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Transplantation of carica (*Vasconcellea pubescens*) at various altitudes of Mount Lawu, Central Java with treatment of shade and different types of fertilizers

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Abstract: *Permatasari A, Sugiyarto, Marsusi, Hailu WH. 2015. Transplantation of carica (*Vasconcellea pubescens*) at various altitudes of Mount Lawu, Central Java with treatment of shade and different types of fertilizers. Nusantara Bioscience 7: 6-14.* Ex-situ conservation efforts to increase crop production can be done by means of transplantation. The aim of this study was to assess the effect of altitude, shade, and type of fertilizer and their interactions to the performance of carica (*Vasconcellea pubescens*) vegetative plants transplanted to Mount Lawu, Central Java, Indonesia. The research was conducted in divided plot design at three altitudes (± 1400, 1600 and 1800 m asl.) with shade treatment as main plots and fertilizer (manure, Zwavelzuur ammonium/ZA fertilizer, combination of manure with Ammonium fertilizer, and control) as subplots. Parameters of vegetative variability were observed. The results of the performance of carica vegetative plant were analyzed using ANOVA followed by Duncan's test at 5% standard test. It was observed that an increase in altitude caused slower growth of carica vegetative parts, but better vegetative growth performance in the presence of shade. For the fertilizers, the best growth parameters were obtained in the treatment of manure with ZA fertilizer. Interaction between altitude, shade, and type of fertilizer significantly influenced the performance of carica vegetative parameters. The best growth parameters are at an altitude of 1400 m above sea level with shade treatment and manure combined with ZA fertilizer.

Keywords: Altitude, *Carica pubescens*, fertilizer, Mount Lawu, shade, transplantation.

INTRODUCTION

Ex-situ conservation can be done by transplanting certain plants to more suitable other areas. It helps to improve crop production and provide better ex-situ conservation, especially for endemic and high efficient plant species (Azkab 1999). Regions for transplantation purposes must have the agro-climatic suitability of environmental conditions required by plants as in their natural habitat. Some important aspects such as climatic conditions, edaphic, and biotic in the region need to be considered to support the success of transplantation. Mount Lawu in Central Java of Indonesia is appropriate transplantation site due to its relatively suitable agro-climatic conditions for highland crops (Laily et al. 2012; Samanhudi et al. 2011; Sugiyarto 2012).

One species of plant that needs to be transplanted is carica or mountain papaya (*Vasconcellea pubescens* A. DC., formerly *Carica pubescens* (A. DC.) Solms; Family Caricaceae), which is native to the Andean highlands, of northwestern South America from Colombia to Bolivia southward to central Chile, typically growing at altitudes of 1500-3000 m asl. (Sánchez 1994; Calabrese 1994; Moya-León et al. 2004). This plant is introduced to Dieng Plateau, Central Java in the colonial era and, now, become the only economical cultivation place of carica in Indonesia, thus this plant is mistakenly considered endemic to the Dieng Plateau. In this plateau, carica is only distributed at an altitude of 1400-2400 m asl. (Budiyanti et al. 2005; Laily et al. 2012; Sumaryono 2012; Fitriningrum 2013). Although carica fruit is popular both locally and abroad for variety of processed food products, production is still limited to be able to meet the needs of the market as compared to its big potential.

Shading, altitude difference and fertilizer type can cause significant effect on the growth performance of carica plant (Sirait et al. 2005). One common type of inorganic fertilizer used by farmers in dry land is Zwavelzuur ammonium fertilizer (ZA) (Prihatini 2012; Sajimin et al. 2013). The combination of organic and inorganic fertilizers can increase availability of N and constant release of nitrate during plant growth. Proper fertilizer combination increases biomass, chlorophyll content and leaf nitrogen content (Nyinareza and Snapp 2007; Suharja and Sutarno 2009; Marliah et al. 2013).

This research assessed the effect of altitude, shade, and type of fertilizer and their interaction to the performance of carica (*V. pubescens*) vegetative plants transplanted to Mount Lawu slopes.

METHODS AND MATERIALS

Study area

The research was conducted from December 2013 until March 2014. Cultivation of *V. pubescens* was done at slope of Mount Lawu, Central Java, Indonesia at altitudes of 1400, 1600 and 1800 m asl. Observations of plant vegetative part characteristics (plant height, total leaves, leaf thickness, and wet weight) were conducted at research sites, whereas analysis of dry weight, leaf width and leaf width index were done at the Central Biology Laboratory of Sebelas Maret University, Surakarta, Indonesia. Chemical analysis was performed at Chemistry and Soil Laboratories of Sebelas Maret University while analysis of chlorophyll content of leaves was conducted at Biochemistry and Agriculture Laboratory of Gadjah Mada University, Yogyakarta, Indonesia.

Plant materials

Carica seedlings (*V. pubescens*) is obtained from Dieng Plateau, i.e. Dieng Wetan Village, Kejajar Subdistrict, Wonosobo District, Central Java, Indonesia.

The research design

This study used a split-plot design. Each treatment is done with 5 replications. There are two main treatment categories: (i) Shade treatment: The main shade plots consists of two levels, namely: S1= no shade S2 = shade. Sub-plots are the type of fertilizer consisting of 4 levels, namely: F1 = control, F2 = manure, F3 = Fertilizer Ammonium sulphate (ZA), P4 = manure: ZA; (ii) The design is done in three altitudes, namely: A1 = ± 1400 m asl., A2 = ± 1600 m asl., A3 = ± 1800 m asl.

