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Effect of Different Shade Levels on Vegetative Growth of *Pogostemon heyneanus* Benth. (Lamiaceae)

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ABSTRACT

A field experiment was conducted to determine the effect of different shade levels (full sunlight, 50% and 70%) on growth of *Pogostemon heyneanus* in terms of plant height, number of leaves, number of branches, branch length, plant spread, stem diameter and total chlorophyll content. The treatments were arranged with Randomized Complete Block Design (RCBD) with three replicates. A two way ANOVA was performed to analyze plant growth data taken at fortnight intervals for the period of two months. During the period of study plant height, number of leaves, number of branches, branch length, plant spread, and plant girth significantly increased with increasing shade levels. For the all tested parameters the highest growth was found in plants grown under the shade of 70%, while that of minimum was found in plants grown under full sunlight. The highest amount of foliar chlorophyll content was found in the plants grown under 70% shade followed by plants grown under 50% shade and full sunlight. The results concluded that *Pogostemon heyneanus* grows well under intensive shade conditions. However, before the recommendations, further studies have to be carried out in terms of total herb yield, oil content, oil composition, secondary metabolite contents and bioactivity for an extended period of time.

KEYWORDS: Chlorophyll content, *Pogostemon heyneanus*, Shade levels, Vegetative growth

INTRODUCTION

Pogostemon heyneanus Benth., otherwise called '*kollankola*', is reported to occur in India, Indonesia, Malaysia and Sri Lanka (Bhatti and Ingrouille, 1997; Keng, 1978). It is believed to be indigenous to Southern India and Sri Lanka (Keng, 1978). The plant is a strongly aromatic, sparsely pubescent shrub which grows wild in moist, partially shady places in semi-evergreen and evergreen forests.

The studies revealed that the essential oil distilled from leaves and stems of *P. heyneanus* is unique in quality as it is rich in acetophenone which is not found in commercially available patchouli oil extracted from *P. cablin* (Murugan *et al.*, 2010). This will give an additional benefit in using *P. heyneanus* for extracting patchouli oil which is highly demanded in food, perfumery and pharmaceutical industries.

Recent studies have found that there is a high potential for commercial scale cultivation of *P. heyneanus* in Sri Lanka (Rathnayake *et al.*, 2014). However, the effect of local external environmental factors on growth of *P. heyneanus* is not studied under the field conditions.

Light is one of the most important limiting factors for growth and biomass of the plant (Long *et al.*, 2012). In medicinal plants, essential oil yield is strictly related to the studied genus of the medicinal plant physiological aspects, which are also influenced by environmental factors; among these, solar radiation is one of the most relevant factors (Mattana *et al.*, 2010). Further studies have revealed that the changes of microclimate due to solar radiation may influence on plant accumulation and distribution of its secondary metabolites (Jaafar *et al.*, 2008).

A study suggests that *P. cablin* which also similar in genus as *P. heyneanus* grows well under partial shade (50%) and the conditions of that particular shade may enhance chlorophyll in leaves, oil content and change the chemical composition of oil (Rao *et al.*, 1997). So far similar study has not been conducted on *P. heyneanus* to study its responses to shade.

Therefore, the main objective of this study is to determine the effects of full sunlight, 50% and 70% shade levels on growth of *P. heyneanus*.

MATERIALS AND METHODS

Experimental Site

Experiment was carried out in the experimental plots of the Department of Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP) from January to May 2016. The experimental site was located in the Low Country Intermediate-Zone (IL_{1a}), at an elevation of 25 m above mean sea level (Panabokke, 1996).

Field Experimental Design and Treatments

The experiment was conducted with three treatments namely under full sunlight, 50% and 70% shade levels using randomized complete block design with three replicates.

Field Planting

Six weeks old rooted hardwood double nodal stem cuttings of *P. heyneanus* were planted on ridges with the spacing of 90 × 75 cm. A plot of 4.5 × 4.5 m was contained 30 plants. Shade treatments were imposed using shading nets of 50 and 70% above the galvanized iron frames and fixed at a height of 3 m above the ground to provide 50 and 70% reduction in light. Sprinkler irrigation kit was installed on the plots to irrigate plants daily and hand weeding was done to keep the plots weed free.

