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Research article

PHYSIOLOGICAL AND MORPHOLOGICALSTUDY OF *CROTON TIGLIUM* LEAVES EXPOSED TO DIFFERENT LIGHT CONDITIONS

[1]Tarini Kumar Jena* and [2]A.N.Misra

[1]P.G. Dept. of Bio Science and Biotechnology, Fakir Mohan University, Balasore, Odisha, India
[2]Centre for Life Science, Central University, Ranchi, Jharkhand, India

ABSTRACT: In this study we have taken *Croton tiglium* to study the effect of different light conditions on the physiological and morphological appreance of the plant. *Croton tiglium*is an ornamental plant used for the interior and garden decoration, belongs to the family Euphorbiaceae, is one of the most popular ornamental plants because of vivid foliage colours and varied leaf shapes. When it is allowed to grow under different light conditions and tested by various parameters like Chlorophyll and Carotenoid Content, Leaf Area and Specific Leaf Weight, Light Microscopy, statistical analysis etc the results shows Low light intensities (LLI) increases the concentration of chl*a* and chl*b* while high light intensities (HLI) on the otherhand reduces the level of chl*a*and chl*b*in the leaves of *Croton tiglium.*
Key words: *Croton tiglium, LLI, HLI,* chl*a,* chl*b*

*Corresponding author: Tarini Kumar Jena, [1]P.G. Dept. of Bio Science and Biotechnology, Fakir Mohan University, Balasore, Odisha, India, E-mail: jena.tarinikumar@gmail.com

INTRODUCTION

Generally it is found that the leaves of plants in shade are thinner and have numerous large chloroplasts than the leaves that are under the sunlight. Different species respond separately to different light intensities. Plant grown in low light condition have higher specific lea area (SLA) and Leaf area ratio (LAR) and lower biomass and root shoot ration (R/S ratio) [1,2]. Light demanding species are more flexible in morphology and biomass allocation in response to light change than shade tolerant species. Hence, light plays an important role in the environment, controlling the process associated with dry matter accumulation and thus contributing to plant growth. The species adaptative plasticity to solar radiation depends on the adjustment of the photosynthetic apparatus, in order to render radiant energy conversion in carbohydrates highly efficient and, consequently, to promote higher growth [3-7].

The genus croton, established by Linnaeus in 1737, is extensive, 625 species being recognized in the Index Kewensis. We have a number of herbaceous species in this country, but none of any economic importance. The croton plant is a native of India and is grown all through the East Indies. It is a small tree fifteen to twenty feet high. The leaves are ovate, petiolate, acuminate, alternate, the margins faintly serrate. The flowers are borne in loose terminal spike-like racemes, and are monoicious, the male flowers being at the top of the the raceme, the females below. The male flowers have five sepals, each sepal bearing a yellow gland, five petals, and from ten to twenty stamens with slender filaments. The female flowers have floral envelopes similar to those of the male, and a large sessile, three-celled ovary, thickly covered with stellate hairs and bearing three slender styles, each style dividing into two linear stigmas. The fruit is a three-celled capsule, each cell having a single seed which yields the croton oil of commerce [8-11].

Croton tiglium is considered indigenous to Malabar, Ceylon, Amboina (of the Molucca islands), the Philippines and Java. Joannes Scott, in his dissertation on the medicinal plants of Ceylon (Edinburg, 1819), states that the seeds of *Croton tiglium* under the name of "gayapala," are a most powerful purgative, and also that the leaves are very acrid, causing an intolerable burning in the mouth and throat [12].This suggests that croton is a kind of plant that has goodmechanisms for light acclimation.In this research programme the aim was to study the physiological,morphological and statistical analysis of adaptation of *Croton tiglium* leaves under different light conditions.

MATERIALS AND METHODS

Treatment plant materials with different light conditions

Stem-cutting croton *Crotontiglium* plants were soil grown in pots, with one plant per pot.Before starting the experiment, all thesame-sized plants were maintained forthree weeks in a glasshouse with mediumlight intensity. For the whole day (8 AM– 5 PM), the average intensity was about 200 µmol $m^{-2}s^{-1}$. When the experimentwas started, the croton plants were dividedinto two groups. A least 50 plants were used in each group. One group wasexposed to full sunlight, of which theaverage light intensity for the whole day was 640 µ mol $m^{-2}s^{-1}$. This treatment iscalled the high light intensity (HLI) treatment. The other was grown under thesaran, which reduced the average light intensity to 25µmol $m^{-2}s^{-1}$. This treatmentis called the low light intensity (LLI) treatment. All plants werecompletely watered and nutritionallysupplied for the whole experiment [13].