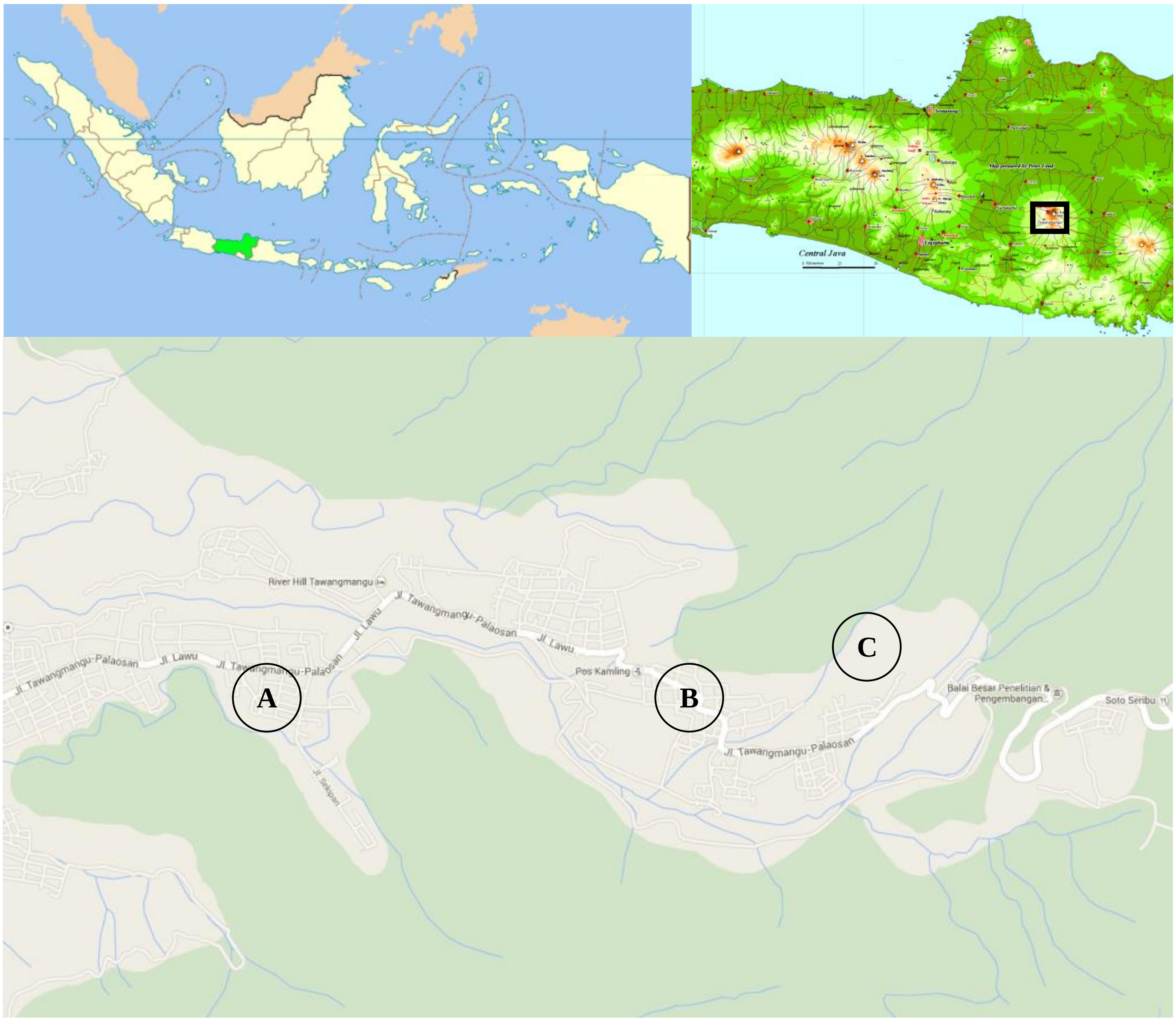

Figure 1. Research location of carica (*V. pubescens*) transplantation in Mount Lawu slope. A. Altitude ± 1400 m asl., located in the Village of Kalisoro, B. Altitude ± 1600 m asl. and C. Altitude ± 1800 m asl., located in the Village of Gondosuli, Central Java (Google Earth 2014).

Soil and rabbit manure preparation

The soil used in this study was taken from the Village of Kalisoro, Sub-district of Tawangmangu, Karanganyar, Central Java (± 1400 m asl). Soil samples were taken using mattock then filtered using a soil filter. Furthermore, the soil is put into a plastic bag. Rabbit dung was collected from a rabbit farm in the Village of Blumbang, sub-district of Tawangmangu, Karanganyar, Indonesia (± 1550 m asl.). The manure is first dried, smoothed using a mortar, and filtered using fertilizer filter, finally put into a plastic bag. Soil and manure which have been screened are taken as much as ± 20 g each for the initial characterization, i.e. the chemical content of the soil analysis before treatment. Initial characterization includes: pH, organic C content, BO, total N, available P_2O_5, exchanged K_2O, Ca, Mg and C/N ratio.

Preparation of planting room and shading

The layout of the experimented greenhouse is presented in Figure 2.

Preparation of growth media

In the treatment without fertilizer, one polybag filled volume of 750 cm^3 with 100% soil. For treatment with any of the fertilizers, soil and fertilizer are put into polybag using volume ratio of 500 cm^3: 250 cm^3 of soils to fertilizer.

