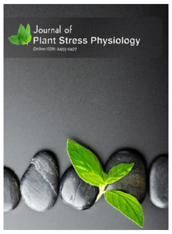
Journal of Plant Stress Physiology 2021, 7: 10-16
doi: 10.25081/jpsp.2021.v7.5924
http://updatepublishing.com/journal/index.php/jpsp

Research Article



ISSN: 2455-0477

Accumulation of total nutrients, dry matter and phytochrome content in *Boesenbergia stenophylla* R.M Smith as affected by different light conditions

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ABSTRACT

A study was conducted to determine the best agronomic practices for the cultivation of jerangau merah as a new medicinal crop. The total nutrients, dry matter yield and phytochrome content of *Bosenbergia stenophylla* R.M. Smith were determined under different light regimes. A study for determining suitable planting media for *B. stenophylla* was conducted at Universiti Putra Malaysia (UPM). The treatments are: i) (M1) with the ratio of 3:2:1 top soil: sand: organic matter, media ii) (M2) consists of soil mixture 3:2:1 placed in water-logged polyethylene bags and media iii) (M3) contained only leaf litters. The results showed that the herbs showed significant higher number of shoots and leaves in the common soil mixture. But, better root development in media containing leaf litters. The study proceeded with field experiment at Ba'Kelalan to determine the effect of different shade level and fertilizing regimes on growth. *B. stenophylla* was cultivated under two different levels of shade cloths: 70% and 90% level of shade and different fertilizing regimes (T1 as control, no fertilizer applied to the plants; T2, chicken dung; T3, NPK Mg and T4, mixed of chicken dung and NPKMg). The study for determining the effects of different shade level and fertilizing regimes on seedling's growth which conducted at Ba'Kelalan in factorial randomized completely blocked design (RCBD). The data collected for 9 weeks of planting which include nutrient content in soil, leaf, PAR and phytochrome content and growth parameters. Regarding the nutrient uptake, the results showed no interactions between fertilizing regimes and shade levels. There were no significant different in nutrient elements except for magnesium and potassium. Magnesium is essential for the formation of chlorophyll which ensure efficiency of photosynthesis when under higher light intensity. Among all the fertilizer treatment, it was showed that chicken dung amendment has higher nutrient uptake. Thus, it is recommended chicken dung should be added into the NPKMg for better nutrient uptake. Further study on suitable fertilizer rate apply to *B. stenophylla* should be taken into consideration. Moreover, plants cultivated under 70% have were higher and have higher dry matter yield than those plants cultivated under 90%. The result also revealed that there was significant different in chlorophyll content of *B. stenophylla* cultivated under 70% which treated either with chicken dung and NPKMG respectively. However, plants under 90% have higher chlorophyll content than those under 70%. Based on the results, plants under 70% shade was taller than those under 90% and there were significant difference in height among treatments under 70%. It was observed plant treated with NPKMg was taller. This study showed that shade and fertilizers significantly affected the dry matter yield of *B. stenophylla*. Moreover, adding NPKMg to the treatments yields more dry matter content of jerangau merah. As for phytochrome content, there was no significant effect of fertilizer on phytochrome content. However, there was significant difference among the shade levels. 90% shade showed higher phytochrome content than those under 70%. In overall, both shade and fertilizer is important in cultivation of Jerangau Merah. 70% shade was observed to have significant effects on growth of jerangau merah and also more economical compared to 90%. Moreover, combination of organic matter and NPKMg also promote the growth of jerangau merah enhance the nutrient uptake efficiency of jerangau merah. However, further investigation of suitable fertilizer and application rate are required to determine suitable fertilizer for jerangau merah and application rate for optimum growth of jerangau merah.

