open space for developed taro, while limiting branched of acacia canopy, focused growth in height, moisturizing regularly in planting stage. The experiment was not irrigated, only rainfed use

Measuring indicators for taro: survival,growth time (from the date of planting to harvest), final plant height, amount of leaf, amount of side shoots,amountof young tubersandmother, volume of young tubersand mother, actual yield (Dao HuyChien, 1999) (Nguyen Thi Ngoc Hue, Dinh The Loc, 2005).

Measuring indicators for acacia: plant height; spread wide; trunk diameter (measured 50cm from the ground).

Calculation of economic efficiency: Efficiency versus monoculture value through profit = Total value - Total costs incurred (cost of materials + labor costs).

Results and discussion

Effects of density on the growth and development of taro intercropped Acacia.

Results of monitoring the growth and development of taro intercropped acacia in some densities are shown in bable 1:

Table 1 Effect of planting density to indicatorsofgrowth and development of taro intercropped acacia at the age 1 and 2 in BacKan (2013 and 2014)

Treatment	Taro growth in 2013				
	Survival rate (cm)	Growth time (day)	Final plant height (cm)	Amount of leaves (leaf)	Amount of side shoots (shoot)
Treatment 1	86.4	210	79.0	8.7	5.1
Treatment 2	82.5	210	79.9	8.9	5.5
Treatment 3	78.7	210	80.3	9.2	5.7
Treatment 4	85.8	210	78.7	8.3	4.8
	Taro growth in 2014				
Treatment 1	76.4	214	75.3	8.5	4.9
Treatment 2	75.2	214	76.6	8.7	5.0
Treatment 3	71.9	214	77.5	9.1	5.1
Treatment 4	74.4	214	74.2	8.2	4.7

Table 1 shows: When reducing the density of taro intercropped acaciaboththe age 1 and 2, the growth indicators such as plant height, number of leaves, number of side shoots are higher than controls; Treatment 3 is the highest, lowest and control Treatment planted with monoculture densities. However, the survival of taro tend contrast, the lowest is Treatment 3 was only 78.7%, and the highest Treatment 1. The reason for this, in our opinion, the high density planting of pit volume hoes more characteristic makes soil more porous and better water holding capacity, allowing survival of taro is guaranteed.

Comparison 2 years: the second year of intercropping (2014) taro plants grow slowly over the first year (2013), specifically survival only from 71.9 to 76.4%; height from 74.2 to 77.5 cm.However, indicators of the leaf, the side shoots, and growth time of the density Treatments is equivalent to the first year. The reason is that the first year of taro less competitive on nutrition and lighting by acacia, the first one ramified at quite suitable for taro plant. Second year bigger acacia trees, the branches many, the increased shading taro plant was thus more competitive on nutrition, light, from which grow slowly over the first year.

Effect of density to the constituent elements of productivity and yield of taro intercropped acacia

Among the components of productivity, the amount and volume of tubers very important contribution and decisive direct actual yield. Results of monitoring the components of yield and productivity of taro intercropped acacia is shown in Table 2:

Table 2 Effect of planting density on the yield component factors andproductivity of taro intercropped acacia at the age 1 and 2 in BacKan (2013 and 2014)

Treatment	Yield component factors andproductivity of taroin 2013			
	Amount of young tubers and mother (tubercluster^{-1})	Volume of mother tubers (kgcluster^{-1})	Volume of young tubers (kgcluster^{-1})	Actual yield (tone ha^{-})
Treatment 1	5	0.20	0.12	5.9
Treatment 2	5	0.27	0.13	7.2
Treatment 3	4	0.26	0.11	6.3
Treatment 4	4	2.17	0.12	5.5
	Yield component factors andproductivity of taro in 2014			
Treatment 1	4	0.16	0.10	5.0
Treatment 2	5	0.21	0.14	5.4
Treatment 3	5	0.22	0.12	4.7
Treatment 4	5	0.15	0.11	4.8

Note: year 2013, CV of productivity: 5.7%, LSD_{05} of productivity: 0.7
year 2014, CV of productivity: 6.6%, LSD_{05} of productivity: 0.6

Table 2 shows:When taro planting density decreased both age 1 and 2, the productivity indicators such constitutes the number of tubes, the volume of tubers that tend to rise higher than the controls, the highest of Treatment 2 and the mode 3, the lowest is controlled by the density planting monoculture. Due to the amount of tubers colonization were not significantly different, but the total volume of tubers on different clusters demonstrate this factor has affected the size taro tubers, tubers bigger than when planted at lower densities. Review yield Treatment 2 obtained showed the highest yield compared to the control at significance level $\alpha = 0.05$.

Comparison 2 years: the second year of taro intercropped acacia (2014) showed that yield and yield components of lower first year (2013), taro yield concrete first year reached 5, 5 to 7.2 tones per ha, from the 2nd year only 4.7 to 5.4 tonesper ha. This is also consistent with the results of evaluation of growth of taro intercropped acacia after 2 years as analyzed in Table 1.

Thus, the components of yield and productivity of Treatment 2 (24,000 clusters per ha) reached the highest value for two years of the experiment. This value confirms that it was intercropped with light competition, nutrition, water and other conditions for major crops, so when intercropped with density as Treatment 2 (by 73% compared to the density monoculture) would be reasonable densities in intercropping structure ofacaciaand taro.