Transplantation of *Carica papaya*, and observation

Two months old of 120 individual *V. pubescens* plants with 25± cm height and 5-10 number of leaf strands/plant were obtained from *V. pubescens* farmers in the village of Dieng Wetan, Sub-district of Kejajar, District of Wonosobo, Central Java at ± 2000 m asl.

In each 3 planting rooms, 40 carica plants were transplanted into polybags, 1 plant per polybag which has been previously filled with soil and manure. Distance between polybags is ± 20 cm, while the distance between the blocks is ± 40 cm. Cultivation was carried out for 12 weeks by watering (250 ml/polybag every 3 days), fertilizing manure and ZA (6.7 g/plant, given in stages, i.e. 2 g/ plant at 1st week, 2 g/ plant at 3rd week and 2.7 g/ plant at 5th week after transplanting) and weeding.

Measurement of environmental factors and observation of the performance of vegetative plant *V. pubescens* was done every 3 weeks for 4 times of observation. Measured environmental factors include altitude, light intensity, air temperature, humidity, wind speed, soil temperature, soil pH, and soil moisture. The performance parameters of *V. pubescens* vegetative parts observed include: Plant height measurements (at age of 3, 6, 9 and 12 weeks), number of leaves (3, 6, 9 and 12 weeks), thickness of leaves at the age of 12 weeks after transplanting, wet weight, dry weight and leaf area index.

Data analysis

Environmental climatic and edaphic measurement data on leaf color were analyzed descriptively. *V. pubescens* vegetative performance parameters (plant height, number of leaves, leaf thickness, leaf area, fresh weight, dry weight, leaf area index and chlorophyll content) were analyzed using Multivariate Analysis of Variance (MANAVA). Duncan's Multiple Range Test (DMRT) at 5% level test was done to check if there was a real difference.

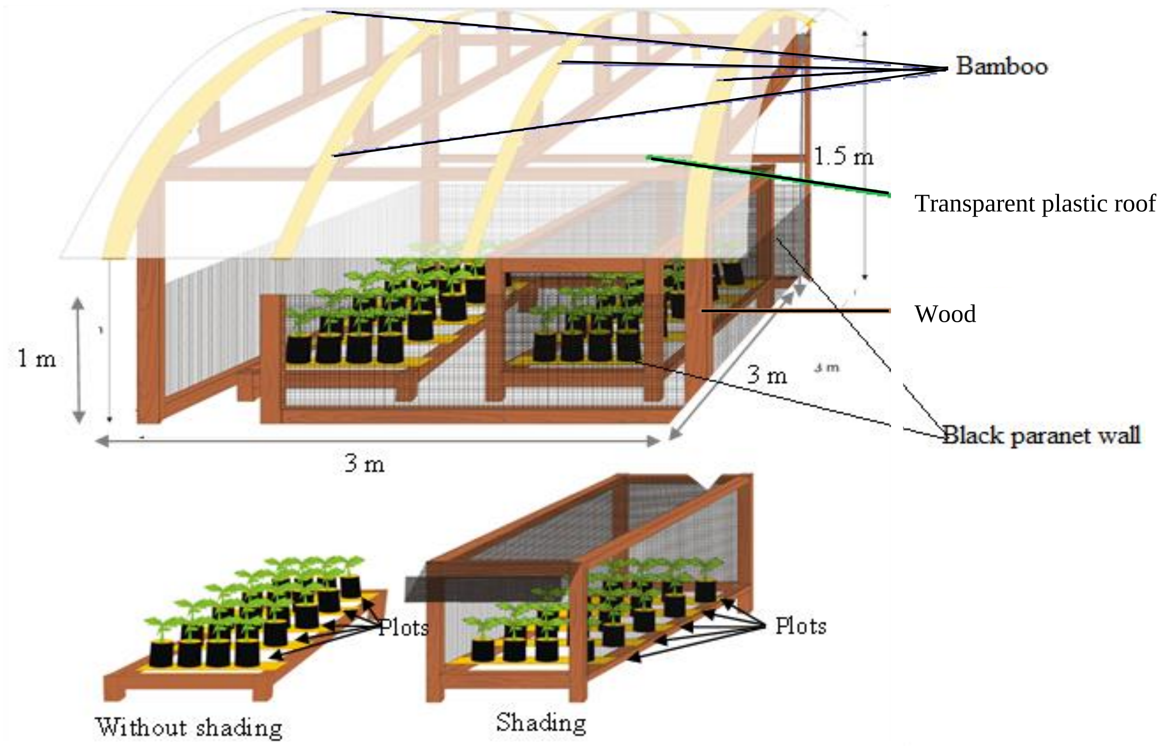

Figure 2. The layout of the experiment greenhouse

RESULT AND DISCUSSION

Geography and climate

Based on the results of measurements of climatic factors in the study site, the light intensity is highest at an altitude of ± 1400m above sea level treatment without shade having light intensity of 220.3 lux, while the lowest light intensity is at an altitude of ± 1800 m asl. with shade treatment measured light intensity of 87.58 lux (Table 1).

