Faculty of Resource Science and Technology

ECOPHYSIOLOGY OF *Amorphophallus brachyphyllus* (Hett.)

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ABSTRACT

The study on growth pattern and biomass allocation of *A. brachyphyllus* (Hett.) was conducted at limestone forest area of Mount Kasat, Sarikin, Bau, Sarawak. Twenty samples ranged between 11.31 - 34.64 mm above ground surface stem diameter with their height recorded within the ranged of 26 - 65 cm. The dry weights mean for twenty plant samples was 34.31 g. Among the plant vegetative parts, the petiole diameter and leaf area (R^2=0.8524, which y = 416.14x - 4700.9) indicated a significant relationship with the strongest interaction occurrence. Biomass allocation analysis consist the (LWR), (SWR), (UWR), (RWR), (SLA) and (LAR) were significant ($p \leq 0.05$) between the twenty plant samples. The forest structure and biomass estimation assessments recorded the total of 220 individual trees (75 species). *Mallotus korthalsii* contributed the highest leaf area index (LAI = 1243.05 m^2), basal area (7364.09 cm^2), highest density (27 individual trees) and important value (IV = 18.36). Besides, the highest biomass was presented by *Artocarpus sericicarpus*, which was 9755.95 kg/ha from the total biomass of 105248.29 kg/ha and leaf area index (LAI) was 13663.21 m^2. The study on the effect of light intensity on the vegetative growth and biomass partitioning of *A brachyphyllus* was carried at Faculty of Resource and Science Technology greenhouse, Universiti Malaysia Sarawak (UNIMAS). The growth of *A. brachyphyllus* was better under the 75% and 50% shading, in which the 75% shade level showed the highest values in petiole length, tuber diameter, leaf weight ratio (LWR), petiole weight ration (SWR) and leaf area ratio (LAR). The 50% shade level also showed the highest values in number of leaflets, plant dry weight (W), leaf area (A), root weight ratio (RWR), specific leaf area (SLA) and dry matter production (DMP). The 0% shading showed the highest values for tuber weight ration (UWR), net assimilation rate (NAR) and leaf area duration (LAD).

Key words: *Amorphophallus brachyphyllus*, shading, biomass allocation

ABSTRAK

Kajian corak pertumbuhan dan allokasi biojisim *Amorphophallus brachyphyllus* (Hett.) *telah dijalankan di kawasan hutan batu kapur Gunung Kasat, Sarikin, Bau, Sarawak. Dua puluh sampel pokok dengan diameter petiol di permukaan tanah berjulat antara 11.31 - 34.64 mm dengan ketinggian dalam lingkungan 26 - 65 cm. Purata berat kering bagi dua puluh sampel pokok ialah 34.31 g. Di antara bahagian vegetatif pokok, diameter petiol dan luas daun (*R^2*=0.8524 di mana y = 416.14x - 4700.9) menunjukkan perhubungan yang signifikan dengan interaksi yang terkuat. Perbandingan allokasi biojisim analisis pertumbuhan bagi dua puluh sampel pokok meliputi (LWR), (SWR), (UWR), (RWR), (SLA) dan (LAR) adalah signifikan (*$p \leq 0.05$*). Dalam kajian struktur hutan dan anggaran biojisim sebanyak 220 pokok individu (75 spesis) telah direkodkan.* *Mallotus korthalsii* *mencatatkan nilai tertinggi dari segi nilai indeks keluasan daun (LAI = 1243.05* m^2*), luas pangkal (7364.09* cm^2*), kedominan (27 pokok individu) dan mempunyai nilai kepentingan yang tertinggi (IV = 18.36). Manakala,* *Artocarpus sericicarpus* *mempunyai nilai biojisim yang tertinggi iaitu 9755.95 kg/ha dari nilai keseluruhan biojisim iaitu 105248.29 kg/ha dan luas indeks daun (LAI) adalah 13663.21* m^2*. Kajian pengaruh kesan intensiti cahaya ke atas tumbesaran vegetatif dan taburan biojisim anak pokok* *A. brachyphyllus* *telah dijalankan di Rumah Tumbuhan Fakulti Sains dan Teknologi Sumber, Universiti Malaysia Sarawak (UNIMAS). Pertumbuhan* *A. brachyphyllus* *adalah baik pada lindungan 75% dan 50% di mana lindungan 75% mencatatkan nilai yang tertinggi untuk tinggi petiol, diameter umbisi, nisbah berat daun (LWR), nisbah berat petiol (SWR) dan nisbah luas daun (LAR). Lindungan 50% pula mencatatkan nilai yang tertinggi untuk bilangan daun, berat kering (W), luas daun (A), nisbah berat akar (RWR), luas daun spesifik (SLA) dan pengeluaran berat kering (DMP). Lindungan 0% memberi bacaan yang tertinggi untuk nisbah berat umbisi (UWR), kadar asimilasi bersih (NAR) dan jangka luas daun (LAD).*

