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Research Article

The influence of agroforestry silviculture on productivity and quality of *Canna edulis* Ker on private forest land

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Abstract: The productivity of private forest land by using agroforestry of Canna edulis Ker aims to achieve food security at the smallholder level. The purpose of this study was to determine the effect of agroforestry cropping patterns on productivity and quality of *Canna edulis* Ker tuber on private forest land. The study was conducted in dry area of the private forest land who are administrativelyincluding Tenggerraharja Village area, SukamantriSubdistrict, Ciamis District, West Java Province, Indonesia. The planting of *Canna edulis* Ker was implemented under the 32 months old *Manglieta glauca* BI stands. The main plots were three pruning intensity of *Manglietia glauca* BI stands i.e. P0 (0 %) , P1 (50%), and P2 (75%). The sub plots were three planting spaces of *Manglietia glauca* BI, i.e. S1 (2m x 2m), S2 (2m x 3 m), and S3 (3m x 3m). The planting of *Canna edulis* Ker by monoculture technique was conducted as a comparison. The results showed that the interaction of planting space and pruning intensity gave a significant result on height growth, wet weight and dry weight of plant, wet weight and dry weight of *Canna edulis* Ker tuber. The growth of *Canna edulis* Ker that ranged from 181.85 cm (P0S1) to 186.30 cm (P1S1) were higher than the monoculture system on *Canna edulis* Ker (138.20 cm). The wet weight and dry weight of tuber that ranged from 2089.3 g and 1429.99 g (P2J2) to 3695.5 g and 2678.09 g (P1S2), whreas those in the monoculture system on *Canna edulis* Ker were 2363.1 g and 1528.7 g. However, the protein, fiber and carbohydrate contents of P0S1, P1S1, P2S1 treatments were lower than those of the monoculture system on *Canna edulis* Ker. The planting pattern of agroforestry were able to improve the plant height of *Canna edulis* Ker tuber but giving less percentage of carbohydrate and protein of tuber than the monoculture.

Key words*: *agroforestry, Canna edulis Ker, Manglietia glauca BI, planting space, pruning intensity.

Introduction

Food crisis is the central issue and becoming the world main issue. It is happened in Indonesia as well. When the food crisis is happened, 60-70% of poor people's income are spent in food. Some factors that causes food crisis are the agricultural land conversion in year is about 50 – 100 thousand hectares/year, the population growth rate is not followed by the improvement of food production, the conversion of foodstuffs to biofuel, and the climate change. The common problems in agriculture is quantity, quality, and continuity of production that have not fulfilled the targets andput the pattern of farming that considersthe sustainability, and less of environmental sound (BP3K, 2012). The agroforestry technique aims to optimize the land use by combining the forestry crops with agricultural crops to improve land productivity. Alley cropping hallway pattern is characterized by tree line spacing among short hallway because it is designed for two goals, i.e. production and conservation on locations with slope variance (not flat) (Suryanto et al. 2005). The improvement of private's income through agroforestry practical in upper area in Mindanao of the Philippines gives 42% - 137% of profit improvement (Magcale-Macandog et al. 2010).

One of the agroforestry's goal in economical aspect is to ensure and repair the food needs (improving the availability of food, diversification of food needs, and the sustainability of availability of food) (Magcale-Macandog et al., 2010). Agroforestry will reduce 9,2% of surface flow and 16 – 48 kg ha^{-1} $a^{-1}$of NO_3-N loss if it is

compared to the monoculture system which has 45-64 kg ha^{-1} $a^{-1}$of NO_3-N loss (Wang et al. 2011). Rao et al. (1998) stated that the interaction of cropping between wood and non-wood components is a success key of agroforestry system. Although the tree is old enough, but the resource sharing system (RSS) can be arranged to produce the prospective agricultural crops. Basic amplifier of RSS is a room dynamic which is based on the quantity of canopy development toward areas processing (Sabarnurdin et al. 2004). Huxley, 1999, stated that the light system action on agroforestry system can be conducted by: 1) eliminating the dead and diseased branches to improve the wood quality, 2) manipulating the size and shape of the canopy to maintain biomass productivity and keep the competition with the underneath plants, 3) pruning to keep production of fruits, leaves, and branches for firewood. A planting space and pruning system become the main factor in agroforestry because the wider tree spacing will increase the processing area for the underneath plants. The initial spacing is an important basic factor in forest management that influencing the final result (Cardoso et al. 2013). Pruning is required for tree maintaining and light intensity improving around the area under canopy.