Edaphic

Results of soil chemical analysis showed that the chemical content of the soil on the slope of Mount Lawu is lower than the Dieng Plateau. The low chemical content of soil nutrients, especially nitrogen can cause chlorosis and inhibit plant growth. Nitrogen nutrients are needed by plants in relatively large amounts at each stage of growth, especially in the vegetative phase (Britto and Kronzucker 2005). Manure is a biological fertilizer that serves to improve the physical, chemical and biological properties of soil, so that the soil can provide both macro and micronutrients in comparable amounts, which plants need to grow and develop properly. The uses of appropriate combination of organic and inorganic fertilizers cause synchronization in improving plant growth. Inorganic fertilizers contain nutrients in a readily available form which can be absorbed and utilized by plants shortly after application. In addition, the presence of inorganic fertilizers can speed up the process of decomposition of nutrients contained in organic fertilizer. If the nutrients contained in the inorganic fertilizers have been exhausted, then the plants can absorb and utilize the nutrients contained in organic fertilizer. Thus, the nutrients that plants need are always available in sufficient quantities, which enable plants to grow and develop optimally (Suharja and Sutarno 2009; Oyo 2010, Larijani and Hoseini, 2012; Ngetich et al. 2012; Prihatini 2012; Marliah et al. 2013).

Vegetative performance of *V. pubescens*

Plant height

Plant height is a very sensitive parameter to climatic factors and nutrient availability in the soil. In shaded conditions, shade-loving plants exhibit better growth parameters because the intensity of light received in a limited number is optimally used by the plants to improve the capacity of photosynthesis. Organic material of photosynthesis product can be used to increase plant height (Marliah et al. 2013). In this research the higher the altitude, the shorter was the plant height (figure 3). However, shade treatment increased carica plant height. For the fertilizer treatment, the average increase in plant height was highest in the combination of manure with ZA fertilizer, while it was lowest for the control.

Total leaves

Leaf number is a major determinant of plant growth speed due to the reason that leaf is a vital organ in the process of photosynthesis. Too high light intensity affect the rate of translocation of photosynthetic products, causing a very rapid rate of CO_2 fixation and an increase in photo-respiration. Excessive increase in photorespiration leads to less than optimal growth, thus inhibiting the formation of leaf organs (Marjenah and Panduwinata 2008).

Table 1. Environmental conditions at the Mount Lawu slopes and Dieng Plateau.

Environmental Factors	Altitude (masl)							
	Sopes of Mount Lawu						The Dieng Plateau *	
	± 1400		± 1600		± 1800		± 1350-1650	± 1700-2000
	WoS	S	WoS	S	WoS	S		
Light intensity (lux)	220.3	110.4	195.1	97.58	175.3	87.58	-	-
Air temperature (°C)	26.42	24.92	23.92	22.42	21.17	19.67	22	20
Air humidity (%)	64.92	66.92	67.42	69.42	69.42	71.2	80	81
Wind speed (knot)	0.392	0.2	0.592	0.2	3.042	2.775	-	-
Soil moisture (%)	41.83	61.83	66.83	88.83	90.25	99.5	-	-
Soil temperature (°C)	26.83	24.83	24.08	21.75	20.17	18.08	-	-

Note: WoS = without shade, S = with shade, - = Not measured; * = from Marliah et al. (2013).

Tabel 2. The results of chemical analysis of the soil on the slopes of Lawu, Dieng Plateau and rabbit dung manure

Chemical composition	Soil at slopes of Mount Lawu site	Soil at Dieng Plateau site*	Rabbit dung manure
Organic C. (%)	0.92	4.68	17.12
BO (%)	1.59	8.06	29.51
N total (%)	0.16	0.28	1.44
available P_2O_5 (ppm)	9.41	15.94	5.51
K_2O exchanged (%)	0.21	0.29	1.32
Ca (%)	2.14	**	1.17
Mg (%)	0.62	**	1.85
pH	5.63	5.84	6.88
C/N ratio	9.94	16.71	11.89

Note: * Marliah et al. (2013) , **: not analyzed.

An increase in altitude caused fewer number of Carica leaves. Number of carica leaves was observed in shade treatment than in the treatment without shade. For treatment of fertilizer type, combination of manure with ZA fertilizer yields highest number of leaves, while the least number of leaves are found in the control. Results of analysis of variance (ANOVA) showed that at 12 weeks after transplantation, the interaction between altitude and type of fertilizer significantly (p-value = 0.044) affect the number of leaves. The interaction between the shade and the type of fertilizer also significantly (p-value = 0.022) affected leaf number. In the interaction between altitude and type of fertilizer, the highest number of leaves were found on an altitude of ± 1400 m asl. and manure with ZA fertilizer treatment as much as 115 leaf strands, while less number of leaves were found at an altitude of ± 1800 m asl. control treatment showed as much as 34 strands. On the interaction of shade and type of fertilizer, the highest number of leaves was found on treatment without shade and manure with ZA fertilizer which was 180 leaf strands, while as low as 50 leaf strands were obtained in the shade treatment without fertilizer.

Leaf thickness

In general, the dicotyledonous plants, leaves under shaded conditions are larger and thinner than the leaf at full light intensity. This is one of the mechanisms of adaptation of plants to acquire more solar radiation that can be passed down, so that the light distribution on the leaves moves evenly to the bottom (Musyarofah et al. 2007). Higher Altitude and fertilization treatment also led to differences in the leaves thickness of the Carica plant. The average leaf thickness is highest in the combination of manure with ZA fertilizer, and lowest for the control. Results of ANOVA showed that at the age of 12 weeks after transplantation interaction between altitude, shade and type of fertilizer significantly (p-value = 0.000) influenced leaf thickness. It is thickest at an altitude of 1400 ± m asl. without shade and combination treatment of manure: ZA fertilizer by 1.11 mm, while the lowest leaf thickness is at an altitude of ± 1800 m asl. with shade and without fertilizer treatment which was 0.013 mm.