Growth Analysis

Ten plants per plot were selected for taking records on plant height, plant spread, stem diameter, number of branches/plant and number of leaves/plant at two week interval.

Determination of Foliar Chlorophyll Content

Acetone with 80% concentration leaf extractions included with 0.5 g of leaf samples were tested for absorbance at wave lengths of 645 nm and 663 nm using a spectrophotometer to determine foliar chlorophyll contents (mg/g) under different shade levels.

Statistical Analysis

Statistical comparison of mean values was performed by General Linear Model (GLM) of ANOVA followed by Duncan's Multiple Range Test using the SAS and presented as means±SD with 95% confidence level.

RESULTS AND DISCUSSIONS

Plant Height

The shade level had significant effect on plant height of *P. heyneanus*. During the study the tallest plants were observed under the 70% shade as 49.3, 60.9, 65.6 and 76.1 cm respectively in two, four six and eight weeks after planting (Figure 1). The plants grown under full sunlight recorded the shortest plant height as 44.4, 46.1, 49 and 56.3 cm respectively in two, four six and eight weeks after planting (Figure 1). In second week of the study though the mean plant height of 70% shade was the highest it was not significantly different from mean plant height of 50% shade (48.9 cm). However, four weeks after planting onwards the mean plant heights of three different shading conditions were significantly different from each other. This was in conformity with the findings of Moniruzzaman *et al.* (2009) stating that plants grown in low light levels showed more apical dominance than those grown in high light environments resulting in taller plants under shade. Shading produced taller plants due to shoot growth as they looked for light, indicating the activation of some phototropism responses to modify plant leaf distribution in order to limit mutual shading (Takemiya *et al.*, 2005).

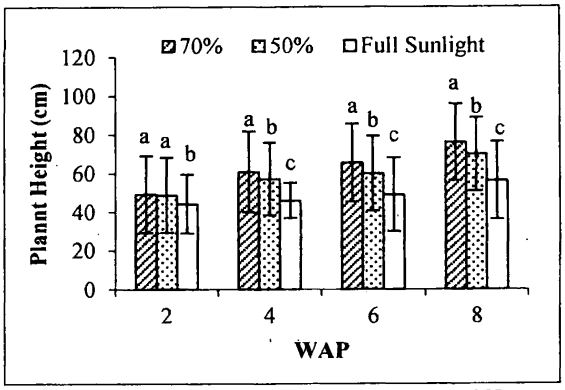

Figure 1. Plant height *vs.* WAP in different shade levels *Means with same letters are not significantly different at the 0.05 level; (n=30), WAP- Weeks After Planting*

Number of Branches per Plant

The 70% shade recorded the highest total number of branches 2.4 and 7.2 respectively 2nd and 8th week after planting (Figure 2). However, 50% shade recorded the highest number of branches 3.6 and 4.7 respectively in 4th and 6th week after planting (Figure 2). Throughout the study the least number of branches 2, 3, 3.3 and 5.5 were found respectively in two, four, six and eight weeks after planting (Figure 2).

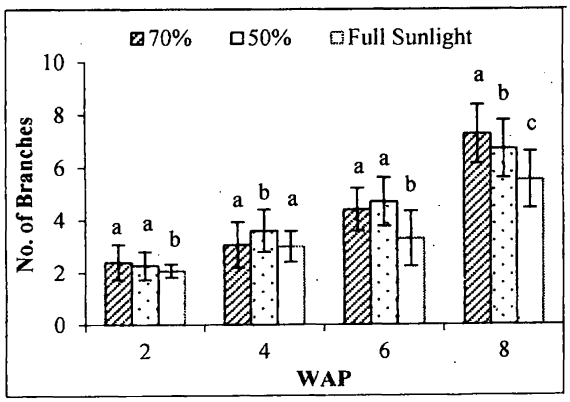

Figure 2. Number of branches *vs.* WAP in different shade levels *Means with same letters are not significantly different at the 0.05 level; (n=30), WAP- Weeks After Planting*

Branch Length

The mean branch lengths were found significantly increased as the intensity of shade was increased. In 2nd week of study the branch length of 70% shade (44.1 cm) was not

significantly different from that of 50% shade (Figure 3). However, mean branch lengths 55.7, 62.7 and 71.1 cm of 70% shade respectively recorded in four, six and eight weeks after planting were significantly different from two other treatments (Figure 3). A significant reduction was observed in branch lengths of plants grown under full sun light as under it the shortest lengths 40.1, 42.6, 45.7 and 52 cm were recorded respectively in 2nd, 4th, 6th and 8th week of the study (Figure 3). This would be mainly due to the elongation in intermodal length of shade grown plants in order to capture more sun light. The increased branch length of shade grown plants due to increased mean intermodal lengths was also reported by Gong *et al.* (1999).