Kata kunci: *Amorphophallus brachyphyllus*, *lindungan, allokasi biojisim*

CHAPTER ONE

INTRODUCTION

Amorphophallus species from the family of **Araceae** or aroid family (Hetterscheid and Ittenbach, 1996) is commonly known as the devil's tongue, voodoo lily, or corpse flower (Talt, 2002). It refers to the horrendous odor of decaying flesh, similar to 'bunga bankai' by the Indonesian community, which means corpse flower (Richerson, 1999).

It is perennial and herbaceous foliage with an underground storage organ, which is usually a tuber of various size and shape that need to be sufficiently anchored to support the tall petiole or inflorescence (Talt, 2002). Besides, the plant species is considered to be the largest unbranched inflorescence in the world as its ability to attain 6.5 to 10.75 foot height (Richerson, 1999). For example, *A. titanum* or giant titan arum is the largest of all *Amorphophallus* species. The health of these plants is measured by the seasonal increased in tuber size especially for young plants.

It is estimated to encompass some 170 species of *Amorphophallus* that mainly covers the vast of distribution in the tropical of the old world - ranging from West Africa eastward into Polynesia (Hetterscheid and Ittenbach, 1996; Talt, 2002). Some could be found throughout the subtropical zones. Thus, within this generic distribution of

Amorphophallus species show a very high degree of endemism. For example, *A. brachyphyllus* is endemically found in Sarawak.

Most of the species appear to be pioneers in areas of disturbed vegetation. Generally, they are found at forest margins, in open forest, on (steep) slopes, in disturbed parts of primary forest, secondary forest and sometimes in very exposed situations such as in limestone karst area. Relatively, few species come from dense forest (Hetterscheid and Ittenbach, 1996; Talt, 2002). More often, the pioneer species of *A. brachyphyllus* assorted well in limestone area.

The species is commonly grown either by sexual or vegetative propagation. Propagating *Amorphophallus* by sexual method consist of pollination process and seedlings that usually germinates rapidly between 1 to 3 weeks, while vegetative growth produce offsets and the development of leaf from the tuber (Hetterscheid and Ittenbach, 1996).

Among the unique characteristic of the plant is the growth development as the plant species that emerged from the storage organ, form erectly stem with fraction of leafage that grow horizontally from the middle of the stem and allotted into few leaflets. After the maturity of the plant species, either the inflorescence development will substituted the mature *Amorphophallus* or grow closely to it (Hetterscheid and Ittenbach, 1996). As for the flowers that are minute and borne at the base of the spadix within an encircling bract or spathe (Hetterscheid, 1994). The flowers indicate an important role in attracting insects and birds, in which act as pollinators.

Typically, like the other species of *Amorphophallus*, *A. brachyphyllus* requires soil that rich in organic matter and trace element beside well drained for the well-growth development, under the ambient temperature (Hetterscheid and Ittenbach, 1996). Beside soil requirements, the species grow well under humid condition and indirect sun exposure as it might confront with growth disturbance. Thus, the species requires appropriate shading level and water supplement for growth development.

This herbaceous plant is highly potential of its extinction, as the plant is easily exposed to human activities disturbance such as deforestation and developments. Exploitation of this plant adversely effects its population. As the rate of the plant habitat destruction is increasing, the present study is conducted to determine and understand the ecology and its response to environmental factors such as light, besides possible cultivation of these plant species. The results obtained will be essential for detail scientific documentation and conservation of *Amorphophallus* species.

