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Full Length Research Paper

Growth and dry matter partitioning of *Andrographis paniculata* to different light intensities and pruning

Nur Faezah, O[a], Siti Aishah, H[a,*], Puteri Edaroyati, M.W[a], Ramlan, M.F[a], Puad, M.A.[b]

[a]Department of Crop Science, [b] Department of Cell and Molecular Biology, University Putra Malaysia, 43400 Serdang, Selangor.

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Studies indicate that the physiological aspects and growth pattern under different light intensities can affect the composition and quality of herbs. The objective of this study was to determine the effect of shade level and method of pruning to optimize high dry herbage yield per hectare of *Andrographis paniculata*. A factorial experiment was arranged in split plot design with three replications. The following shade levels: 0, 20%, 30% and 50% were the main plot while number of pruning: 0, 1 times and 2 times were the sub plot. Both factors, shade levels and pruning showed significant interaction effect on total leaf area, shoot fresh weight and shoot dry weight. Root fresh weight and dry weight were not influenced by both factors. Shoot fresh weight and shoot dry weight showed significant increase with the increase in shade levels. Meanwhile the lowest shoot dry weight was recorded from plant grown under full sunlight. Method of pruning significantly produced higher shoot fresh weight by 18.6% and shoot dry weight by 15.4% compared no unpruned plant. *A .paniculata* grown under shade and undergone one time pruning would help in higher biomass production.

Keywords: *Andrographis paniculata*, light intensity, method of pruning, biomass production

INTRODUCTION

Andrographis paniculata known as “king of bitters” belongs to family Acanthaceae (Kumar et al, 2012). It is an annual herb and shrubs plant which distributed in tropical Asian countries, often in isolated patches. It can be found in a variety of habitats such as plains, hillsides, coastlines and distributed areas such as farms and wastelands. *A. paniculata* is one of major herbs that has been proven to posses various pharmacological activities including anticancer and immunostimulatory (Kumar et al., 2012), anti-inflammatory as well as anti-malarial (Mishra et al., 2007).The suitable environment to plant *A. paniculata* is in moderate, tropical and subtropical climate with rainfall of 1500-2000mm per year (Zaharah et al., 2001). *A. paniculata* will grow well in shaded places such as undergrowth in forest (Valdiani et al., 2012).

The issues currently facing the herbal industry begin right at the cultivation stage. With no standardized farming practices especially for high temperatures and rainfall area such as Malaysia, it is difficult to achieve consistency in output and quality, with supply often not being enough to cope with market demand (Ganesan, 2011). There are still

*Corresponding author email: s_aishah@upm.edu.my

lacking in research and development on agronomic cultural practices. This may be lack of information on growth and physiology related to different light intensities and method of pruning of *A. paniculata* (Saravanan et al., 2008).

Pruning is an important cultural practice that has been shown to enhance both productivity and quality of plant. A study by Yilmaz et al. (2004) on tea shown that pruning affected the composition and quality of tea leaves. Calatayud et al. (2008) reported that pruned plant has higher capacity to promote the photosynthetic light reaction, a large number of metabolic sinks and a higher turgor pressure compared to unpruned plant. Plants have a functional equilibrium between their above ground parts (leaves) and below ground parts (roots). If plants are pruned the starch reserves in the roots are utilized for shoot growth to maintain equilibrium (Zeing, 2003).

Light is the major factor to the life cycle of plant, because it is the energy source that triggers the process of photosynthesis. All plants need sunlight to make their food, and if the available sunlight is reduced the plant have to change and adapt in various ways in order to acclimatize to a new environment. Excessive light intensity resulted in photosynthesis inhibition as it has destructive effect on photosynthetic pigments (Kumar et al, 2012). A characteristic of *A. paniculata* leaf is that it changes its color from green to red and vice versa from time to time, when exposed to varying intensities of light and shaded. Their leaves that exposed to bright sunlight had up 35% lower chlorophyll and 30% higher oxalic acid concentrations, indicating that the change in pigment composition and oxalic concentrations may be defensive mechanism to protect the photosynthetic apparatus from bright light (Palaniswamy, 2005). Shading is important as to reduce high light intensity and temperature and also to reduce moisture requirement. Under natural conditions, *A. paniculata* is found in both shaded and wide open areas. Light is one of the aspects in environment factor found to be influenced the secondary metabolite production in *A. paniculata* (Kumar et al., 2012).

