# EFFECTS OF DIFFERENT TYPES AND RATES OF BIOCHAR SUBSTRATES ON GROWTH PERFORMANCES AND YIELD OF KAEMPFERIA PARVIFLORA WALL. EX. BAKER GROWN ON SOILLESS CULTURE SYSTEM

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## Abstract

Black ginger (Kaempferia parviflora Wall. Ex. Baker) is herbaceous plant belonging to the Zingiberaceae family and famously used in treating metabolic ailments, increasing vitality to human body, and relief gastrointestinal disorder. Recently, Black ginger has increased attention from many researchers to identify their medicinal value to treat diseases. However, agronomic aspect particularly from growth and yield performances of black ginger is still lacking. Thus, a greenhouse experiment was conducted to determine the effects of different types of biochar substrates and rates on growth and yield performances of black ginger as an alternative planting method to replace soil cultivation method. By using fertigation system as an adoption of soilless culture system, basic growth media were combined with different types of biochar substrates and rates which treatments applied were: i) cocopeat (CP) (control, 4kg), ii) CP (3.8kg) with 200g rice husk biochar (RH), iii) CP (3.6kg) with 400g RH, iv) CP (3.4kg) with 600g RH, v) CP (3.8kg) with 200g palm kernel shell biochar (PKS), vi) CP (3.6kg) with 400g PKS, vii) CP (3.4kg) with 600g PKS, viii) CP (3.8kg) with 200g sugarcane baggase biochar (SB), ix) CP (3.6kg) with 400g SB, x) CP (3.4kg) with 600g SB, xi) CP (3.8kg) with 200g coconut shell biochar (CS), xii) CP (3.6kg) with 400g CS, and xiii) CP (3.4kg) with 600g CS. The experiment was arranged in a Randomized Complete Block Design (RCBD) with two factors and three replications. As expected, biochar has promising effects on the growth and yields of black ginger. CPSB-black ginger with 600g of biochar had high and comparable value for number of leaves, plant height, plant per rhizome, total fresh weight, fresh and dry weight (leaves, rhizomes, and roots), leaf area, and leaf area index (LAI). Thus, CPSB combination with 600g rates of biochar could be suggested as effective growing media for ginger cultivated in fertigation system.

**Keywords:** Black ginger, biochar, fertigation system

## BACKGROUND

Black ginger (Kaempferia parviflora Wall. Ex. Baker) belongs to the Zingiberaceae family and commonly known as “cekur hitam” in Malay, and Krachai-dam in Thai language. The rhizome of this plant has been traditionally used in Malay and Thai medicine as health-promoting herbs in relieving body pains, allergy, gastrointestinal disorders, and fungal infections. Recently, the anti-cancer, anti-viral, anti-mycobacterial, anti-gastric ulcer, anti-allergenic, anti-cholinesterase, and anti-mutagenic activities of this herb are widely investigated. However, agronomic aspect particularly from growth performance and quality of black ginger is still lacking. Black ginger can be cultivated on various types of soils but prefers loose, well-textured and well-drained fertile soils. In Malaysia, ginger family normally cultivated using shifting cultivation technique to avoid soil-borne disease and pest (Yaseer Suhaimi et al., 2015). This in turn reduce the farmer profits. Thus, to increase the growth, yield and postharvest qualities of black ginger, the adoption of a soilless culture system by using different growing media could be the most prefrable alternative to be discovered. Plants cultivated in soilless culture system produce higher yields, 3 to 5 folds as compared to soil-based culture system (De Rijck et al., 1998). In soilless system, most widely used growth medium is coco peat (CP). It is an agricultural by-product obtained after the extraction of fibre from the coconut husk. It also has high wettability or the ability to absorb water but lack of nutrient content (Ain Najwa et al., 2014; Arachchi and Somasiri, 1997; Awang et al., 2009). Thus, CP requires addition of mineral nutrients from fertilizer, manure, biochar and other agriculture materials.

