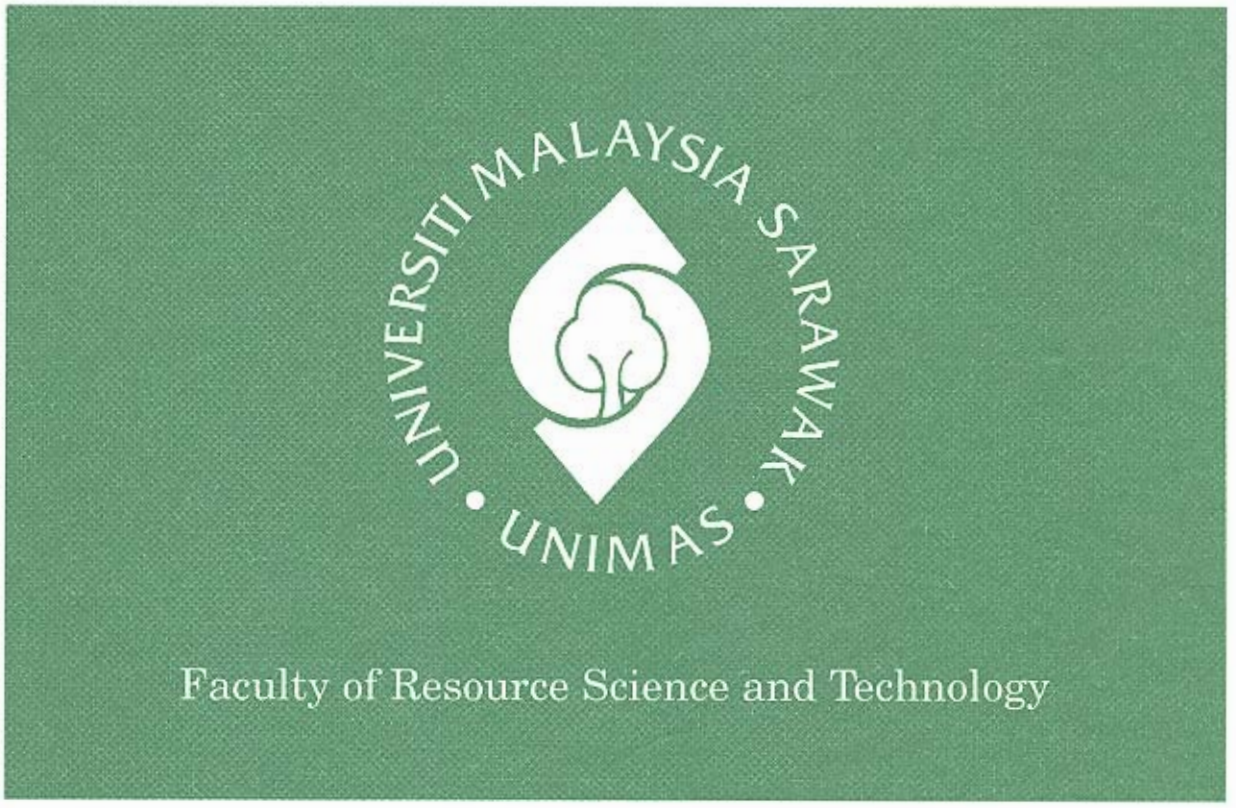

RESPONSE OF *Crytocoryne pallidinervia* (Engler)ON LIGHT INTENSITY AND WATER DEPTH

Md Djzamanni Yahya

Bachelor of Science with Honours
(Plant Resource Science and Management)
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RESPONSE OF *Cryptocoryne pallidinervia* (Engler) ON LIGHT INTENSITY AND WATER DEPTH

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the requirements for the degree of Bachelor of Science with Honours

(Plant Resource Science and Management)

Faculty of Resource Science and Technology

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Response of *Cryptocoryne pallidinervia* (Engler) on Light Intensity and Water Depth

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ABSTRACT

The study of the effect of different light intensity and water depth on the growth pattern of *Cryptocoryne pallidinervia* Engler (Araceae) was conducted at Universiti Malaysia Sarawak (UNIMAS) campus. Samples were collected from Sg. Prasak, Sematan, Sarawak, where the occurrence of *C. pallidinervia* was determined. Samples were cultivated to different light regimes (tree canopy shading, 50% shading and 75% shading) and water depth regimes (0 cm, 7 cm and 15 cm). The study comprises of growth measurement, biomass allocation and photosynthesis measurement. Samples cultivated for the study showed significant difference on the effect of different light intensity and water depth. Pulse amplitude modulated fluorometer (Diving-PAM, Walz Gmbh, Germany) equipment was used to measure the photosynthetic activity of photosystem II (PSII). Different light regime and water depth resulted different growth pattern and different photosynthetic activity.

Keywords: *Cryptocoryne pallidinervia*, light intensity, water depth, growth pattern, photosynthesis.

ABSTRAK

Kajian kesan intensiti cahaya dan kedalaman air terhadap corak pertumbuhan Cryptocoryne pallidinervia *Engler (Araceae) dijalankan di kampus Universiti Malaysia Sarawak (UNIMAS). Sampel diambil dari Sg. Prasak, Sematan, Sarawak di mana kehadiran C. pallidinervia telah ditentukan. Sampel ditanam kepada keadaan cahaya berbeza (lindungan kanopi pokok, lindungan 50% dan lindungan 75%) dan keadaan keadalaman air yang berbeza (0 cm, 7 cm dan 15 cm). Kajian ini meliputi ukuran pertumbuhan, alokasi biojisim dan ukuran fotosintesis. Sampel yang ditanam untuk kajian ini menunjukkan perbezaan signifikan terhadap kesan intensiti cahaya berbeza dan kedalaman air berbeza. Alat "pulse amplitude modulated fluorometer" (Diving-PAM, Walz Gmbh, Germany) digunakan untuk mengukur aktiviti fotosintesis di fotosistem II (PSII). Keadaan intensiti cahaya dan kedalaman air yang berbeza mengakibatkan corak pertumbuhan dan aktiviti fotosintesis yang berbeza.*

Kata kunci: Cryptocoryne pallidinervia, *intensiti cahaya, kedalaman air, corak pertumbuhan, fotosintesis.*

1.0 INTRODUCTION

Cryptocoryne (Araceae), also known as the Keladi Air by the local people of Sarawak, is an endemic aquatic plant. According to Jacobsen (1985), there were 10 species of *Cryptocoryne* found in Sarawak. The species were *C. auriculata*, *C. bullosa*, *C. ciliata*, *C. ferruginea*, *C. grabowskii*, *C. keei*, *C. lingua*, *C. pallidinervia*, *C. striolata* and *C. zonata*. Another three new species of *Cryptocoryne* found in Sarawak were *C. uenoi* (Bastmeijer & Bogner, 2002), *C. yujii* (Sasaki, 2002) and *C. zaidiana* (Ipor *et al.*, in press).

