RELATIVE LIGHT INTENSITY AND KITCHEN WASTE COMPOST EFFECTS ON PRODUCTION OF *ANDROGRAPHIS PANICULATA*

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ABSTRACT

Andrographis paniculata commonly known as "Hempedu Bumi" is widely used as traditional medicine in Asia to treat hypertension, diabetes, flu, sore throat etc.. Farming of this plant species as a medicinal plant is challenging because it is necessary to avoid chemicals as far as possible to ensure its quality. This study was conducted to investigate the effects of shading and application of kitchen waste compost on growth performance and yield of potted A. paniculata. Seedlings at six weeks after sowing, having height of 2 to 4 cm, were transplanted into polybags sized 23 x 25 cm containing mixture of top soil, sand and cocopeat at 3:2:2. Kitchen waste compost derived from dumped vegetables, fish refuse and expired or dumped bread at 3:1:2 was prepared with 1 kg cocopeat as bulking agent using an automated mini composter. Composting took one month. The compost was then applied to polybags with moist media mixture at 0, 25, 50, 75 and 100 g per polybag. Compost was incorporated into media at a depth of approximately 5 cm at one week before seedling transplanting. Growth performance and yield of A. paniculata as affected by compost application was studied in the greenhouse under full relative light intensity (RLI) and 50% shade provided by commercial 50% shade netting. Watering was done daily with automated overhead mist sprinkler in the greenhouse. Results showed that plants grown under full RLI did not differ from those under shade netting in height but produced more branches and leaves as the main plant part to harvest. Compost at application rate of 75 to 100 g per polybag was the best to enhance the economic yield of A. paniculata in terms of growth of leaves.

Key words: medicinal plant, shading, growth performance, yield, greenhouse

Introduction

Throughout Malaysia, there are approximately 15,000 flowering plants, and about 2,000 of these plants have medicinal and therapeutic values (Ibrahim, 2006; Jamal, 2006). *Andrographis paniculata*, or locally known as "Hempedu Bumi", is one of the commonly consumed medicinal plants. It grows as a wild plant in the open fields but at times, planted specially for medicinal product development to treat diseases such as hypertension, diabetes, flu, fever, diarrhea, dysentery, cough and snake bite. (Biffa, 2003; Jaganath and Teik, 2003; Anonymous, 2008; Niranjan et al., 2010; Akbar, 2011). This medicinal plant is listed in National Key Economic Area (NKEA) in agricultural sector. It is also listed in 16 Entry Point Projects (EPPs) as one of the five main high value herbs focused on its production and supply. Nowadays, planting of medicinal plants becomes challenging as it is preferred to avoid the use of chemical pesticides and even inorganic fertilizers for better quality and food safety reasons (Bhat Savitha et al., 2012).

Application of compost has been widely practised in organic farming as substitutes to inorganic fertilizers to supply the nutrients needed for optimal plant growth. Compost also improves the porosity, permeability, chemical properties and microbial activities in soil (Akhtar, 2000; Valarini et al., 2009; Leu et al., 2010; Desalegn et al., 2011). After long period, compost can even improve the soil structure. Some types of compost were reported to sustain essential nutrient availability for plants for many years with reduced leaching as usually found with many inorganic forms of fertilizers (Sullivan et al., 2002). In other cases, compost was only capable to supply partial nutrients needed for high yield in some crops. In medicinal plant farming, application of organic fertilizer is not only aimed for enhanced yield, but also as a means to increase the active compounds and antioxidants within their plant parts quantitatively (Sharafzadeh and Ordookhani, 2011). The current study was carried out to enhance organic production of *A. paniculata* using compost derived from some common kitchen wastes.

Material and Method

Location of Study

The study was conducted in Puncak Alam campus, Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA (N 03°11.84', E 101°26.93'). Kitchen waste compost was prepared in the media preparation area and experiment on the application of kitchen waste compost combined with light intensity effect on the production of *A. paniculata* was carried out in a greenhouse equipped with automated overhead mist sprinkler system in this campus.