CHAPTER TWO

LITERATURE REVIEW

The plant genus *Amorphophallus* was well known recently since the edition of the largest species; *A. titanum* by an Italian Botanist, Odoardo Beccari, a century ago. It was considered to be new in the field and the background information on the plant species were less to be known. Thus, the plant benefits and functional were vague as seldom research or study was conducted as the additional to the understanding of the plant species.

Commonly, the previous researches were conducted in the purpose of studying the plant characteristics and growth requirements. For example, determining the appropriate level of shading for growth development and population pattern.

As *Amorphophallus* species required lower in light intensity, it was referred to low level of shading requirement. In determining the appropriate shade level required by the plant species was based on the change occurrences such as number of leaflets, plant height and tuber diameter.

According to the recent research conducted by Ronald Charles Singka (2004), the 75% level of shading using different *Amorphophallus* species; *A. borneensis* resulted positively in the plant growth development as the study showed consistent increased in number of leaflets and plant height. But, other lower shade level such as 50% shading also resulted in the increased of plant diameter. Thus, this showed that *Amorphophallus* species required lower in light intensity or higher percentage of shade levels. This fact was proven through the comparison of 0% shade level, in which most of the experimentalized species faced the death point or result negatively in the growth development.

According to Mohd Imransyah (2003) who conducted the similar assessment using different plant species; *R. exaltata*, a type of weed species showed that plant at 0% shade level were initially higher than those from 50% and 75% shade level. Shortest plant heights were recorded at 75% shading. Ishimine et. al (1985) noted that the light reduction at certain degree would reduce plant tallness. Thus, other plant species showed opposite requirement in light intensity compared to *Amorphophallus* species that indicated an increased in plant height, under lower light exposure or higher in level of shadings. This showed that different plant species obliged different requirement in sun exposure as it depending on the plant characteristics and physiology.

Research using other plant species with different requirements as comparison, such as *P. asiatica* that was studied by Kobayashi et. al (2001) reported that the reproductive plant parts were reduced compared to the population plants in exposed site. Oppositely, *Amorphophallus* species showed a great increased in reproductive parts. According to Petterson (1982), shading would delay the reproductive development of plant but this fact was not acceptable for *Amorphophallus* species.

Plant grew under 0% shade level produced the highest total of dry weight, followed by the higher shade levels, in which reported by Ipor and Price (1993) on their study of *P. conjugatum*, a type of weed species. Another C4 weed species was also reported in the reduction of biomass production when shaded (Burton et. al, 1959 & 1988; Chen et. al, 1969: Santos et. al 1997) compared to the result reported by Ronald Charles Singka (2004) that showed the increasing of biomass production under lower percentage of sun exposure for *A. borneensis*.

The plant leaf weight ration was relatively with the plant leaf area. As the result on plant leaf area shown by Ronald Charles Singka (2004) for *A. borneensis* was increased correspondingly with the level of shading, compared to the result reported by Mohd Imransyah (2003) using *R. exaltata*, in which showed the reduction of total leaf area at 75% of shade level. The result obtained was reasonable because of the reduction that occurred in total leaf number at the shade level, as assumed by Ipor and Price (1993) in their study of *P. conjugatum*. Similar results were reported for stem and root weight ration (SWR and RWR), in which conducted by Roland Charles Singka (2004) compared to the research reported by Mohd Imransyah (2003) that resulted adversely.

In other study, Ronald Charles Singka (2004) reported that the increased in shade level percentage would result significant increased in the photosynthesis rate, as the photosynthesis rate at 75% could explain the highest rate in total dry weight (W). Thus, the net assimilation rate (NAR) for 0% shade level showed the highest value compared to

50% and 75% of shade level, while the 75% shading resulted in highest value of leaf area duration (LAD).

In studying the growth population pattern of *Amorphophallus* species, consisted the distribution and vegetative growth relationships in the random established plots. The differences of the plant distribution was related with the seeds distribution as assumed by the recent study conducted by Rofidza Sendi (2004) for *A. hewitti* and *A. brachyphyllus* at Mount Aup, Sarikin, Bau. It was reported that birds were the main seed dispersal, in which gradually ascendant the plant population. According to Ridley (1930) and Murray (1986), the light and colorful berries of the plant species were the main attraction of the dispersal agent such as insects and birds. Besides, Hetterscheid and Ittenbach (1996) also reported that *A. titanum* was dispersal by Buccerotidae while *A. gigas* by 'Bulbuls'.