KEYWORDS: Jerangau merah, chlorophyll, cultivation, Zingiberaceae

Received: September 13, 2019
Revised: March 14, 2021
Accepted: March 17, 2021
Published: March 31, 2021

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INTRODUCTION

Boesernbergia stenophylla R.M. Smith is classified as highly endemic to the Borneo Highland in Sarawak. Records showed that they are specifically distributed in the Ba'kelalan and Bario regions (Poulsen, 2006; Aicher *et al.*, 2015). It is locally known as jerangau merah (malay) meaning red jerangau with reference to the maroon leaf sheath (Christensen, 2002; Ahmad & Jantan, 2003; Poulsen, 2006). It is related to gingers, turmeric and galangal which are all in the Zingiberaceae family and contained chemical properties of medicinal values. It grows in a clustering habit where it can reach up to 45 cm tall in height (Casey *et al.*, 2004). *B. stenophylla* is classified as understorey herbs, preferring heavy shades and organic soil. Its flower is white in colour resembling an orchid flower but they rarely produces flower. Their main mode of reproduction is through lateral vegetative rhizomes. A genetic variation studies using SSR and RAPD marker showed no variations among *B. stenophylla* accession from three sub populations (Aicher *et al.*, 2015). This is a common characteristics in plants that used vegetative rhizomes as their mode of reproduction. *B. stenophylla* is a favourite and highly sought herbs among locals in Sarawak because it is believe that the rhizome was able to weaken the effects of alcohol intoxication. Many of its uses revolve around on the local traditional knowledge and beliefs but none of these traditional knowledge are supported with scientific evidence. This includes uses to avoid alcohol intoxication, to relieve cough, diarrhoea and food poisoning, to cure flu in chickens and to evict evil spirits. Although its uses are not reported and given scientific studies, like many gingers, it may have many medicinal value that can be given further investigations. It was found that the essential oils of *B. stenophylla* is a source of methyl (*E*)-cinnamate' (Ahmad & Jantan, 2003). The antimicrobial activities of methyl cinnamate showed that they are antibacterial against *Escherichia coli*, *Bacillus subtilis* and *Staphyloccocus aureus* and, antifungal activity against *Candida albicans* (Huang *et al.*, 2009). It was also seen that *Eucalyptus olida* produced a strong defensive chemical methyl cinnamate that was suitable as nematicide (Ahmad & Jantan, 2003). Regardless of its uses and purposes, due to over harvesting, finding the plant in their natural habitat has becoming difficult due to the declining number of population and population size. Therefore efforts to put this species under cultivation would benefits both the local folks and their ecology.

Previous cultivation studies showed that *B. stenophylla* grows poorly under nursery conditions and also in *in vitro* cultures (Aicher *et al.*, 2015). A cultivation program for *B. stenophylla* was developed at Ba'kelalan in hoping that local folks are able to propagate and cultivate this plant and to reduce the number of harvesting from their natural habitat. Future goals also include to reintroduce the cultivated plant back into the forest as part of a conservation act. This study hypothesize that it is more successful to cultivate *B. stenophylla* at the vicinity of their natural population and by giving them optimum agronomic management. Light play an important role in plant growth and is more crucial for understorey plants. When light passes through a forest canopy, green and far red (FR) wavelengths are transmitted or reflected while red (R) and the blue wavelengths are absorbed (20). Direct light can penetrate to the understory through gaps in the canopy, appearing as sun flecks and from these short, intense bursts of direct light, plants in the understory rely on diffuse light for photosynthesis (Brodersen & Vogelmann, 2007). *B. stenophylla* have dark green leaf adaxial and maroon leaf abaxial, indicating high level of anthocyanin in its leaf. Presence of anthocyanin does not increase the efficiency of photosynthesis but anthocyanic tissues absorbed significantly more blue-green light (Hughes *et al.*, 2008).The occurrence of the pigment on the abaxial surface rather than the adaxial might prevent interference of light absorption by anthocyanin at low light intensities, providing photoprotection only when intensities are high enough to penetrate the mesophyll. Light has different effects on members of the Zingiberaceae family. Ginger is a semi shade plant, and it was showed that 790 $\mu mol\ m^{-2}s^{-1}$ is suitable light intensity for maximum TP production (Ghasemzadeh *et al.*, 2010). Leaf area per plant showed significantly higher and the number of tillers per plant increased significantly under normal light condition as compared to reduced light condition in *Zingiber officinale* (Cole *et al.*, 2016). *Curcuma* sp. 'Precious Petuma' and *C. parviflora* 'White Angel' can be grown under shade levels of up to 60% without jeopardizing plant quality but *Curcuma alismatifolia* 'Chiang Mai Pink' requires to be grown under full sun (Kuehny *et al.*, 2005). An induced off-season flowering was obtained in *Boesenbergia siphonantha* in India through low temperature and night break, where the night break treatments were carried out in the green house by exposing the plants to 2 additional hours (Kuehny *et al.*, 2005). Knowing the plant habits towards light exposure is of a great significance for improving their agronomic practices. *B. stenophylla* is not a cultivated plant therefore how light intensity affects its growth is not known. Since this plant was never cultivated, many aspects in its agronomic practices requires studies. This study begins with determination of suitable planting media and followed by an investigation on the effects of different levels of shades: 70% and 90% and effects of organic and inorganic fertilizer on growth of *B. stenophylla*. The objectives includes 1) to determine suitable planting media for the cultivation of *B. stenophylla* (Aicher *et al.*, 2015) to determine N uptake of the plant from organic and inorganic fertilizer application and (Brodersen, & Vogelmann, 2007) to determine effects of different shade levels on growth of *B. stenophylla*.