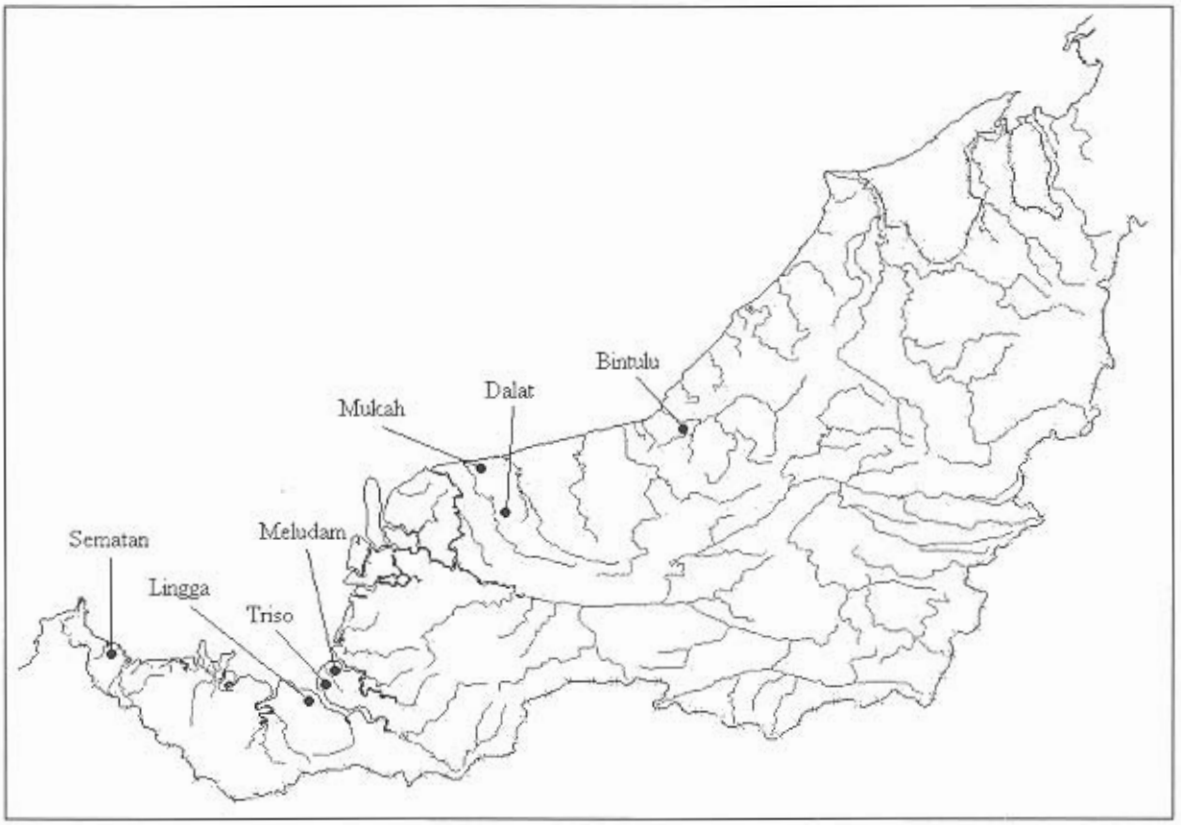


Figure 1: Seven areas of *C. pallidinervia* natural habitat found in Sarawak.

Jacobsen (1985) stated that there are three different habitats in where the *Cryptocoryne* can grow. They are the inner tidal zone as amphibious life form, slow to fast running water as aquatic life form and at the bank of smaller rivers as rheophytic life form. Most of the *Cryptocoryne* are evergreen perennial herbs with procumbent to erect rhizomes and short to long runners.

Each species of the *Cryptocoryne* possesses distinguishable features, which characterised each of the species. For example, *C. pallidinervia* is characterised by the limb of the spathe that has prominent, red protuberances and a broad, yellow collar zone with red spots (Arends, Bastmeijer & Jacobsen; 1982). Its leaves are cordate shaped.

The physical appearances possessed by the *Cryptocoryne* have promoted the plants from the particular genus to be highly potential as aquarium plants. According to Rataj and Horeman (1977), the genus *Cryptocoryne* contains some of the commercially most important aquatic species used in the aquarium plant trade. This has made them the marketable products in the global market.

The species also has the importance for the aquatic ecology. In its natural habitat, it provides nutrients to other aquatic organisms. As it undergoes the photosynthesis process, oxygen is being supplied to the water and lowers the BOD (*biological oxygen demand*) of the water. The uptake of excessive nutrients from the contaminated water helps to clean it up. According to Jacobsen (1985), *Cryptocoryne* can grow well under a thick canopy. The condition of low light intensity and high humidity level under the canopy promotes growth of the particular species. *Cryptocoryne* can even grow at high intensity of shading

(approximately 90% shading). He added that even at submerged condition, flowering may occur, however, it is sterile.

C. pallidinervia was found in swamp areas. However, a lot of the swamp areas experienced destruction as they were developed for agriculture. This has disturbed the habitat of the species. Thus, leading to the extinction of this species. Human activities on the development and deforestation have created major disaster to the habitat of various flora and fauna. *Cryptocoryne* is a sensitive plant. Destruction of its natural habitat may cause a decrease to its population. It has a very limited distribution. Due to the decreased population and limited distribution, the species has a high risk of facing extinction.

There is not much study done on this species. Hence, the objective of this study is to determine the effects of different light intensity and water depth levels on growth pattern of the particular species of *C. pallidinervia*. This includes the biomass allocation, photosynthesis, growth measurement and individual leaf area development of the *C. pallidinervia* study.