Growth pattern and levels of shade (%) can affect the composition and quality of the plant. Therefore, the objective of this study was to determine the effect of shade level and method of pruning to optimize high dry herbage yield per hectare.

MATERIALS AND METHODS

Experimental design

The factorial experiment was carried out at University Putra Malaysia from June 2014 to September 2014. The treatments were arranged in split plot design with three replications. The following shade levels: 0, 20%, 30% and 50% were the main plot while number of pruning: 0, 1 times and 2 times were the sub plot. Netting was used to provide shade according to treatment level. Plants were irrigated manually twice per day. The level of light intensity was calculated based on light intensity measured at noon (approx. 1600-1700 mmol m-2s-1) using light meter (Li-COR Model LI-189).

Planting materials and maintenance

Scarified seeds were sown in petri dish and kept in the seed germinator at 28 °C with 70 % relative humidity for 7 - 10 days. The scarification method was conducted as described by Talei et al., (2012). Seedling were transferred into jiffy pot and placed at the nursery for 1 month. Sandy clay loam soil was used as planting media. The soil was mixed with 15 t/ha of EFB biochar during soil preparation and organic fertilizer was applied at transplanting and second fertilizer applied at 6^{th} weeks after transplanting (WAT). The amount of organic fertilizer used was calculated equivalent to N (210 kg of N per ha). Four week old seedlings were transplanted into polybags measuring 35 cm x 40 cm. Pruning was done by cutting the tip of the growth bud (angled at a moderate 35 - 45 degree slant) at the same level. First pruning was done at 6^{th} WAT and second pruning was at 8^{th} WAT. Whole plants were harvested after 12^{th} WAT prior to the sign of flowering.

Growth analysis

The following parameters were measured: plant height, leaf area, number of branches, fresh weight (FW) and dry weight (DW). The plant heights were recorded at 2 weeks interval after transplanting. Plant height was measured from the base of the plant at media surface to the top of the youngest newly expanded leaf using steel meter-ruler (Cornelissen, 2003). After harvesting, plants were washed from soil particles using tap water and separated into shoots (leaf and stem) and roots. Roots and shoots were separately weighed. Leaf samples including petiole were measured for total leaf area per plant using LI-3100C Leaf Area Meter (Li-COR, Lincoln, NE, USA). All samples were oven dried at 50°C to a constant mass and then weighed (Model Sartorius A&D FX200iWP, Germany). Dry weight for roots and shoot were recorded and root/shoot ratio was calculated for each treatment.

Statistical analysis

The data were analyzed using analysis of variance (ANOVA) and a significant difference between means was done by least significant difference (LSD) test ($p < 0.05$).

RESULTS AND DISCUSSION

Generally, light is one of the most important environmental factors, providing plants with both a source of energy and

Table 1. ANOVA of means square [MS (Pr > F)] for no of branches and total leaf area (TLA) of *A. paniculata* as influenced by shade levels and pruning

Source	No of branches	TLA
Shade levels (S)	4.32ns	3977.01**
Pruning (P)	2.49ns	1396.79*
S x P	2.26ns	524.18*
CV (%)	10.79	12.75

ns ** * non-significant or significant at $p \leq 0.01$, $p \leq 0.05$, respectively

Table 2. ANOVA of means square [MS (Pr > F)] for shoot fresh weight (SFW), shoot dry weight (SDW), root fresh weight (RFW), root dry weight (RDW) and root to shoot ratio of *A. paniculata* as influenced by shade levels and pruning

Source	SFW	SDW	RFW	RDW	Root : Shoot
Shade levels (S)	109.79**	154.77**	30.04**	7.14**	0.015 **
Pruning (P)	64.18*	5.25**	3.31*	0.04ns	0.005 *
S x P	13.18*	0.98*	0.59ns	0.022ns	0.004 *
CV (%)	7.07	4.68	4.30	6.93	6.21

ns ** * non-significant or significant at $p \leq 0.01$, $p \leq 0.05$, respectively.