The impact of the taro plant density on the growth of Acacia.

To evaluate the impact of the taro plant density on the growth of Acacia. Results of monitoring indicators acacia tree growth are presented in Table 3:

Table 3 Effect of the intercrop taro density on the growth of Acacia at age 1 and 2 in BacKan (2013 and 2014)

Treatment	Acacia growth in 2013		
	Tree height (cm)	Canopy width (cm)	Trunk diameter (cm)
Treatment 1	162	85.4	1.9
Treatment 2	155	86.7	2.2
Treatment 3	152	97.2	2.0
Treatment 4	158	84.6	2.1
Monoculture	153	88.0	1.9
	Acacia growth in 2014		
Treatment 1	284	186.2	4.8
Treatment 2	315	188.4	5.3
Treatment 3	291	197.1	4.1
Treatment 4	294	191.6	4.4
Monoculture	273	165.7	3.4

Note: year 2013, LSD_{05} of tree height: 5.8; $LSD_{05}$of tree height: 0.4
year 2013, LSD_{05} of tree height: 13.2; LSD_{05} of tree height: 0.5

Table 3 shows: when taro intercropped with acacia in both age 1 and 2, the acacia trees grow better than no intercropping, especially the 2nd year of this very obvious influence to all growth indicators such as height, width canopy and trunk diameterof acacia, and the difference is significant compared with acacia monoculture.

Comparing the density intercropped shows 1st year planting density (Treatment 2 and Treatment 3) has been found to increase the growth of the trees, into the 2nd year of this influence more clearly first year.

Thus, in conditions of taro intercropped, acacia trees grow better than monoculture. reason when intercropped with taro, acacia tree has nutritional supplements, tending, pruning reasonable spread ... have a positive impact to the trees, such as increasing soil fertility, taro covering increases soil moisture, reduce weeds , reduce surface erosion creates good conditions for the growth of acacia.

Figure 1 The taro intercropped acacia in the first year

Figure 2 The taro intercropped acacia in the second year

Assessing the effectiveness of economic models taro intercropped acacia than not intercrop

Assess the effectiveness of economic models taro intercropped acacia than not intercropfrom one hectare model of intercropping pattern density as Treatment2 (24,000 clusters per ha) was by 7.2 tones per ha (2013) and 5.4 tonesper ha (2014), results in table 4:

Table 4 Comparison of economic efficiency of model taro intercropped acacia than not intercropin BacKan, the year 2013 – 2014

Content	Unit	Unit price (USD)	Amount		Income	
			In model	Out model	In model (USD)	Out Model (USD)
Cost of the first year (A)					**2277.725**	0
Taro varieties	Kg	1	800	0	800	0
Fertilizer					1477.725	0
Manure	*Tone*	*25*	*10*	*0*	*250*	0
N	*Kg*	*0.45*	*345*	*0*	*155.25*	0
P	*Kg*	*0.2*	*575*	*0*	*115*	0
K	*Kg*	*0.55*	*172.5*	*0*	*94.875*	0
Taro care	Labor	7.5	100	0	750	0
Acacia care	Labor	7.5	15	0	112.6	0
Total revenue in the first year (B)					**4320**	0
Income from taro	Kg	0.6	7200	0	4320	0
Profit (B-A)					**2042.275**	0
Cost of the second year (C)					**2277.725**	0
Equivalent to first year					2277.725	0
Total revenue in the first year (D)					**3240**	
Income from taro	Kg	0.6	5400	0	3240	0
Profit (D-C)					**962.275**	0
						0

Table 4 shows that the model taro intercropped for high profit: The first year (2013) is 2042.275 USDper ha; second year (2014) is 962.275 USDper ha; 2 years profit was 3004.550 USDper ha.

Also, taro intercropped with forest land is used to improve acacia plantation, as soil moisture, reduce erosion and limit soil hardened, reduce weeds ... a new stage planted acacia canopy before delivery, while contributing the creation of favorable conditions for better growth acacia.

Conclusions

The density of taro intercropped with acacia trees have a positive impact on the growth and development of the main crop and intercrop trees, including 24,000 taro planting density plant per ha (73% of control density) is best for yield at 7.2 tonnes per ha in the first year and 5.4 tonnes per ha in tesecondyear.

Acacia tree grown inverygoodconditionintercropping, in which the best well in taro planting density of 24,000 clusters per ha with tree height reaches 315 cm, trunk diameter reaches 5.3 cm.

Economicefficiencyfromintercroppingpatterntaroandacaciain the model with taro planting density of 24,000 clusters per ha reached the highest in the first year (2042.275 USD per ha), 2nd year although decreased over the first year but reached 962.275 USD per ha.

Also, taro intercropped with forest land is used to improve acacia plantation, as soil moisture, reduce erosion and limit soil hardened, reduce weeds ... a new stage planted acacia canopy before delivery, while contributing the creation of favorable conditions for better growth acacia.

It should continue to expand the model and assess Acacia in the next year to confirm the results of research and improve the process of planting taro intercropped with acacia trees

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