2.0 LITERATURE REVIEW

Several studies have been done on *Cryptocoryne* species. Some of them are the ecological and the DNA fingerprinting studies. These studies were meant for the conservation of the species. Based on Mahmud (2004) study on the ecology of *C. pallidinervia*, the species grows well on the acidic condition in peat swamp areas.

According to Jacobsen (1985), the species can be found in the inner tidal zone as amphibious life form, slow to fast running rivers as aquatic life form and at the bank of some smaller rivers as rheophytic life forms. The *C. pallidinervia* plant is sensitive to its environmental surroundings. It grows well under high humidity level with no direct sunlight penetration. The plant may die if exposed to direct sunlight where the surroundings are too hot for its growth condition. Low humidity condition can also cause the plant to die as the transpiration rate raise higher, contributing to its water loss (Jacobsen, 2004 pers. comm.).

Different species and different genotype amongst species has different levels of temperature tolerance. This however is affected by the protein synthesis. The protein synthesis is a very thermosensitive metabolic process. According to Howarth (1993), changes in temperature affect both the amount and type of protein synthesised and this displays a strong correlation with physiological thermosensitivity.

According to Ougham and Howarth (1988), plants are able to develop thermotolerance to a normally lethal temperature by prior short exposure to a sub-lethal temperature, during the time the heat shock proteins (HSPs) synthesis occurs. The more thermotolerant of a plant, the higher the temperature maximum of HSP synthesis.

Different light condition may give different formation of leaf. According to Ipor *et al.* (2003), higher light intensity promotes higher number of leaves being developed by a plant, however, with low intensity condition, less number of leaf produced but the leaf area of an individual leaf tends to expand broader. According to Grime and Mackey (1993), under the forest canopy, which is the lower vegetation, small differences in height are associated with large changes in intensity, direction and quality of radiation and establishment of a seedling maybe dependent upon morphological responses to shade.

Large leaves will tend to be disproportionately long-lived due to a relatively long-time to develop. It is also likely that leaves with high dry weight/fresh weight ratio will be long-lived (Hodgson and Booth, 1993). A leaf of a plant has the function of transpirating water to the environment. Higher rate of water loss than the rate of water uptake by a plant may cause drought stress, and eventually the plant would die.

According to Rundel and Pearcy (1990), critical acceptance of foliar absorption as a means of obtaining water requires the demonstration of four criteria, which are:

- The gradient of decreasing water potential from atmosphere to plant.
- Morphological specialisations for water absorption.
- Significant absorption and redistribution of water.

- Consequence reduction in plant water potentials.

Several studies have demonstrated that other aquarium plants, including *Aponogeton* and *Anubia* species, can be propagated *in vitro* (Huang *et al.*, 1994). Forest clearing activity does not only affect the sediment charges on the river flow. It also contributes to the gap opening as the trees are felled. The gap provides direct sunlight penetration to the ground, and this affect the growth of the herbaceous plants. According to Raghavendra (1998), due to the strong dependence of photosynthesis on incident light and influences of light on stomatal conductance, variability in incident light intensity is usually overwhelming contributor to variability rates of net photosynthesis and transpiration.

Anderson and Osmond (1987) stated that it is now established that growth in high versus low light results in increased rubisco activity, capacity of cytochrome F and chloroplast coupling factor per unit leaf area. According to Tyystjarvi (1992) recovery from photoinhibitory damage is slower in shade than sun plants because repair occurs in the stroma lamellae, which, due to the extensive grana stacking, are of limited extent in shade chloroplasts. Light generally exerts a strong regulatory influence on shoot elongation in seedlings (Hart, 1988).

Amount of absorbed light of a leaf is affected by the amount of chlorophyll in the particular leaf. Higher the chlorophyll content, the greater the amount of light absorbed (Crawford, 1989). Plants grown on stimulated shade appears not only taller but also narrower due to the suppression of lateral bud expansion (Morgan, 1981).

3.0 MATERIALS AND METHOD

3.1 Sampling and Study Area

Sampling of *Cryptocoryne pallidinervia* was made at Sg. Prasak, near Kpg. Keranji in Sematan area. The sampled media were the mixture of sandy loam soil and the peat swamp soil. The sandy loam soil was sampled at Sg. Prasak, where the plant samples were collected. The plant samples and the media samples were then brought to the greenhouse located at Universiti Malaysia Sarawak (UNIMAS).

3.2 Cultivation

Rhizome cuttings were made for the cultivation of the *C. pallidinervia*. The cultivation of the rhizome cuttings of *C. pallidinervia* was conducted at the peat swamp forest. The potting was the mixture of sandy loam soil and the peat swamp soil sampled from the peat swamp forest. 150 successful samples of *C. pallidinervia* cuttings were cultivated. Each cutting was transplanted in a polythene bag (10 cm x 12 cm) and the bags were placed inside basin (47 cm x 24 cm). Each basin contained 10 bags.

3.3 Light Intensity

Three different light regimes were applied to the experiment. The light treatments were under tree canopy shading condition, 50% shading condition and 75% shading condition. Different intensity of lathe netting was used to obtain the 50% and 75% shading conditions. Samples for the 50% shade treatment were placed inside a 50% lathe house. Meanwhile, the samples for the 75% shade treatment were placed inside the 75% lathe house. Two basins (20 samples) were used for each treatment. Water depth of 10 cm

(measured from media surface) was applied to all light regimes. The plants were subjected to growth measurement and biomass allocation analysis.

3.3.1 Growth Measurement

All 60 plant samples were labelled before the measurement of every two weeks. The measurements included in this study were plant height, number of leaf and number of lateral shoots developed.

3.3.1.1 Development of Individual Leaf

In another assessment, development of individual leaf was also assessed. Each individual leaf was traced weekly on a piece of plastic board sized 22.5 cm x 31.0 cm without severing the leaf. Every trace of the leaf represented the individual leaf area of the particular leaf. The area of each trace was measured using leaf area meter.