According to Rofidza Sendi (2004), *A. hewittii* was reported to be more actively dispersal compared to *A. brachyphyllus* as the plant species grew individually in a wider range of an area. It was also reported that *A. brachyphyllus* was less easy to adapt when compared to other *Amorphophallus* species. This explained the values recorded for the plant height and diameter of *A. brachyphyllus* that grew in a cluster or in group was measured smaller in size compared to *A. hewittii*, as the result of competition that occurred between the same plant species for space, light and nutrient. Thus, this contributed to the higher value of root and weight ratio of the plant species. Besides, the seeds of the *A. hewitti* showed significant differences in numbers, length and width compared to *A. brachtphyllus* (Rofidza Sendi, 2004).

Asmawatti Zaini (2004) also conducted the similar assessments in her study on the ecology of *A. borneensis* at Mount Gayu, Padawan. The results of the study showed that the plant species was considered to be lower in density as the total of plants discovered in the established random plots was less in numbers. Through the observation in the study area showed that most of the plant species grew individually, similar to the growth pattern of *A. hewitti*. Asmawatti Zaini (2004) also reported that the growth pattern of the plant species was varied between plants and different plots, as the plant growth developments were better in moderate shading.

The study on the relationships among the plant vegetative parts conducted by Asmawatti Zaini (2004) for *A. borneensis* was significant between the plant height and ground surface stem diameter with more than 80% of interaction occurred compared to other vegetative parts. The similar assessment conducted by Rofidza Sendi (2004) for young plants of *A. hewitti* showed no significant relationship as less than 50% of the interaction occurred between the plant vegetative parts. Meanwhile, mature plants showed a strong interaction between the plant height and diameter, and total plant wet weight with more than 90% of the plant growth was significantly related with each other.

As for the growth pattern and biomass allocation for *A. hewitti*, Rofidza Sendi (2004) reported that the growth analysis were significantly different for young and mature plants, except for root weight ratio (RWR) of the mature plants.

The study on soil characteristic and chemical analysis were also conducted by Asmawatti Zaini (2004), in the purpose of determining the type of soil required by the plant species for growth developments and survival. According to Asmawatti Zaini, *A. borneensis* grew well in acidic soil with the elements contained in the soil were highly consisted of Nitrogen (N), Carbon (C) and other minor elements such as Calcium (Ca), Magnesium (Mg), Kalium (K) and Natrium (Na). Besides, the percentage of clay, silt and sand were also discovered in the soil composite of the study area. Thus, this approved that the plant species grew well in well-drained soil, which could give well aeration for its root survival. Hetterscheid and Ittenbach (1996) also stated that *Amorphophallus* species required soil that were rich in organic matter and trace element beside well drained for the well-growth development.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The survey and seed collection of *Amorphophallus brachyphyllus* were conducted at the area of Mount Kasat, Sarikin, Bau while the effect of light to the plant species vegetative growth developments was conducted at FRST greenhouse, UNIMAS.

3.2 Seedling Germination and Transplanting

The selected seeds of the plant species were germinated in a seedbed sized 1.1 to 1.2 m (3.5 to 4 feet) wide with the propagation media of pure sand, under the greenhouse conditions (Hartmann, Kester, Davies and Geneve, 2002).

Two weeks after germination, the seedlings were transplanted in (10 x 12) cm^2 polybegs with propagation media ratio of 3:1:1 (soil: sand: organic matter). After two weeks, the young seedlings were then transplanted under three different shade levels that was the 0% shade (open shade or direct sun exposure), 50% shade and 75% shade. The 50% and 75% shade regimes were obtained by using different intensity of lathe netting sized (2 x 2x 2) m^3. The light intensity of the shading regimes were checked using the Skye Light Meter (Skye Instrument Limited, UK). Each shade was planted with 10 selected seeds of *A. brachyphyllus* and watering was carried out twice per day; every morning and evening depending on the weather condition.

Five seedlings were selected randomly and labeled for the vegetative growth measurements such as the petiole length, number of leaflets and tuber diameter. The plant tuber diameter was measured with Mitutoyo Digimatic Caliper. The vegetative measurements were commenced on the first day of seedlings transplanted in different shading conditions and followed by every two weeks.