Analysis ofstatistical data

All experiments were done withCompletely Randomized Design (CRD) with 3 replicates. Means werecompared by one-way analysis of varianceand Least Significant Difference (LSD).

Measurement of level of Carotenoid and Chlorophyll content

Total photosynthetic pigments wereextracted from 0.5 g of leaf tissues with10 ml of 80% acetone. The supernatantwas then used for the determination of the chlorophyll *a* (chl*a*), chlorophyll *b* (chl *b*), and carotenoid contents [13].

Measurement of specific leaf weight and area

Leaf area was determined by usingleaf area meter (Systronics digital portable leaf area meter Model WDY500A). To determine thespecific leaf weight, fifteen leaf discsfrom each sample were randomly chosento measure leaf fresh weight and dryweight. Then, the specific leaf weight wascalculated from the equation:

Specific leaf weight= leaf dry weight / leaf area. [13]

Light Microscope

At least 15 slice of leaf tissues weresampled from one leaf. For each treatment,3-5 replicates for each leaf position wereobtained. Forty-micrometer thick leaf cross-sections were viewed using a Nikonmicroscope. Photomicrographs were taken using Kodak Gold 100 film withautomatic exposure setting.

RESULTS AND DISCUSSION

Adaptation of Photosynthetic Pigment toDifferent lighting condition

Threereplicates were used for the measurements to determine the photosynthetic pigment contents changes, chl *a* and chl *b*, and carotenoid content in the leaves,these weremature before starting the light treatment(the fifth leaf from the top).Data collection was performedevery two weeks for seven weeks. Thepigment content determination was alsodone in the mature leaves, developingunder different light intensities. Threereplicates were used for each experiment.Each treatment was done by using 20, 30 and 40 day-old leaves. Chl *a* and chl *b* contents in the fifth leaves when the plants were movedto the light treatment condition (time =week 0) were approximately 580µg/g FW, and 190 µg/g FW, respectively (Fig. 1).After three weeks in high light intensity, chl *a* and chl *b* contents in the LLI leaveswere significantly different from those inthe HLI leaves. Compared with thechlorophyll content in the leaves at time 0, both chl *a* and chl *b* contents in LLI leaves increased, while chl *a* and chl *b* contents in HLI leaves decreased. The increase inchlorophyll content in LLI leaves and thedecrease in chlorophyll content in HLIleaves were also detected in the fifth week after the light treatment. In the seventh week, both chl *a* and chl *b* levels were similar to the levels previously detected in week 5 (Fig. 1). No light intensity effectcould be detected for the carotenoidcontent of the mature croton leaves (Fig. 2).After seven weeks of light treatment,the leaf colours of the LLI leaves and HLI leaves could be easily distinguished. HLIleaves were more yellowish than the LLIleaves. Therefore, this characteristic wasin agreement with the photosyntheticpigment content data, indicating that thechlorophyll content increased in LLI leavesand decreased in HLI leaves. Interestingly, a decrease in chlorophyll content wasobserved in the yellowish leaves, while throughout the period of the lighttreatmentthe carotenoid contentwas maintained at the same level (Fig. 2).

