Faculty of Resource Science and Technology

RESPONSE OF *CRYPTOCORYNE CORDATA* Griffith var. *CORDATA* (Griffith) N. Jacobsen (ARACEAE) TO SHADING 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 cordata* Griffith var. *cordata* (Griffith) N.Jacobsen (Aracea) was conducted at University Malaysia Sarawak (UNIMAS) campus. Plant materials were collected from Sg. Bebar, Pahang. Samples were cultivated to different shade (tree canopy shading, 50% shading and 75% shading) and different water depth regimes (0 cm, 10 cm and 30 cm). The assessments comprised of growth measurement, biomass allocation and photosynthesis measurement. Samples conducted in this 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. Different light regime and water depth resulted different growth pattern and different photosynthetic activity.

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

ABSTRAK

Kajian kesan intensiti cahaya dan kedalaman air yang berbeza terhadap corak pertumbuhan Cryptocoryne cordata Griffith var. cordata (Griffith) N.Jacobsen (Aracea) *(Aracea) dilakukan di kampus Universiti Malaysia Sarawak (UNIMAS). Sampel diambil dari Sg Beban, Pahang. Sampel ditanam kepada keadaan cahaya berbeza (lindungan pokok, lindungan 50% dan lindungan 75%) dan pada keadaan kedalaman air yang berbeza (0 cm, 10 cm dan 30 cm).Kajian ini meliputi ukuran pertumbuhan, alokasi biojisim dan ukuran fotosintesis. Sampel yang dilakukan untuk kajian ini menunjukkan perbezaan signifikan terhadap kesan intensiti cahaya berbeza dan kesan kedalaman air yang berbeza. Alat "pulse amplitude modulated fluorometer" (Diving-PAM, Walz Gmbh, Germany) digunakan untuk mengukur aktiviti fotosintesis. Keadaan intensiti cahaya dan kedalaman air yang berbeza mengakibatkan corak pertumbuhan dan aktiviti fotosintesis yang berbeza.*

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

1.0 INTRODUCTION

The name *Cryptocoryne* (Araceae), is from the Greek words *cryptos*- hidden, and *koryne*-club, refers to the club shaped spadix hidden in the inflated basal section *(i.e. kettle)* of the spathe. *Crypocoryne* is the aquatic plant and only can survive with the present of water. *Cryptocoryne* are generally small to medium, amphibious, perennial herbs that reproduce vegetatively by runners, and sexually by trumpet shaped flowers *(spathe)* pollinated by small flying insects. All species can be grown out of water *(emersed)*, but some have a distinct preference for growing in the submersed state *(C. aponogetifolia, C. balansae, C. retrospiralis)*. Conversely, other species prefer to grow in the emersed state *(e.g. C. ciliata, C. lingua, C. costata, C. auriculata, C. zaidiana)*. Most species of *Cryptocoryne* will flower and propagate vegetatively more readily in the emersed state. (Jacobsen, 1985).

Cryptocoryne is also known as tropical-bog, kiambang batu (Melayu Sarawak), kelatai (Iban), hati-hati paya (Semenanjung Malaysia), keladi laut, bakong (melayu Samarahan), Teron Amun (Melanau) and tropong ajer (Banjarmasin, Kalimantan) (Ipor *et al*, 2005). Nowadays, *Cryptocoryne* have a high value because today it become a commercially plant to be exported for the international aquarium markets. According to Rataj and Horeman (1977), the genus *Cryptocoryne* contains some of the commercially most important aquatic species used in the aquarium plant trade.

There are nearly 50 species of *Cryptocoryne* in the South-east Asia. *Cryptocoryne* species can be found growing in three major differents habitats as reported by Jacobsen (1977). The habitats were in the inner tidal zone, slow to fast running rivers and streams and the banks of some smaller rivers and streams. Most of the *Cryptocoryne* are evergreen perennial herbs with procumbent to erect rhizomes and short to long runners. According to Jacobsen (1985), there are eleven species found such as *C. ciliata (*Roxburgh) Schott, *C. auriculata* Engler, *C. bulosa* Engler, *C. ferruginae* Engler, *C. grabowskii* Engler, *C. lingua* Engler, *C. zonata* De Wit, *C. pallidinervia* Engler, *C. striolata* Engler, *C. keii* Jacobsen, and *C. longicauda* Engler. Each species of the *Cryptocoryne* possesses distinguishable features, which characterised each of the species.