3.3.2 Biomass Allocation

Five plants from each light regime were selected randomly and were harvest after 30 days of transplanting. The leaf area measurement of individual plants was done before drying the samples using the AT Delta-T scan equipment. The leaf, root, petiole and rhizome were separated prior to oven drying at 60°C for seven days to determine their dry weight. Similar harvest or assessment was done after 60 days of transplanting. The biomass allocation assessment was done by using method described by Patterson and Flint (1983) as follows:

Leaf Weight Ratio (LWR): L/W

Petiole Weight Ratio (PWR): P/W

Root Weight Ratio (RWR): R/W

Rhizome Weight Ratio (RhWR): Rh/W

Leaf Area Ratio (LAR): LA/W

Specific Leaf Area (SLA): LA/L

Whereby, W = Whole plant dry weight, L = Leaf dry weight, P = Petiole dry weight, R = Root dry weight, Rh = Rhizome dry weight, LA = Total leaf area for a plant

Dry Matter Production, DMP = $\Delta W = W_2 - W_1$

Net Assimilation Rate, NAR = $[(W_2/A_2) - (W_1/A_1)] \times [\alpha / (\alpha-1)] / \Delta T$

Leaf Area Duration, LAD = $[\Delta A/ (\ln A_2 - \ln A_1)] \times \Delta T$

Whereby, W_1 = Total plant dry weight at the beginning of the interval, W_2 = Total plant dry weight at the end of the interval, $\Delta A = A_2 - A_1$, A_1 = Total leaf area of plant at the beginning of the interval, A_2 = Total leaf area of plant at the end of the interval, $\alpha = (\ln W_2 - \ln W_1) / (\ln A_2 - \ln A_1)$, ΔT = time duration between two harvest.

3.4 Water Depth

Three different water levels or depths, 0 cm, 7 cm and 15 cm were used in this experiment. The depths of the water levels were measured from the media surface to the water surface. For each treatment, twenty plants were placed in the designated water depth. All basins used for the water depth study were placed under 75% shading. Each water level was maintained and monitored everyday. Similar assessment in light response such as growth measurement and biomass allocation was conducted for response on water depth.

3.5 Photosynthesis

The photosynthesis measurement was done on both light intensity and water depth study. In measuring the photosynthetic rate, "WALZ Diving-PAM Flourometer" equipment was used. Three uniform leaves were selected from each plant to determine their maximal fluorescence yield. On every light regime and water depth comprised of 5 plants, each leaf was dark-adapted for 10 minutes prior to photosynthesis measurement. Another measurement was done to determine the light curve (electron transport rate vs. photosynthetic active radiation) of a plant under each regime. The light curve experiment was done in a darkened room. Samples were put in a basin with 10 cm water depth level. Uniform leaves were selected for the experiment. Leaves were dark-adapted using dark-leaf clip for 10 minutes before measurement starts.

4.0 RESULTS

4.1 Light Intensity Response

Light intensity measurement was done on four different light regimes which were direct sunlight, tree canopy shading, 50% shading and 75% shading. it was observed that tree canopy shading and 75% shading has approximately similar light intensity within the 13 hours measurement, only that at 1400 hours the light intensity for tree canopy shading increased higher than that under the 50% and 75% shading. Direct penetration of sunlight to the samples under tree canopy shading was observed (Figure 2).

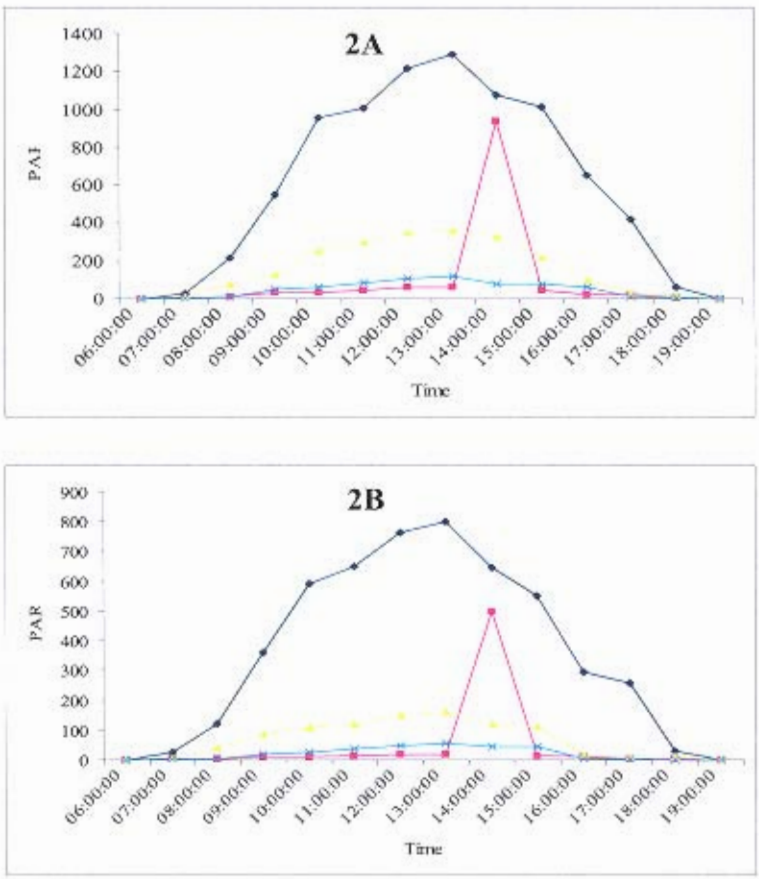


Figure 2: Light intensity within 13 hours on, both, above water condition (2A) and under water condition (2B) of direct sunlight (—◆—), tree canopy shading (—■—), 50% shading (—▲—) and 75% shading (—✳—).

4.1.1 Growth Measurement

Plants under tree canopy and 75% shading regimes were significantly higher than that under the 50% shading regimes. On week 2, plants under tree canopy shading regime were significantly higher than that under 50% and 75% shading. On week 6 to week 8 there were significant different on plant height of that under all light regimes. Between week 2 to week 4, plants under 75% shading regime experienced tremendous change of plant height, however, it grew steadily after week 4 (Figure 3).

