The Effect of Planting Time and Density of Corn (Zea Mays L.) On The Growth and Yield of Taro (Colocasia Esculenta L.)

Schott var. Antiquorum in Intercropping

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Abstract: *Objectives of the research were (1) to study the effect of planting time and density of corns on the growth and the yield of taro, which is grown in intercropping system, and (2) to determine the right planting time and appropriate density of corn in order to obtain optimal growth and yield of taro in intercropping system. Research in the field was conducted at Landungsari Village, Malang from September 2012 to July 2013. The research used a Split Plots Design by placing the planting time of corn as the main plot, which comprised of 3 levels, such as : (1) the corn was grown 30 days earlier before the taro, (2) the corn and the taro were grown simultaneously, and (3) the corn was grown 30 days later after planting the taro. The plant density was placed as the son plot, which includes 3 types: (1) 15,000 plants ha^{-1}, (2) 29,000 plants ha^{-1}, and (3) 43,000 plants ha^{-1}. The treatments have been done by 3 replications.*
Results of the research showed that the appropriate time of planting corn in intercrop system with taro was growing both crops simultaneously, and they have produced taro tubers for about 13.51 tons ha^{-1} or 30 days after planting, the yield of taro tubers were 14.12 tons ha^{-1}, so that they produced higher yield of taro. Meanwhile, for the corn density of 15,000 plants ha^{-1} have produced the highest yield of taro, 16.13 tons ha^{-1}.
Keywords: *Planting time, Density level, Corn (Zea mays L.) and Taro (Colocasia esculenta (L.) Schott var. Antiquorum*

I. Introduction

The rapid growth of population has been followed by the increasing demand of foods, particularly rice. However, the demand has not been able to be fulfilled immediately due to the decreasing productivity of rice in Indonesia. This is due to the decreasing land area for farming, particularly wet land (rice-field) that has changed into non-farming land, such as for settlements, stores, and etc (Suwarto, 2005). In relation to the problem above, and in order to make the land use and varying plants to be efficient, intercrop is presumed as the most appropriate strategy.

Intercrop is one of planting system that combining two or more plants in the same farming land at the same or different time (Mimbar, 1994). Considerations that concern with the selection of plant types for intercrop according to Gliessman (2006) include (1) the plants with different rooting depths; (2) the plants with different photosynthetic lines; and (3) the plants with different requirements of nutrients.

Besides those requirements, the success in planting the intercrop has also been affected by the planting time arrangement and the intercrops density (Finlay, 1974). Planting time arrangement is an alternative to increase productivity of the farm land, because planting time will affect the achievable production. Therefore, planting time arrangement should be concerned in order to obtain better yield (Syaifuddin, 2008). Results of the research (Ridwan et al., 1995) stated that the planting of peanuts between two rows of corn in 100 cm spacing, has been able to produce 2.93 ton ha^{-1} dry legumes.

Reasons why taro is selected as the intercrop include (1) taro is potential as carbohydrate sources, which is healthy and safe to be consumed. It is due to this crop contains low starch (amylum) and reduction sugar in comparison with sweet potato, cassava, bentol tuber, mbothe tuber, as well as ground rice (Suminarti, 2009). (2) Taro tuber is an essential exported-commodity nowadays. But, in accordance with the yield per land area unit and time, the yield is low, 5 – 7 ton ha^{-1}, particularly in the farmer level, while the potential production has reached 20.7 ton ha^{-1} (Onwueme, 1978 and Suminarti, 2009). Such lower yield is presumed as a result of : (1) in general, taro is planted in the yard as a mixed cropping by irregular layout, (2) varied spacing of the crops due to no guidance of the standard spacing. In connection with the problem, this research is required in order to gain information and solution, as well as to facilitate the taro management to increase its productivity.

Objectives of the research were (1) to study the effect of planting time arrangement and density of corns on the growth and the yield of taro, which is grown in intercropping system, and (2) to determine the right

planting time and appropriate density of corn in order to obtain optimal growth and yield of taro in intercropping system.

II.   Material And Method

The research applied a Split Plots Design (SPD) by 3 replications. The planting time of corn was placed as the main plot (J), which comprised of 3 levels, such as : (1) the corn was grown 30 days earlier before the taro (J_1), (2) the corn and the taro were grown simultaneously (J_2), and (3) the corn was grown 30 days later after planting the taro (J_3). The plant density was placed as the son plot (P), which includes 3 levels: (1) 15,000 plants ha^{-1} (P_1), (2) 29,000 plants ha^{-1} (P_2), and (3) 43,000 plants ha^{-1} (P_3). Based on both treatments, 9 combinations of treatments and along with 3 replications, 27 units of treatment combinations have been obtained.