According to Jacobsen (1985), *Cryptocryne* can grow well under a thick canopy. For the light intensity, it must be of low intensity and the shady daylight might be perfect. *Cryptocoryne* can even grow at high intensity of shading (approximately 90% shading). The flowering process may occur, however, it is sterile even at submerged condition. The *Cryptocoryne* is importance plants for aquatic ecology because it provides nutrients to other aquatic organism. Its occur through the photosynthesis process in this plants where oxygen is being supplied to the water and lowers the BOD (*biological oxygen demand*) of the water.

Cryptocoryne cordata Griffith var. *cordata* (Griffith) N.Jacobsen was found in swamp area. The *C. cordata* are all characterized by a broad yellow limb of the spathe, more or less with a brown tinge. According to Jacobsen (1985), the southern Malay Peninsula, large, cordate leaved forms with a more or less yellow limb of the spathe represent the *Cryptocoryne cordata*. He added, specimens of *C. cordata* (2n=34) from Johore (the area best investigated and best represented by herbarium specimens) are not very variable in morphology, and they have brown green marmorated leaves, and long spathes with a rather smooth, yellow limb of the spathe together with a broad collar zone. A typical collar is lacking, but there may be a thickened 'collar zone'. The leaves vary from cordate to elliptic, from green to deep brown, lower side of the leave from pale green to deep purple.

The impacts of rainforest logging on river systems in Malaysia have been highlighted by Douglas *et al.* (1993). In Malaysia logging and ground clearance increase river sediment yields by two to fifty times. The high sediment load in the water could result in a massive destruction of riverine habitats. Perhaps this is one of the main culprits that caused the populations of *Cryptocoryne* to decline. According to Chan *et al.* (1985) the swamp forest was the main source of timber, therefore, the forest were logged on commercial scale for many years since early this century. *C. cordata* species is categorized as shaded plants. Therefore with the opening of the areas, the plants could not grow in an exposed habitat where the light intensity is relatively high.

According to Jacobsen (1985), most *Cryptocoryne* species that were found in Borneo are endemic and are greatly exposed to extinction due to the rapid exploitation and demolishment of the forest. The problems occur is come from human that done the development without think about the coming effect. When human cut the trees for development, the problem will be occur is the erosion because the land is without any covers that protect them. The water such as form rain running very fast and washed out all the nutrients and the substrate need by the *Cryptocoryne*. The population of *Cryptocoryne* species will decrease slowly for the long time and exposed to extinction. *Cryptocoryne* is the sensitive plants for the changes in the environment. Human activities that result in the changes in the environment such as paddyfield, drainage canals, and fishponds reservoirs will decrease of the population of *Cryptocoryne*.

However, there is not much study done on *Cryptocoryne cordata* Griffith var. *cordata* (Griffith) N.Jacobsen. The present study is conducted to determine the effects of different light intensity and water depth levels on growth pattern of the particular species *C. cordata*. The assessment was includes the biomass allocation, photosynthesis, growth measurement and individual leaf area development of this species.

2.0 LITERATURE REVIEW

Plants from the genus *Cryptocoryne* are highly exploited for the aquarium industry and apparently fetch high prices in the international aquarium market (Mansor, 1991). The population of *Cryptocoryne* faces drastic decline due to exploitation and habitat destruction caused by human activities, such as river clearing and adverse water quality which are results of upstream forest logging, shifting cultivation. Large scale agriculture activity and road construction among others.

According to Jacobsen (1985), there are three different habitat of *Cryotocoryne* species generally in the inner tidal zone (amphibious mode of life); slow to fast running rivers and streams (aquatic way of life) and the banks of some smaller rivers and streams (rheophatic way of life). Most species will grow in sand mixed with peat litter (50/50% volume) and it is an excellent medium to cultivate *Cryptocoryne*.