The higher the altitude, the thinner the carica leaves. Altitude directly affects the environmental conditions where the plants grow (Malinikova et al. 2013). If light intensity is too low, metabolic processes such as photosynthesis and transpiration of plants are reduced. When photosynthesis is low, little photosynthetic products are formed, so that the growth of the plant including the leaves organ formation and leaf thickness are reduced (Musyarofah et al. 2007; Nurnasari and Djumali 2010).

However, too high temperature causes water shortage in organs of plants. If there is water shortage, leaves do Stomatal closure. As a result, photosynthesis is reduced while transpiration is high. The higher the altitude, the higher is the wind speed. Wind can directly affect soil temperature and moisture, supply CO_2 for photosynthesis of plants. However, too tight wind speed can cause high transpiration, resulting in slow plant growth including the formation of leaf organs and thin leaves (Setiawan 2009).

Leaf width

Leaf area became one of the main parameters for the efficiency of photosynthesis. Carica is shade loving plant which is seen by more optimal leaf area in shaded conditions. It aims to expand the area of the light-harvesting so as to obtain more solar radiation that can be used optimally in the process of photosynthesis (Pradnyawan et al. 2004). The presence of shade caused an increase in leaf area. In addition, fertilizer can also lead to differences in leaf area on the carica plant. An average leaf area was highest in the combination of manure: ZA fertilizer, but lowest for the control. Results of ANOVA showed that interaction between altitude and type of fertilizer, altitude, and shade, significantly influence leaf area with p-values 0.000 and 0.003, respectively. Leaf area was large at an altitude of ± 1400 m asl. with manure: ZA fertilizer treatment, while the lowest leaf area is at an altitude of ± 1800 m asl. with control treatment. Leaf area was large at an altitude of ± 1400 m asl. with shade treatment, while the lowest leaf area at an altitude of ± 1800 m asl. and treatment without a shade.

Environmental conditions such as light intensity, wind speed and CO_2 content in the air directly affect the height of the growing crop. Increasing light intensity is correlated with an increase in air temperature. Metabolic processes such as photosynthesis and respiration of plants are affected by air temperature (Setiawan 2009; Fanindi et al. 2011). As altitude increase, carica leaf width decrease. The higher the altitude, the lower will be the air temperature. This caused a decrease in photosynthetic rate, and metabolic disturbance, so that the growth of the plant including the leaves, organ formation and leaf area formed not optimal.

Table 3. Interaction between altitude factor and type of fertilizer as well as the interaction between the factors of shade and type of fertilizer to the number of *V. pubescens* leaves at the age of 12 weeks after transplanting.

Treatment				**Total leaves (shoots)**
Altitude (m asl.)	1400	Fertilizer	Control	53^{bc}
			M	86^{d}
			ZA	61^{c}
			M: ZA	115^{e}
	1600	Fertilizer	Control	46^{b}
			M	92^{d}
			ZA	57^{bc}
			M: ZA	97^{d}
	1800	Fertilizer	Control	34^{a}
			M	84^{d}
			ZA	53^{bc}
			M: ZA	88^{d}
Shade	Without shading	Fertilizer	Control	83^{c}
			M	157^{f}
			ZA	103^{d}
			M: ZA	180^{g}
	Shading	Fertilizer	Control	50^{a}
			M	105^{d}
			ZA	68^{b}
			M: ZA	120^{e}

Note: numbers followed by different letters indicate significant difference test results of Duncan test at 5% level.

Plants in shaded conditions generally have less number of leaves and larger leaf area than plants in conditions without shade (Haryanti 2010). The increase in leaf area is a mechanism of adaptation of plants to shade. Increased leaf area serves to enlarge the area for light capture. Adaptation of plants to stress shade can be done in two ways, by an increase in leaf photosynthetic area and reducing the amount of light transmitted and reflected (Sirait et al. 2005). The presence of shade increased leaf area of carica plant.

In addition to shade, leaf area is also affected by the presence of fertilizer treatment. In this study, treatment of manure with ZA fertilizer is the best combination to increase leaf area for carica plant. The increase in leaf area is a result of the activity of cell division and elongation, which in turn is influenced by the availability of nutrients. The results of this study are consistent with studies of Adam et al. (1989), Using nitrogen fertilizers on *Festuca arundinacea* plant showed an increase in the duration of the elongation of epidermal cells, mesophyll cell division and the ratio of mesophyll/epidermis, thus increasing leaf area.

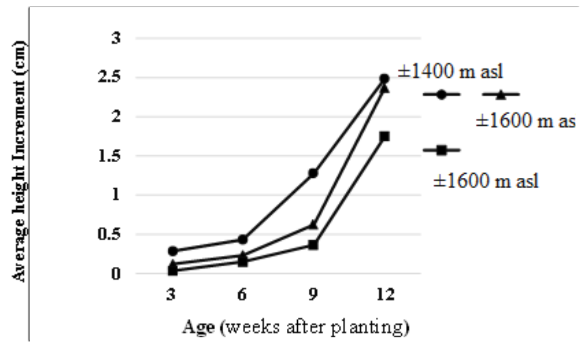

Figure 3. The influence of altitude on the average *V. pubescens* height increase.