In another assessment, five seedlings from each shading were selected randomly and harvested after 60 days of transplanting to determine the biomass allocation. The leaflets, petiole, roots and tubers of the plant species were separated for the fresh weight determination. While the leaflet width surface was measured by using the Area Measurement System (leaf area method), the tuber diameter was measured using the Mitutoyo Digimatic Caliper. The separated vegetative parts were oven dried at 60°C for 72 hours to determine the dry weight of each part. Similar harvest and assessment will be carried out after 30 days of first harvest.

The growth analysis and biomass allocation pattern of the seedlings was assessed, using the method described by Petterson (1982). Abbreviations and formulas for the calculations were summarized as below:

Mathematical Growth Analysis Formulas

Calculation requiring data from single harvest:

Given that W, L, R, S and A = total plant dry weight, leaflets, roots, petiole and leaf area, then

Leaf weight ratio	(LWR)	= L/W, g/g
Petiole weight ratio	(SWR)	= S/W, g/g
Root weight ratio	(RWR)	= R/W, g/g
Specific leaf area	(SLA)	= A/L, dm^2/g
Leaf area ratio	(LAR)	= A/W, dm^2/g

Calculation requiring data from two harvests over a time interval, ΔT:

Given that ΔT: length of harvest interval (days) W_1 and W_2 = total plant dry weight (g) at the beginning and end of the interval, then:

Dry matter production (DMP) = $\Delta W = W_2 - W_1$, g

$\Delta A = A_2 - A_1$, dm_2

Net assimilation rate (NAR) or rate of dry matter production per unit leaf area = $(W_2/ A_2 - W_1/ A_1) \times (\alpha / (\alpha - 1) / \Delta T$, where $\alpha = (\ln W_2 - \ln W_1) / (\ln A_2 - \ln A_1)$, g dm^{-2}, day^{-1}.

Leaf area duration (LAD) or total amount of leaf area present during harvest interval = $\Delta A / (\ln A_2 - \ln A_1) \times \Delta T$, dm^2 days.

3.3 Growth Pattern and Allocation Biomass of *Amorphophallus brachyphyllus* at Mount Kasat, Sarikin, Bau

At least 20 samples of *A. brachyphyllus* were selected randomly within the study area, in the purposed of determining the growth pattern and biomass allocation of the plant species. The parameter for vegetative growths that were recorded included the plant petiole length and diameter, number of leaflets, leaf area, tuber diameter and the plant fresh weight. The leaflet area was measured using the leaf area method (Area Measurement System). Subsequently, all the separated vegetative parts were oven dried at 60°C for a week (7 days) to determine their total dry weight. As for the biomass allocation, the Mathematical Growth Analysis formula as summarized previously was used for the calculation, that requiring from the single harvest assessed pattern.

3.4 Floristic Composition and Total above Ground Biomass Estimation of Mount Kasat Forest

Ten plots sized (20x20) m^2 each was made randomly in the study area. Within the established plot areas, all the stands with diameter breast height (DBH) $\geq$ 5.0 cm were identified and measured for the plant petiole length and diameter, for the purposed of studying and determining the relationships among the plant vegetative parts and the environment of the study area.

The dormant plant species was determined using the method described by Brower *et. al.* (1990) were as summarized below:

Relative frequency	(Rf)	= 100/Tf x f
Relative density	(Rd)	= 100/Td x d
Butt area	(BA)	$= 3.14 \times (DBH/2)^2$
Relative dormancy	(RD)	= BA/TBA
Important value	(IV)	= Rf + Rd + RD

Whereby, the DBH = Diameter Breast Height, TBA = Total Butt Area, Tf = Total of Frequency, Td = Total of Dormancy, d = Dormancy and f = Frequency.

