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The effects of teak shades at different ages on early growth of 3 tuber species in Semin Village, Gunung Kidul

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Abstract. The government's efforts in maintaining the food security includes developing alternative food sources, developing local food crops and improving the use of dry land for food crops cultivation. Planting tubers are common in private forest lands, such as in Semin Village, where arrowroot (*Maranta arundinacea* L.) can live under teak (*Tectona grandis* L.) stands. Based on this, a trial was conducted on planting three species of tubers, namely arrowroot/garut, canna/ganyong (*Canna discolor* Lindl.), and yam/gembili (*Dioscorea esculenta* (Lour.) Burk.) under teak stands. In mixed cropping patterns, there are limitations in obtaining light and nutrient sources for the plants underneath. Therefore, this study aimed to determine the morphological adaptation of three species of tubers, especially under the shade of teak, at different ages. The research design was completely randomized (CRD), while data analysis used two-way Anova. The results showed that the difference in relative light intensity (RLI) at eight weeks after planting had a significant effect on the height, the number of shoots or stems, and the number of leaves of the tested tubers. The size of the plant and the diameter of the stem showed the highest average under the shade of seven years teak stand, the contrary, the highest number of shoots or stems found in the open areas.

1. Introduction

Food security poses a condition where food supply is sufficient for a country until at an individual level. It is reflected from the adequate food availability both in quality and quantity, fit to eat, diverse, nutritious, equal, and affordable, moreover does not contradict with religion, beliefs, and the culture of the community, to be able to live healthy, active and productive in a sustainable manner (1). One of the government efforts in food security development includes discovering alternative food source as rice substitution through local food-carbohydrate sources- plant species development, and dry land utilization (2).

In Gunung Kidul Regency, the uncultivated dry land has the potential to overcome food shortages. In 2016, there were seven villages which still included in the food insecurity, namely,



Banyusoco, Duwet, Grogol, Karangasem, Kenteng, Mertelu, and Wonosari (3). Until 2018, 3 villages remained to experience food insecurity, including Watugajah and Tegalrejo villages (Gedang Sari sub-district), Girikarto village (Panggang sub-district), and the alert status in Sumberejo village (Semin sub-district). Therefore, various programs were implemented, such as developing food barns using home gardens or establishing village nurseries that involved farmer groups or women farmer groups (4). The Women Farmer Group (KWT) Menur located in Wareng 4 Hamlet, Wareng Village, Wonosari District, in the last two years (2015-2016), was able to supply the needs of tubers seeds outside Gunungkidul, including Sleman, Bantul, and Kulonprogo. The species of tubers developed were gembolo, gembili, uwi, arrowroot, taro, suweg, canna, and kleci potatoes (5). These tubers include alternative tubers, the tuber species in which the plant production and the product utilization are not prioritized to be developed by the Government (6), but still, have benefits as food and have functional value as well as significant tubers such as cassava and sweet potato.

In Semin Village itself, many people have planted arrowroot (*Maranta arundinacea* L.) and canna (*Canna discolor* Lindl.) tubers under the stands in private forests. Private forests in Semin Village were dominated by teak stands (*Tectona grandis* L.f.) (7). However, there were also other stands such as mahogany (*Swietenia mahagoni* L.Jacq.) and sengon (*Paraserianthes falcataria* (L.) Nielsen). The community in Semin Village utilizes the canna plant by consuming the tubers, while the arrowroot is used by processing the tubers into chips or flour. Arrowroot flour is also used as stomach ache medicine or processed into pastries or cakes. The Manfaati Women Farmers Group (KWT) in Semin Village had succeeded in increasing the selling value of products from tubers. For example, the price of arrowroot tubers is 10,000 IDR/kg; processed arrowroot flour can reach 50,000 IDR / kg. When the arrowroot tubers are off-season, the price of arrowroot flour reach to 100,000 IDR/kg (5).

Therefore, it is important to optimize the utilization of the dry land area under the tree stands to achieve food security in Gunung Kidul Regency using tuber-based agroforestry patterns. This study was purposed to determine the morphological adaptation of 3 types of tubers planted under different ages of teak.

2. Methods

The planting was in December 2018, while the plant growth observations were carried out in February 2019. The location was in Semin Village, Semin District, Gunung Kidul Regency. The research design used a complete randomized design with data analysis using two-way ANOVA. The research treatment was a planting trial of 3 types of tuber plants, namely arrowroot/garut (*Maranta arundinacea* L.), canna/ganyong (*Canna discolor* Lindl.), and yam/gembili (*Dioscorea esculenta* L.) under different teak shade included five years teak, seven years teak and control (no shade area). The parameters observed were the height and diameter of the clump (for arrowroot and canna) or stem (for yam) and the number of leaves and shoots (arrowroot and canna) or branch (yam).