Based on Jacobsen (1985), *Cryptocoryne* can grow well under thick canopy. The condition of low light intensity and humidity level under the canopy promotes growth of particular species. They even can grow at high intensity of shading (90%). Shady daylight might be perfect but growing *Cryptocoryne* indoors in a greenhouse most have to use artificial lighting by fluorescent tubes. Depending on the species, some plants can stand close to the tubes (30 - 50 $\mu mol/m^2$ see) other plants must have some distance to the tube or the tube must be covered with a plastic net to reduce the light intensity (10 μmol/m^2 see). The photoperiode can be 12 hours a day. That's for cultivation the *Cryptocoryne* in the greenhouse.

Successful plant growth requires a balance of light, nutrients, trace elements, and carbon dioxide (CO_2). The light should be provided in a spectrum the plants can absorb, must be of great enough intensity to keep the plant alive, and should be consistently on 10-14 hours a day. But, for *Cryptocoryne*, the condition of low light intensity and high humidity level under the canopy promotes growth of the particular species. The plant may die if exposed to direct sunlight where the surroundings are too hot for its growth condition. According to Jacobsen (1985), low humidity condition can also cause the plant die as the transpiration rate raise higher, contributing to its water loss. Most nutrients for *Cryptocoryne* are supplied by availability in soils and water. CO_2 is supplied partly from the air through the photosynthesis process.

Light requirements depend on the species, but most require low to moderate lighting. According to Ipor *et al.* (2005), higher light intensity promotes higher number of laves 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. The amount of light will dictate the size, number and shape of the leaves and the height of the plant.

The photosynthesis process is makes the plants grow. Higher concentrations of CO2 and high light intensity also increase photosynthesis and plant growth. During the time that plants are exposed to light, carbon dioxide is absorbed and oxygen is expelled. The gases enter the plant mainly through the leaves. The carbon dioxide and water are chemically combined with the chlorophyll in the plant to produce simple sugars. The sugars are converted to starch and oxygen is produced as the by-product. The chlorophyll is what absorbs the light to create the process of photosynthesis. The process of photosynthesis is often considered to have an optimum, maximum and minimum temperature (Bannister, 1976).

The *Cryptocoryne* naturally absorbs more nutrients through the roots during photosynthesis. Growth is limited by the amount of carbohydrates that are created during photosynthesis. Photosynthesis is limited by the amount of light energy available (required intensity and spectrum) and the amount of nutrients and CO2 available. At a certain threshold of energy, no photosynthesis will occur. Above that threshold, more and more photosynthesis occurs until an upper threshold is reached. (Ougham and Howarth, 1988)

According to Howarth (1993), changes in temperatures affect both the amount and type of protein synthesized and this displays a strong correlation with physiological thermosensitivity. *Cryptocoryne* are tropical plants and therefore experience warm temperatures with very little fluctuation all year round. Lower temperatures normally result in slowed growth. Some of the more delicate *Cryptocoryne* respond well to a warm substrate which is very desirable and enhances growth in all plants by speeding up the metabolic processes occurring in the root system including nutrient uptake.

Temperature is the major determinant of the rate at which plant, or organ within a plant, develops towards maturity. Often, the rate of organ initiation and development can be approximated by its linear relation with the temperature of the tissue under investigation. This is thus for germination, leaf primordium initiation, leaf expansion, and root development extension. Exposure the *Cryptocoryne* to more extreme temperatures may result in cold or heat stress and permanent damage to the exposed tissue. 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. (Ougham and Howarth, 1988).

The nutrient availability in the soil can effected the growth of the plants. Each type of soils has their own nutrients for the plants growth. The streams where *Cyptocoryne* are native are typically low in dissolved nutrients. All nutrients are supplied to the plant through the root system embedded in this iron rich, muddy substrate and importantly, from constant slow leeching into the streams from springs. These springs maintain constant, low levels of nutrients in the streams to be absorbed by the plants. Most of the plant needs the enough nutrients, minerals and substrate for perfect growing. Most of the *Cryptocoryne* species growing well and the population are more dense and abundant with the higher amounts of nitrogen, calcium and natrium (Ipor *et al.*, 2003).

3.0 MATERIALS AND METHODS

3.1 Sampling and Study area

Sampling of *Cryptocoryne cordata* was made at Sg. Bebar, Pahang, Peninsula Malaysia. The samples were collected from natural habitats. The samples were brought to green house at FRST, University Malaysia Sarawak (UNIMAS) for cultivation and to obtain sufficient number of lateral shoots.