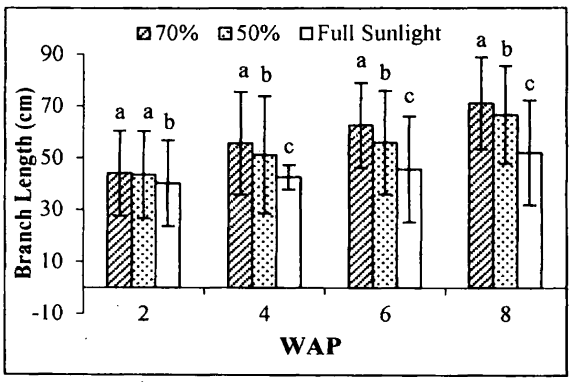

Figure 3. Branch length *vs.* WAP in different shade levels *Means with same letters are not significantly different at the 0.05 level; (n=30), WAP- Weeks After Planting*

Number of Leaves per Plant

Two weeks after planting the plants of 50% shade had the highest total number of leaves per plant (54.7) followed by 70% shade (53.8) and under full sunlight (24.2) (Figure 4). However the plant heights of 50% and 70% shades were significantly not different. Four weeks after planting onwards significant increase was found in plants of 70% as it recorded the maximum number of leaves per plant 219.4, 404.4 and 668.0 respectively in four, six and eight weeks after planting (Figure 4). A significant reduction was observed in total number of leaves per plant under full sun light as it recorded 83, 160.8 and 198 respectively in four, six and eight weeks after planting (Figure 4). According to Wahid *et al.* (2007) high temperatures at low shade levels can cause damages in foliar growth such as the burning of leaves, leaf abscission, discoloration and ultimately the reduction in leaf yield. This would be a one such reason behind the significant reduction which was found in total number of leaves as the intensity of shade was reduced. Similar results were obtained by Rachmah *et al.* (2015) where the significant decrease was observed in total number of leaves as the level of shade intensity was decreased.

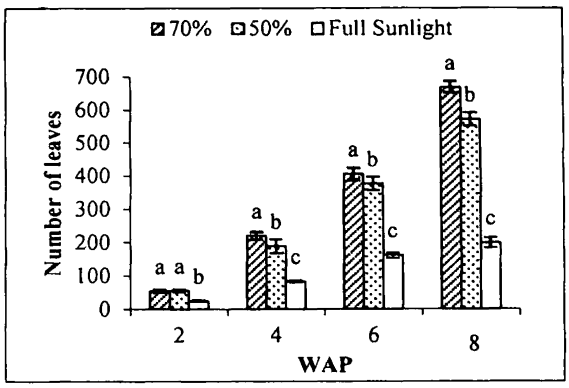

Figure 4. Number of Leaves *vs.* WAP in different shade levels *Means with same letters are not significantly different at the 0.05 level, (n=30), WAP-Weeks After Planting*

Plant Spread

It was clearly observed that the shading had significant effect on spread of plants. The plant spreads 28.90, 52.23, 70.25 and 91.90 cm taken respectively in 2nd, 4th, 6th and 8th weeks of the study under the 70% shade were significantly the highest whereas spreads 170.8, 206.53, 238.16 and 380.21 cm found respectively in 2nd, 4th, 6th and 8th weeks of the study under the full sun light were significantly the least (Figure 5). This was mainly due to the increase in vegetative growth of *P. heyneanus* in terms of branch length, total no of leaves and leaf with the increase in shade.