MATERIALS AND METHODS

Determination of Suitable Planting Media

Plant samples were collected from the Ba'Kelalan Highland. The planting studies was conducted at the Horticulture Unit of Universiti Putra Malaysia Kampus Sarawak Bintulu (UPMKB) and plants were grown under shade house with 70% shade, provided by black plastic nettings. The three treatments were consisted of media 1 (M1) with the ratio of 3:2:1 top soil: sand: organic matter, media 2 (M2) consists of soil mixture 3:2:1 placed in water-logged polyethylene bags and media 3 (M3) contained only leaf litters. Water-logged was achieved by placing the bags in containers filled with water. Each treatments consisted of four replicates with 15 samples per replicate.

Effects of Different Shade Level and Fertilizing Regimes on Seedling's Growth

Field experiments were conducted at Ba'kelalan (3°58'51.26N, 115°36'48.06"E) with temperature ranging between 19°C to 20°C and at elevation of 975m. Plants were collected from the surrounding forest and hardened for 3 months before planting them in soil mix as planting media. The planting media was organic soil collected from the forest and then slowly cook in open fire and then the pH was recorded. The experiments were arranged in factorial randomized blocked design (RCBD) under two different shade levels of 70% and 90% provided by using plastic nettings. The fertilizer treatments used in the experiment are; (i) T1 as control, no fertilizer applied to the plants (ii) T2, chicken dung (iii) T3, NPKMg and (iv) T4, mixed of chicken dung and NPKMg. Data collection was carried out after 9 weeks of planting. The data includes nutrient content in soil, leaf, PAR and phytochrome content and growth parameters. As for the growth parameters such as number of leaf, height of plant chlorophyll content was recorded every week. Chlorophyll content was recorded by using chlorophyll meter. At the end of the field study, the plant samples were harvested for further laboratory analysis. Some plant samples were air-dried for nutrient analysis and for obtaining dry matter weight. However, some fresh plant samples were processed freshly for determination of phytochrome concentration by referring to method of Jabben and Dietzer (1978). The extracted solutions were measured with spectrophotometer with measuring beams at 660nm and 730nm. The soil nutrient elements were obtained by nutrient analysis depending on types of nutrient elements. Total N in soil was obtained by Kjeldahl method which involved the process of digestion, distillation, and titration. P elements were obtained by using aqua regia method, followed by blue colour development (method of molybdenum blue). Similarly, total K and Mg in soil were obtained by using Aqua regia method for soil sample preparation. However, the sample solutions were analysed by using Atomic Absorption Spectrometry (AAS) for further determination of total K and Mg. The data were analysed for significance using analysis of variance (ANOVA) at the $P<0.05$ level in SAS 9.3.