Biochar is well known as the carbon-rich product obtained from the heated substrates such as wood, manure, or leaves in a closed container with little or no available air at high temperature (Nartey and Zhao, 2014). It enhances properties and increases soil fertility (Lehmann et al., 2006) by stimulating the ability to hold carbon, improve food safety and lessen the ability of microbes to mineralise the carbon (Baldock and Smernik, 2002) and increase growth (Siti et al., 2012). Many reports focus more on the impacts of biochar on crop production on soils with low nutrients (Crane-Droesch et al., 2013) and acid soils (Liu et al., 2013) and alkaline soils (Borchard et al., 2014). However, the benefits of biochar on crop production in soilless cultivation system is scarce. Moreover, biochar can potentially be used to reduce leachability of mineral nutrients and also its alkaline characteristic contribute to bioavailability of the nutrients. Besides, fertilizers and environmental pollution could also be reduced by minimizing agriculture wastes as aforementioned. Moreover, this new-developed soilless growing media are light, easy to handle and cost effective. Therefore, this experiment aimed at evaluating the effects of different types of biochar substrates on the growth, yield and postharvest quality of black ginger planted without soil under greenhouse condition.

## METHODS

The experiment was conducted in a greenhouse at the School of Food Science and Technology, Universiti Malaysia Terengganu. Black ginger and rice husk biochar were collected from MARDI (Malaysian Agricultural Research and Development Institute), Serdang and BERNAS Rice Mill,Tumpat, Kelantan respectively. While, for palm kernel shell biochar was obtained from Malaysian Palm Oil Board (MPOB), Bandar Bangi, Selangor. While, coconut shell and sugarcane bagasse substrates were collected from the Gong Badak, Kuala Terengganu. The coconut shell and sugarcane bagasse then were further processed into biochar by conventional method of pyrolysis. Black ginger rhizomes were cut into 2-4 cm width containing 2 to 3 buds. Each rhizome then placed in the assigned growing media viz. viz. i) cocopeat (CP) (control, 4kg), ii) CP (3.8kg) with 200g rice husk biochar (RH), iii) CP (3.6kg) with 400g RH, iv) CP (3.4kg) with 600g RH, v) CP (3.8kg) with 200g palm kernel shell biochar (PKS), vi) CP (3.6kg) with 400g PKS, vii) CP (3.4kg) with 600g PKS, viii) CP (3.8kg) with 200g sugarcane baggase biochar (SB), ix) CP (3.6kg) with 400g SB, x) CP (3.4kg) with 600g SB, xi) CP (3.8kg) with 200g coconut shell biochar (CS), xii) CP (3.6kg) with 400g CS, and xiii) CP (3.4kg) with 600g CS. The experiment was arranged in a randomized complete block design (RCBD) with two factors; different amount and types of biochar substrates. Each treatment then replicated three times. All black ginger plants were irrigated by using fertigation system as according to modified method of MARDI. Irrigation was scheduled for 5 to 10 minutes per day at every 0800h and 1500h. The experiment was conducted for 8 months, from February 2016 to August 2016. The parameter evaluations were growth and postharvest performances such as plant height, plant per rhizomes, number of leaves, fresh and dry weight of individual plant organs (leaves, rhizomes, and roots), individual chlorophyll, caratenoids, total chlorophyll, leaf area and leaf area index. Plant height was measured 1cm above the surface ground using scale for weekly basis from the day after planting. Number of leaves and plant per rhizomes were manually count for every 7 days interval. Fresh weight of whole plant, leaves, rhizomes, amd roots were measured using analytical electronic balance and then were dried in universal oven at 65ºC for 2-3 days as according to the method of Husni et al. (1990). Meanwhile, Leaf area was recorded by using leaf area meter and expressed in cm2. Individual chlorophyll, caratenoids and total chlorophylls were determined by using the method of Wan Zaliha and Nurul Azilla (2015).

The experimental data were subjected to two way analysis of varience (ANOVA) using GLM (General Linear Models) procedures with SAS 9.1 and further seperated by Tukey for minimum significance difference at P≤0.05 (SAS Institute Inc., 1999).

## RESULT AND DISCUSSION

As shown in Fig. 1, 2 and 3, there was no interaction between two factors, different types and different rates of biochar on number of leaves, plant height, and plant per rhizome of black ginger. However, irrespective of biochar rates, different types of the substrates significantly affect number of black ginger leaves, plant height and number per rhizome starting on 70DAP (Fig. 1A, 2A and 3A). The combination of CPSB recorded the highest number of leaves throughout the planting period. Meanwhile CP which acts as control treatment had the lowest number of leaves. Meanwhile, without regard to different types of substrates, leaves number of black ginger was not affected by the application of different rates of biochar. Similar results were also recorded on plant height and plant per rhizomes. In general, CPSB can be said the most effective substrate in improving the growth of black ginger. This findings were in agreement with the report of Yaseer Suhaimi et al. (2010), where rice husk biochar at varying amounts and mixed with cocopeat resulted in a positive effect on the growth performaces of ginger grown in soiless culture system. In addition, Dao et al. (2013) claimed that sugarcane bagasse biochar increased the growth of maize grown on sandy and feralite soils. Furthermore, regardless of different types of biochar, 600g of substrate was promising in enhancing black ginger leaves number and plant per rhizome. Possibly, biochar play a significant role in increasing the availability of nutrients for plant growth due to their characteristic in adsorbs and immobilizes nutrient and micro-organisms as well as in preventing leaching of mineral nutrients to underground water (Lehmann and Joseph, 2009).