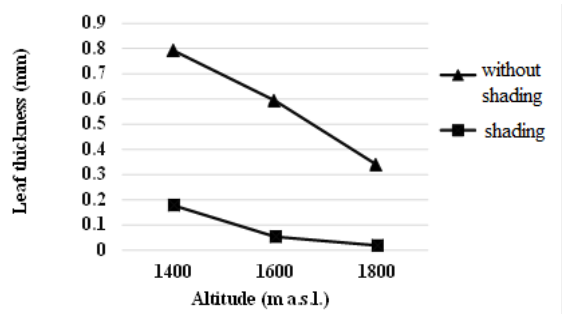

Figure 4. The influence of altitude and shade on the leaf thickness *V. pubescens* at 12 weeks after transplanting.

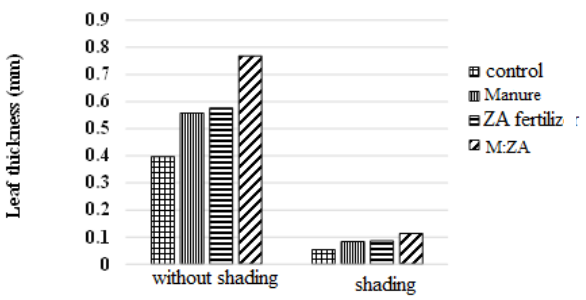

Figure 5. Effect of shade and type of fertilizer to leaf thickness of the plant *V. pubescens* at the age of 12 weeks.

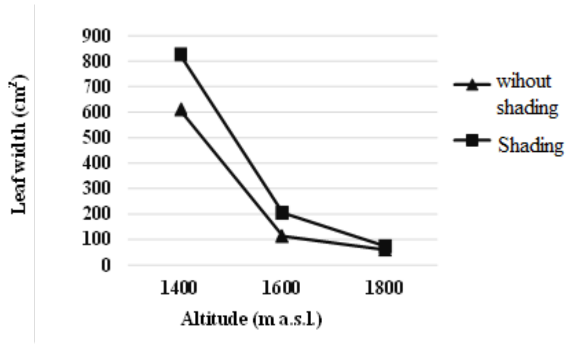

Figure 6. The influence of altitude and shade to leaf width of *V. pubescens* at 12 weeks.

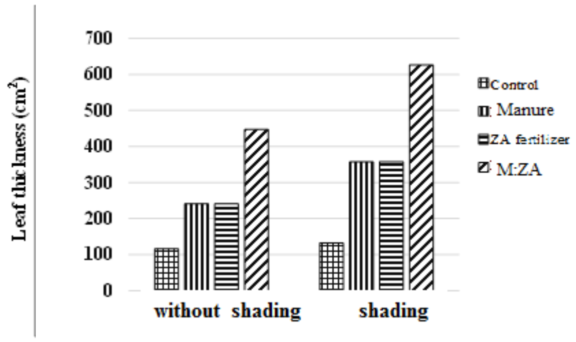

Figure 7. Effect of shade and type of fertilizer to the leaf width of *V. pubescens* at 12 weeks.

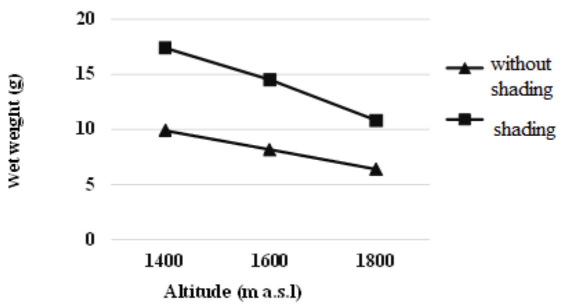

Figure 8. The influence of altitude and shade to *V. pubescens* wet weight at 12 weeks after transplanting.

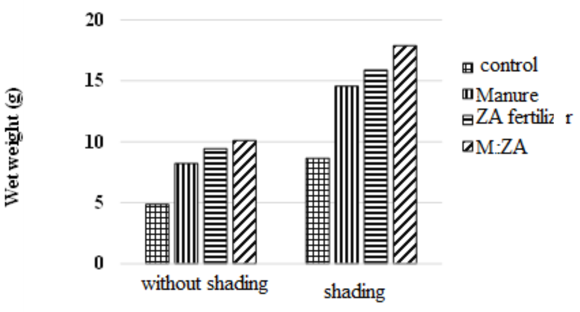

Figure 9. Effect of shade and type of fertilizer to *V. pubescens* wet weight at 12 weeks after transplanting

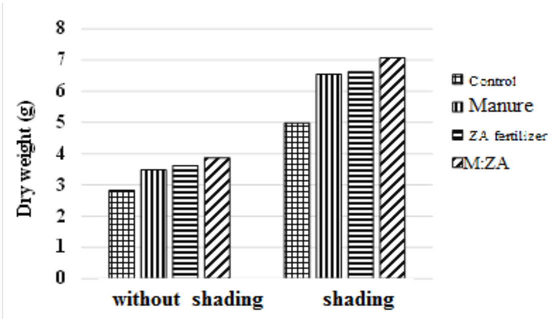

Figure 10. Effect of shade and fertilizer on the dry weight of the plant *V. pubescens* at 12 weeks after transplanting

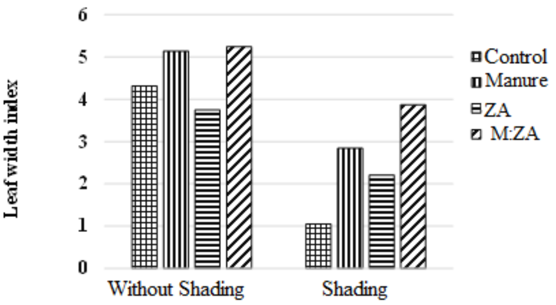

Figure 11. Effect of shade and type of fertilizer to the plant *V. pubescens* leaf area index at 12 weeks after transplanting.