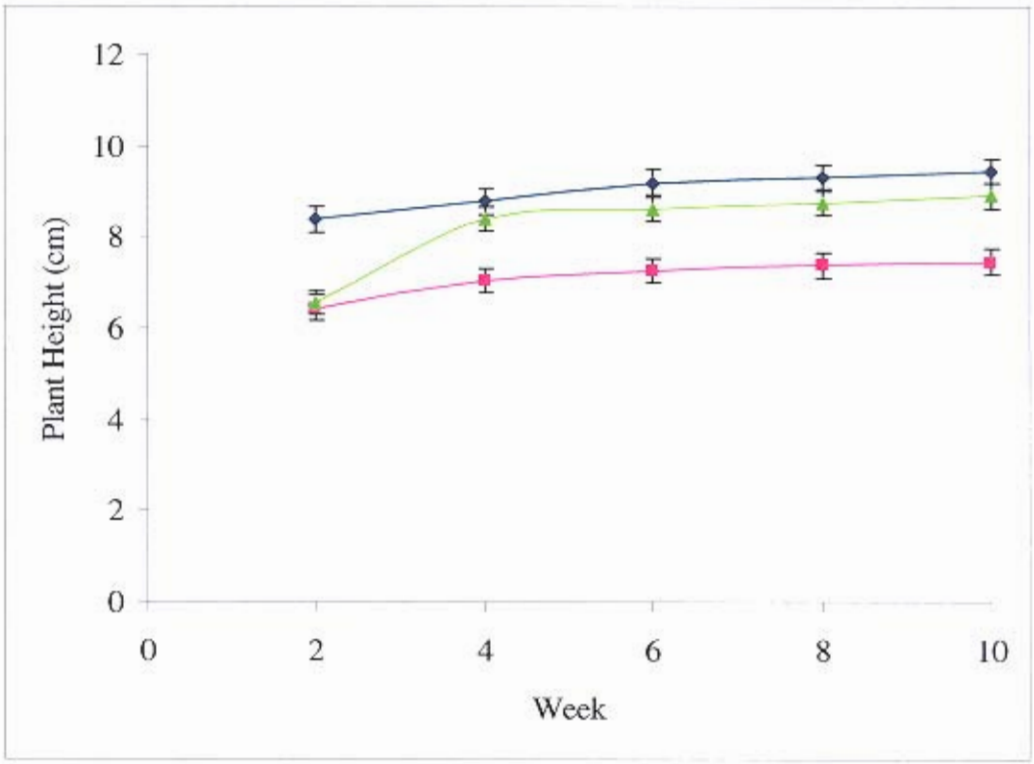


Figure 3: Effect of shading on plant height in *C. pallidinervia*. Tree canopy shading(—◆—), 50% shading(—■—) and 75% shading(—▲—). Vertical bars are values of LSD = 0.05.

Plants under tree canopy shading produced significantly more leaves than the other two light regimes. Plants under 75% shading produce least leaf. However, there was no significant different on number of leaf produced by plants under 50% and 75% shading. Plants under all light regimes were not significantly different on leaf produced on week 2 to week 4. After 6 weeks transplanting the plants to the light regimes, leaf production of plants under tree canopy shading regime increase more than the other two light regimes. From week 2 to week 10, leaf produced by plants under 50% and 75% shading regimes are still almost the same (Figure 4).

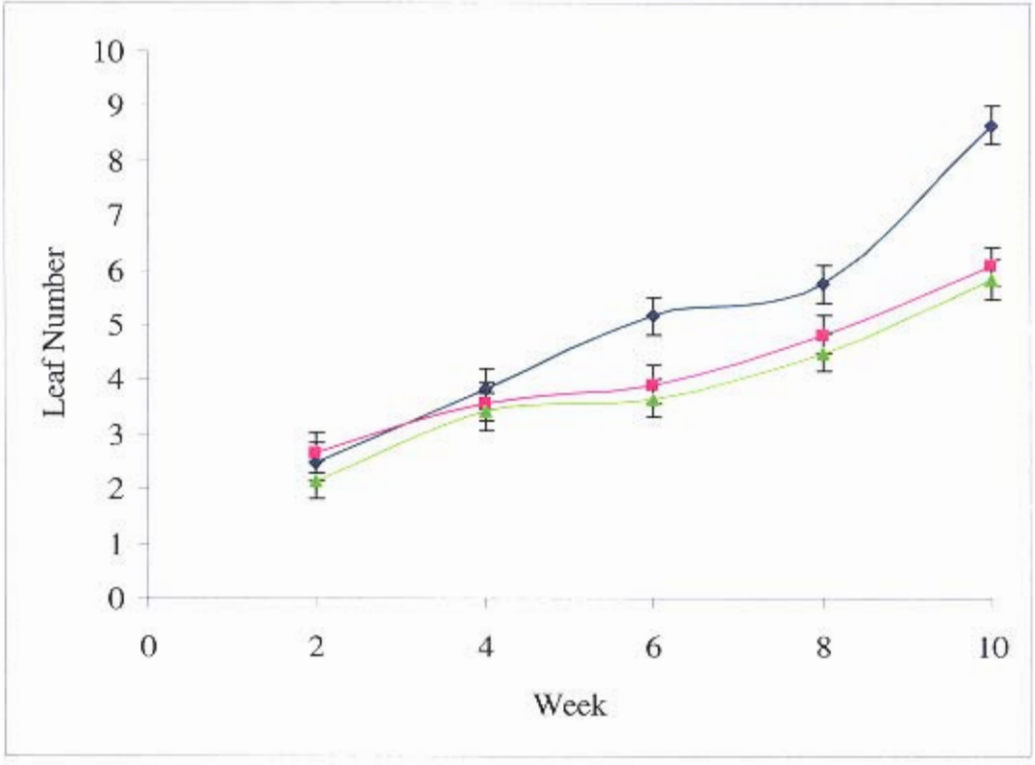


Figure 4: Effect of shading on number of leaf in *C. pallidinervia*. Tree canopy shading(—◆—) 50% shading(—■—) 75% shading(—▲—).Vertical bars are values of LSD = 0.05.

After 10 weeks of transplanting the plants to the light regimes, plnats grown under tree canopy shading produced significantly more lateral shoots than that under the 50% and 75% shading regimes. Also on the tenth week, numbers of lateral shoots produced by plants under all light regimes were significantly different. Plants under 50% shading regime produced lateral shoot the earliest which was after two weeks of transplanting. At the same week, plants under 0% and 75% shading regime have not yet produce any lateral shoot. Plants under 75% shading regime produce lateral shoot later than that under 0% and 50% shading regime, after 8 weeks of transplanting. On week 8, number of lateral shoot produced by plants under 0% shading regime increased more than that under 50% shading regime (Figure 5).