Suhardi (2011) stated that the food crops which is potentially to be developed in private forest in Java are all kinds of tuber and *Canna edulis* Ker is one of it. Its starch is potentially in replacing wheat and rice flour as food diversification (Harmayani et al. 2011). *Canna edulis* Ker can be processed into flour for the babies food beside it can be eat as a dessert and main food as well (Lembaga Biolog Nasional, 1977). *C. Edulis*is an efficient plant in nitrogent use, tollerant with dry, and having high productivity (Herman et al.,1998). *C. Edulis* can be planted under the tree or at the low sunlight intensity condition (Richana and Sunarti, 2004). This research aims to find out the productivity of *Canna edulis* Ker on *Manglieta glauca* BI agroferestry system in silviculture area by covering the planting space and pruning intensity. It is also compared with the monoculture planting pattern.

Material and Methods

The research was conducted in dry area of private forest in Tenggerraharja Village, Sukamantri Sub District, Ciamis Distric of West Java Province. It has S 07 06 550; E 108 22 900 of coordinate position. This area has ± 894 m above the sea surface, 20,4 ^{0}C- 31 ^{0}C of temperature,62,13%-89,75% of moist level, 2.071 mm/year of rainfall level, and it is in C type (Schmid and Fergusson) (BP3K, 2012).

The research required 32 months old *Manglieta glauca* BI stands with 3 kinds of planting spaces, seeds of *Canna edulis* Ker, insectiside, compost, NPK, urea, etc. It required oven, hoe, sickle, rope, water container, length gauge, bucket, calipers, scales, cameras, termohygrometer, GPS, lux meter, stationery, as well. Land clearing was conducted by clearing the reed and hoeing the soil for 10 – 30 cm of depth. The planting space for *Canna edulis* Ker was 120 cm x 80 cm. The planting hole was made in 40 cm of length, 40 cm of width and 20 – 30 cm of depth. 800 g/hole of compost from chicken manure was the basic fertilizer for *Canna edulis* Ker planting. The advance land weeding and fertilizing could be conducted at the same time after *Canna edulis* Ker was 2 and 4 months old. It required 70 g/plant with 1:2 of urea and NPK doze ratio.

The split plot design was used with three pruning intensities, i.e. P0 (0%), P1 (50%) and P2 (75%) as the main plot and three planting spaces, i.e. S1 (2 m x 2 m), S2 (2 m x 3 m) and S3 (3 m x 3 m) as the subplot. *Gross plot* of *Manglietia glauca* BI was 7 x 7 plants, and *net plot* of *Manglietia glauca* BI was 5 x 5 plants. The total of *Manglietia glauca* BI plants was 49 x 3 pruning intensities x 3 planting spaces = 441 plants of *Manglietia glauca* BI.

The light intensity was measured on 9 spots of each trial, i.e. 3 spots under the tree, 3 spots between the trees, and 3 spots in the middle of tree diagonal. It was conducted in open area as well for the comparison. Temperature and humidity measurement was conducted in every morning, noon, and afternoon for 2 months. Data of rainfall level was received from secondary data of Extension Agency of Agricultural, Veterinary, and Forestry Extension in Technical Executor Unit of Sukamantri Sub District area for 10 years, from 2002 up to 2011.

To find out the growth of agricultural crops, the measurement on plants' height, wet weight, and dry weight of stem and leave was conducted. The productivity of plants was be measured by scaling the wet weight and dry weight of *Canna edulis* Ker. The chemical analytic of carbohydrate, fiber, and protein was conducted in laboratory by taking sample of the harvested *Canna edulis* Ker in each trial unit.