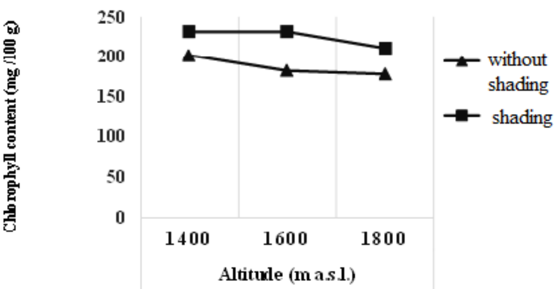

Figure 12. The influence of altitude and shade on leaf chlorophyll content *V. pubescens* at 12 weeks after transplanting.

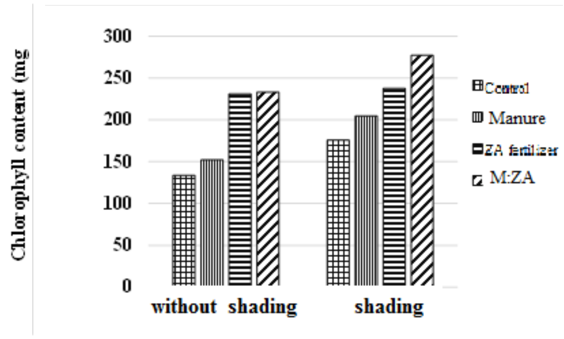

Figure 13. Effect of shade and type of fertilizer to *V. pubescens* leaf chlorophyll content at 12 weeks after transplanting.

Wet weight

Wet weight is a combination growth and development of plant tissue, such as plant height, leaf number and leaf area. It plays a role in determining the quality of a crop product. The higher the altitude, the lower is the wet weight of carica plant. This is because of the influence of environmental conditions where the plants grow such as air temperature, air humidity, and oxygen content in the air and soil conditions. At higher altitude, air temperature and CO_2 content get lower which can lead to decreased photosynthesis and disturbance in metabolism so that the plant will have low wet weight (Fanindi et al. 2011).

The shade and fertilizer increased wet weight of carica. Wet weight of the carica plant is higher in shaded conditions than plants without shade. According to Wasonowati (2009), this is due to the wet shaded plants contain more chlorophyll b per unit weight of leaf. Increasing the amount of leaf chlorophyll may increase the rate of photosynthesis, so the accumulation of plant photosynthetic products increases. Thus, the wet weight of the plants will also increase. In addition to shade, fertilizer treatment also increases the wet weight of the plant. The average wet weight was highest on a combination of manure with ZA fertilizer, and lowest in control. Fertilizers contain a variety of nutrients needed for plant growth and development. Nutrients, especially N play an important role in improving plant growth, increase protein synthesis, increase the formation of chlorophyll and root-shoot ratio. Therefore, balanced fertilizer can increase the rate of plant growth (Napitupulu and Winarto 2010; Milenkovic et al. 2012).

Results of ANOVA showed that at the age of 12 weeks after transplanting, interaction between altitude, shade and type of fertilizer significantly (p-value = 0.041) affect the wet weight of the carica plant. Wet weight was highest at an altitude of ± 1400 m asl. with shade treatment and combination of manure with ZA fertilizer, whereas the wet weight was lowest at an altitude of ± 1800 m asl. with no shade and no fertilizer treatments.

Dry weight

Biomass of plants can be used to describe and study the plant growth. This is because plant biomass is relatively easy to measure and is the most representative indicator of growth to get the overall appearance of the plant growth.

Plant biomass can be determined by measuring the dry weight of the plant. The higher the altitude, the lower was dry weight of the carica plant. The presence of shade and fertilizer increased carica plant dry weight. The average dry weight was highest in the combination of manure with ZA fertilizer, and lowest for the control.

Results of ANOVA showed that interaction between altitude, shade and type of fertilizer significantly (p-value = 0.013) affected the dry weight of the carica. Dry weight was highest at an altitude of ± 1400 m asl. with a shading treatment and combination of manure with ZA fertilizer treatment, and lowest at an altitude of ± 1800 m asl. for treatment without shade and without fertilizer. At higher altitude, low air temperature, light intensity, humidity, and CO_2 content lead to decreased photosynthetic and metabolic rate, which results in lower dry weight (Fanindi et al. 2011). Plants in shaded conditions have total leaf area larger than plants without shade. According to Sirait (2008), the increase in leaf area can optimize the total dry weight of a plant. If a plant has an optimal total leaf area, the rate of photosynthesis and photosynthetic product will increase. Thus the plant dry weight also increased. Application of fertilizer is also one of the factors that affect plant dry weight.

Leaf Area Index (LAI)

Leaf area index (LAI) values reflect the potential level of leaf surfaces enabled for the process of photosynthesis. Higher altitude and shade caused lower LAI of carica. Fertilizer treatment improved carica LAI. Highest LAI value was found in treatment without shade and manure with ZA fertilizer, while the lowest value is found in control treatment. Results of analysis of variance showed that at the age of 12 weeks after transplantation, interaction between altitude, shade and type of fertilizer significantly (p-value = 0.003) affected carica leaf area index.