Kitchen Waste Compost Preparation

The compost was prepared at four months ahead. Dumped vegetables, mainly those belonging to the family of Brassicaceae, fish refuse (gills and internal organs) and expired or dumped bread collected from kitchens of local restaurants at 3:1:2 were composted with 1 kg cocopeat as the bulking agent using an automated mini composter (IMP Organic, Taiwan). An amount of 1.5 to 2 kg of raw materials was loaded into the composter according to the mentioned ratio at alternate days for a week until full level of the composter. There was no additional enzyme or microbial inoculant or water added. The three cylindrical bars in the composter turned automatically for 2 min at 30 min intervals to assist the population growth of natural occurring microorganisms to perform the composting of the raw materials. The temperature indicator on the composter showed higher temperatures during composting procedure indicating the active degradation process carried out by the microorganisms. It had, however, always been below 50 °C throughout the composting procedure, allowing hormonal and enzymatic compounds of the raw materials remained intact for benefits of the growth of plants applied with this compost later.

After reaching full level of raw materials, the composting materials were let to partially mature for a week where the volume was concurrently reduced to half. Then, feeding of raw materials was repeated for a week until full level again, also at alternate days, with an amount of 1.5 to 2 kg raw materials each time. The composting materials were then allowed to mature in the following two to three weeks until the temperature of the compost, as shown by the temperature indicator of the composter, dropped to ambient temperature. The compost was then unloaded from the composter, followed by sealing in plastic bags to avoid compost from absorbing moisture from the air until use.

A total of two batches of compost of the same composition of raw materials were prepared. Then, the different batches of compost were mixed evenly prior to experimentation.

Test Material

Fully mature capsulated fruits of *A. paniculata* were collected from one single vigorous mother plant. Fruits were broken open and the seeds collected were sown on moist peatmoss in perforated plastic trays. Seed germination was carried out in a bright place in the greenhouse. Watering was done twice daily for 10 min with automated overhead mist sprinkler in the greenhouse. Seed germination took place after two weeks and seedlings of height of 2 to 4 cm with four to five leaves by six weeks after sowing were transferred to polybags as test materials in this study.

Experimental Procedure

Planting media was prepared and filled in polybags sized 23 x 25 cm at ten days before seedling transplanting. Polybags were filled with top soil, sand and cocopeat at 3:2:2. Polybags were then transferred into greenhouse and arranged according to a split plot design, where relative light intensity (RLI) factor, i.e. 50% shading provided by commercial 50% shade netting and full RLI without shade netting, was assigned as the main plots. Within each main plot, polybags were applied with kitchen waste compost at rates of 0, 25, 50, 75 and 100 g, respectively, as sub plots. Each treatment was replicated five times, each with a single plant.

Media of polybags was moistened with tap water for 10 min twice daily via overhead mist sprinkler in the greenhouse at two days before application of compost. Compost was then applied accordingly at depth of approximately 5 cm into media in each polybag at one week prior to transplanting of the seedlings. Such compost application procedure was carried out based on preliminary study indicating that compost incorporated into media was more effective for enhancing growth of plants, besides avoiding mould growth on compost when applied as surface application on media. Media was left moist continuously with the timed mist sprinkler until transplanting of the seedlings.

After incorporation of compost for a week, seedlings were transplanted into the polybags. Each polybag was planted with two seedlings but culled to leave only one seedling per polybag at two weeks after transplanting. Growth of the seedlings was maintained with just automated overhead mist sprinkler twice daily, each for 10 min, in the greenhouse. No additional fertilization was carried out. Minimal weeding was carried out while there was no pest and disease problem throughout the study period.

Data Collection

Plant growth performance in terms of height and number of leaves, as the plant part with highest medicinal and economic values, as affected by RLI and compost application rate was monitored weekly for a period of eight weeks. Plant height was measured using a measuring tape from the root collar to the end of the apical shoot. Leaves with width of ≥1 cm were counted as the number of leaves gained.