Then, the data of *Canna edulis* Ker's growth and production was analyzed by variance analysis or F test. If the result was significant, it was continued by Duncan Test with 95% of test level. Data of *Canna edulis* Ker's carbohydrate, fiber, and protein was analyzed by a simple statistic, i.e. taking the average of each trial.

Results and Discussion

According to the variance analysis, it was shown that the interaction of pruning and planting spaces of *Manglieta glauca* BI stands had significant result on height, wet weight, and dry weight of tuber and *Canna edulis* Ker as shown at Table 1. To find out the significant result of best average on each interaction of treatment, the Duncan Test was conducted as shown at Table 2.

Table 1. The result of variance analysis on influence of pruning and planting space of *Manglieta glauca* BI stands on the growth and production of *Canna edulis* Ker (plant height, tuber wet and dry weight, plant wet and dry weight)

Source Of Variance	F-Calculation				
	Plant Height	Tuber Wet Weight	Tuber Dry Weight	Plant Wet Weight	Plant Dry Weight
Pruning	14,38*	8,02*	10,15*	2,91*	3.66*
Spacing	15,34*	5,30*	5.65*	1.95ns	2,46ns
Pruning *Spacing	3,67*	18,43*	12,49*	3,38*	4,91*

* significantly different at 0,05 level

According to Duncan Test result, it was shown that the height growth of *Canna edulis* Ker on agroforestry planting pattern was relatively higher and significantly different than on monoculture pattern. The *Manglieta glauca* BI stands in agroforestry planting pattern caused the growth area of *Canna edulis* Ker was relatively less in order to obtain the sun light. It stimulated the height growth of *Canna edulis* Ker plants in order to obtain the sunlight.

The dry weight of *Canna edulis* Kerhad a better significant differences under stands with 50% pruning and 2m x 3m of planting space than the monoculture pattern and other treatments. According to all parameters, on the agroforestry pattern, *Canna edulis* Ker could heigher than the monoculture pattern. *Canna edulis* Ker plants could grow properly under the covered area so that it could be planted under the yearly plants (Richana and Sunarti, 2004).

The best harvesting product was produced on the silviculture treatment on stands with 50% pruning intensity and 2m x 3m planting space (61.92% of light intensity). Under tree stands with lower sun light intensity the evaporation would be reduced. It caused the better water availability. At the open space, the higher sunlight intensity caused the higher evaporation. *Canna edulis* Ker in optimal light intensity would be more effective to do the photosynthesis in produced the plants biomass. Light, water, and nutrition capture was depended on quantity, surface area, distribution and effectiveness of individually element in canopy or rooting system of its species and combination (Suryanto *et.al*, 2005).

The harvest was the result ofthe accumulation ofdry weightin a certain time. Efficiently, the dry weight of harvest depended on plant efficiency in using the sun radiation and keeping it properly (Suryanto et al. 2005). Based on the laboratory analysis on carbohydrate, protein and fiber of *Canna edulis* Ker, it was shown that the agroforestry pattern gave a lower result than the monoculture as shown in Figure 1. The chemical analysis of tuber of *Canna edulis* Ker in the more open area would produce much carbohydrate/ protein. It was caused by the sunlight intensity in the open area (monoculture of *Canna edulis* Ker) was more, so that the photosynthesis of carbohydrate would be higher

Starch was the first polysaccharide organic material that was produced from the reaction between carbondioxide of air and water inside the ground on photosynthesis by using the sunlight radiation energy (Harmayani et al. 2011). Akhila and Beevy (2011) stated that the protein profile on most seasonal plants species was depended on environmentaland storage condition. light deprivation result in disruption of metabolism, thus causing reduction in the rate of photosynthesis and carbohydrate synthesis(Djukri dan Purwoko, 2013).