RESULTS AND DISCUSSIONS

Suitable Planting Media for *B. Stenophylla*

The survival rate of plants was above 90% for all three media but media that was water log significantly reduced the survival rate (Table 1). By 15 weeks, the survival rate in media 2 reduced further to 96.11%. The number of leaves and new shoots were significantly higher on plants in the common soil mixture (Table 2). However, root development was significantly better in media containing leaf litters (Table 3).

Considering that *B. stenophylla* are commonly found near the river bank in their natural population, it was thought that high soil moisture would play an important role on its cultivation.

Table 1: Survival rate of *B. stenophylla* planted in three different media after 15 weeks of planting

Media	Mean of survival rate (%)
Common soil mixture of 3:2:1	99.29±0.44[a]
Water-logged soil mixture 3:2:1	98.26±1.44[b]
Leaf litters	99.55±0.23[a]

Means within columns with the same superscripts are not significantly different (Duncans's Test at $P>0.05$)

Table 2: Mean number of leaves and clumps of *B. stenophylla* in three different media

Media	Parameter	
	Number of leaves	Number of clumps
Common soil mixture of 3:2:1	8.95[a]	3.25[a]
Water-logged soil mixture 3:2:1	7.07[c]	2.63[b]
Leaf litters	8.14[b]	2.32[c]

Means within columns with the same superscripts are not significantly different (Duncans's Test at $P>0.05$)

Table 3: Root measurement for *B. stenophylla* planted in three different media

Media	Parameters	
	New roots length (cm)	Rhizome length (cm)
Common soil mixture of 3:2:1	25.68[b]	20.13[b]
Water-logged soil mixture 3:2:1	13.76[c]	20.74[b]
Leaf litters	33.24[a]	25.06[a]

Means within columns with the same superscripts are not significantly different (Duncans's Test at $P>0.05$)

However, water log media was not suitable therefore water should be supplied through irrigations. Root development was better in media containing leaf litter, therefore this study suggest to add leaf litters to the soil mixture of 3:2:1 for *B. stenophylla* cultivation. In previous study conducted by Aicher *et al.* (2015), temperature was a key factors in the success of its cultivation. It was observed that the plants struggle to developed when temperature was higher than 26 °C but produced new shoots when temperature goes down to 22 °C. Their natural population was found at a higher altitude with temperature ranged from 16°C to 26 °C. With that in mind, this study was conducted at the vicinity near to where they were found naturally.

The Effects of Shade and Fertilizing on Nutrient Content in *B. Stenophylla*

Applying different level of shade and fertilizing regimes did not resulted in any significant effects on the nitrogen content (Table 4) and potassium (Table 5) in *B. stenophylla*. There were some significant difference in phosphorus (Table 6) and magnesium content among treatments (Table 4). However, all shade levels gave no significant effects and there was no interactions between shade levels and different fertilizing regimes. As for magnesium content (Table 7), there was a significant different between treatment 2 and 3 but, all treatments were not significant with control.

Table 4: Effects of two shade levels and fertilizing regimes on nitrogen uptake

Source	DF	ANOVA SS	Mean Square	F Value	Pr>F
block	3	0.025	0.008	2.210	0.122
shade	1	0.001	0.001	0.370	0.553
trt	3	0.008	0.003	0.690	0.569
shade*trt	3	0.014	0.005	1.240	0.326
shade*block	3	0.024	0.008	2.100	0.135
Error	18	0.068	0.004		
Corrected Total	31	0.140			

Table 5: Effects of two shade levels and fertilizing regimes on phosphorus uptake