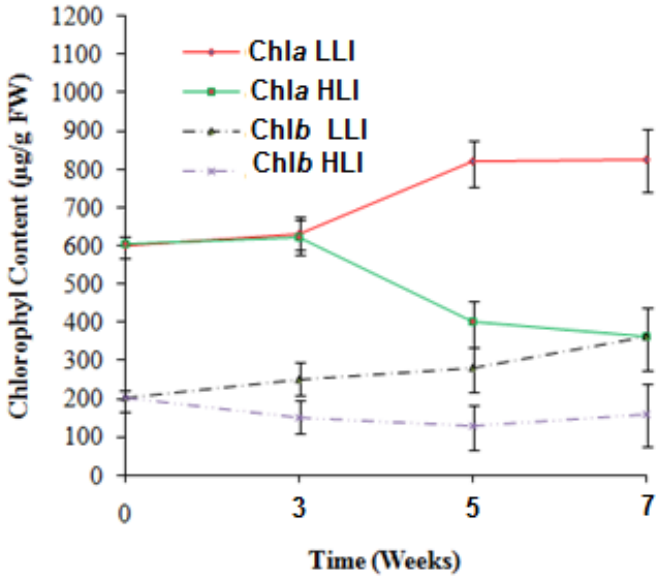

Figure 1. Statistical analysis data of level of Chl *a* and *b* contents in the fifth leaves from the top.Error bars represent ± 1 SD

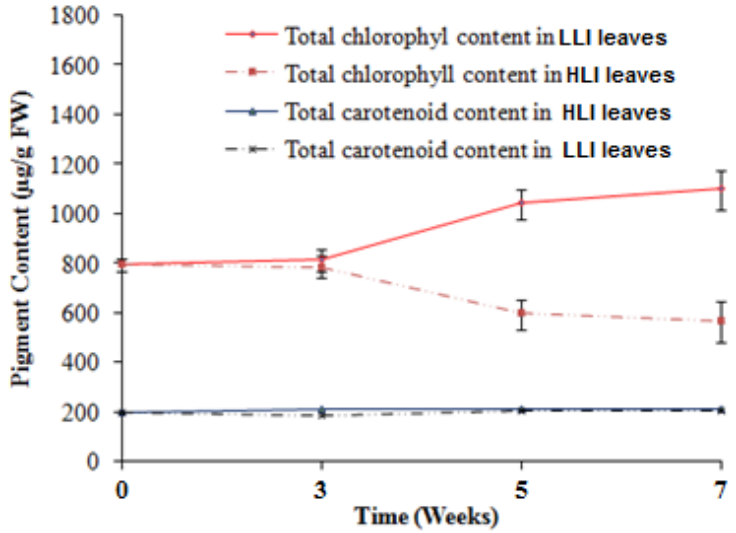

Figure 2. Total chlorophyll and total carotenoid contents in the fifthleaves fromthe top, starting the experiment (week 0). Results are the means of fivereplicates and error bars represents± 1 SD.

At the ages of 20, 30, and 40 days old the photosynthetic pigment levelsof leaves were detected developing under the LLI and HLI conditions.Leaves at different ages under the sameconditions showed similar levels ofchlorophyll content, but both chl *a* and chl *b* levels in the HLI leaves were significantlylower than the ones in LLI leaves (Fig. 3).The carotenoid level is independent on leafage. A slightly higher levelof carotenoid content was detected in the LLIleaves when compares with the HLI leaves (Fig. 4). This suggests that in case of the LLI leaves there is an increase in the antenna complex size. The chl *a*/*b* ratios of 20, 30, and 40 day-old leaves developing in the samelight conditions, were similar. The average chl *a/b* ratio of the LLI leaves was2.5, which was significantly differentfrom that of HLI leaves, 3.4. These dataindicated that when the croton leavesdeveloped in the low light intensitycondition, the antenna complex wasincreased in order to maximize the lightabsorption for photosynthetic processes inthe low light intensity environment.However, a difference in chl *a*/*b* ratio in the LLI leaves and HLI leaves that werefully developed before the light treatmentwas not clearly seen from this experiment.The adaptation in chlorophyllcontent composition in croton leaves tothe different light regimes is similar tothat found in other species.[2,13].

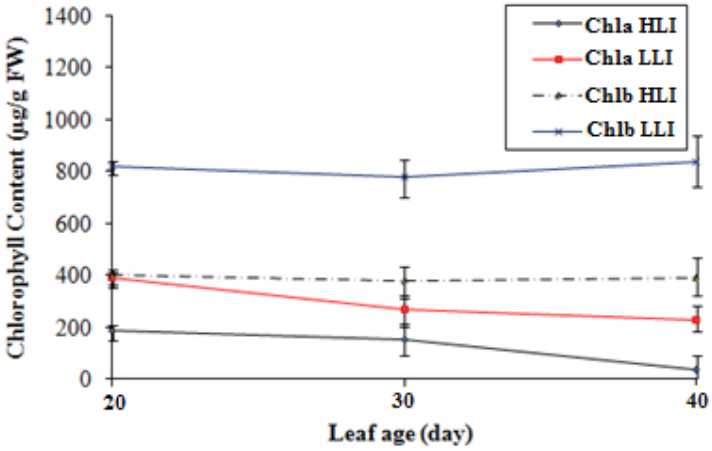

Figure 3. Chl *a* and *b* contents in the mature leaves that developed in thehigh light intensity (HLI) or low light intensity (LLI) condition.