The estimation for the total above ground biomass of woody plants was calculated by the following allometric formula (Yamakura *et. al.*, 1986; Mustafa, 1997). The formulas were as followed:

W_S (weight stem)	$= 2.0903 \times 10^{-2} (D^2H)^{0.9813}$
W_B (weight branch)	$= 0.1192\ W_S^{1.059}$
W_L (weight leaf)	$= 9.146 \times 10^{-2}\ W_{TC}^{0.7266}$
Biomass estimation	$= W_S + W_B + W_L$
Leaf rate index, μ	$= 11.67\ W_L^{0.9412}$

Whereby, W = weight, S = stem, B = branch, L = leaf, D = diameter, H = height and TC $= W_S + W_B$.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Light Effect on Plant Vegetative Growth

Plants at 50% shading were initially higher compared to those plants placed under 0% and 75% of shade level after the first 8 weeks (56 days) of transplanting. But the following 4 weeks, in which after 12 weeks (84 days) of transplanting resulted an insufficient increased in rate of petiole length for plants at 75% shade level (18.8229 ± 8.21885). In the intervening period, the shortest plants in length were recorded at 0% shading (11.7314 ± 2.03269).

The values of petiole length were significantly different between the 75% and 0% shading ($p=0.006$). Similar results between 0% and 50% shading values were also analysed significantly different ($p=0.005$) but insignificant for 75% and 50% shade level ($p=0.463$). This was obviously showed by the graph plotting in Figure 1a. Thus, this showed that the plants under 75% shading were great in growth, followed by 50% shading (22.3200 ± 4.00310). Besides, the fertility of the plant species was showed under higher rate of shade level (Hetterscheid and Ittenbach, 1996). The level of shading was correlationally with the degree of light intensity and plant humidity, in which the reduction of light intensity increased the humidity of the plant habitat and resulted the increasing of the petiole length.

The level of shading was significantly influenced the number of leaflets as it was the main organ for plant in food production through the process of photosynthesis, which affected the growth and plant developments (Barden, Halfacre and Parrish, 1987). The plant seedlings for each shade level showed an insufficient rate of increased in number of leaflets after 12 weeks of transplanting (Figure 1b).

The first 2 weeks (14 days) of transplanting resulted a swifter increased in number of leaflets for plants at 50% shading compared to the other two shade levels. But, the result altered on the fourth weeks (28 days) of transplanting, after the emergence of new leaflets for plants under 75% of shade level. By the end of the transplanting (12 weeks) resulted higher leaflets production for plants under 50% shade level. Meanwhile, plants grown at 0% shading (5.1429 ± 0.22254) had shown a slow increased in leaf production, in which none emergence of new leaflets were recorded from 0 to 6 weeks (42 days) of transplanting. Eventually, a slow increased of leaves productions were shown after 8 to 12 weeks (56 to 84 days) of transplanting.

The production of leaves for plants under 50% shading were significantly different with plants at 0% shading ($p=0.036$) but insignificant different if compared to 75% shading ($p=0.360$). If the lowest and highest percentage of shade level were compared, an insignificant different analysis was obtained for those shade levels ($p=0.405$). The maximum production of new leaflets was recorded for plants at 50% shading (6.0286 ± 0.90501), followed by 75% shading (5.5714 ± 0.49570).

Increasing shade level to 75% had significantly affected the tuber diameter of *A. brachyphyllus*, in which recorded the largest size of tuber compared to 50% and 0% of shade level after 12 weeks of transplanting (Figure 1c). The eighth week (56 days) of transplanting showed the tuber size for plants at 50% shading were the largest in value but at the last 4 weeks, the tuber diameter for both 50% and 75% shade level were almost similar. The 12 weeks of transplanting resulted plant tubers at 75% shading (19.3929 $\pm$ 3.35289) were the largest among those at 0% and 50% shade level (20.6143 $\pm$ 1.70934). The diameter rate for plant tubers at 0% shading (16.1257 $\pm$ 0.89686) were recorded the smallest with a slow increased, each week of the transplanting.

The tuber diameter was significantly different between the 75% and 0% of shade level (p=0.035). The similar result also recorded between the 0% and 50% shading (p=0.004) but not between 75% and 50% shade level (p=0.572). Plant tuber was purposed of storage organ that involved in the plant growth and developments, in which influenced the length and leaflets production of the plant (Talt, 2002). Besides, the health of the plant species especially the young plants was based on the size or tuber diameter (Richerson, 1999).

Each comparison done above that included the petiole length, number of leaflets and tuber diameter showed a similar result that reported by Roland Charles Singka (2004) for *A. borneensis*. This showed that *Amorphophallus* species were likely to live under lower in light intensity and humid area for better growth development (Hetterscheid and Ittenbach, 1996). Besides, through observations showed that the higher percentage of light intensity or direct sunlight exposed to the plant species would cause scorches, wilting and injury or damages.