All plants were harvested at the end of eight weeks when a few plants started flowering. At harvest, whole plant in each polybag was removed carefully from the media. Roots were then cleaned carefully and thoroughly with tap water. Then, stem diameter was measured at root collar using a digital vernier caliper. Plant parts of leaves, stems and roots were separated carefully and placed into paper bags accordingly. These plant parts were dried in a convection oven at 60 °C for several days until three unchanged dry weight was obtained. For each measurement of dry weight, plant parts were cooled in a desiccator prior to weighing using an analytical balance.

With the data mentioned above, plant sturdiness quotient at eight weeks was computed as height to stem diameter ratio. Leaf weight ratio (LWR) at eight weeks was also calculated as dry weight of leaves to total plant dry weight ratio.

Experimental Design and Statistical Analysis
The experiment was based on a split plot design as described above. Analysis of variance (ANOVA) was carried out with the collected data and treatment means were compared using Tukey's Honestly Significant Difference (HSD) test at 5% level of significance.

Results and Discussion

Plant height of *A. paniculata* was not significantly affected by 50% shading in the greenhouse (Table 1). Kitchen waste compost, on the other hand, enabled fast recovery of the seedlings from transplanting shock; plants treated with compost ranging from 25 to 100 g in polybags showed significantly better growth in terms of height from two weeks after transplanting onwards (Tables 1 and 2). The plants applied with compost were two-fold in height, and were above 45 cm, at the end of the study period of eight weeks, as compared to control of only 21 cm in height (Table 2). The treated plants, however, did not show any significant difference in this parameter as affected by the different rates of compost as applied.

Table 1: F-value for variables affecting plant height

Variable	Period (weeks after planting)							
	1	2	3	4	5	6	7	8
Replicate	2.08^{ns}	0.63^{ns}	0.94^{ns}	0.19^{ns}	0.80^{ns}	0.73^{ns}	4.30^{ns}	5.32^{ns}
RLI	0.97^{ns}	0.05^{ns}	0.83^{ns}	0.08^{ns}	0.25^{ns}	0.07^{ns}	0.75^{ns}	4.38^{ns}
Replicate x RLI	1.46^{ns}	2.61^{ns}	2.56^{ns}	2.41^{ns}	1.36^{ns}	1.03^{ns}	0.88^{ns}	0.98^{ns}
Compost rate	1.58^{ns}	3.53*	5.29**	6.87***	8.03***	10.34***	14.06***	14.05***
RLI x Compost rate	0.77^{ns}	1.33^{ns}	2.57^{ns}	2.30^{ns}	1.75^{ns}	1.03^{ns}	0.69^{ns}	0.58^{ns}

ns, *, **, *** indicate no significant difference, significant difference at 5%, 1% and 0.1% level of significance respectively.

Table 2: Mean comparison for plant height as affected by application rate of compost

Compost rate (g)	Plant height in cm by period (weeks after planting)							
	1	2	3	4	5	6	7	8
0	2.1^{a}	2.5^{b}	3.7^{b}	5.1^{b}	7.5^{b}	10.9^{b}	14.5^{b}	21.1^{b}
25	2.7^{a}	5.0^{a}	9.1^{a}	14.9^{a}	21.8^{a}	29.3^{a}	37.1^{a}	46.4^{a}
50	2.0^{a}	4.3^{ab}	7.5^{a}	14.5^{a}	23.0^{a}	32.3^{a}	42.2^{a}	52.3^{a}
75	2.4^{a}	3.9^{ab}	7.2^{ab}	11.5^{a}	20.4^{a}	30.0^{a}	40.1^{a}	50.6^{a}
100	2.2^{a}	3.5^{ab}	7.0^{ab}	9.7^{ab}	20.5^{a}	28.3^{a}	37.2^{a}	46.1^{a}

Means having the same letter within column are not significantly different at 5% level of significance.