There was quite stable carotenoid contentobserved under both conditions.Because of the photoprotective role ofcarotenoids, their content was expected toincrease under the high light condition [11].The stable carotenoid content in crotonleaves in high light intensity conditionssuggested that the conditions used in thisexperiment were not so stressful that the
plants had to adjust themselves byincreasing the carotenoid content. Onlythe reduction of the antenna complex sizeby decreasing the chlorophyll content wasenough for plant survival in such conditions.

The Effects of Light Intensity on theLeaf Area

The fully developed fifthleaf from the top of the plants was chosen to measure the leaf area. The fifth leaf was developed before thetreatment started. The leaf sizes werevaried (Fig. 5), but the varying lightintensity did not lead to a significantdifference in leaf area. On the contrary,the leaf areas of new mature leavesdeveloping in the different lightconditions were significantly different.The 20 day-old LLI leaves wereapproximately 4 times larger than HLIleaves at the same age (Fig. 6).In the high light intensity condition,the leaves at the different ages did notshow significant differences in leaf size,but in the low light treatment, the newerleaves tended to be significantly largerthan the previous ones that developed inthe same condition (Fig. 6). These dataindicated the adaptation of the leaf size inthe low light condition in order to maximize the photosynthetic capacity byenlarging the leaf size. The smaller leafarea in the HLI leaves was advantageousfor the HLI grown plants. The higher plant growth rate can be achieved as the smallerleaves on the top part of the plants will allow the sun light to get through to thelower ones, maximizing the capacity for thephotosynthesis of the whole plant.

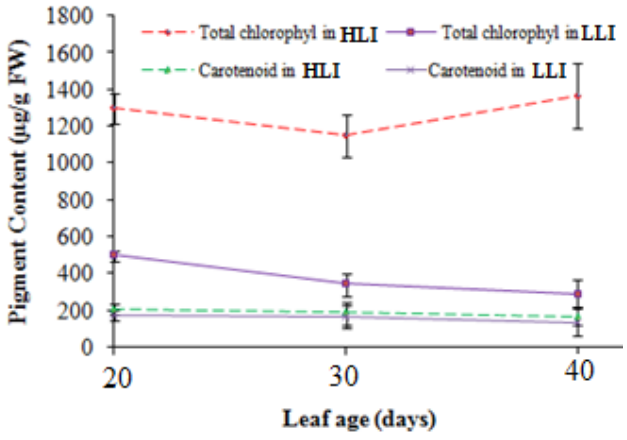

Figure 4. Total chlorophyll and total carotenoid contents in the mature leaves thatdeveloped in the high intensity light (HLI) or low intensity light (LLI) environment.

The Effects of Light Intensity on Leaf Thickness

Thickness of leaf was indicatedby specific leaf weight data. Lightintensity did not affect the thickness of theleaves that were mature before the lighttreatment was started, according to thespecific leaf weight data (Fig. 7). Aconsistent result was also found from theleaf anatomy study. There is no significantdifference between observed between LLI and HLI leafstructure during seven weeks of the light treatment (data not shown). In contrast, the light intensityeffects on leaf thickness could be clearlyseen in the leaves that developed in thedifferent light conditions (Fig. 7). Theleaves developing to maturation in the LLIcondition were thinner than the same-agedleaves developing in the high lightcondition, resulting in lower specific leafweight (Fig. 7).