3.2 Cultivation

The potting media used in cultivation of *C. cordata* was sandy loam soil. Individual plants were detected and preparation of planting materials. All petioles were cut before transplanting in plastic trays. The established uniformed lateral shoots were selected and transplanted in plastic pot containing mixture of clay, loam and sand. The pots were then placed in plastic basin (42 cm x 32 cm). Each basin contained 6 pots.

3.3 Light Intensity

Three light regimes such as under tree canopy shading condition, 50% shading condition and 75 % shade levels were obtained by placing different layer of black lathe netting. Tree canopy shading was obtained by placing plants directly under the tree canopy. Two basins comprised of 12 pots were placed in each different light regime. The total number of samples used for light intensity treatment is 36 plants. The water level was maintained of 0 cm (water level at soil surface).

3.4 Water Depth

This experiment was conducted based on three different water depths, 0 cm, 15 cm, and 30 cm. Twelve uniform plants (arranged in two basins) were placed in every different water depth; *vis.* 0 cm (water level at media surface), 15 cm (water level at 15 cm from media surface) and 30 cm (water level at 30 cm from media surface). For all different water depths, the plants were placed under tree canopy condition. The water levels were monitored daily by adding rain water to maintain desired level.

3.4.1 Growth Assessment

For both light intensity and water depth study, the growths measurement of the plants in different treatments were assessed in term of total plant height, total leaf number, biomass allocation, photosynthesis and duration of flowering. The reading for all experiments was collected every 2 week.

3.4.2 Biomass Allocation

For both shading and water depth experiments; five plants from each treatment were selected randomly and harvested after 50 days of transplanting. Each part of the plants was separated according to all vegetative parts such as petioles, leaf blades and roots. The separate vegetative parts were oven dried at 60°C for 72 hours to determine their dry weight. The leaf area of individual plants was determined by using the AT Delta-T scan equipment before it was oven dried. The biomass allocation assessment was analyzed mathematically by using the method described by Patterson and Flint (1983) as follow:

Leaf weight ratio (LWR) = L/W (g/g)

Petiole weight ratio (PWR) = P/W (g/g)

Rhizome weight ratio (RhWR) = Rh/W (g/g)

Root weight ratio (RWR) = R/W (g/g)

Leaf Area Ratio (LAR) = LA/W (cm^2/g)

Specific leaf area (SLA) = LA/L (cm^2)

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.

3.5 Photosynthesis

"WALZ Diving-PAM flourometer" equipment was used for measuring the photosynthetic rate of *C. cordata* var. *cordata* for different shade levels and water depths. For maximal quantum yield, ten uniform leaves were selected from each shade levels and water depths. The leaves were dark adapted for 10 minutes prior to photosynthesis measurement. The light curve [Electron Transport Rate (ETR) vs. Photosynthetic Active Radiation (PAR)] of plants from different growth condition was also determined. Three uniform leaves were selected from every light regimes and water depths.

4.0 RESULTS

4.1 Light Intensity Response

4.1.1 Growth Measurement

4.1.1.1 Plant Height

Plants under 50% and 75% shading were higher than the plants under tree canopy (Figure 1). From the first two weeks, plants under 50% shading regime seemed to be higher than the plants under tree canopy and 75% shading. However, the plants height showed no significant different to all light regimes and grew steadily starting from week 2 until week 10.