Despite insignificant effects of shading on plant height, both factors of shading and application rate of compost generally had significant interaction resulting in more leaves produced in compost treated plants grown under full RLI from three weeks after planting onwards (Tables 3, 4 and 5). Application of as low as 25 g compost was sufficient to enhance leaf production of *A. paniculata* under full RLI but such application rate could only last for four weeks after planting. In the next three weeks until end of the study period at eight weeks after planting, plants applied with 75 g compost eventually had the highest number of leaves (158) under full RLI. Those applied with highest rate of 100 g compost had slightly lower number of leaves. Plants grown under 50% shade had below 100 leaves at harvest despite the application of compost. Previous study by Devkota and Jha (2010) also showed that increasing level of shading could reduce growth and development of leaves in sun loving plants. Plant toxicity symptom was shown in plants applied with higher rates of 75 and 100 g compost under 50% shading. Application of 50 g compost per polybag enabled development of the highest number of leaves among all plants under the shade netting. The controls with no compost applied had the poorest growth of leaves throughout the study period, with those under 50% shade developed only 10% (16 leaves) of the highest number of leaves gained by plants under full RLI at harvest (Table 5).

Table 3: F-value for variables affecting plant leaf number

Variable	Period (weeks after planting)							
	1	2	3	4	5	6	7	8
Replicate	0.52^{ns}	0.69^{ns}	0.40^{ns}	0.54^{ns}	1.40^{ns}	0.78^{ns}	5.24^{ns}	14.36 *
RLI	0.02^{ns}	8.60 *	9.89*	13.71*	12.95*	24.11**	50.54**	131.50***
Replicate x RLI	1.82^{ns}	1.42^{ns}	1.80^{ns}	2.15^{ns}	2.41^{ns}	1.31^{ns}	0.85^{ns}	0.31^{ns}

Compost rate	1.21 ns	2.55 ns	4.91**	9.46***	5.10**	9.36***	17.09***	22.56***
RLI x Compost rate	0.58 ns	2.29 ns	3.98**	5.88***	2.66 ns	3.26*	3.39*	3.06*

ns, *, **, *** indicate no significant difference, significant difference at 5%, 1% and 0.1% level of significance respectively.

Table 4: Mean comparison for plant leaf number at five weeks as affected by application rate of compost

Compost rate (g)	Plant leaf number at 5 weeks after planting
0	11.4 b
25	37.1 a
50	32.6 a
75	34.4 a
100	33.6 a

Means having the same letter are not significantly different at 5% level of significance.

Table 5: Mean comparison for plant leaf number as affected by interaction of RLI and application rate of compost

RLI	Compost rate (g)	Period (weeks after planting)				
		3	4	6	7	8
Full RLI	0	7.2 b	9.2 c	10.4 d	18.0 d	23.4 de
	25	17.8 a	33.2 a	61.6 abc	79.8 abc	110.0 abc
	50	11.2 ab	14.4 bc	60.8 abc	100.0 ab	137.6 ab
	75	12.8 ab	22.4 ab	80.4 a	116.8 a	158.4 a
	100	10.6 b	18.2 bc	69.8 ab	110.4 ab	141.2 ab
50% shade	0	7.2 b	7.8 c	12.2 d	14.0 d	16.0 e
	25	8.2 b	12.8 bc	26.4 cd	42.6 cd	67.6 cde
	50	9.8 b	14.2 bc	40.4 bcd	66.0 bc	94.4 bc
	75	8.2 b	10.8 bc	27.0 cd	45.6 cd	70.4 cde
	100	8.4 b	10.6 bc	32.4 bcd	53.2 cd	76.8 cd

Means having the same letter within column are not significantly different at 5% level of significance.

At harvest, plants grown under full RLI had significantly bigger stems, at an average of 4.40±0.27 mm in diameter, resulting in significantly sturdier plants that are more wind resistant (Table 6). Plants applied with compost also had significantly bigger stems, similar trend as that found with plant height, but this did not contribute significantly to the sturdiness of plants (Tables 6 and 7).

From the economic point of view, interaction between shading and compost application rate had a significant role in leaf production by means of leaf dry weight (Table 6). Plants grown with 100 g compost under full RLI had the highest leaf dry weight, attributed to the bigger leaves formed, as compared to those having the highest number of leaves with application of 75 g compost (Table 8). Full RLI and application of compost at up to 100 g per polybag resulted in the production of leaves proportionally to the total biomass gained by plants respectively. This was indicated by the insignificant leaf weight ratio (LWR) among all plants, irrespective of shading and compost treatment effects (Table 6).