Source	DF	ANOVA SS	Mean Square	F Value	Pr>F
block	3	8267828.125	2755943	3.85	0.027
shade	1	1181953.125	1181953	1.65	0.215
trt	3	8399703.125	2799901	3.91	0.026
shade*trt	3	1741253.125	580418	0.81	0.504
shade*block	3	5077403.125	1692468	2.37	0.105
Error	18	12873606.25	715200		
Corrected Total	31	37541746.88			

Table 6: Effects of two shade levels and fertilizing regimes on potassium uptake

Source	DF	ANOVA SS	Mean Square	F Value	Pr>F
block	3	13013350	4337783	1.110	0.371
shade	1	51200	51200	0.010	0.910
trt	3	9317050	3105683	0.790	0.513
shade*trt	3	6201900	2067300	0.530	0.668
shade*block	3	10489200	3496400	0.900	0.463
Error	18	70317650	3906536		
Corrected Total	31	109390350			

Table 7: Effects of two shade levels and fertilizing regimes on magnesium uptake

Source	DF	Anova SS	Mean Square	F Value	Pr>F
block	3	1573137.5	524379	1.70	0.204
shade	1	987012.5	987013	3.19	0.091
trt	3	4236937.5	1412313	4.57	0.015
shade*trt	3	1066237.5	355413	1.15	0.356
shade*block	3	1052437.5	350813	1.13	0.362
Error	18	5568125	309340		
Corrected Total	31	14483887.5			

The results shows that there was no significant different between total Nitrogen in every treatments ($P<0.2172$). However, among the fertilizer treatments of T2 (chicken dung), T3 (NPKMg) and T4 (chicken dung and NPKMg), T3 shows the higher total nitrogen as shown in Table 1. The total nitrogen in *B. stenophylla* was significantly different among the plants grown in different levels of shade (90% and 70% shade level) with a *P* value of 0.0333.

This study presents the first report on cultivation of *B. stenophylla* under two shade levels and three different fertilizing regime. There were no baseline studies that can be used to design the cultivation experiment. Aicher *et al.* (2015) carried out a preliminary study on the effects of different shade levels and different planting media composition at a different location. It was at a lower elevation and coastal environment. Plants that were not given shade died and ones that were under both 70% and 90% have very slow growth. With these results, a decision was made to carry out cultivation experiments which are near to its natural population. This was also done to provide knowledge to local growers on how to cultivate them so that they will reduce collecting jerangau merah directly from the forest. As a conservation purposes, this study intend to provide sufficient seedlings that can be reintroduced into the wild and help to increase their population size which has already showing sign of depletion at a dangerous level.

The fertilizing regimes were developed following the recommended fertilizing requirement for ginger (*Zingiber officinale*). Although there was no significant difference between the shade levels and fertilizing regimes, this study however provides new insights for the cultivation of *B. stenophylla*. First of all, cultivation of *B. stenophylla* requires shade as those that were grown under direct sunlight (control), even at higher elevation and lower temperature, died due to prolonged exposure to light. Although, there was no significant difference between the two percentages of shades, this study suggest to apply 70% and this will reduce the cost of using plastic nets, or to intercrop them between fruit trees.

Table 8 showed that the nitrogen content ranged from 0.51-0.95 ppm, lowest when treated with chicken dung and highest when no fertilizer was applied. Although there were no significant difference among all treatment as shown in Table 8, this study recommend that the used of compound fertilizer should be added with organic matter. This is because, the nutrient uptake was slightly higher when chicken dung was applied. It was showed that the nitrogen content was lower as compared to the other nutrient under both shade levels. Under 70% shade the nitrogen content was lower than the ones that was supplied with fertilizer but under 90% the nitrogen content was higher than the ones that was supplied with fertilizer. The non-significance different between control and the treatments showed that optimization of type of fertilizer and their rates requires further studies. However, Aicher *et al.* (2017) mentioned that planting *B. stenophylla* in polybags will limit their growth as the rhizomes requires bigger space for lateral growth. Shoots will formed on the third new lateral rhizomes therefore it was recommended that the cultivation will be more suitable on raised beds. For that matter, fertilizing is required as nutrient from the soil will soon deplete especially after a long period of cultivation period. With the right amount and rates, application of nitrogen and phosphorus will gives better growth in plants (Semchenko *et al.*, 2012) which is why this study will not recommend avoiding fertilizer application for *B. stenophylla* cultivation but it will requires further investigations to obtain the optimum type of fertilizer and the optimum rate. Nevertheless, for now this study recommend to apply fertilizer with additional of organic matter. This study gives more attention to the uptake of magnesium. Under both shades level, magnesium uptake was influenced by the application of chicken dung. Magnesium is the core construction block for the formation of chlorophyll. The insufficient amount of magnesium will caused the degradation of chlorophyll hence reduce the efficiency of photosynthesis.