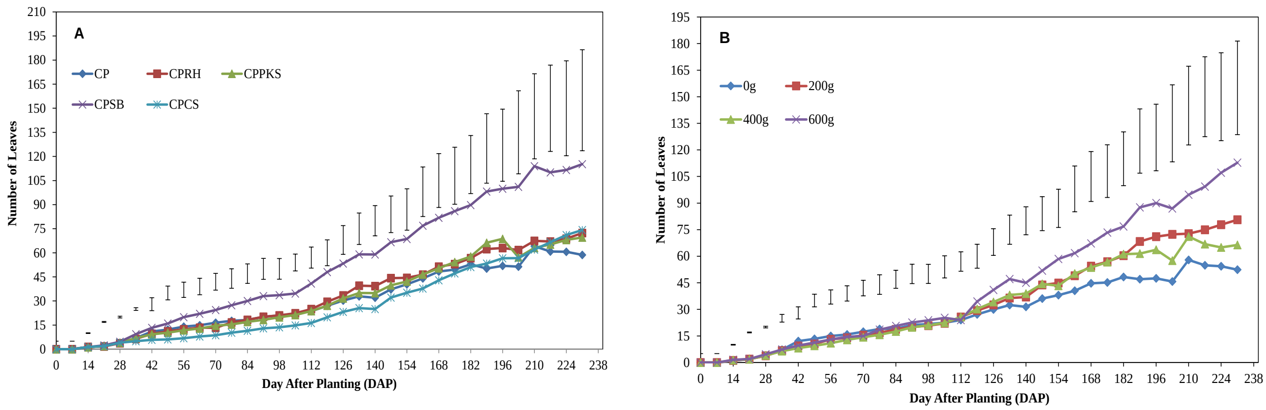


Fig. 1: Effects of different types (A) and rates (B) of biochar substrates on number of leaves of Black ginger grown on soilless growing media.Vertical bar represents HSD value at 5% significant level

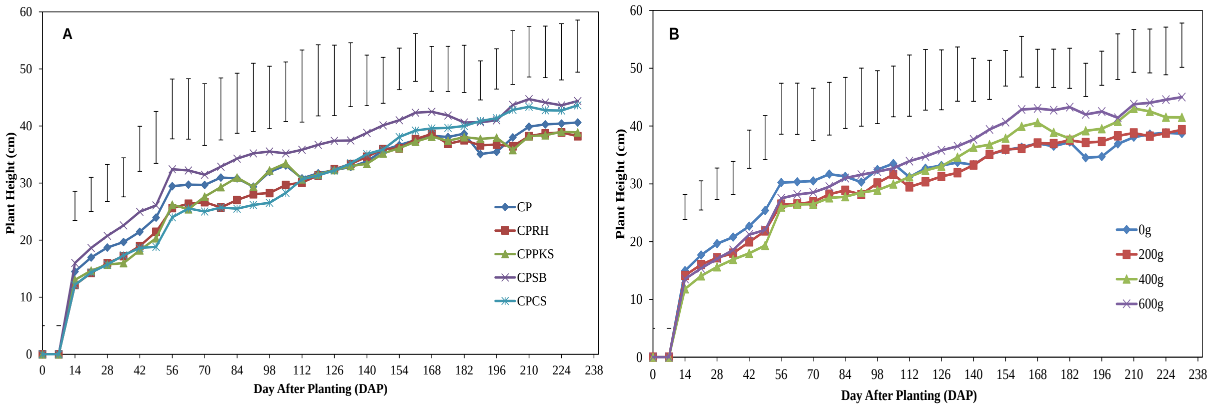


Fig. 2: Effects of different types (A) and rates (B) of biochar substrates on plant heights of Black ginger grown on soilless growing media.Vertical bar represents HSD value at 5% significant level.