Table 6: F-value for variables affecting stem diameter, sturdiness quotient, leaf dry weight and LWR at harvest

Variable	Stem diameter	Sturdiness quotient	Leaf dry weight	LWR
Replicate	13.99*	4.78 ns	10.95 *	1.47 ns
RLI	71.84***	45.49**	213.74***	0.01 ns
Replicate x RLI	0.19 ns	1.08 ns	0.12 ns	1.03 ns
Compost rate	19.11***	2.33 ns	18.75***	1.80 ns
RLI x Compost rate	0.92 ns	0.23 ns	6.01**	1.60 ns

ns, *, **, *** indicate no significant difference, significant difference at 5%, 1% and 0.1% level of significance respectively

Table 7: Mean comparison for plant stem diameter at harvest as affected by application rate of compost

Compost rate (g)	Plant stem diameter at harvest (mm)
0	2.11 b
25	4.12 a
50	4.57 a
75	4.45 a
100	4.73 a

Means having the same letter are not significantly different at 5% level of significance.

Kitchen waste compost was found appropriate as an organic fertilizer for *A. paniculata*. It has positive effects on this medicinal plant as that reported also with many other types of composts applied in horticultural field and farming systems (Ikeh et al., 2012; Masarirambi et al., 2012; Mahboobeh et al., 2014; Panah and Vash, 2014). Application of kitchen waste compost was effective in improving growth of the this medicinal plant probably due to improved media nutrition, soil aggregate and water holding capacity of media as this medicinal plant consumes high amount of nutrients and water for optimal growth (Vengadaramana and Jashothan, 2012; Wang et al., 2013).

Table 8: Mean comparison for leaf dry weight at harvest as affected by interaction of RLI and application rate of compost

RLI	Compost rate (g)	Leaf dry weight (g)
Full RLI	0	0.7549 c
	25	4.9515 b
	50	5.2927 b
	75	9.5035 a
	100	10.9098 a
50% shade	0	0.4009 c
	25	3.1160 bc
	50	5.3303 b
	75	3.6819 bc
	100	4.3374 bc

Means having the same letter are not significantly different at 5% level of significance.

Conclusion

Production of *A. paniculata*, especially in leaf production, was effectively improved with 75 to 100 g kitchen waste compost under full RLI. Further study on the effectiveness on this compost for enhancing the content of andrographolide, as the main and most important active compound of this medicinal plant, is necessary to place such practices at a greater height in organic production of this medicinal plant. Relationship between nutritional value of the compost and plant should also be explored in detail for precised application of compost and composting technology for production of this medicinal plant and benefits of mankind.

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References

Akbar, S. (2011). *Andrographis paniculata:* A review of pharmacological activities and clinical effects. *Alternative Medicine Review*, 16(1), 66-77.

Akhtar, M. (2000). Effect of organic and urea amendments in soil on nematode communities and plant growth. *Soil Biology and Biochemistry*, 32, 573-575.

Anonymous. (2008). *Intellectual Property and Traditional Medical Knowledge*. World Intellectual Property Organization, Publication No.933(134), 1-4.

Bhat Savitha, D., Ashok B. K., Rabinarayan, A. & Ravishankar, B. (2012). Importance of kunapajala (traditional liquid organic manure) of *Vrikshayurveda* medicinal plant cultivation. *Global Journal of Research on Medicinal plants and Indigenous Medicine*, 1(7), 272-279.

Biffa, M. A. (2003). *Conservation and Diversity of Hempedu Bumi (Andrographis paniculata nees) Germplasm in Malaysia*. Dissertation of Master of Agricultural Science, Faculty of Agriculture, Universiti Putra Malaysia, 1-25.