Table 8: The mean value of nitrogen, phosphorus, potassium and magnesium content in *B. stenophylla* after the application of two different shade levels and three different fertilizing regimes

Shade Levels	Treatments	Nitrogen		Phosphorus		Potassium		Magnesium	
		Mean	SD (±)	Mean	SD (±)	Mean	SD (±)	Mean	SD (±)
70%	Control	0.72	0.04	5018.33	2046.61	742.60	208.33	4386.67	554.74
	Chicken dung	0.91	0.24	2221.67	874.73	881.60	519.97	5473.33	2551.42
	NPKMg	0.79	0.18	2855.00	2038.14	743.53	145.58	4186.67	768.46
	N PKMg+Chicken dung	0.68	0.08	3511.67	2704.96	796.13	136.14	4040.00	589.24
90%	Control	0.93	0.32	2358.33	1680.23	808.67	160.35	6093.33	185.83
	Chicken dung	0.51	0.11	1511.67	670.08	360.60	186.29	5540.00	1128.01
	NPKMg	0.54	0.25	3986.67	3259.46	1674.40	1430.54	5813.33	1116.12
	N PKMg+Chicken dung	0.70	0.31	5070.00	2849.86	725.60	93.63	6220.00	1569.20

The Effects of Different Shade Levels and Fertilizing Regimes on the Chlorophyll Content

The effects of different shade levels and fertilizing regimes on the chlorophyll content is shown in Tables 9 and 10. In Table 9, there was no significant difference in the chlorophyll content among treatments that was under 90%. However, there was significant different in the chlorophyll content in *B. stenophylla* under 70% shade and when it was given chicken manure or NPKMg (Table 10). The combination of chicken manure and NPKMg did not gave any significant effects on the chlorophyll content. However, the chlorophyll content was lower than control. This study showed that plants under 90% has higher mean chlorophyll content as compared to those under 70% shade. Shade-plants essentially follow strategies of optimum use of available energy and of conservation of energy. Adaptations to achieve these strategic goals include thinner leaves with a relatively higher chlorophyll content per unit leaf volume (Middleton, 2001). Species that are stress-tolerant occupy habitats of low productivity and limited resources. This holds true for shade plants. Species that are mainly restricted to deeply shaded habitats often show permanent abaxial anthocyanin colouration (Lee *et al.*, 1979). This is due to the low quality light intensity that reached the forest floor. Those available are mainly of longer wavelength, and lie in the red region of the optical spectrum. It is therefore to be expected that plants growing in this habitat will show adaptations enhancing the utilization of red light (Middleton, 2001). The abaxial leaf of *B. stenophylla* are maroon which often disappear when exposed to higher light intensity (Figure 1a). This was also observed on plants that was cultivated under 70% shade (Figure 1b).