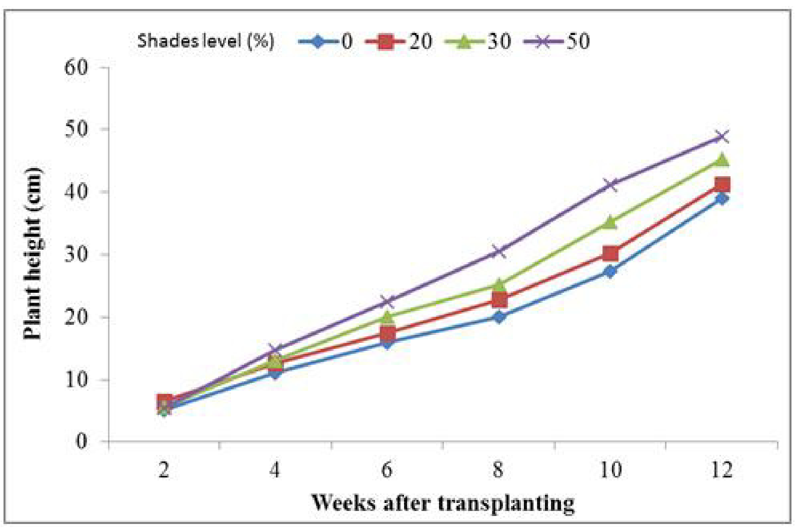

Figure 1. Effect of shades levels on plant height at various plant ages

informational signals that regulate their growth and development. The effects of shade levels and pruning on number of branches and total leaf area of *A. paniculata* were shown in Table 1. Analysis of variance shown in Table 1 indicated that there were insignificant interaction effect on number of branches while there were significant interaction effect on total leaf area. Furthermore, analysis of variance indicated interaction effects for shoot fresh weight, shoot dry weight and shoot to root ratio, however there were no significant interaction effect between shade levels and pruning on root fresh weight and root dry weight (Table 2).

In this experiment, results suggested that the response of *A. paniculata* to light is similar to many shade avoiding plants growing under different shade levels. Plant height was varied under different light intensities. Across all the light intensities, the height of the plant increased with increased in shade levels (Figure 1). At 12 weeks after transplanting (WAT) the tallest plant was recorded from plant grown under 50% shade. Plant height was reduced

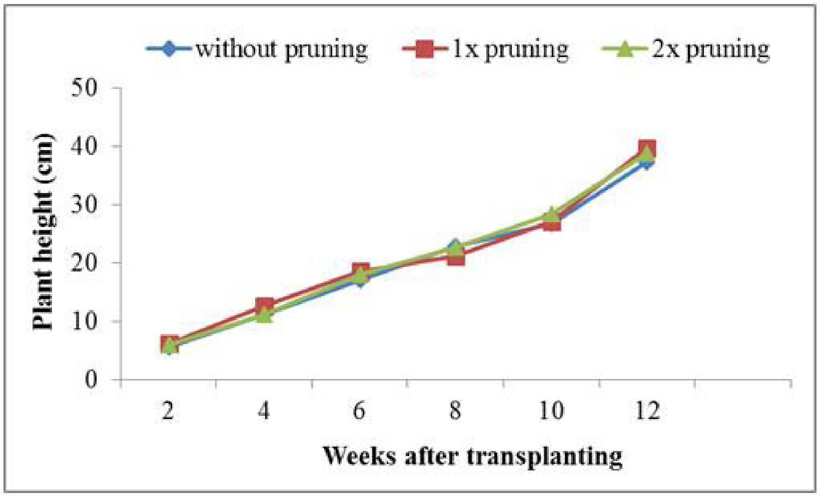

Figure 2. Effect of pruning on plant height at various plant ages

Table 3. No of branches, total leaf area (TLA), shoot fresh weight (SFW), shoot dry weight (SDW), root fresh weight (RFW) and root dry weight (RDW) as affected by different shade levels and number of pruning of *A. paniculata.*