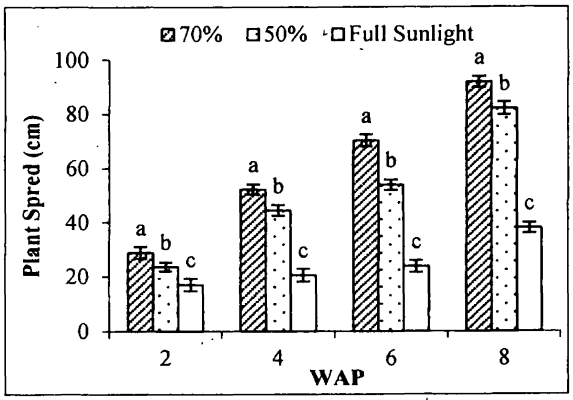

Figure 5. Plant spread *vs.* WAP in different shade levels *Means with same letters are not significantly different at the 0.05 level; (n=30), WAP- Weeks After Planting*

Stem Diameter

The highest plant stem diameter was observed in plants under 70% shade as it recorded mean stem diameter of 4.6, 6.6, 10.7 and 14.7 mm respectively in two, four, six and eight weeks after planting while that of the minimum was observed in plants grown under full sunlight as 3.9, 5.9, 6.5 and 9.2 mm respectively in two, four, six and eight weeks

after planting (Figure 6). During the first month of the study, the stem girths of plants under full sun light was significantly different from all other treatments but in between 50 and 70% shade levels the stem diameter was not significant. Fourth week onwards until the end of the study the mean stem diameters were significantly different from each other (Figure 6). This was in contrast with the findings of Rathnayake *et al.* (2015) where the stem diameter of *P. heyneanus* was not significantly different between the open field and under the partial shade of mature coconut palms. However girth responses to different shading conditions obtained in this study could be explained as an expansion in stem geometry to bare intense vegetation growth which was found with the increase in shade.

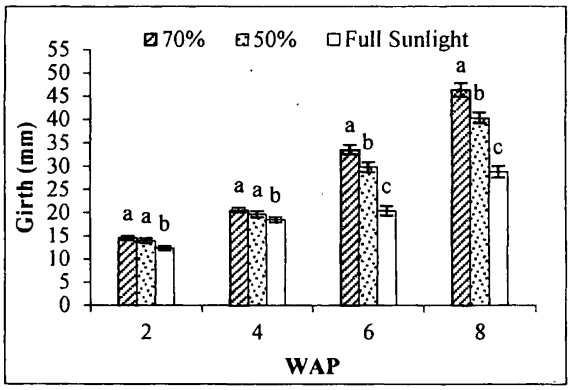

Figure 6. Plant girth *vs.* WAP in different shade levels *Means with same letters are not significantly different at the 0.05 level, (n=30), WAP- Weeks After Planting*

Foliar Chlorophyll Content

The highest mean chlorophyll a, b and total chlorophyll contents were found under the 70% shaded plants respectively as 1.47, 0.65 and 2.11 mg/g (Table 1) while those of the least were found in plants grown under full sunlight respectively in 1.09, 0.45 and 1.54 mg/g (Table 1). The chlorophyll a, b and total chlorophyll found in plants under the 70% shade were significantly different from those of plants under the 50% shade and under the full sunlight. However, there were no any significant differences between the plants under the 50% shade and full sunlight. This would be mainly due to the ability of plants in increasing total chlorophyll content for improving the efficiency of light harvesting to withstand intensive shaded conditions. The findings of foliar chlorophyll of the study can be further confirmed by in Rao *et al.* (1997) where the higher chlorophyll content of *P. cablin* was found under the partially shaded conditions than the open field.

Table 1. Foliar chlorophyll a, b and total chlorophyll contents under different shade levels

Shade level	Chloro. a	Chloro. b	Total Chloro.
70%	1.47±0.08 [a]	0.65±0.04[a]	2.11±0.12 [a]
50%	1.13±0.10 [b]	0.46±0.04 [b]	1.59±0.14 [b]
Full Sunlight	1.09±0.09 [b]	0.45±0.04 [b]	1.54±0.13 [b]

Means with same letters are not significantly different at the 0.05 level; Chloro.- Chlorophyll

CONCLUSIONS

Pogostemon heyneanus had the highest vegetative growth under the shade of 70%. It could be partially justified that *P. heyneanus* could be successfully cultivated under the intensive shaded conditions. However, the current study has to be further continued on herbage yield, oil content, oil composition, secondary metabolite contents and bioactivity for an extended period of time before recommendations.

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