3. Results and discussion

This paper presents information on morphological adaptation on early growth of tuber plants, viz., eight weeks after planting (WAP), produced under the teak stand. The observation result is presented in Table 1 and Figure 1.

Table 1. Effects of treatment on tuber plant growth parameters.

No.	Parameter	Treatment		
		Shade level	Tubers species	Shade level * Tubers species
1	Height (cm)	*	*	*
2	Diameter (cm)	is	*	is

3	Number of shoot/stem (piece)	*	*	*
4	Number of leaves (sheet)	*	*	*

Notes: * significant difference on $\alpha < 0,05$; is= insignificant

The difference in shade level had a significant effect on the height, number of shoots, and number of leaves of tuber plants at the age of 8 WAP (Table 1). In contrast, the species of tuber had a significantly different effect on all parameters observed. The level of shade was measured using relative light intensity (RLI). The RLI of the research area under five years teak was 45.13%, while under seven years teak was 38.76% and 100% on open area (8). The difference in the morphological adaptation of the three types of tuber plants can be seen in Figures 1 and Figure 2.

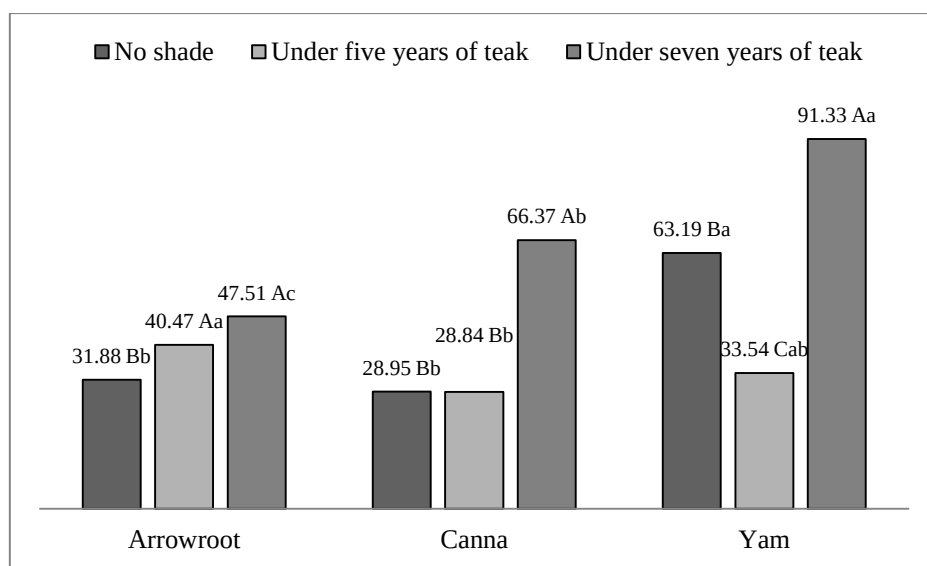


Figure 1. Height growth of the tubers species under different RLI at 8 WAP (cm).

The study conducted by (9) on white canna at 9 months of harvest showed that combination treatments of shade intensity and canna varian had a significant effect on canna plant height, whereas 50 % of shade intensity increased the height of the white canna to 194.33 cm compared to RLI 70% (148.33 cm) and 0% (123 cm). The height of three species of tuber plants under seven years teak was higher on average compared to other locations (Figure 1). The three species of tubers showed adaptation to dense shade by growing taller, presumably to get more sunlight. In no shade area, yam plants also showed good growth compared to other tuber species. The yam stem is a climber plant that grows vines, covering the nearest tree or the bamboo stakes (Figure 3).

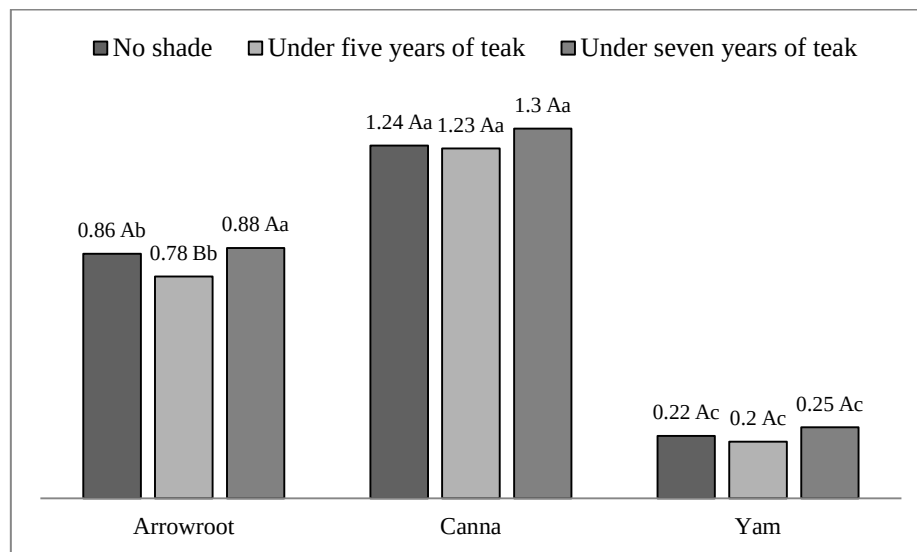


Figure 2. Stem diameter growth of the tubers species under different RLI at 8 WAP (cm).