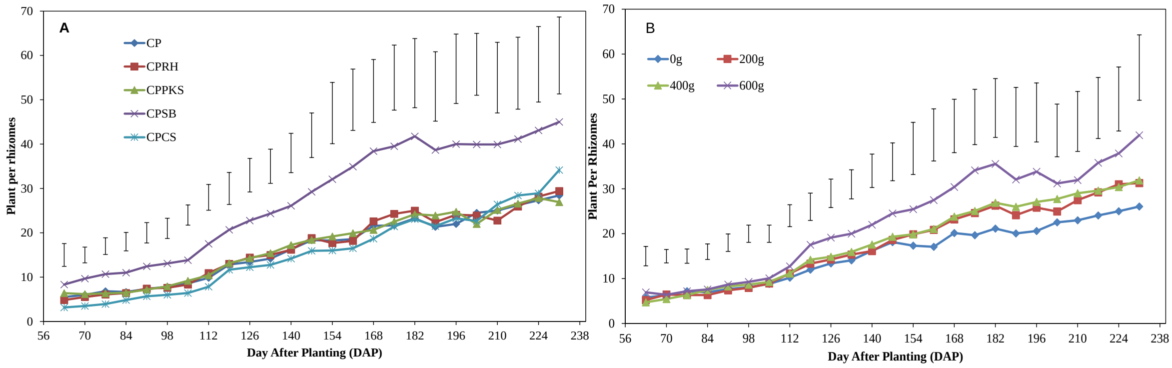


Fig. 3: Effects of different types (A) and rates (B) of biochar substrates on plant rhizomes of Black ginger grown on soilless growing media.Vertical bar represents HSD value at 5% significant level.

On the other hand, a significant interaction was recorded between different types and different rates of boichar substrates on total fresh weight, fresh weight (leaves, rhizomes, and roots), and dry weight (leaves and roots) of black ginger (Table 1). CPSB at 600g resulted in the highest values for all parameters as aforementioned. As according to Graber et al. (2010), biochar application significantly enhanced the leaf area, canopy dry weight, number of nodes and yield of pepper and tomato cultivated under optimal fertigation system. In contrast, no significant interaction was recorded between the two factors on individual chlorophyll (chlorophyll a and chlorophyll b), carotenoids and total chlorophylls (Table 2). Similarly, noapparent effects were observed in all parameters above either with the application of different types or different rates of biochar substrates. Although, the concentrations of individual chlorophyll, carotenoids and total chlorophylls were similar among treatments, CPCS at 400g tend to had higher values as compared to others. In contrast, Erwan et al. (2013) claimed that the highest value of chlorophyll content in cauliflower were recorded in plant grown on cocopeat incoporated with oil palm biochar. Possibly, the higher amout of chlorophylls content might be due to plant chlorophyll absorbs sunlight, which converts CO2 and water into glucose (Sims and Gamon, 2003). However, in the present study, the total chlorophyll content was not differ among soilless growing media applied.

Table 1: Effects of different types and rates of biochar substrates on total fresh weight, fresh weight (leaves, rhizomes, and roots), and dry weight (leaves and roots) of black ginger grown in soilless growing media.

| Factor | Total fresh weight (g) | Leaves fresh weight (g) | Rhizomes fresh weight (g) | Roots fresh weight (g) | Leaves dry weight (g) | Roots dry weight (g) |
|---|---|---|---|---|---|---|
| Growth media (GM) | | | | | | |
| CP | 957bc | 732a | 147a | 31.17a | 25.32a | 1.88a |
| CPRH | 1027ab | 820a | 156a | 30.67a | 33.14a | 1.54a |
| CPPKS | 451c | 291b | 155a | 40.48a | 28.00a | 1.87a |
| CPSB | 1538a | 1063a | 258a | 26.71a | 46.52a | 1.46a |
| CPCS | 977bc | 801a | 142a | 26.12a | 33.73a | 1.15a |
| Pr > F | *** | *** | ns | ns | ns | ns |
| Biochar rates (R) | | | | | | |
| 0g | 255c | 502a | 57bc | 23.97a | 13.50a | 1.23a |
| 200g | 819b | 611a | 153ab | 26.31a | 26.49a | 1.29a |
| 400g | 915b | 634a | 142b | 31.15a | 27.32a | 1.59a |
| 600g | 1438a | 1067a | 251a | 37.0aa | 48.59a | 1.98a |
| Pr > F | *** | *** | ** | ns | ns | ns |
| Interaction (GM x R) | *** | *** | ** | ** | ns | *** |

Means with different letters are significantly different at the 5% level according to Tukey test. ns = non-significant (P≤0.05).CP = cocopeat, CPRH = cocopeat+rice husk biochar, CPPKS = cocopeat+palm kernel shell biochar, CPSB = cocopeat+sugarcane bagasse biochar, and CPCS = cocopeat+coconut shell biochar.