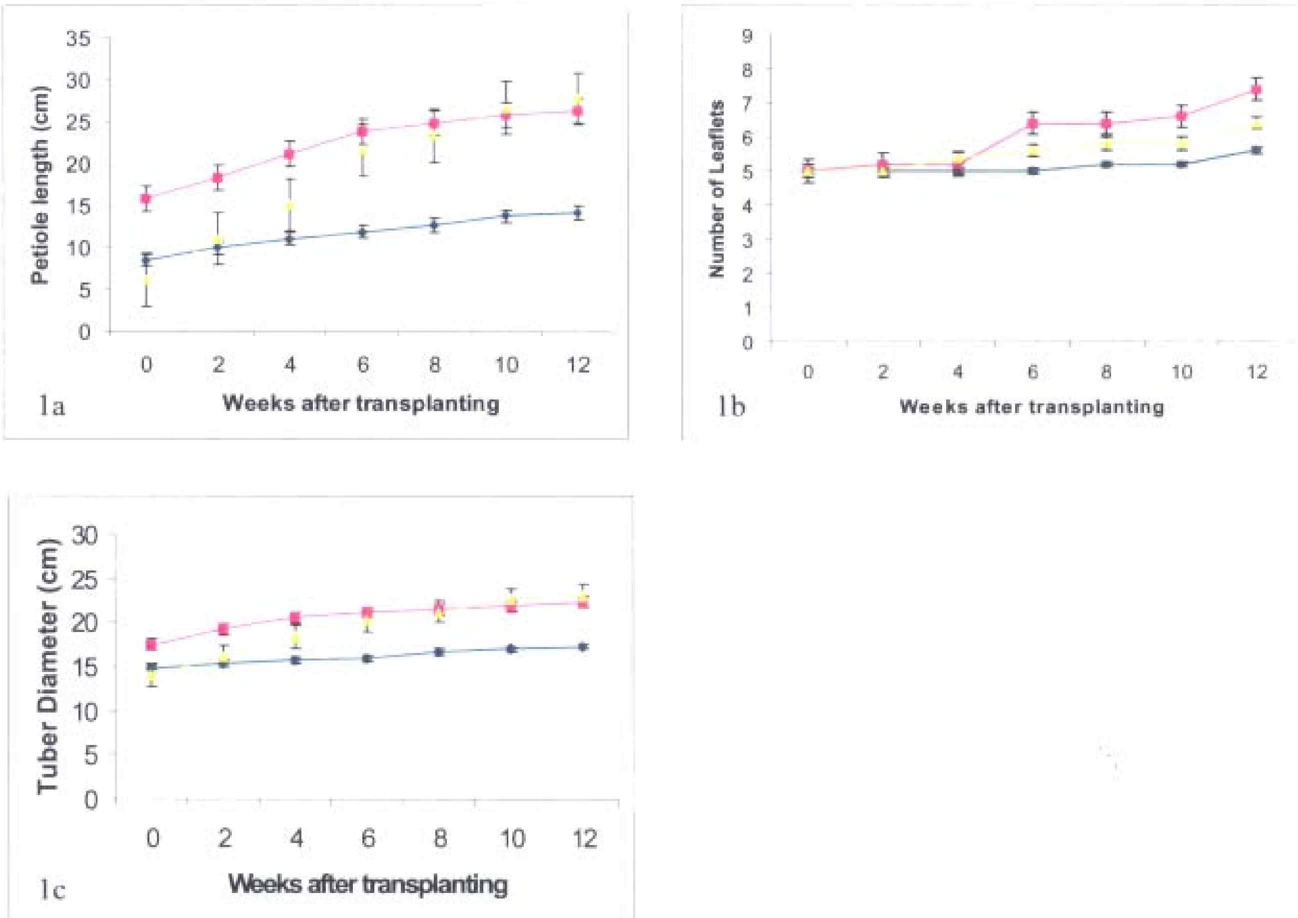

Figure 1: Effect of light on vegetative growth of *A. brachyphyllus* after 90 days of transplanting under 3 different shadings; 1a) Petiole length, 1b) Number of leaflets and 1c) Tuber diameter. ◆ 0% shading ■ 50% shading ▲ 75% shading