Factors	No of branches	TLA (cm^2)	SFW (g)	SDW (g)	RFW (g)	RDW (g)	Root : Shoot
Shade levels (S) (%)							
0	15.7 a [z]	756.93 c	26.21 d	6.49 d	15.58 b	2.24 b	0.34 a
20	16.1 a	937.30 b	31.18 c	8.60 c	15.19 b	2.37 b	0.27 b
30	16.3 a	1103.32 a	45.60 b	13.24 b	25.81 a	3.84 a	0.28 b
50	16.7 a	1093.94 a	49.11 a	15.52 a	25.23 a	3.85 a	0.24 c
Pruning (P)							
0	15.4 a	826.16 b	34.41 b	10.21 b	20.08 a	3.03 a	0.30 a
1x	16.4 a	1013.41 a	39.83 a	11.40 a	20.22 a	3.14 a	0.28 b
2x	15.7 a	1004.06 a	40.82 a	11.78 a	21.00 a	3.06 a	0.26 c
S x P	ns	*	*	*	ns	ns	*

ns * non-significant or significant at $p \leq 0.05$, respectively. [z] Means with same letter are not significantly different by LSD, at 5%.

when grown under high and medium light intensity compared to low intensity .This result inclined with the previous experiments whereby shade avoiding species are typically taller than shade tolerant species growing under shade (Mattana et al., 2006). According to Saravanan et al. 2008, *A. paniculata* plants were shorter and having reduced internodal length and compact grown under open light. Relatively taller plant observed at 12 WAT when plant undergone 1x and 2x pruning compared to non-pruning plant (Figure 2).
There was a significant interaction effect between shade levels and pruning of *A. paniculata* for total leaf area, shoot fresh weight, shoot dry weight and shoot to root ratio (Table 3). However, there was no significant interaction on number of branches, root fresh weight and root dry weight. Number of branches was not significantly different regardless of shade levels. Meanwhile, root fresh weight and root dry weight were not affected by pruning. Total leaf area showed a significant quadratic relationship with both factors, whereby the total leaf area increased as shade level increased with 1x pruning (Figure 3). There was a significant quadratic decrease in leaf area for 2x pruning as shade level increase to 50% shade. A significant interaction effect between shade levels and pruning was

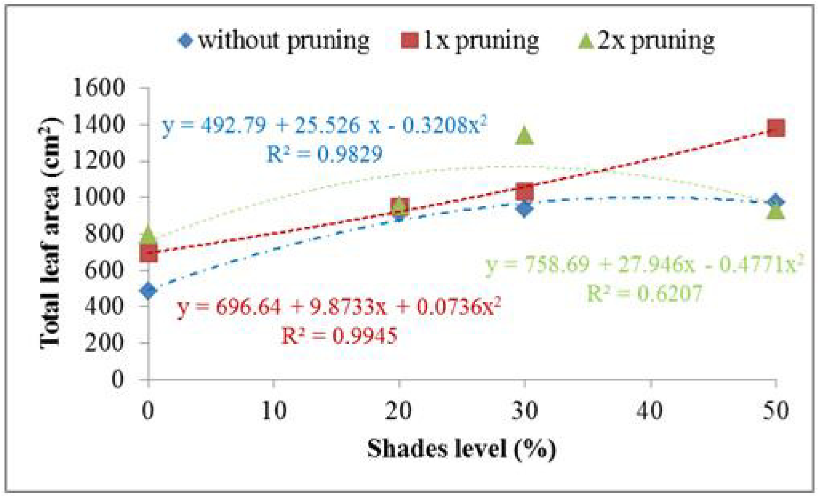

Figure 3. Total leaf area as affected by different shade levels and number of pruning of *A. paniculata*