Effects of Different Shade Levels and Fertilizing Regimes on the Height of Plants

Plants that were cultivated under 70% (Table 11) shade were taller than the ones in 90% (Table 12). They were significant difference in height among treatments under 70% shade and NPKMg fertilizer produced taller plants. There was no significant different among treatments under 90% shade. In the previous study carried out by Aicher *et al.* (2015), jerangau merah that was exposed to higher light intensity tend to be shorter with darker green while those exposed to lower light intensity was taller with lighter green leaves. Those exposed to full sun did not survive. This indicates that jerangau merah was not able to acclimatize towards direct exposure to light and determined as shade tolerant. Shade tolerant plants are usually understorey forest dwellers and captures sunflecks for photosynthesis. Leaves exposed to high radiation levels after a long period of low light require a light-priming induction period of up to 60 minutes before a steady-state photosynthetic

Table 9: Effects of different fertilizing regimes under 90% on the chlorophyll content

Treatments	Mean	Estimate	Standard error	t Value	Pr>|t|
Control	65.12	0.68	1.70	0.40	0.73
Chicken manure	62.25	0.68	0.24	2.82	0.11
NPKMg	69.48	0.03	0.19	0.17	0.88
Chicken manure + NPKMg	68.59	0.33	0.19	1.72	0.23

Table 10: Effects of different fertilizing regimes under 70% on the chlorophyll content

Treatments	Mean	Estimate	Standard error	t Value	Pr>|t|
Control	60.58	1.88	1.94	0.97	0.51
Chicken manure	54.95	2.15	0.30	7.25	0.02
NPKMg	54.24	0.99	0.20	4.86	0.04
Chicken manure+NPKMg	54.24	0.56	0.45	1.25	0.34

Table 11: Effects of different fertilizing regimes under 70% on plant height

Treatment	Mean Height (cm)	Estimate	Standard error	t Value	Pr>|t|
Control	32.44	1.054	0.070	15.120	0.004
Chicken manure	32.81	1.003	0.126	7.990	0.015
NPKMg	33.44	0.720	0.063	11.490	0.008
Chicken manure+NPKMg	32.08	0.798	0.185	4.310	0.050

Table 12: Effects of different fertilizing regimes under 90% on plant height

Treatment	Mean Height (cm)	Estimate	Standard error	t Value	Pr>|t|
Control	24.20	0.693	0.417	1.66	0.238
Chicken manure	24.22	0.668	0.489	1.37	0.306
NPKMg	26.53	0.679	0.204	3.33	0.080
Chicken manure+NPKMg	26.69	0.178	0.493	0.36	0.753

Figure 1: (a) Jerangau merah planted under 90% shade with darker green adaxial leaves and (b) under 70% with lighter green adaxial leaves. Leaves abaxial for both plants loose the anthocynin that gives the abaxial the maroon colour after cultivation

rate is reached. It has been shown that the degree of induction accumulates during a sequence of rapid consecutive sunflecks (Hutchings & de Kroon, 1994). Even though jerangau merah is shade tolerant, higher light intensity as 30% light promotes better growth as compared to only 10% light.

Effects of Different Shade Levels and Fertilizing Regimes on Dry Matter Content

Providing shade and fertilizers clearly has a significant effect on the dry matter content in cultivated *B. stenophylla* (Table 13). In Table 14, it was shown that applying NPKMg was significantly better than chicken dung but, adding chicken dung to NPKMg was significant to NPKMg own its own. Accumulation of dry matter was higher in plants cultivated under 70% (Table 15).

Fert signi effects on dry matter. It was concluded that application of NPKMg and 70% shade was the best for jerangau merah growth and also economical as it reduce the cost.

The Effects of Different Shade Levels and Fertilizing Regimes on Phytochrome Content

The fertilizing regimes applied did not gives any significant effects on the phytochrome content in leaves (Tables 16 and 17). There was no interaction between shade levels and fertilizing regimes but, the phytochrome content was higher in 90% shade (Table 18). This was clearly shown in Figure 1a where plants that was under 90% has darker green colour as compared to those under 70% shade.