Table 2: Effects of different types and rates of biochar substrates on chlorophyll content and total chlorophyll of black ginger grown in soilless growing media.

| Factor | Chlorophyll content ($mg.g^{-1}FW$) | | | Total chlorophyll ($mg.g^{-1}FW$) |
|---|---|---|---|---|
| | Chlorophyll a | Chlorophyll b | Carotenoid | |
| Growth media (GM) | | | | |
| CP | 0.76a | 0.45a | 2.86a | 1.21a |
| CPRH | 0.68a | 0.42a | 2.65a | 1.10a |
| CPPKS | 0.74a | 0.45a | 2.77a | 1.20a |
| CPSB | 0.74a | 0.45a | 2.91a | 1.20a |
| CPCS | 0.81a | 0.50a | 3.00a | 1.30a |
| Pr > F | Ns | Ns | ns | ns |
| Biochar rates (R) | | | | |
| 0g | 0.73a | 0.43a | 2.75a | 1.16a |
| 200g | 0.77a | 0.50a | 2.91a | 1.24a |
| 400g | 0.76a | 0.50a | 2.91a | 1.22a |
| 600g | 0.72a | 0.45a | 2.78a | 1.17a |
| Pr > F | Ns | Ns | ns | ns |
| Interaction (GMxR) | Ns | ns | ns | ns |

Means with different letters are significantly different at the 5% level according to Tukey test. ns = non-significant (P≤0.05).CP = cocopeat, CPRH = cocopeat+rice husk biochar, CPPKS = cocopeat+palm kernel shell biochar, CPSB = cocopeat+sugarcane bagasse biochar, and CPCS = cocopeat+coconut shell biochar.

Table 3: Effects of different types and rates of biochar substrates on leaf area leaf area index (LAI) of black ginger grown on soilless growing media

| Factor | Leaf area (cm2) | Leaf area index (LAI) |
|---|---|---|
| Growth media (GM) | | |
| CP | 7229ab | 4.30ab |
| CPRH | 5166ab | 3.08ab |
| CPPKS | 3727b | 2.21b |
| CPSB | 10138a | 6.04a |
| CPCS | 9100ab | 5.42ab |
| Pr > F | ** | ** |
| Biochar rates (R) | | |
| 0g | 5869a | 3.49a |
| 200g | 6311a | 3.76a |
| 400g | 7109a | 4.23a |
| 600g | 9356a | 5.57a |
| Pr > F | Ns | ns |
| Interaction (GM x R) | ** | ** |

Means with different letters are significantly different at the 5% level according to Tukey test. ns = non-significant (P≤0.05).CP = cocopeat, CPRH = cocopeat+rice husk biochar, CPPKS = cocopeat+palm kernel shell biochar, CPSB = cocopeat+sugarcane bagasse biochar, and CPCS = cocopeat+coconut shell biochar.

Meanwhile, the interaction was significant between the two factors for leaf area and leaf area index (LAI) (Table 3). The application of different types of biochar substrates at varying amounts increased the leaf area and LAI. Regardless the amount of biochar substrates, CPBS had the biggest leaf area and LAI as compared to other treatments. The possible reason might be attributed to the pore size of the substrates. Warnock et al. (2007) claimed that a greater proportion of micro-pores may yield a higher surface area, and thus greater nutrient retention capability. In addition, Hunt et al. (2010) reported that biochar with various pore sizes play a vital role in enhancing the physical, chemical, and biological characteristics of soils thereby improving yield and the growth performances of the grown plants.

In conclusion, combination of cocopeat and sugarcane baggase (CPSB) at 600g had the potential to replace commercial growing media (cocopeat alone) as its exhibit higher and comparable values of yield and growth performances. Moreover, this newly-developed soilless growing media are light, easy to handle and cost effective. Besides that, the usage of fertilizers and environmental pollution could also be reduced by minimizing these agricultural wastes.

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