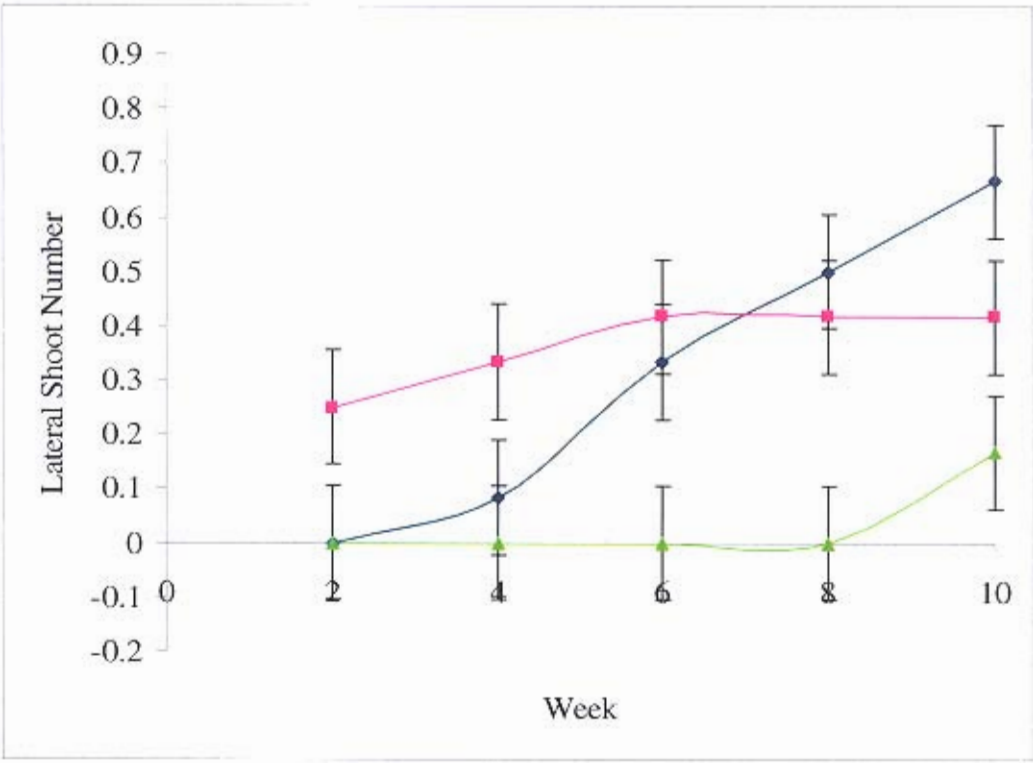


Figure 5: Effect of shading on number of lateral shoot in *C. pallidinervia*. Tree canopy shading(—◆—), 50% shading(—■—) and 75% shading(—▲—).Vertical bars are values of LSD = 0.05.

4.1.1.1 Individual Leaf Area

Figure 6 showed that after five weeks of transplanting of the plant samples to different shading intensities, plants that were grown under the shading regime of 75% recorded highest reading for individual leaf area development. While, plants grown under the tree canopy shading recorded the lowest reading for individual leaf area development on the particular week. This show that the individual leaf area of plants that were grown under 75% shading regime have the broadest individual leaf after five weeks of transplanting.

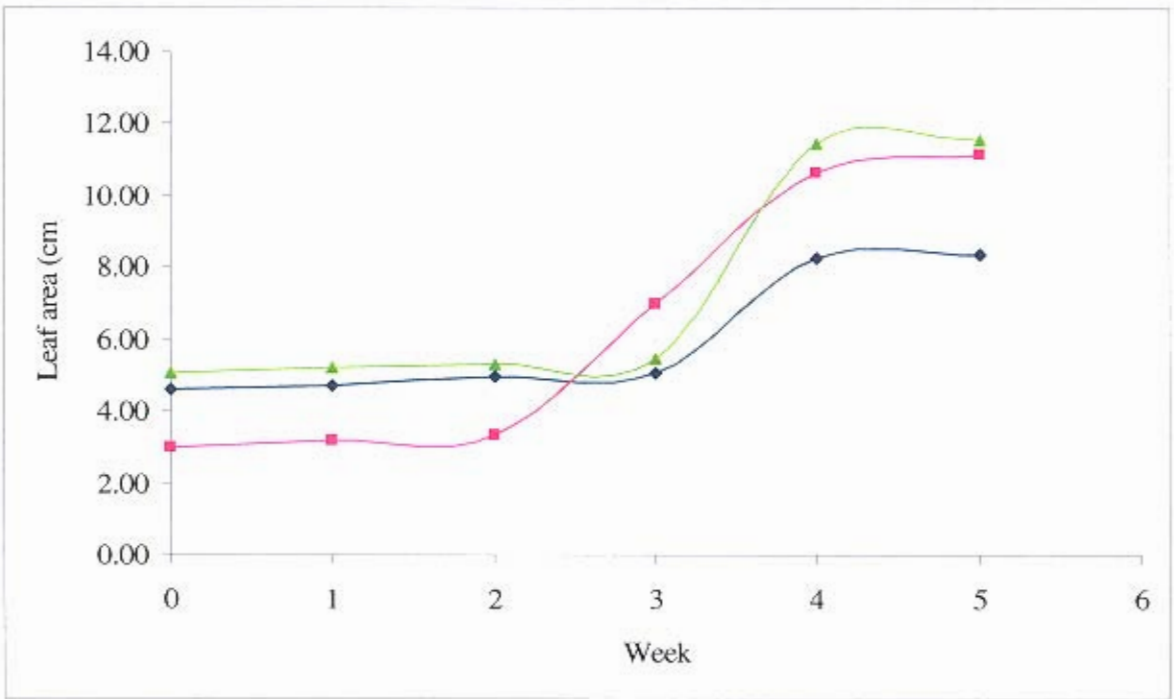


Figure 6: Effect of shading on individual leaf area in *C. pallidinervia*. Tree canopy shading(—◆—), 50% shading(—■—) and 75% shading(—▲—).