Chlorophyll content of leaves

Chlorophyll content can be measured to determine the genotype of plant adaptability, which can be visualized from the color of leaves. Treatment of altitude, shade, and type of fertilizer affected plant physiology of carica. The higher the altitude, the less green were the carica leaves. The green color indicates an increase in leaf chlorophyll content of plants. The higher the altitude, the lower was the average leaf chlorophyll content, while the shade and fertilizer treatments increased average leaf chlorophyll content. In the treatment of fertilizer, the average leaf chlorophyll content was high in combination of manure with ZA fertilizer, while the lowest average leaf chlorophyll content was in control.

Results of analysis of variance showed that at the age of 12 weeks interactions between altitude, shade and type of fertilizer factors significantly (p-value = 0.000) affected carica leaf chlorophyll content. Leaf chlorophyll content was highest at an altitude of ± 1400m above sea level with shade and combination manure: ZA fertilizer treatment which was 308 mg/100 g, while the leaf chlorophyll content was lowest for the altitude of ± 1800 m above sea level for the treatment without shade and without fertilizer which was 112.56 mg/100 g.

Increasing the amount of chlorophyll per unit leaf area and the ratio of chlorophyll a/b is one way of avoidance to the shaded conditions. This mechanism helps to improve the efficiency of light capture per photosynthetic unit area (Musyarofah et al. 2007). Plants can tolerate the low light intensity with a lower rate of respiration by avoiding damage to the enzyme pigment. Nutrients contained in the fertilizer, such as N, Mg and Fe are major components in the formation of chlorophyll. N nutrient availability can affect the growth, production and quality of crops, especially in the vegetative phase such as the formation and growth of shoots, leaves, stems and roots. Moreover, in most plants, N is the nutrient that regulates the absorption and use of nutrients like P, K and other constituents (Chanseetis et al. 2012).

Without shading

Shading

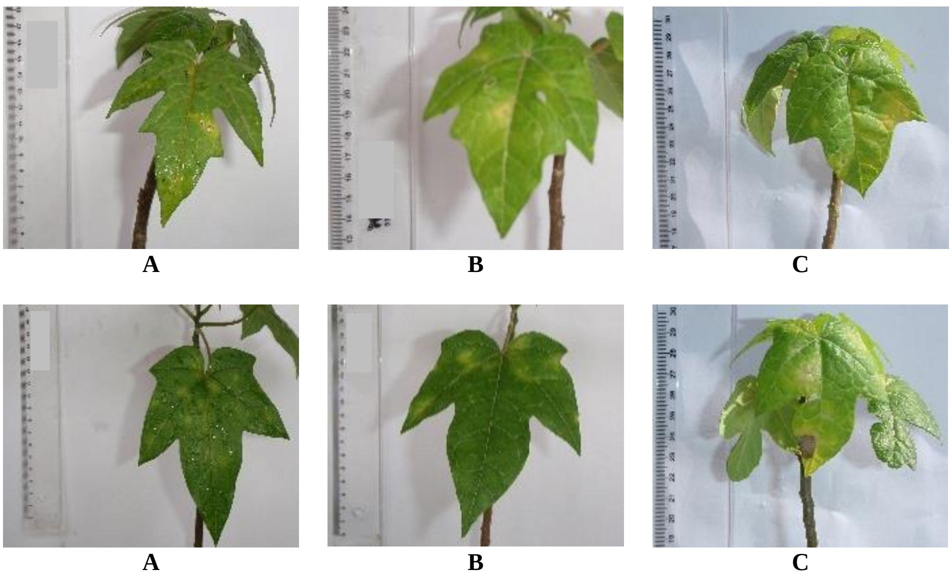

Figure 14. *Vasconcellea pubescens* leaf chlorosis symptoms in the control treatment, A. ± 1400 m asl, B. ± 1600 m asl, C. ± 1800 m asl.

In this study, chlorosis occurred with the control treatment at all altitudes for both the treatment with or without shade. This is because the nutrient content of the soil, especially N is low. The occurrence of chlorosis begins with the appearance of yellow spots, with irregular shape of the leaf blade and leaf color becoming yellowish green. These symptoms continue, thus showing when the leaves become more yellowish the entire surface of the yellow leaf, including the veins and leaves fall.

Effect of altitude on the performance of *V. pubescens* vegetative plant until the age of 12 weeks after transplanting showed slower growth parameters with increasing altitude. The best *V. pubescens* growth parameters are recorded at an altitude of 1400 m above sea level. Shade treatment affected the vegetative parameter performance of *V. pubescens* at the age of 12 weeks after transplanting. For most parameters, best growth performances were found in treatment with shade. Fertilizer type affected the performance of *V. pubescens* vegetative plant up to the age of 12 weeks after transplanting. The plants showed better growth performance parameters in the presence of fertilizers. The growth parameters were found in the order of: Manure with ZA fertilizer > manure > ZA > control. Interaction between altitude, shade, and type of fertilizer significantly affected the performance of *V. pubescens* vegetative parameters. The best growth parameters are at an altitude of 1400 m above sea level with shade treatment and combination of manure with ammonium sulfate (ZA) fertilizer.

To evaluate the total success of the *V. pubescens* transplantation at different altitudes on the Mount Lawu, it is necessary to conduct further research that examines the development, quality and quantity of production, i.e., generative phase of the plant.

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