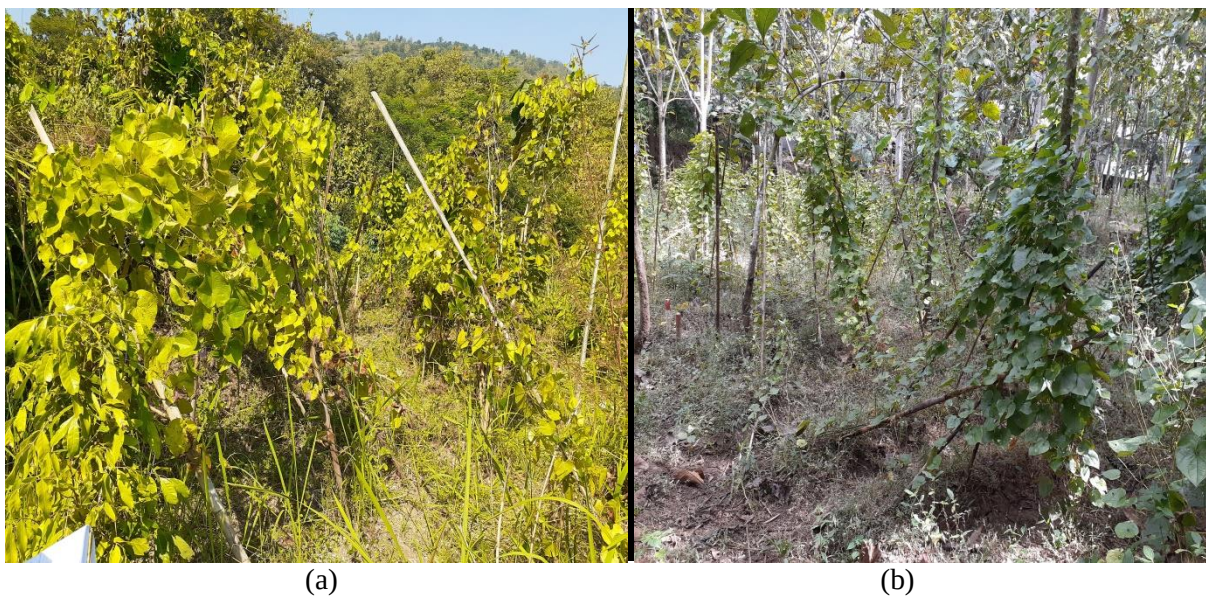


Figure 3. Yam plants in no shade area (a) and under five years teak (b).

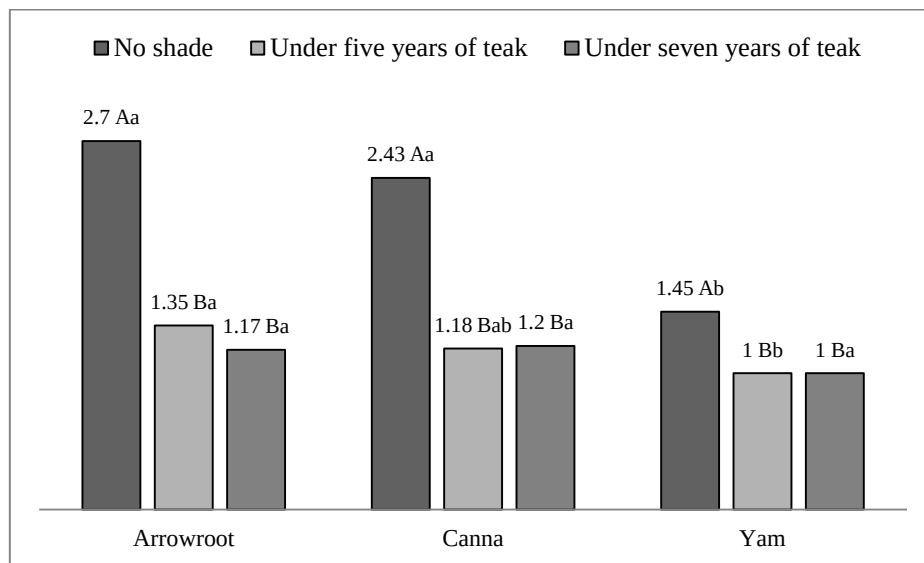


Figure 4. DMRT post hoc test result on the number of shoots (piece) at 8 WAP.