4.1.2 Biomass Allocation

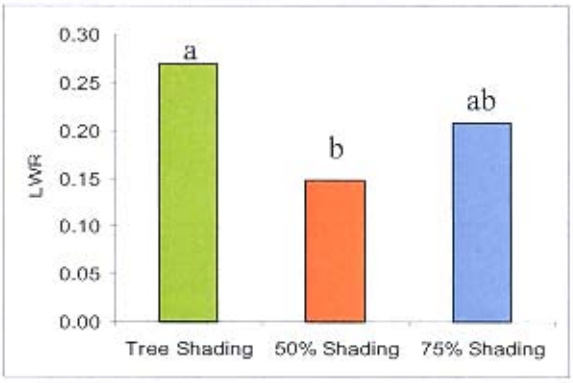
Table 1 showed that there was significant different on values of dry matter production (DMP) and leaf area duration (LAD) among the three different light regimes. Plants under 50% shading regime showed significantly higher value of net assimilation rate (NAR) than that under the other light regimes.

Table 1: Effect of shading on dry matter production (DMP), net assimilation rate (NAR) and leaf area duration (LAD) of *C. pallidinervia* during the 30th to 60th day interval after transplanting.

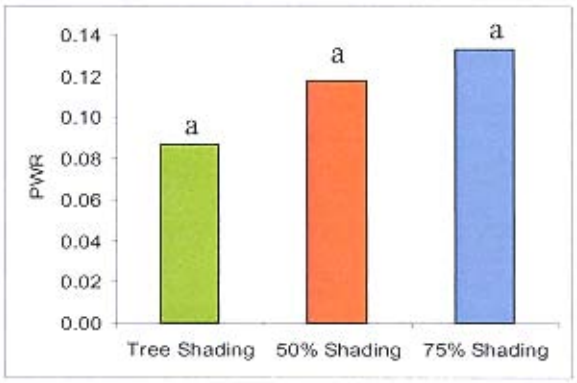
Shading	DMP	NAR	LAD
Tree Canopy	0.20a	0.00014b	1588.92a
50%	0.14b	0.00039a	420.55c
75%	0.11c	0.00017b	737.80b

Within each column, values sharing the same letter are not significantly different at 5% level.

Leaf weight ratio (LWR) of plants under the 50% shading regime recorded significantly lower value than that under the tree canopy shading. Petiole weight ratio (PWR) values of plants under all light regimes were not significantly different. However, plants under 75% shading regime showed highest value for PWR. Rhizome weight ratio (RhWR) of plant under tree canopy shading regime was significantly lower than that under 50% shading. Plants under tree shading canopy recorded significantly higher value of root weight ratio (RWR) than that under the other light regimes. Leaf area ratio (LAR) of plants under 50% shading regime showed significantly lower value than that under tree canopy shading, but not significantly differed with that under 75% shading. However, there was no significant different between all light regimes on specific leaf area (SLA) (Figure 7).



7A



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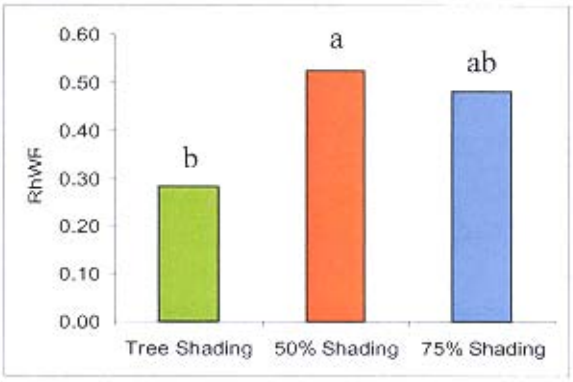

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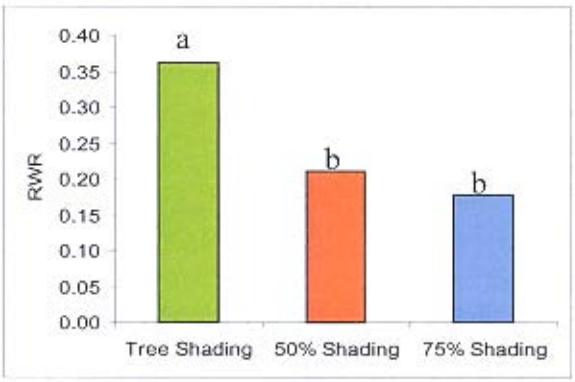

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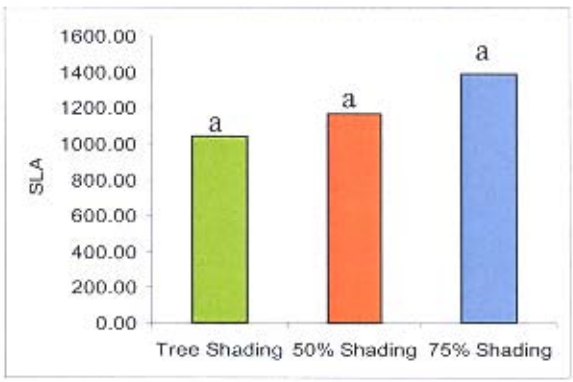

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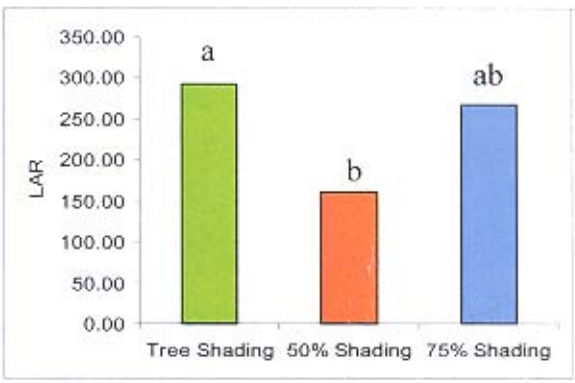

7F

Figure 7: Effect of shading on vegetative growth, leaf area production and biomass allocation in *C. pallidinervia*. (30th day harvest). 7A = Leaf Weight Ratio (g/g); 7B = Petiole Weight Ratio (g/g); 7C = Rhizome Root Ratio (g/g); 7D = Root Weight Ratio (g/g); 7E = Specific Leaf Area (cm^2/g); 7F = Leaf Area Ratio (cm^2/g). Values sharing the same letter are not significantly different at 5% level.

