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EFFECT OF SHADING AND MULCHING ON THE GROWTH PERFORMANCE OF *Andrographis paniculata* Burm f.

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Abstract: *Andrographis paniculata* Burm f. is herbal plant that has shown potential for commercialisation. To obtain optimal production, proper plant management techniques must be identified. Therefore, this study aims to determine the effects of shading and mulching materials on the growth of *A. paniculata*. The study employed both shading and non-shading treatments to examine the effects, and five different types of mulching treatment were utilised: Non-mulched, coconut husk, rice husk, gravel, and sand. The results revealed that there were no significant differences between plants grown with or without shading, as well as between plants with or without mulching. Therefore, it was concluded that *A. paniculata* can survive and grow under both shaded and direct sunlight conditions, without the necessity of mulching. However, if mulching is deemed necessary, it is recommended to utilise finer materials that can easily decompose in the soil. This study represents an original idea that was developed and carried out to answer questions related to the cultivation of *A. paniculata.*

Keywords: Mulching, shading, growth performance, coconut husks.

Introduction

Malaysia, situated in Southeast Asia is a country that is rich in natural sources and is well-suited for the production of traditional herbal medicine production, particularly for commercial purposes. Among the plant species considered for commercial cultivation is *Andrographis paniculata*, locally known as "*Hempedu Bumi*" (Hossain *et al*., 2014). This medicinal plant, belonging to the Acanthaceae family is also known by various names such as Kalmegh, Kalnath, Kiriat and Mahatila, which means the "king of bitters" (Vijaykumar *et al*., 2007). The primary active compound in *A. paniculata* is andrographolide, which imparts a bitter taste (Sharma *et al*., 2017). *A. paniculata* is a medicinal plant that has been extensively utilised in traditional Asian medicines for centuries. Generally, it is used as a remedy for diabetes, high blood pressure, influenza, gonorrhoea and fever relief (Joseph, 2014). The plant is known for its "blood purifying" properties, making it useful in ailments where blood "abnormalities" are believed to contribute to the disease such as skin eruptions, boils, scabies, and chronic undetermined fevers (Akbar, 2011). Furthermore, recent studies have demonstrated the presence of anti-SARS-CoV-2 activity in *A. Paniculata*, suggesting its potential application in the treatment of COVID-19 (Sangiamsuntorn *et al*., 2021).

With the growing utilisation of *A. paniculata* in medicinal applications, ensuring high production and quality of the plants is crucial. One of the possible management approach for *A. paniculata* cultivation is mulching. Mulching materials can be categorised into three types: Organic materials, inorganic materials, and special materials (Kader *et al*., 2017). Organic mulching materials include agricultural waste (straw and stalks), wood industrial wastes (sawdust), processing residue (rice husks), and animal waste (manure). In contrast, inorganic mulching materials typically consist of petroleum-based products such as polyethylene plastic films (Gill, 2014) and synthetic polymers (Kyrikou & Briassoulis, 2007). Special mulching materials such as gravel (sand-gravel), concrete, and tephra mulch (Kader *et al*., 2017) can also be employed. It is crucial to choose mulching materials that do not harm the environment, particularly to the soil. This could be done by using mulching materials based on plant residue such as agricultural crop by-products. This type of mulching materials can improve soil health, promoting the growth of healthy plant populations and associated organisms. According to Chalker-Scott (2007), mulches are well-known for their ability to enhance formation of many woody and herbaceous species. Moreover, mulching plays a crucial role in producing medicinal plant raw materials that are free from chemical contamination, ensuring their safety when consumed or during subsequent processing stages. The scarcity of agricultural space has emerged as a significant challenge in recent times, emphasising the importance of optimal use of land, particularly in plantation areas. In Malaysia, vast expanses of land are dedicated to oil palm and rubber cultivation, presenting an opportunity to introduce valuable plant species such as *A. paniculata* that can thrive under the shading conditions created by these crops. This endeavour holds great potential for benefiting farmers and the country as a whole. Light intensity plays a pivotal role on plant growth, development, leaf size, crop yield, and the production of phytochemical compounds (Ayatullah *et al*., 2019). Changes in light conditions have a substantial impact on a wide array of physiological reactions. The efficiency of light-dependent processes has been shown to have a large impact on the production of tomato, pepper (Ili´c *et al*., 2015; Selahle *et al*., 2015; Mashabela *et al*., 2015), lettuce (Ili´c *et al*., 2017), and fresh herbs (Buthelezi *et al*., 2016).