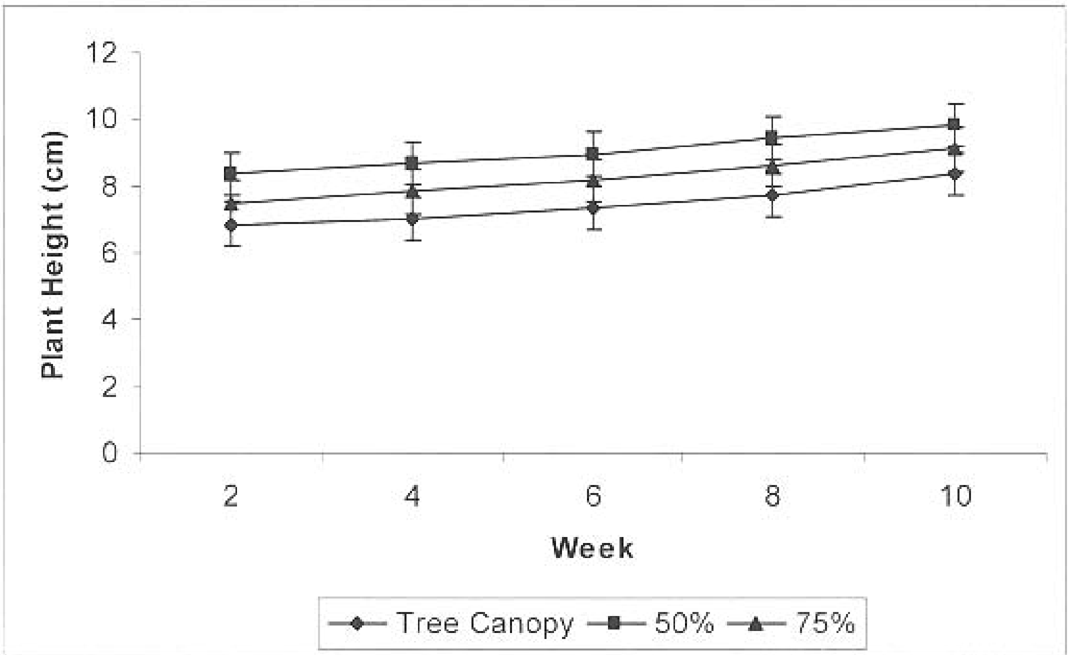

Figure 1: Effect of shading on plant height of *C. cordata* var. *cordata*. Vertical bars are values of LSD = 0.05.

4.1.1.2 Total Number of Leaves

Plants under 50% shading produced significantly more leaves than the under tree canopy and 75% shading. Least leaf number was recorded on plants under tree canopy shading. Starting from week 2 to week 8, plants under 75% shading were produced leaf steadily but seemed the tremendous change after week 8 to week 10. Plants under tree canopy shading were significantly different on leaf produced on week 2 to week 4, whereas plants under 50% showed the significantly different in producing of leaves on week 6 to week 8. Over all, plants grown under tree canopy shading showed a positive development in the number of leaves developed. At both 50% shading, the number of leaves increased from week 2 till week 6, but on week 8, the number of leaves showed no increment. However, on the week 8 till week 10, plants in all light regimes showed increment in the number of leaves produced (Figure 2)