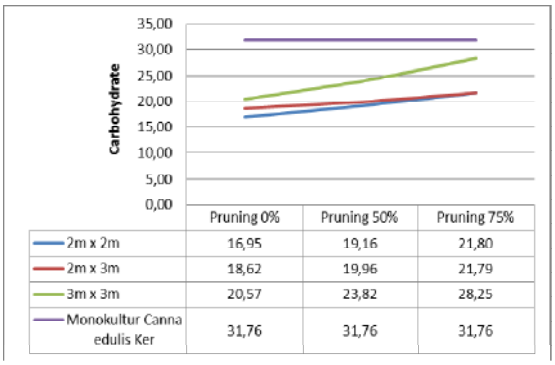
Canopy caused the accumulation of N on certain parts of plants, one of it was seed. Norton *et al.* (1991) stated that the canopy could reduce the green production, but increase the nitrogen of plant. Decreased levels of nitrogen affects plant photosynthesis and chlorophyll content either through photosynthetic enzymes that degrade photosynthate (starch) are formed, will further decrease the weight of the wet tuber and tuber dry weight (Djukri dan Purwoko, 2013)

Table 2. Result of Duncan Test: the influence of pruning and planting space of *Manglieta glauca* BI stands on growth and production of 8 months old *Canna edulis* Ker (plant height, tuber weight, and plant weight)

No	Treatment	Light Intensity (%)	Plant Height (cm)	SD	Weight of Tuber per Clum (g)						Weight of Plant per Clum (g)					
					Wet		SD	Dry		SD	Wet		SD	Dry		SD
1	M	100	138.20 b	16.30	2363.1	b	1274.58	1528.7	b	769.58	1445.6	ab	715.58	697.6	b	449.63
2	P0S1	45.59	181.85 a	25.31	1804.8	bcd	831.16	1124.9	bc	745.67	929.0	b	237.77	440.2	bc	262.97
3	P0S2	47.15	179.50 a	24.99	1302.6	d	533.77	893.4	bc	477.66	575.8	b	245.15	253.8	c	109.47
4	P0S3	68.74	187.40 a	19.24	1946.6	bc	683.79	1082.1	bc	545.74	662.0	b	75.35	289.8	bc	124.63
5	P1S1	27.82	186.30 a	36.66	1514.8	cd	926.86	1109.5	bc	630.62	572.6	b	77.25	132.4	bc	55.12
6	P1S2	61.92	184.55 a	22.09	3695.5	a	1321.60	2678.1	a	1181.74	1959.4	a	1181.49	937.8	a	753.48
7	P1S3	42.11	138.30 b	20.12	2102.6	bc	560.84	1445.6	b	588.54	946.8	b	330.74	445.0	bc	135.42
8	P2S1	43.44	182.55 a	21.60	1985.4	bc	539.90	1302.2	bc	489.21	1089.8	b	96.72	452.4	bc	65.47
9	P2S2	73.29	152.50 b	29.15	2089.3	bc	945.02	1430.0	b	778.70	1295.2	ab	401.80	146.6	c	36.46
10	P2S3	73.07	174.10 a	39.27	2015.2	bc	800.89	1223.6	bc	737.43	1355.4	ab	1110.35	153.8	c	106.60

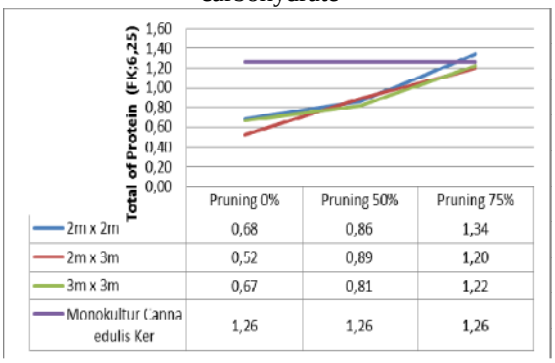
*)Value followed by sma letter indicated not different at level 0.05; SD = standard Deviation

