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Article

The Growth of Tiwai (*Eleutherine Americana* L. Merr.) under Different Forest Tree Stands in Agroforestry System

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ABSTRACT

Agroforestry is a method and system of land management involving the simultaneous cultivation of farm crops and trees Land use under forest stands in the community has not been optimal. This research aims to study the growth, yield and qualitatively secondary metabolite content and find the best microclimate based on stand of different forest trees of Tiwai (*Eleutherine americana* L. Merr.). The research was carried out at research field of Agrotechnology Innovation Centre at Kalitirto, Berbah, Sleman, Yogyakarta and laboratory of agriculture production, Institute of Agriculture "INTAN" Yogyakarta. Treatments are combinations of forest tree stand i.e. gaharu, teak, mahogany, and control, and plant spacing factors i.e. 25 x 20 cm and 20 x 20 cm, and arranged in split block design with 3 replications. Plant height, leaf numbers, bulb weight and productivity were observed and analyzed statistically using analysis of variance approach. The treatment effects are studied by mean comparisons using Duncan Multiple Range Test with α = 5%. Qualitative data such as flavonoid content were descriptively analyzed. The result showed that there are statistically different growth and yield of Tiwai grown under forest tree stands. Tiwai which was grown under teak and gaharu with density 20 x 20 cm yielded similar productivity with control which is 271–331 g/m^2 and equal to 578–883 kg boulbs/ha. There is different brewed colors from dark red to deep purplish Red. Types of tiwai secondary metabolite were dependent upon tree stands. At control, and under mahogany and gaharu, more apigenin was observed, whereas kaempferol and lutenoid were found under teak and gaharu. The tiwai cultivation under tree stands probably provided benefit with the 1.5 B/C ratio in the agroforestry system.

Keywords: agroforestry; growth; secundary metabolite; tiwai.

INTRODUCTION

Agroforestry is a method and system of land management involving the simultaneous cultivation of farm crops and trees (Anggraini and Wibowo 2007). Forest areas that are very potential for crop cultivation are spread out under teak, sengon and fruit trees. Land use under forest stands in the community has not been optimally expolited. The use of open land or in the form of young production forests are still quite extensive, therefore there is the opportunity to be used with agricultural crops. Agricultural crops that are cultivated by farmers around the forest are usually selected accordingly, easy to cultivate, high economic value, easy maintenance, low capital and easy marketing. Medicinal plants are usually planted under forest trees in multiple cropping.

One crop characteristic that must be fitted to agroforestry is shading tolerance. There are different types of crop showed the ability to tolerate shading included food crop and some medicinal plants. One of medicinal plants that has been developed is Tiwai or dayak onion which is a family plant of Iridaceae, typically grown in Kalimantan although originating from tropical America. Ecologically, Tiwai can be found in mountainous areas at

an altitude of 600-2000 meters above sea level (Galingging, 2007). Tiwai plants in the form of seasonal bulbs can grow very strong, large clumps, and have a height of 20-50 cm, fibrous roots. The bulbs are underground oval or ovate form, red color and no smell. Bubls can be consumed 3-6 months after sowing. The growth of bulbs is closely related to the availability of phosphorus and potassium in the soil. The bulbs contain secondary metabolites such as alkaloids, glycosides, flavonoids, phenolics, quinones, steroids, tannin substances and essential oils that are useful for cancer drugs, but can also be used to overcome heart problems, increase endurance, anti-inflammatory, antitumor and can stop bleeding (Galingging, 2006; Puspadewi et al., 2013).

There are different tree plants cultivated commercially in industrial forest. In tropical region, teak, mahagoni, acasia and gaharu are normaly planted at smallholder forest. Such stands will be used to grow tiwai and the effect to growth, yield and secondary metabolite content will be observed.

MATERIALS AND METHODS

The research was carried out at research field of Agrotechnology Innovation Centre Universitas Gadjah Mada at Kalitirto, Berbah, Sleman, Yogyakarta and laboratory of agriculture production, Institute of Agriculture "INTAN" Yogyakarta. Treatments consist of combinations of forest tree stand as the main plot i.e. gaharu, teak, mahogany, and control, and plant spacing factors as sub plot i.e. 25 x20 cm and 20x20 cm, arranged in split block design with 3 replications. Observations were made on irradiation intensity, temperature and humidity, plant height, number of leaves, number of bulbs, bulb size, bulb weight and yield, brewed color, qualitative test of secondary metabolic flavonoids using thin layer chromatography (TLC).

Plant height, leaf numbers, bulb weight and yield were analyzed statistically using analysis of variance approach. The treatment effects are studied by mean comparisons using Duncan Multiple Range Test with α = 5% and 1%. Qualitative data such as flavonoid content were descriptively analyzed.