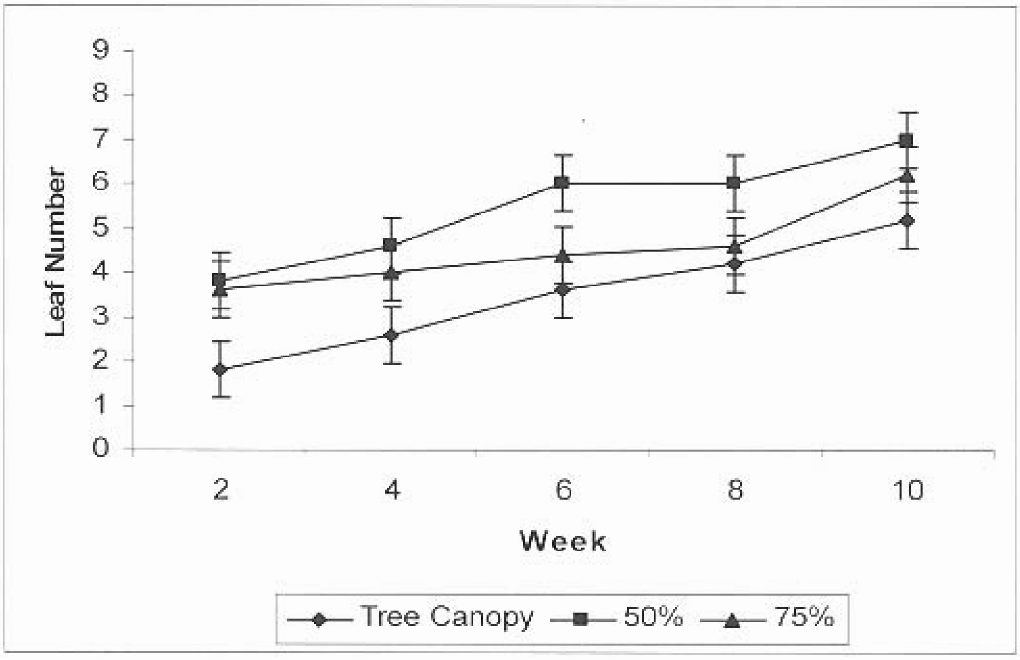

Figure 2: Effect of shading on number of leaf in in *C. cordata* var. *cordata*. Verticals bars are values of LSD = 0.05.

4.1.2 Biomass Allocation

Plants under 50% shading recorded significantly lower value than under 75% shading for the leaf weight ratio (LWR). For the petiole weight ratio (PWR) and leaf area ratio (LAR), plants under all shading was resulted there are no significantly different between all light regimes. Rhizome weight ratio (RhWR) value of the plants under tree canopy shading was significantly lower than the value of the plants under 50% shading. For the root weight ratio (RWR), plants under tree canopy shading was significantly lower than under 50% shading. The plants under 50% shading recorded significantly higher value of specific leaf area (SLA) than the plants under the other light regimes.(Figure 3)