M Monoculture of *Canna edulis* Kerr
P0S1 0% pruning intensity; 2x2 m tree spacing
P0S2 0% pruning intensity; 2x3 m tree spacing
P0S3 0% pruning intensity; 3x3 m tree spacing
P1S1 50% pruning intensity; 2x2 m tree spacing
P1S2 50% pruning intensity; 2x3 m tree spacing
P1S3 50% pruning intensity; 3x3 m tree spacing
P2S1 75% pruning intensity; 2x2 m tree spacing
P2S2 75% pruning intensity; 2x3 m tree spacing
P2S3 75% pruning intensity; 3x3 m tree spacing



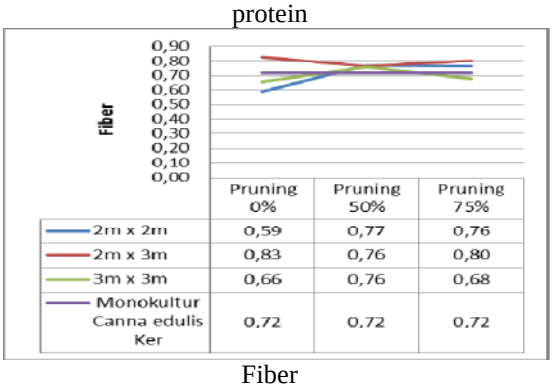
	Pruning 0%	Pruning 50%	Pruning 75%
2m x 2m	16,95	19,16	21,80
2m x 3m	18,62	19,96	21,79
3m x 3m	20,57	23,82	28,25
Monokultur Canna edulis Ker	31,76	31,76	31,76

carbohydrate



	Pruning 0%	Pruning 50%	Pruning 75%
2m x 2m	0,68	0,86	1,34
2m x 3m	0,52	0,89	1,20
3m x 3m	0,67	0,81	1,22
Monokultur Canna edulis Ker	1,26	1,26	1,26

protein



	Pruning 0%	Pruning 50%	Pruning 75%
2m x 2m	0,59	0,77	0,76
2m x 3m	0,83	0,76	0,80
3m x 3m	0,66	0,76	0,68
Monokultur Canna edulis Ker	0.72	0.72	0.72

Fiber

Figure 1. Percentage of carbohydrate, protein and tuber of *Canna edulis* Ker tuber on agroforestry silviculture and monoculture

Lott et al. (2009) stated that the main function of tree canopy was to protect the plants from high temperature especially in tropical area and it would be more effective in the climate change era like nowadays. The improvement of land productivity could be conducted if the combination of tree and C3 type of plant were used (Muthuri et al. 2005). *Canna edulis* Ker was the C3 type of plant in order to have good adaptation on canopy. Productivity of *Canna edulis* Ker had not shown the significant reduction. It was in line with the closer of spacing of *Manglieta glauca* BI. Similar result was shown by the experiment on one kind of tuber i.e. *Xanthosomasagittifolium*(L.) Schott. It was covered the best height, total of leave's chlorophyll of *Xanthosomas agittifolium*(L.) Schott under 75% of canopy. The improvement of leave's chlorophyll as the adaptation to improve the capacity of unlimited light capture (Anggarwulan et al. 2008). A different response was showed by the covered by pea plants. 50% canopy caused faster harvesting time, higher stem, fewer pea seed, smaller seed size, and lighter seed weight than the area without canopy (Susanto and Sundari, 2011). Ong et al. (2006) stated that pruning on agroforestry system was a kind of management in serving a better environment during the planting time of under plantation. Youkhana and Idol (2009) stated that mulch as the pruning product could improve C and N element in the soil and reduce the soil solidity especially on upper soil layer (20 cm of depth).

Conclusion

The influence of agroforestry silviculture planting pattern in the interaction of pruning x spacing is significantly different on growth and production of *Canna edulis* Ker. The agroforestry planting pattern is able to improve plant height of *Canna edulis* Ker but giving less percentage of carbohydrate and protein of tuber than the monoculture. The best production of tuber dry weight on *Manglietaglauca* BI is obtained by the 50% of pruning and 2m x 3m of plant spacing (61.92% of light intensity). It is 2678.1 g/clump. The private forest of *Canna edulis* Ker is technically feasible for community food availability improvement

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