Instruments of the research include: analytic scales, leaf area meter, oven, sliding calipers, thermometer, and lux meter. Materials of the research include taro germs var. Antiquorum, corn seeds of Pioneer P-21 variety, K (KCl : 60% K_2O) fertilizer, N (Urea : 45% N) fertilizer, and phosphate (SP-36 : 36% P_2O_5) fertilizer, as well as goat manure as compost (300 gram plant^{-1}).

Parameter of observation on the taro plant : The observation was conducted destructively by taking 2 plants as sample for each combination, which was done at 70, 107, 140 dap and at the harvest time (at 175 dap) that included growth and yield components.

Growth and yield components of the taro plant include : numbers of leaf, numbers of plantlet, total dry weight and the tuber yield (ton ha^{-1}).

The obtained data will be analyzed using analysis of variance (F-test) at the level $p = 0.05$, and if any significant effect existed, it would be followed by SSD test at the level of $p = 0.05$.

III.   Result And Discussion

Results of the research showed a significant interaction between planting time and density of corns on the observed variable of taro that include number of leaf (Table 1), number of plantlet (Table 3), dry weight of total plant (Table 4), and yield of tuber (ton ha^{-1}) (Table 5).

Table 4 shows that the lowest total dry weight of taro was obtained when the corn was planted 30 days earlier before planting the taro, which was combined in diverse density. Meanwhile, total dry weight of the plants reflected the amount of assimilate produced by the plant, which played as energy of the growth.

The growth can be defined as the increasing size, weight, and multiplication of protoplasm (Sitompul and Guritno, 1995). The increasing size and weight of plant are due to the process of cellular extension, cellular prolongation, and cell division, which require some energy. Whereas the energy resulted by the taro plant with the corn, which was planted 30 days before planting the taro, was low, so that the plant's ability to establish new organs was very slow as shown through the result of observation on numbers of leaf, leaf area, and number of plantlet (Table 1, 2, and 3). The comparable report was given by Syaifuddin (2010) that when the corn and mungbean were grown simultaneously, the growth of mungbean did not show any unstressed character. However, when the corn was planted 30 days earlier than the mungbean, it inhibited the growth of mungbean and at last, it produced lower total dry weight of the plants, weight of 100 seeds and the obtainable yields (ton ha^{-1}), in which each of them has reduced for about 36.23 %, 21.84 %, and 20.64 %, respectively, in comparison with when both crops were planted simultaneously. It has been conformed to other report (Nulhakim et al., 2008), which suggested to plant the sweet corn and peanuts simultaneously or 15 days after the planting of peanuts, therefore, both of them will grow well and produce high yields.

Leaf is the place where the photosynthetic process occurs, and it means that more leaves will extend the area of photosynthetic process of the plant. Meanwhile, leaf area is the capacity of plant to perform the photosynthetic process. Therefore, the plant that has less number of leaf and narrower leaf area will produce less assimilates as well. Assimilate is a simple carbohydrate, which is comprised of three molecular binds, such as C, H, and O, as well as along with other molecules, such as N, S, P, K, and some micronutrients, such as Mg, will construct a carbohydrate. Some of energy from this carbohydrate will be utilized for the plant growth, and the other will be stored as the food reserve and the remains will be stored in the sink.

Such low yield of tuber (ton ha^{-1}) has been caused by low components of growth as a result of strict competition between the corn and the taro in obtaining better grown environment factor. Sitompul and Guritno (1995) suggested that competition occurs if an individual of a given plant group exists in a group of other plant, while the grown environment factor is restricted. Such restricted grown environment, both on the soil surface and below the soil surface, will affect the growth and development of the plant, particularly if both two grown environment factors are required in the same time and amount. Competition between crops and weeds toward water, light, and CO_2, as well as nutrients, and land, may intra-specific (between individuals in a population) and inter-specific (between two or more populations, for instance between the plants and weeds) (Bomford, 2004). Competition for light and carbon dioxide is highly determined by the canopy structure and the area of

photosynthesis; meanwhile, competition for water and nutrients is highly determined by the root activities, pattern of their distributions, and the ability in absorbing water and nutrients. Competition that occurs during the initial growth of vegetative phase is not so affected, but the competition becomes stricter along with the growing plant (Ara,2007).

As a whole, intercropping between corn and taro has still provided some benefits in comparison with monoculture system. Higher values were shown by the calculation result of LER. When the individual plant was observed separately in the intercropping system, it showed that taro and corn has produced lower yield than the taro or corn was planted in monoculture system. As we know that land equivalent ratio (LER) is the sum between the yield of intercrops and the yield of monoculture in the same management level (Paulus,2005).