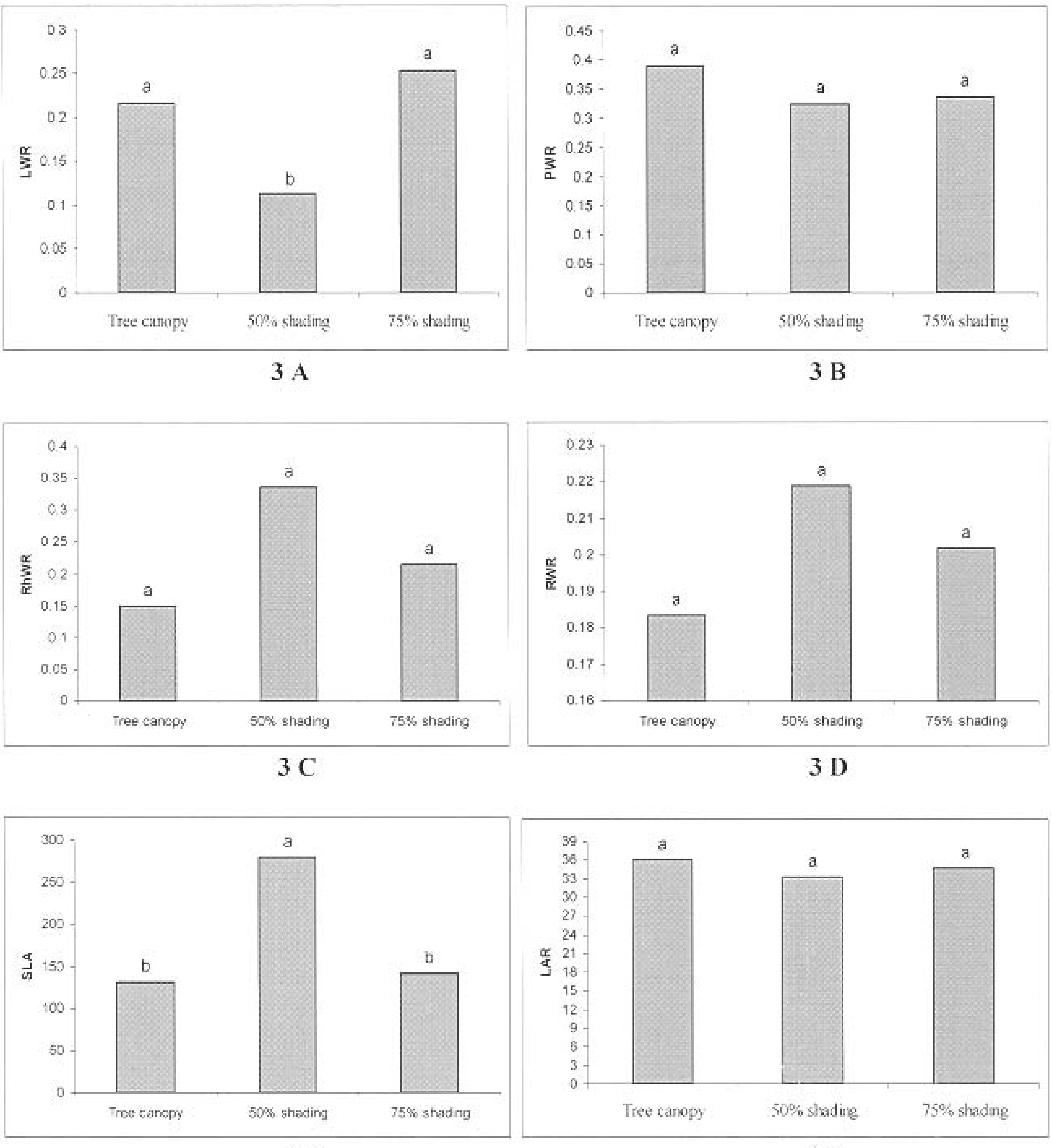

Figure 3: Effect of shading on biomass allocation of *C. cordata* var. *cordata*.. (50 day harvest). 3A= Leaf Weight Ratio (g/g); 3B = Petiole Weight Ratio (g/g); 3C = Rhizome Weight Ratio (g/g); 3D = Root Weight Ratio (g/g); 3E = Specific Leaf Area (cm^2/g); 3F = Leaf Area Ratio (cm^2/g). Values sharing the same letter are not significantly different according to Duncan's multiple range test.

4.2 Water Depth Response

4.2.1 Growth Measurement

4.2.1.1 Plant Height

Plants in the water depth of 30 cm were significantly higher than plants in the 0 cm and 15 cm of water depth regimes. Plants in water depth 30 cm and 15 cm increased higher since week 4 until week 10. But, plants in 0 cm showed little movement throughout assesstment. Plants in all water depth regimes were not significantly different on plant height on week 2. However, plants in water depth 0 cm showed the significant different on plants height after week 8 till week 10 (Figure 3)

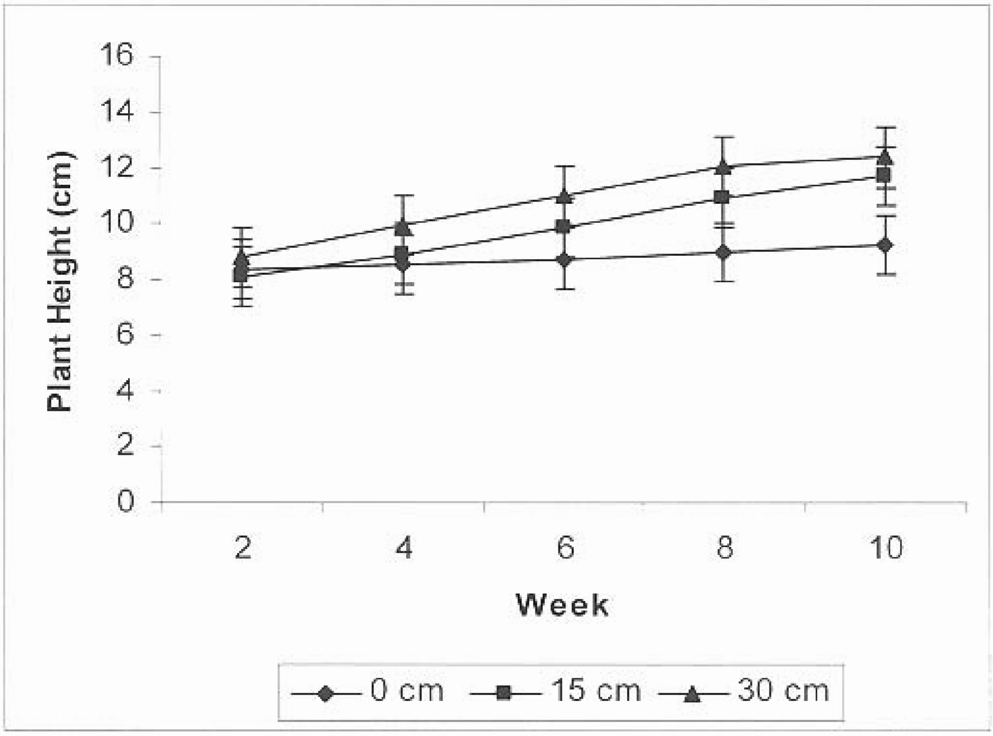

Figure 3 : Effect of water depth on plant height in *C. cordata* var. *cordata.* Vertical bars are values of LSD = 0.05.