The control of temperature and light is important as it affects the growth and quality of medicinal plants. Hot and sunny regions characterised by high temperatures and dry conditions can have increased solar radiation, temperature, and vapor pressure deficit, posing considerable challenges for growers or farmers as they have severe effects on plants, such as heightened plant stress, and reduced crop productivity and fruit quality (Gent, 2007). Shading is an economical and effective method to mitigate heat accumulation and manipulate the greenhouse environment, especially during hot seasons (Sethi & Sharma, 2007; Holcman & Senthelhas, 2012). While shading is commonly applied during seed germination, it holds potential as a management strategy for the production of *A. paniculata.* Although this plant naturally thrives in full light conditions, the exploration of its adaptability to shade is an understudied area. Plants that can flourish under shaded conditions have significant potential for mixed cropping, offering opportunities to enhance overall farm production and increase farmers' income.

According to Briassoulis *et al*. (2007), shading not only mitigates pollution, but also positively impacts the quality and homogeneity of the production. Additionally, shading has been found to influence the production of secondary metabolite in medicinal plants. For instance, basil grown under red net shading exhibited higher production of total phenolics and flavonoids (Milenković *et al*., 2021). In this study, a net was employed as a shade simulation, replicating the effects of real trees with a lighting rate of 70%. The application of few mulching materials was also observed to determine their effects on the growth performance and yield of *A. paniculata*.

Materials and Methods

Plant Materials

The study was conducted in the Greenhouse, Department of Agrotechnology, Universiti Malaysia Terengganu, from April to September 2017. *A. paniculata* seedlings were propagated through stem cuttings and allowed to grow for 2 weeks before being transplanted into polybags filled with a mixture of 5 kg of topsoil and 0.08 g of NPK green fertilizer (15:15:15) per bag. The average height of the seedlings used for transplantation was 10 cm.

Field Experiment

The plants were cultivated in two main plots, namely with (N1) and without shading (N2), and subjected to different type of mulching treatments. The shading was accomplished using a shade net with a 30% shade coefficient, meaning it blocked 30% of the light intensity. Four munching treatments were employed: Control without mulch (T0), coconut husk (T1), rice husk (T2), gravel (T3), and sand (T4). The experimental designed followed a split-plot design using complete randomisation, with four replicates for each main plot and were arranged randomly across four blocks. A layer of approximately 30 mm thickness of the specific mulching material was evenly distributed within each polybag for all the different mulching treatments (Hanim *et al*., 2014). Adequate watering was provided twice a day to maintain moist soil conditions. Pest and disease control measures were implemented throughout the plant's growth. Additionally, a 0.08 g portion of NPK green fertiliser with a ratio of 15:15:15 was applied to each polybag every 2 weeks.

Analysis of Plant Growth Characteristics

The plant height, number of leaves, number of branches, and leaf area were measured using a measuring tape and Ca I-202 Portable Laser Leaf Area Meter at two-week intervals, starting 3 weeks after the mulching application to the plants. At 12 weeks after planting, the fresh weight and dry weight of the plants were measured.

Data Analysis

All results obtained in this study was analysed by using two-way ANOVA using the IBM SPSS statistics software version 20. This application of two-way ANOVA was appropriate for this study since it involved two treatments, namely shading and the types of mulching material. Tukey's test was performed for multiple comparison of means, with statistical significance set at $p<0.05$.

Results and Discussion

Parameter of Growth Measured

Table 1: Growth performance of *A. paniculata* with different treatments of mulching and shading

Source of Variation (S.O.V)	Plant Height		Number of Branches		Number of Leaves		Leaf Area	
	Shading	Without Shading	Shading	Without Shading	Shading	Without Shading	Shading	Without Shading
Soil (control)	3.75^{aA}	13.125^{aA}	0.75^{aA}	3^{aA}	4.25^{aA}	15.17^{aA}	3.17^{aA}	9.72^{aA}
Soil + coconut husk	8.8125^{aA}	27.28125^{aA}	4.75^{aA}	12^{bcA}	14.33^{aA}	50.29^{aA}	27.81^{aA}	32.07^{aA}
Soil + rice husk	10^{aA}	15.5^{aA}	3.25^{aA}	7.5^{abcA}	14.38^{aA}	23.29^{aA}	16.60^{aA}	19.73^{aA}
Soil +gravel	15.8125^{aA}	8.5^{aA}	6.5^{aA}	3.5^{abA}	19.92^{aA}	10.54^{aA}	23.53^{aA}	8.5^{aA}
Soil + sand	3.75^{aA}	26.8125^{aA}	1.25^{aA}	15.25^{cB}	5.08^{aA}	47.50^{aB}	13.95^{aA}	37.44^{aA}
P-value	ns	ns	ns	0.038	ns	ns	ns	ns

*Mean values with the same letter in the same column for each attribute are not significantly different at p<0.05, **: Significant at p<0.05, ns=not significant.*
Different lowercase letter means significant difference between treatment.
Different uppercase letter means significant difference between shading and without shading.