RESULT AND DISCUSSION

Micro environments under forest trees differ in temperature, humidity and irradiation intensity, pH ranges from 7-7.3. At planting locations with high irradiation intensity and low humidity, the height of tiwai or dayak onion plants is lower than those grown at low intensity, high humidity. In high light intensity, more than 50 percent of tiwai or dayak onion plants produce flowers. The lowest intensity was measured under mahagony compared to the others. It is between 2000-7510. Temperatures vary between 25-30 °C. Moisture during the study is between 35-70 percent. The acidity of the soil around normal tree stands ranges from 7 to 7.3.

The result showed that there are statistically different growth and yield and quality of Tiwai grown under forest tree stands (Table 2 and 3). Differences in planting distance affect number of bulbs and yield due to competition in obtaining nutrients, sunlight, water and air even photosynthesis. Although the number of bulbs is a lot due to tight spacing, but the highest weight of the tiwai bulbs harvested for 3 months after planting for planting without shade which is similar with planted under gaharu tightly. Results of the Kurniawati et al. (2005) on Pegagan (*Centella asiatica* L.(Urban)), shading effects decrease leaf area indeks, yield, and composition of triterpenoid content of Indian Pennywort. No shading treatment showed optimum growth and yield. The combination of 25% shading and small type of Indian Pennywort gave the highest triterpenoid content. Both types of Indian Pennywort showed best growth; the difference in length of petiole, number of leaf and shoots but the small one gave the best yield.

Tiwai which was grown under teak and gaharu with density 20x20 cm yielded similar productivity with control which is 271–331 g/m2 and equal to 578–883 kg bulbs/ha. Plant growth and development as well as the content of secondary metabolic compounds (flavonoids, alkaloids etc.) in tiwai bulbs are influenced by genetic and environmental factors.

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Table 1. Comparison of the color of brewed bulbs and metabolic compounds of flavonoids

Spacing	Control		Teak		Gaharu		Mahogany	
	Brewed color	Flavonoid compunds	Brewed color	Flavonoid compunds	Brewed color	Flavonoid compunds	Brewed color	Flavonoid compunds
25 x 20 cm	16 Dark red	Apigenin	256 Deep purplish Red	Kaemferol	16 Dark red	Kaemferol	16 Dark red	Apigenin
20 x 20 cm	256 Deep purplish Red	Apigenin	256 Deep purplish Red	Luteolin	16 Dark red	Apigenin	256 Deep purplish Red	Apigenin

Table 2. Growth and yield of Tiwai under three forest trees stand

Parameter	Control	Teak	Gaharu	Mahogany
Plant height (cm)	35.319 c	34.572 c	38.237 b	45.548 a
Number of leaves/plant	32.055 a	20.833 b	20.833 b	15.095 b
Number of bulbs/plant	3.500 a	2.389 b	3.267 a	2.000 b
Weight of bulbs (g)	13.071 a	10.345 a	9.827 a	5.408 b

Remarks: The mean in the row followed by the same letter is no highly significantly different on the Duncan Multiple Range Test with α 1%.

Table 3. Yield of Tiwai onion on different plant spacing under three forest trees stand

Spacing (cm x cm)	Control	Teak	Gaharu	Mahogany	Average
25 x20	257.933abc	183.200 cd	164.910bcd	144,520 de	225.325
20 x20	331.139 a	288.264 ab	271.611abc	75,014 e	277,995
Average	294.536	235.732	218,261	109,767	(+)

Remarks: The mean in the row or coloumn followed by the same letter is not significantly different in the Duncan Multiple Range Test with α 5%; (+) : interaction.

Genetic factors are related to planting material, while environmental factors that affect them are soil fertility, temperature, humidity and sunlight intensity.

There are different brewed colors from dark to deep purple red. Types of tiwai secondary metabolite (flavonoid) were dependent upon tree stands. Tiwai which planted under teak trees and gaharu plant spacing of 25 cm x 20 cm produces Kaemferol. Luteolin is found on Tiwai under teak grown more dense. Apigenin compounds were produced on open space and under Mahogany both a spacing of 25 x 20 cm and 20 x 20 cm and under the gaharu planted with a spacing of 20 x 20 cm. Although the results of brewed bulbs bring out almost the same color, here are differences in flavonoid compounds because of antosianidin. Tiwai under gaharu produces dark red color (16 Dark red) which consists of Kaemferol and Apigenin compounds. Likewise on open space, tiwai produces a dark purplish red steaming (256 Deep purple red).

CONCLUSIONS

The result showed that there are statistically different growth and yield of Tiwai grown under forest tree stands. Tiwai which was grown under teak and gaharu with density 20 x 20 cm yielded similar productivity with control which is 271 – 331 g/m2 and equal to 578 – 883 kg boulbs/ha. There is different brewed colors from dark red to deep purplish Red. Types of tiwai secondary metabolite were dependent upon tree stands. At open space, under mahogany and gaharu, more apigenin was observed, whereas kaempferol and lutenoid were found under teak and gaharu. The tiwai cultivation under tree stands probably provided benefit with the 1.5 B/C ratio in the agroforestry system.

Picture 1. Tiwai under teak (a), gaharu (b), mahogany (c) and control (d)

Picture 2. Laboratory test for Qualitative data metabolic compounds of flavonoids

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