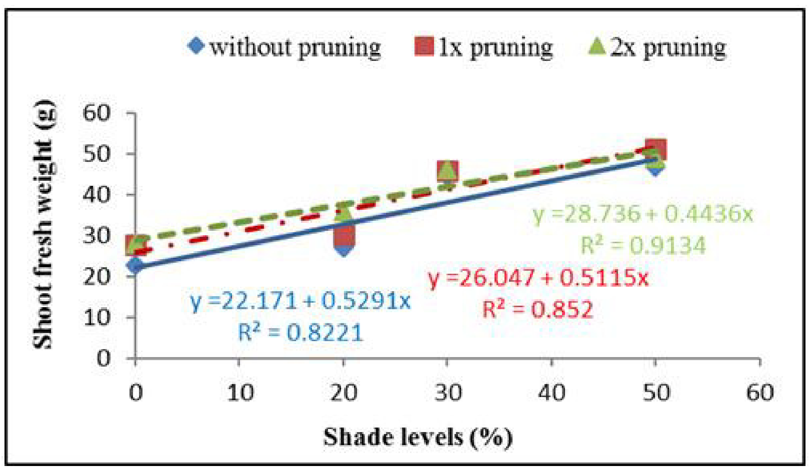

Figure 4. Shoot dry weight as affected by different shade levels and number of pruning of *A. paniculata*

found on shoot mass (Table 3). From Figure 4, the effects of shade levels and pruning indicated significant linear interaction effect between both factors on shoot fresh weight. Similar trend was obtained on shoot dry weight (Figure 5), whereby the regression showed higher shoot dry weight produced when plant grown under 50% shade and had one time pruning.

Shoot fresh weight and shoot dry weight showed significant increase with the increase in shade levels (Table 2). The lowest shoot dry weight was recorded from plant grown under full sunlight. Method of pruning significantly produced higher shoot fresh weight by 18.6% and shoot dry weight by 15.4% compare to non-pruning plant. This result was similar to Calatayud et al. 2008 who noted pruned roses plants showed significantly higher values for the fresh weight to dry weight ratios. This is due to the expansion of new shoots that may cause a temporary depletion of stored metabolites from older shoots, hence causing a decrease in flower production (Calatayud et al., 2008).

There was a significant linear decrease in root to shoot ratio of number of pruning as shade level increase to 50% (Figure 6). Across all the light intensities, a significantly higher root to shoot ratio when plant exposed to full sunlight (0% shades), while the lowest was recorded by plant grown under 50% shade. Among number of pruning, significantly lower root-shoot ratio when undergone 2x pruning. The root to shoot ratio is usually given as the ratio of the weight of the roots to the weight of the top of a plant. The better shoot growth attributed to lower root to shoot ratio. Most plants are able to adapt to changing conditions if the changes are not too drastic or rapid. According to Harris (1992), an increase in the root-shoot ratio would indicate that a plant was probably growing under less favorable conditions. In this study, the top of the plant is pruned hence, relatively more carbohydrates are utilized to