Plant Height

Table 1 presents the mean height of *A. paniculata* based on the application of shading and the types of mulching treatment. The plant height for all mulching treatment plants without shading were higher compared with shaded plants, except for the "soil + gravel" treatment. However, according to the ANOVA analysis, there was no significant difference for the growth performance of the plant height based on the shading application $F(1,150) = 42.611$, $p<.05$ and the types of mulching treatment ($F(4,150) = 4.571$, $p<.05$). Furthermore, there was no interaction between the shading treatment and mulching treatment.

Plant Branches

Output table indicated that there is no significant interaction for the shading* treatment. In other words, the impact of the types of mulching material on the number of plant branches is not influenced by the shading application, as evidenced by the non-significant F-value, $F(4,230)=0.014$, $p<.05$. As shown in Table 1, the mean number of plant branches for all types of mulching treatment is higher for plants without shading compared with plants with shading. However, the only significant difference between shading and without shading was in the "soil + sand" mulching treatment. No significant differences were found in the number of branches among shaded plants across all mulching treatment. Among plants without shading, a significant difference in the number of branches was identified only for the sand treatment compared with the control. Based on the results table the highest mean number of plant branches (15.25) was observed for the sand mulch treatment in plants without shading, followed by coconut husk (12) and rice husk (7.5). Therefore, it can be concluded that the presence or absence of shading does not significantly affect the number of branches of *A. paniculata*, and only the sand mulching treatment without shading has a significant effect on the number of plant branches.

Plant Leaves

According to the ANOVA analysis, there is no significant difference for the growth performance of plant leaves based on the shading application. Additionally, there is no significant difference in the number of leaves among plants across all mulching treatments, with or without shading. Furthermore, no significant interaction was found for the shading treatment. The types of mulching material does not significantly affect the number of plant leaves, whether plants were shaded or not. However, a significant difference in the number of leaves was observed between plants with "soil + sand" mulching under shading compared with those without shading. Based on the Table 1, it can be concluded that different mulching types do not affect the number of plant leaves, and only the shading application on plants with "soil + sand" mulching is affected by the shading treatment.

Leaf Area

From the ANOVA analysis, it was found that there was no significant difference in the growth performance of the leaf area based on the shading application and the types of mulching treatment. Additionally, the output table also shows that there was no significant interaction for the shading* treatment. This suggests that the plant leaf area was not influenced by the mulching type or the shading application, as indicated by the non-significant F-value, $F(4,30)=.971$, $p>.05$. However, it is worth noting that plants without shading, specifically those treated with sand and coconut husk mulching, exhibited the highest leaf area compared with the other treatments.

Fresh Weight and Dry Weight

The results in Table 2 present the fresh weight and dry weight of *A. paniculata*. When comparing the shading application, it was observed that both the plant fresh weight and dry weight were higher for plants without shading compared to plants with shading for all types of mulching treatments. According to Table 2, plants with "soil + coconut husk" mulching without shading has the highest fresh weight (16.87 g) and dry weight (5.18 g), while plants with soil cultivated under shading (the control for shading treatment) has the lowest fresh weight (0.27 g) and dry weight (0.08 g). After the "soil + coconut" mulching treatment, those with sand mulching exhibited the highest fresh weight (13.56 g), followed by rice husk (6.34 g), and gravel (3.81 g). For plants with shading, the "soil + coconut husk" mulching treatment was followed by the "soil + sand" treatment (13.56 g), rice husk (6.34 g), and the "soil+ gravel" treatment (3.81 g).

Table 2: The fresh and dry weights of *A.paniculata*

	Fresh Weight		**Dry Weight**	
Treatment	**Shading**	**Without Shading**	**Shading**	**Without Shading**
Soil (control)	0.27^{aA}	1.72^{aA}	0.08^{aA}	0.44^{aA}
Soil + coconut husk	1.89^{aA}	16.87^{aA}	0.45^{aA}	5.18^{aA}
Soil + rice husk	2.99^{aA}	6.34^{aA}	0.92^{aA}	1.63^{aA}
Soil +gravel	3.63^{aA}	3.81^{aA}	0.98^{aA}	1.11^{aA}
Soil + sand	0.54^{aA}	13.56^{aA}	0.11^{aA}	4.11^{aB}
P-value	ns	ns	ns	ns

*Mean values with the same letter in the same column for each attribute are not significantly different at p<0.05, **: Significant at p<0.05, ns = not significant. Different lowercase letter means significant difference between treatment. Different uppercase letter means significant difference between shading and without shading.*

All of the fresh and dry weights of *A. paniculata* did not show significant differences among all treatments, despite the variations in the values of fresh weight and dry weights. The results from the ANOVA analysis in Table 2 indicate that the shading application ($F(1,30) = 9.190, p>.05$) did not significantly influence the growth performance of the plant fresh weight. Similarly, different types of mulching treatments also did not show significant differences in the plant fresh weight ($F(4,30)=1.731, p>.05$). However, the output table reveals a significant interaction effect for the shading* treatment. This suggests that the influence of mulching type on the plant fresh weight depends on the shading application ($F(4,30)=0.102, p>.05$).