Table 1. Average numbers of leaf as a result of interaction between different planting time of taro and density of corns at observational time of 105 dap

Treatment	Density of corn (plant ha⁻¹)		
	15,000	29,000	43,000
Planting time of corn			
30 days before planting taro	10.33 c	7.00 b	3.00 a
	A	A	A
Planting corn and taro simultaneously	13.00 b	11.33 ab	10.00 a
	B	B	B
30 days after planting taro	12.33 b	12.33 b	9.67 a
	B	B	B
SSD 5%		1,677	

Notes: Numbers followed by the same letter in the same column (capital letter) or in the same row (small letter) at each the age of observation show insignificant difference based on SSD test at the level of 5%; dap : days after planting

Table 2. Average leaf areas of taro at the whole observational time due to different planting time of taro and density of corns

Treatment	Average leaf area (cm²)/age of observation (dap)		
	70	105	140
Planting time of corn			
30 days before planting taro	555.26	684.90 a	929.75 a
Planting corn and taro simultaneously	578.17	891.98 ab	1221.14 b
30 days after planting taro	611.03	1069.79 b	1270.12 b
SSD 5%	insig	247.93	140.27
Density of corns (plant ha⁻¹)			
15,000	895.63 c	1367.11 c	1775.23 c
29,000	515.80 b	767.61 b	1041.10 b
43,000	333.03 a	621.94 a	604.67 a
SSD 5%	123.80	161.78	164.63

Notes: Numbers followed by the same letter at the same observation age, show insignificant difference based on SSD test at the level p=5%. dap = days after planting, insig = insignificant

Table 3. Average numbers of plantlet per plant as a result of interaction between different planting time of taro and density of corns at the age of observation 105 dap

Treatment	Density of corn (plant ha⁻¹)		
	15,000	29,000	43,000
Planting time of corn			
30 days before planting taro	5.83 c	4.67 b	2.83 a
	A	A	A
Planting corn and taro simultaneously	9.67 c	7.00 b	3.00 a
	B	B	A
30 days after planting taro	10.00 c	7.33 b	5.33 a
	B	B	B
BNT 5%		1,027	

Notes: Numbers followed by the same letter in the same column (capital letter) or in the same row (small letter) at each the age of observation show insignificant difference based on SSD test at the level of 5%; dap : days after planting

Table 4. Average dry weight of total taro (g) as a result of interaction between different planting time of taro and density of corn at the observation age of 105 dap and 140 dap

Treatment	Density of corn (plant ha⁻¹)		
	15,000	29,000	43,000
Planting time of corn			
30 days before planting taro	94.55 b	62.15 a	48.30 a
	A	A	A
Planting corn and taro simultaneously	166.83 c	91.25 b	52.15 a
	B	B	A
30 days after planting taro	169.86 c	104.00 b	59.92 a
	B	B	A
SSD 5%		26.097	
Planting time of corn			
30 days before planting taro	139.39 b	136.57 b	102.34 a
	A	A	A
Planting corn and taro simultaneously	182.54 c	142.48 b	111.27 a
	B	A	A
30 days after planting taro	211.52 c	158.49 b	111.77 a
	C	B	A
SSD 5%		14.203	

Notes: Numbers followed by the same letter in the same column (capital letter) or in the same row (small letter) at each the age of observation show insignificant difference based on SSD test at the level of 5%; dap : days after planting

Table 5. Average yields of ton ha⁻¹ taro at the harvest time due to different planting time and density of corns

Treatment	Yield of tuber (ton ha⁻¹)	
Planting time of corn		
30 days before planting taro	12.28	a
Planting corn and taro simultaneously	13.51	b
30 days after planting taro	14.12	c
SSD 5%	1.19	
Density of corn (plant ha⁻¹)		
15,000	16.13	c
29,000	13.28	b
43,000	10.49	a
SSD 5%	1.01	

Notes: Numbers followed by the same letter show insignificant difference based on SSD test at the level of 5%

Low yield of taro per individual in intercropping system was caused by less population grown in such planting system. Based on t-test, it can be seen that the highest yield of tubers was derived from the taro plant, which was grown 30 days after planting the corn at the density of 15,000 plants ha⁻¹, 971.17 gram plant⁻¹. The value was much lower 19.43% by monoculture than the taro plant itself.

IV.   Conclusion
The appropriate time of planting corn in intercrop system with taro is planting both of the crops simultaneously, and it will produce taro tubers for about 13.51 ton ha⁻¹ as well as 30 days after planting the taro, which produces higher yield, 14.12 ton ha⁻¹. The density of corn, 15,000 plants ha⁻¹ has also produced the highest yield of taro, 16.13 ton ha⁻¹.

V.   Suggestion
It is recommended to the farmers that higher yield of taro tubers can be obtained by planting the corn 30 days after planting taro plants in the density of 15,000 plant ha⁻¹.

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