Lee *et al*. (1979) proposed the 'back-scattering' hypothesis, which proposes that anthocyanins close to the lower epidermis may reflect adaxially transmitted red light back into the mesophyll, to maximize the absorption of red photons by the mesophyll cells, which could be especially advantageous in light-limited environments. On the other hand, more recently, some authors have proposed an alternative/opposite theory in which abaxial anthocyanins would contribute to attenuate the internal scattering of green light, protecting photosynthetic mesophyll cells during

Table 13: Effects of different shade level and fertilizer regimes on dry mater content

Source	DF	Anova SS	Mean Square	F Value	Pr>F
rep	2	6.295	3.147	2.55	0.114
trt	3	14.826	4.942	4.00	0.03
shd	1	25.792	25.792	20.86	0.0004
shd*trt	3	24.489	8.163	6.60	0.0052
Error	14	17.307	1.236		
Corrected Total	23	88.7092			

Table 14: The effects of fertilizing regimes on dry matter yield (dmy)

Treatments	Mean
Control	2.758[b]
Chicken Dung	2.733[b]
NPKMg	4.662[a]
NPKMg+Chicken Dung	3.207[ab]

Table 15: The effects of different shade levels on dry matter yield

Shade Level	Mean
70%	4.3767[a]
90%	2.3033[b]

Table 16: Effects of different shade levels and fertilizing regimes on phytochrome content

Source	DF	Anova SS	Mean Square	F Value	Pr>F
rep	3	0.0019	0.0006	0.33	0.804
trt	3	0.0017	0.0006	0.29	0.830
shd	1	0.0141	0.0141	7.33	0.013
shd*trt	3	0.0088	0.0029	1.52	0.239
Error	21	0.0405	0.0019		
Corrected Total	31	0.0669			

Table 17: The effects of fertilizing regimes on phytochrome content

Treatments	Mean
1	0.0120[a]
2	0.0241[a]
3	0.0177[a]
4	0.0044[a]

Table 18: The effects of different shade levels on phytochrome content

Shade Level	Mean
70%	0.0064[b]
90%	0.0356[a]

sunflecks and particularly during sun patches, which are longer in duration (Hughes *et al*., 2008).

CONCLUSIONS

The finding from this study was able to provide recommendations and agronomic practices for the cultivation of jerangau merah. When cultivating them in containers, the suitable planting media was 3:2:1 (top soil:sand:organic matter) ratio soil media. The media cannot be water log and growth performance was better if leaf litter or other organic matter was added. However, it was found that the growth performance is poorly when rhizomes are restricted in a container. Therefore, it is more suitable to cultivate them in raised beds. Soil should be amended with more organic matter and treated prior to cultivation. *B. stenophylla* is determined as a shade tolerant plant. It does not grow under direct exposure to sunlight. Preferably, it required lower temperature and higher altitude. Light intensity play a vital roles in its growth. It was shown that two different shade levels did not affected the nutrient uptake of nitrogen and phosphorus but plays some roles in potassium and magnesium uptake. The uptake of K and Mg was more in plants cultivated under 70% shade. Different type of fertilizing regimes showed no significant different among treatment and control. This study recommend to provide compound fertilizers (NPKMg) because NPKMg produce plants with higher dry matter content. However, more studies is required to obtain the optimum fertilizing rate. Chlorophyll content and phytochrome content was higher in plants that was cultivated under 90%, making plants having darker green leaves and shorter. Plants that was treated with different fertilizing regimes showed no significant different in chlorophyll and phytochrome content. Plants that was under 70% shade was taller, has lighter green leaves and higher dry matter content. Photosynthesis would be efficient in plants with higher chlorophyll content and phytochrome content, hence it would expect that these plants will have higher yield. However, this was not shown in yield in term of plant height and dry matter content. Therefore, this study suggest to carry out further studies on effect of 90% shade on leaves size, sugar or starch content and secondary metabolites in the rhizomes. This study suggest that jerangau merah is more suitable to be planted on raised beds, provided with NPKMg at 150 kg/ha, cultivated under 70% and preferably near to the vicinity of the natural population

ACKNOWLEDGEMENTS

The authors are grateful to Universiti Putra Malaysia and Ministry of Higher Education for providing the technical and financial support under the FRGS, respectively.

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