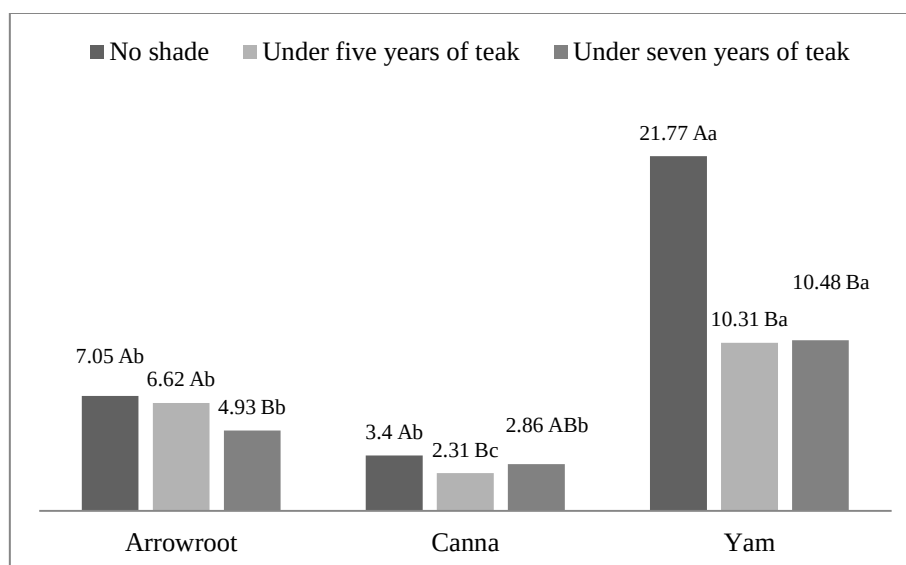


Figure 5. DMRT post hoc test result on the number of leaves (sheet) at 8 WAP.

Figures 4 and 5 explain that at the early stage, the number of shoots and leaves of tuber species in the no-shade area reached the highest number compared to the other 2 locations, in contrast to the height and diameter, they get the highest growth under the shade of 7 years teak. It is suspected that tuber plants in no shade location multiply the leaves number to absorb maximum light to maximize the photosynthesis and can be used to increase the number of shoots in arrowroot and canna plants or stems in the yam plants. Study on white canna (9) showed that 50% shading gave the highest number of leaves (101 sheets) at 9 months harvest compared to 0% (53.67 sheets) and 70% (45.33 sheets). This study (9) also showed that the highest number of leaves reached by canna plant on open area (RLI 0%) at 11 months of harvest (113.33 sheets). As for the tuber plants under seven years teak, the increase in height and stem diameter is thought to be an attempt by the plant to get more sunlight.

The elevation of the research area was 230-325 m.a.s.l. with temperature of 17.3-35.5°C (8), categorized as a lowland area. Concerning photosynthesis, the variation in elevation has a significant impact on physiological response and influences the tuber productivity, particularly in the arrowroot plant, in which the tuber in the lowland has a 30 % higher tuber growth rate and 43.07 % higher tuber yield compared to that in the highland (10).

The growth characteristics of the three tuber species at 8 WAP showed different responses that include morphological adaptation. It was influenced by the physiological response to the climatic conditions presented by the different RLI. This study reveals that the three species of tuber plants could grow well both in open areas with full sunlight and under shade (RLI 45.13% and 38.76 %). Different microclimatic conditions (RLI percentage) are potentially affect the photosynthate distribution between shoot and tuber, even though the location had the same elevation (10). Moreover, rainfall is the most essential factor that affecting the tuber species adaptation (11). Under the low RLI percentage, the plant grew more focused in height and diameter. While in the open areas, the development is more focused in shoots and leaves.

4. Conclusion

The different RLI percentages affected the morphological response and adaptation of the three tuber species. The cultivation of arrowroot, canna, and yam in an open areas and under the teak shade resulted in different responses of plant growth as the form of adaptation to RLI variation. Tuber plants' height and diameter growth were higher under the teak shade. The highest average diameter and height were reached by the tuber plants under seven-year-old teak stands. Meanwhile, an increase in the average number of shoots and leaves was achieved by tubers planted in the open areas. However, these three species of tubers can grow properly both in full sunlight conditions and under shade, up to RLI 38.76%. This result showed that in the early stage (8 WAP), arrowroot, canna, and yam plants could tolerate both full sunlight and dense shade. It is suggested that arrowroot, canna, and yam are suitable to grow in mixed cropping patterns where there are limitations in obtaining light and nutrient sources for the plants underneath.

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