Based on the result, the shading application did not significantly affect the growth performance of the plant dry weight. Different type of mulching treatments also did not show significant difference in the plant dry weight ($F(4,30)=1.612, p>.05$). However, it should be noted that the shading treatment had a significant effect on the dry weight of plants with "soil + sand" mulching. The output table indicates that there is no significant interaction between the mulching treatment and shading treatment, suggesting that the influence of the type of mulching on the plant fresh weight is not dependent on the shading application ($F(4,30)=0.038, P>0.05$).

The findings indicate that *A. paniculata* grown without shade demonstrate the highest growth performance compared with plants grown under shade. This is related to the growth habitat of *A. paniculata* that required a lots of sunlight. This can be attributed to the plant's preference for abundant sunlight, as stated by Akbar (2011) who emphasized the importance of high-intensity sunlight for commercial production and optimal growth of *A. paniculata*. Valio (2001) 30%, 10.6%, 4.8% and 1.8% of full sunlight. Shading for 60 days had no effect on survival, but it influenced all growth parameters measured. Total biomass decreased with decreasing irradiance, reflecting reductions in dry mass of leaves, stems, and roots. In response to shading, allocation of biomass to leaves increased, while allocation of biomass to roots decreased. Specific leaf area, leaf area ratio, and leaf mass ratio increased with decreasing irradiance. Decreases in relative growth rate were caused by reductions in net assimilation rate rather than leaf area ratio. Photosynthetic efficiency, as determined by the Fv/Fm ratio (Fv = variable fluorescence, Fm = maximal fluorescence also noted that shade-induced reduction in plant height is primarily caused by the decrease in internode number. Furthermore, Nur Faezah *et al.* (2016) suggested that *A. paniculata* reponds to light in a manner similar to shade-avoiding plants growing under different levels of shade.

The findings suggest that mulching is beneficial in *A. paniculata* production, as it resulted in increased growth. Although different types of mulching did not significantly influence plant leaf area, fresh weight, and dry weight. It can be concluded that the highest growth performance of *A. paniculata* was observed with coconut husk treatment, followed by sand, rice husk, gravel, and the control group. This indicates that using mulch materials can enhance growth performance and potentially lead to higher yields compared to no mulch materials. It is important to note that the observed effects of mulching may have been limited by the short duration of the experiment, which was only 3 months. Similar to organic fertilisers, which require time to show positive effects compared with chemical fertilisers, mulching also takes time to exhibit its full potential on plant growth. For instance, rice husk takes a longer time to decompose, mix with the soil, and be absorbed by plants.The increased in plant height in mulched plants can be attributed to improved availability of soil moisture and optimal soil temperature provided by mulches (Lee & Nikraz, 2015). Ahmad *et al.* (2011) reported that chili plants receiving mulch materials exhibited maximum plant height, while plants without mulch had the lowest height. This suggests that the availability of moisture and enhanced temperature during growth period of the plants influenced their heights. Furthermore, the increased number of plant leaves and branches observed in plants treated with mulch can be attributed to enhanced vegetative growth performance. Hallidri (2001) mentioned that mulching can increase the vegetative growth of plants such as stem or trunk diameter, as well as plant branches. Kader *et al.* (2017) highlighted the benefits of organic mulching materials such as straw and grass, which can improve soil moisture availability by reducing soil evaporation and maintaining soil temperature, thus, promoting crop production.

From the growth parameters, the morphological growth of *A. paniculata* under shading was not negatively affected. This finding is consistent with Saravenan *et al*. (2008), who reported no significant difference in *A. paniculata* grown under 30% and 50% shading coefficients compared with the control. It has been suggested that higher shading coefficients may contribute to better morphological growth, as observed by Liphan and Detpiratmongkol (2017). Thus, *A. paniculata* can be considered to be tolerant to shading conditions.

Conclusion

In summary, the shading and types of mulching materials did not have a significant influence on the overall growth and production of *A. paniculata*, except for the number of branches. This suggests that *A. paniculata* has the potential to thrive under shading conditions such as in oil palm and rubber plantations, where light intensity is around 70%. However, for optimal outcomes, the application of mulching for *A. paniculata* is not recommended, as there was no significant differences in the growth performance and yield of *A. paniculata* compared with plants without mulching. Based on these findings, further research in the field is recommended to explore the actual effects of planting *A. paniculata* under crop shade, including studying growth rates, yields, and the presence of active compounds in *A. paniculata.*

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