4.2 Water Depth Response

4.2.1 Growth Measurement

Plants in the water depth of 15 cm were significantly higher than that in the other two water depth regimes. However, plant height of plants in the water depth regimes of 0 cm and 7 cm were not significantly different since 2 weeks after transplanting until the tenth week (Figure 8).

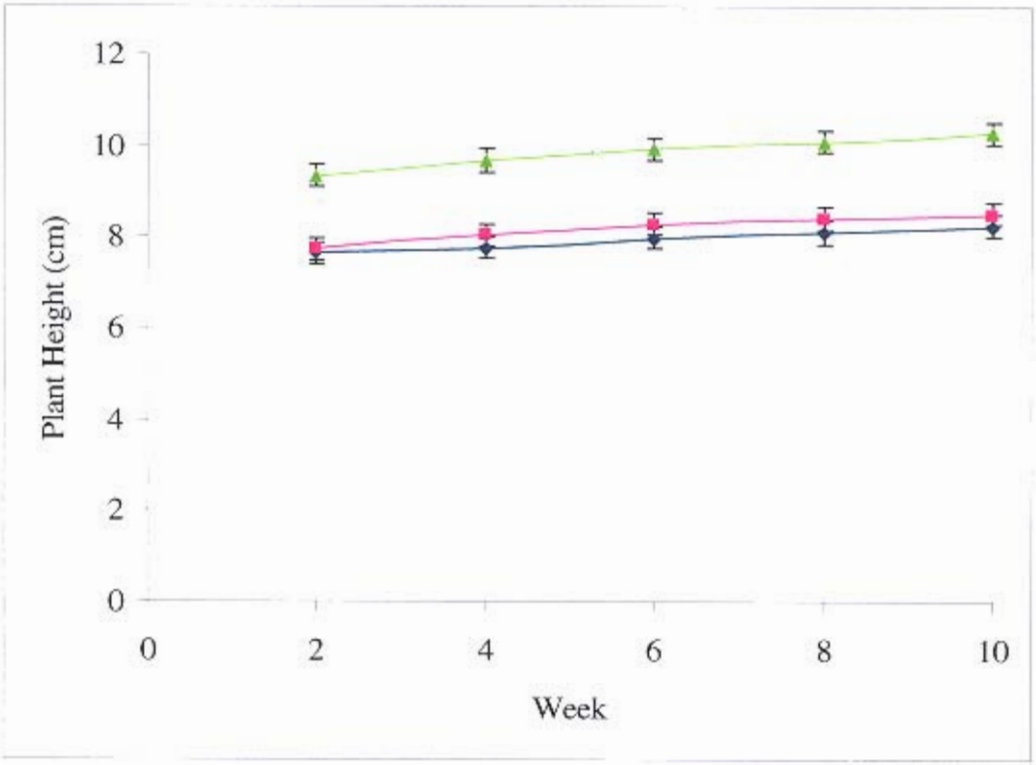

Figure 8: Effect of water depth on plant height in *C. pallidinervia*. 0 cm depth(—◆—), 7 cm depth(—■—) and 15 cm depth(—▲—).Vertical bars are values of LSD = 0.05.

Plants in the water depth of 7 cm have significantly less leaves than that in the other two water depth regimes. There was no significant different observed on leaves produced by plants in the water depth of 0 cm and 15 cm (Figure 9).

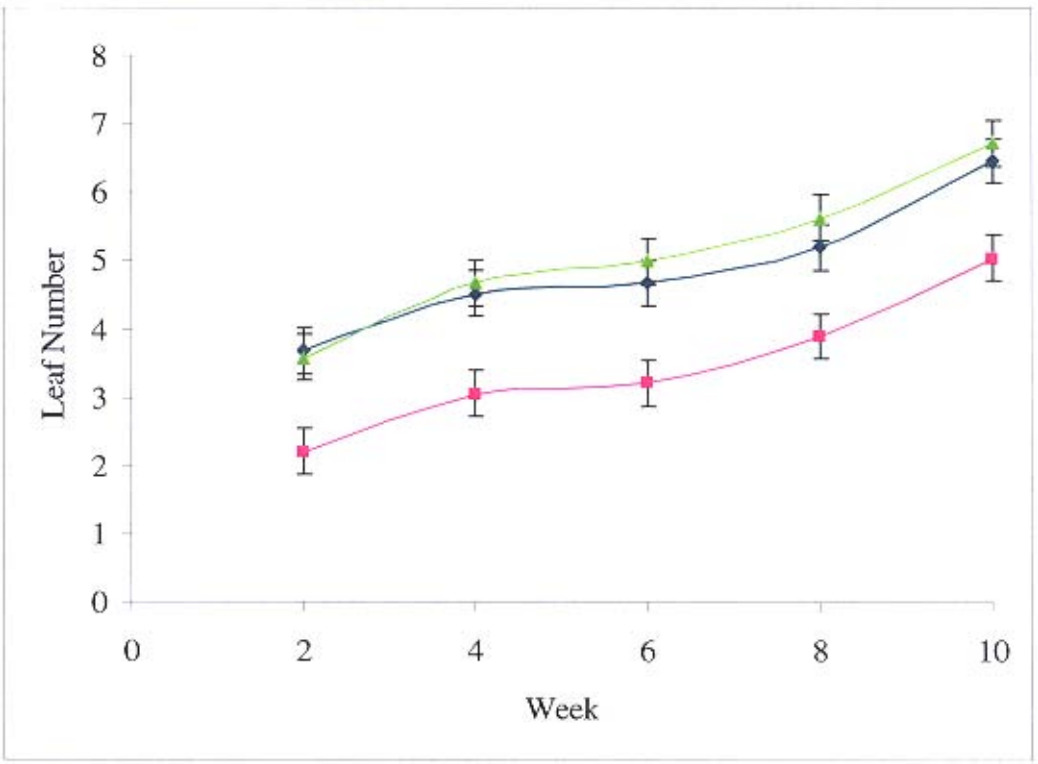

Figure 9: Effect of water depth on number of leaf in *C. pallidinervia*. 0 cm depth(—◆—), 7 cm depth(—■—) and 15 cm depth(—▲—).Vertical bars are values of LSD = 0.05.