Desalegn, G., Binner, E., Lössl, A., Vierheiling, H., Liebhrd, P. & Lechner, P. (2011). Influence of quality compost on plant growth and mycorrhizal colonisation in corn. Universität für Bodenkultur Wien Department für Angewandte Pflanzen-wissenschaften und Pflanzenbiotechnologie. Retrieved on 5 October 2014 from http://wwwtropentag.de/2011/abstracts/posters/140.pdf.

Devkota, A. & Jha, P. K. (2010). Effect of different light levels on the growth traits and yield of *Centella asiatica*. *Middle-East Journal of Scientific Research*, 5(4), 226-230.

Ibrahim, N. (2006). Tumbuhan Liar Berkhasiat Ubatan. *Berita Harian*, 20 Disember 2006, 11.

Ikeh, A. O., Ndaeyu, N. U., Uduak, I. G., Iwo, G. A., Ugbe, L. A., Udoh, E. I. & Effiong, G. S. (2012). Growth and yield responses of pepper (*Capsicum frutescens* L.) to varied poultry manure rates in Uyo, Southeastern Nigeria. *Asian Research Publishing Network Journal of Agricultural and Biological Science*, 7(9), 735-742.

Jaganath, I. B. & Teik, N. L. (2003). Malaysian Herbs Series 1. *Smile*, May/Jun 2003, 4p.

Jamal, J. A. (2006). Malay traditional medicine. An overview of scientific and technological progress. *Tech Monitor*, Nov-Dec 2006, 37-49.

Leu, J. M., Traore, S., Wang, Y. M. & Kan, C. E. (2010). The effect of organic matter amendment on soil water holding capacity change for irrigation water saving: Case study in Sahelian environment of Africa. *Scientific Research and Essays*, 5(23), 3564-3571.

Mahboobeh, Z., Morteza, A. S., Mryam, T. & Reza, S. A. (2014). Effects of organic and chemical fertilizer on quantitative and qualitative characteristics of peppermint (*Mentha piperita* L.). *International Journal of Agriculture and Crop Sciences*, 7(5), 237-244.

Masarirambi, M. T., Dlamini, P., Wahome, P. K. & Oseni, T. O. (2012). Effects of chicken manure on growth, yield and quality of lettuce (*Lactuca sativa* L.) "Taina" under a lath house in a semi-arid sub-tropical environment. *American-Eurasian Journal of Agricultural and Environmental Sciences*, 12(3), 399-406.

Niranjan, A., Tewari, S. K. & Lehri, A. (2010). Biological activities of *Kalmegh* (*Andrographis paniculata* Nees) and its active principles - A review. *Indian Journal of Natural Products and Resources*, 1(2), 125-135.

Panah, D. D. & Vash, F. F. (2014). The effect of biological and chemical fertilizers on yield of *Calendula officinalis* in greenhouse conditions. *Journal of Novel Applied Sciences*, 3(12), 1435-1438.

Sharafzadeh, S. & Ordookhani, K. (2011). Organic and bio fertilizers as a good substitute for inorganic fertilizers in medicinal plants farming. *Australian Journal of Basic and Applied Sciences*, 5(12), 1330–1333.

Sullivan, D. M., Bary, A. I., Thomas, D. R., Fransen, S. C. & Cogger, C. G. (2002). Food waste compost effects on fertilizer nitrogen efficiency, available nitrogen, and tall fescue yield. *Soil Science Society of America Journal*, 66, 154–161.

Valarini, P. J., Curaqueo, G., Seguel, A., Manzano, K., Rubio, R., Corenjo, P. & Borie, F. (2009). Effect of compost application on some properties of a volcanic soil from central south Chile. *Chilean Journal of Agricultural Research*, 69(3), 416-425.

Vengadaramana, A. & Jashothan, P. T. J. (2012). Effect of organic fertilizer on the water holding capacity of soil in different terrains of Jaffna peninsula in Sri Lanka. *Journal of Natural Product and Plant Resources*, 2(4), 500-503.

Wang, F., Tong, Y. A., Zhang, J. S., Gao, P. C. & Coffie, J. N. (2013). Effects of organic materials on soil aggregate stability and soil microbiological properties on the Loess Plateau of China. *Plant Soil Environment*, 59(4), 162-168.