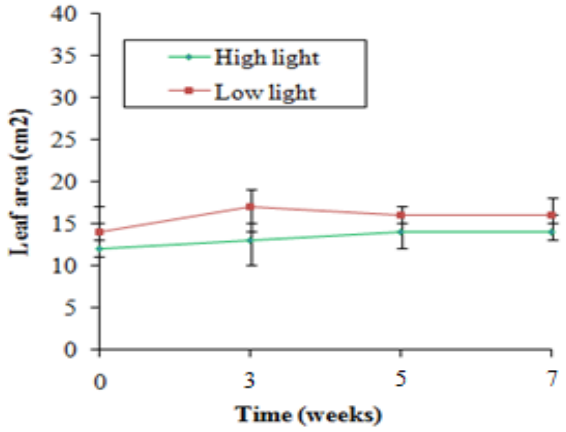

Figure 5. Leaf area of the fifth leaf from the top of the plant starting the experiment (week 0).

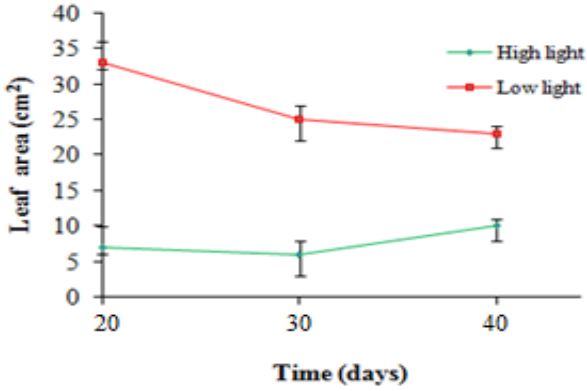

Figure 6. Leaf area of the mature leaves (20, 30, and 40 day-old leaves) developingin the provided light treatments.

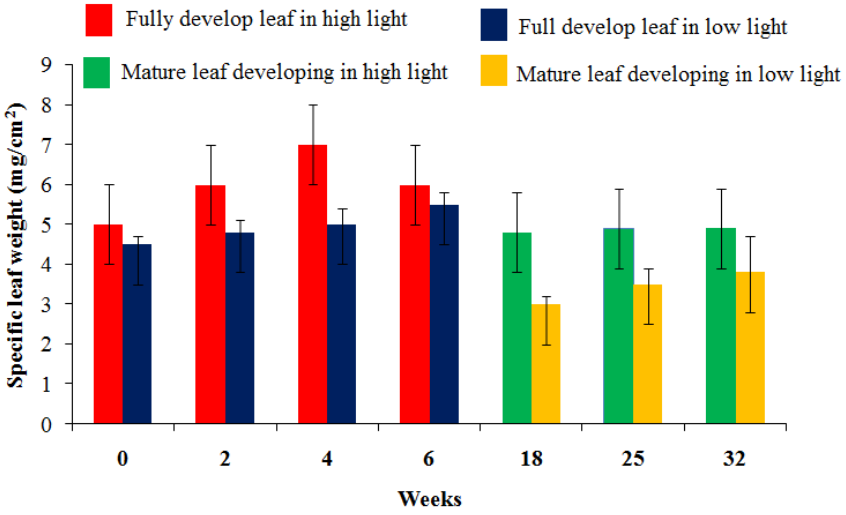

Figure 7. Specific leaf weight of the leaves that fully developed before and duringthe light treatment. The results obtained from fully developed leavesare the means of five replicates, and the results obtained from thedeveloping leaves are means of three replicates.

Because of the sieve effect and light channeling, the light penetrates the first layer ofpalisade cells, [13] In the highintensity light condition, many cell layersbenefit from the light absorption, but inthe low light condition, the irregularshapedcells increase the interfacesbetween air and water which reflects andrefracts the light, thereby randomizing itsdirection of travel. This process of lightscattering increases the probability for light absorption [13].The second layer ofirregular-shaped palisade cells in the LLIleaves may help the light scatteringprocess to increase the light absorption.

CONCLUSION

The physiological, morphologicaland anatomical adaptations of crotonleaves were strongly affected by the intensities of lights. The chlorophyll content has found to be changed as compared after the treatment of leaves with different intensities of lights. LLI increases the concentration of chl *a* and chl *b* while HLI on the otherhand reduces the level of chl *a* and chl *b* in the leaves of *Croton tiglium.* Mature leaves remained unaffected and shows no morphological and anatomical changes.

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