4.2.1.2 Total Number of Leaf

Plants in all water depth regimes had no significant difference after 2 weeks of transplanting (Figure 5). Plants in the water depth of 15 cm have higher production of leaf after week 8. Plants in the water depth of 30 cm produced least leaves on week 2 until week 4, and there after increased tremendously. On week 4, there was no significantly different on leaf produced in all water depth regimes. However, there was no significant different in the increase of leaves number of the plants in all water depth regimes. This indicated that the different water depth cannot influence the number of leaves produced (Figure 4)

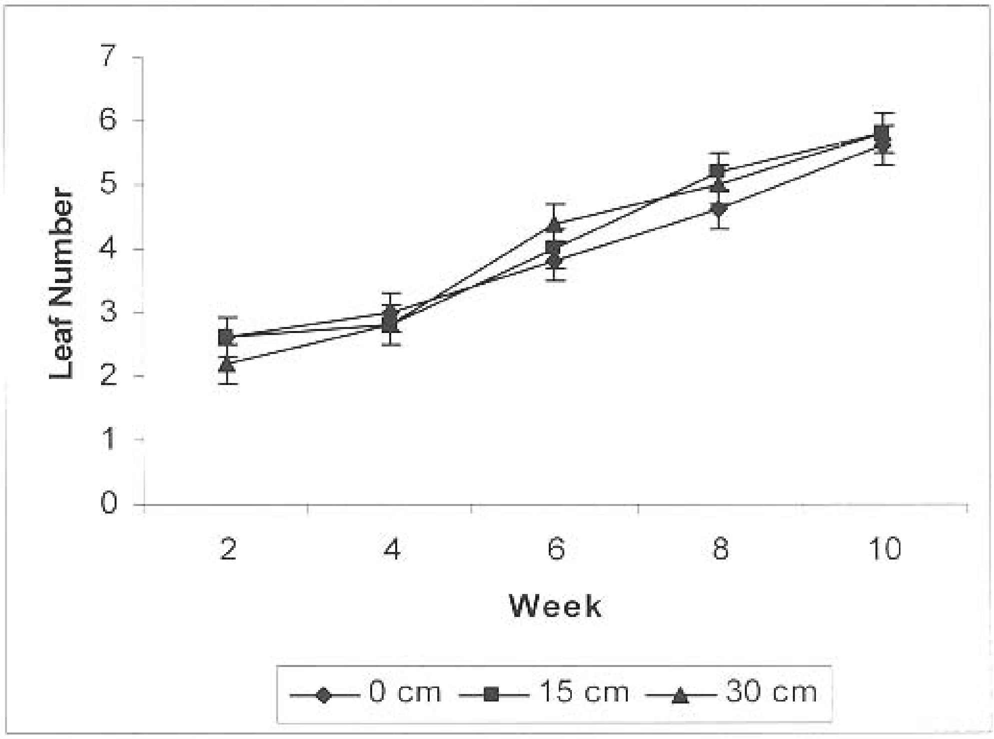

Figure 4 : Effect of water depth on number of leaf in *C. cordata* var. *cordata*. Vertical bars are values of LSD = 0.05.

4.2.2 Biomass Allocation

Leaf weight ratio (LWR) of plants in the water depth of 0 cm recorded significantly higher value than other water depth regimes. Petiole weight ratio (PWR) and rhizome weight ratio (RhWR) in all water depth regimes showed no significant different. Plants in 0 cm recorded the significantly lower value than that plants in the water depth of 15 cm for the root weight ratio (RWR). Specific leaf area (SLA) of plants in all water depth regimes was significantly different (Figure 6)