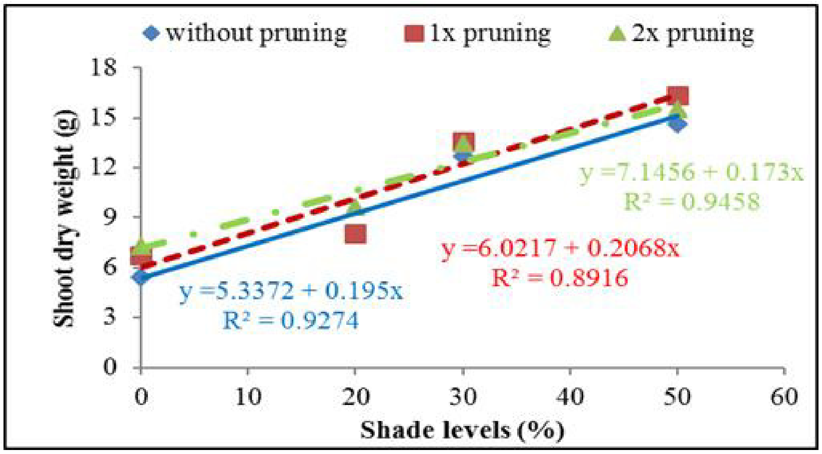

Figure 5. Shoot dry weight as affected by different shade levels and number of pruning of *A. paniculata*

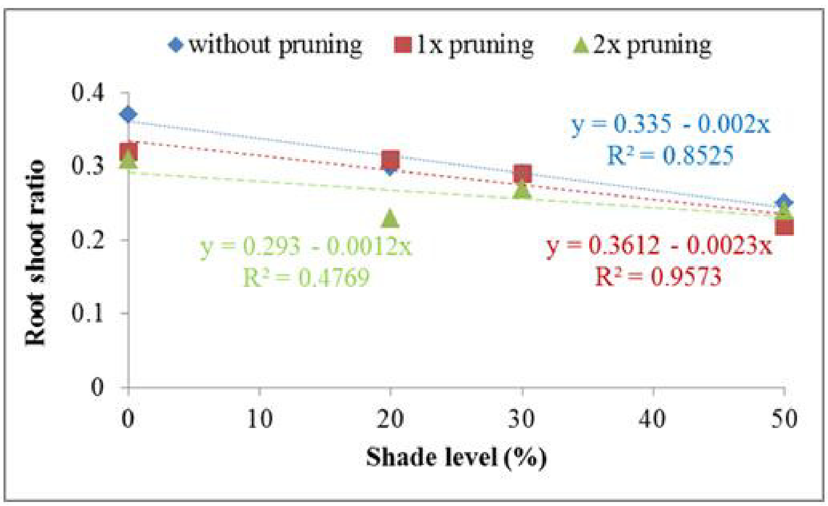

Figure 6. Root to shoot ratio as affected by different shade levels and number of pruning of A. paniculata

restore the top and less are available for the roots. In opposition, if roots are damaged or nutrients and water become limiting, relatively more carbohydrates go to roots and less to the top (Harris, 1992).

Dry matter partitioning in vegetative organs and yield formation are affected not only by temperature, light and plant density but also by the fertilizer and by agronomic cultural practices. The accumulated mass and partitioning proportion directly influence vegetative and reproductive growth and population of the plant (Wang et al., 2012). Growth and physiology responses to light environment and cultural practices especially method of pruning can be useful measurements to determine favorable habitat conditions for the successful cultivation and conservation of medicinal plants. Furthermore, leaf area measurement is a great value in physiological and agronomic studies. Leaf area is important for plant light interception, growth analysis, photosynthesis, leaf area index estimation among others (Uzokwe et al., 2012). According to Sebahatin and Necdet (2007), decreasing light intensity reduced leaf area rapidly but at any given light intensity, increasing temperature resulted in a slight increase in leaf area. Shading is important as to reduce high light intensity and temperature and also to reduce moisture requirement.

CONCLUSIONS

In summary, it can be concluded that different light intensities and pruning are able to change growth of *A. paniculata* as both shade levels and pruning showed significant effect on growth of this plant. Shoot fresh weight and shoot dry weight showed significant increase with the increase in shade levels. In view of light factor, *A.*

paniculata grown under 50% shade were taller and had higher shoot dry weight. Whereas one time and two times of pruning gave higher shoot dry weight compared to unpruned plant. Results indicated that plant exposed to 50% shade and had one time pruning improved the biomass production. Increasing shade to the optimum ranges increased the plant height.

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