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Evaluating the Benefits of Empty Fruit Bunch Compost from Oil Palm into Coconut Coir Dust Growing Media for Soilless Culture Practice

Mohd Fauzihan Karim[1,2*], Nur Nazifah Saimi[2]

[1]Sustainable Agriculture and Green Technology (AG-Tech) Research Unit, Kulliyyah of Science, International; Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia

[2]Department of Plant Science, Kulliyyah of Science, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia

ABSTRACT

This study was conducted to provide a preliminary and fundamental evaluation of oil palm empty fruit bunch (EFB) compost into coconut coir dust for soilless cultivation. Four-leafed chilli seedlings were transplanted into polybags containing either of 100% coconut dust or a mixture of coconut dust and EFB compost in a ratio of 3:1 (v/v). A few parameters, such as fruit yield, fruit number, relative chlorophyll content, and maximum quantum yield of Photosystem II, were evaluated. The incorporation of EFB compost into coconut coir dust media significantly increased fruit fresh weight around 35.7% as well as 23.5% increase in the overall number of fruits. Additionally, there was an observed improvement in the chlorophyll content values at four distinct stages, specifically during the fruiting and mature stages. Nevertheless, there was a marginal increase in the Fv/Fm reading in media amended with EFB compost. This study suggests that the addition of EFB compost can be advantageous in enhancing the growth and productivity of chilli plants in soilless culture cultivation.

Keywords: EFB compost, chlorophyll content, Fv/Fv, coconut coir dust, soilless culture

ABSTRAK

Kajian ini dijalankan untuk menyediakan penilaian awal dan asas ke atas campuran kompos tandan kosong kelapa sawit (EFB) ke dalam medium sabut kelapa untuk penanaman tanpa tanah. Anak pokok cili yang mempunyai empat helai daun telah dipindahkan ke dalam polibeg yang mengandungi kandungan sama ada 100% habuk kelapa atau campuran habuk kelapa dan kompos EFB dalam nisbah 3:1 v/v. Beberapa parameter asas, seperti hasil buah, bilangan buah, kandungan relatif klorofil dan hasil kuantum maksimum Fotosistem II, telah dianalisis. Penambahan kompos EFB ke dalam media habuk sabut kelapa mampu meningkatkan jumlah berat segar buah sekitar 35.7% lebih tinggi berbanding rawatan kawalan 100% habuk kelapa serta 23.5% peningkatan dalam jumlah keseluruhan bilangan buah. Di samping itu, terdapat peningkatan yang diperhatikan dalam bacaan kandungan klorofil pada empat peringkat pertumbuhan yang berbeza, khususnya semasa peringkat berbuah dan matang. Namun begitu, terdapat peningkatan kecil dan tidak ketara dalam bacaan Fv/Fm untuk pokok yang ditanam di dalam media yang telah ditambah dengan kompos EFB. Kajian ini mencadangkan bahawa penambahan kompos EFB boleh memberi manfaat dalam meningkatkan pertumbuhan dan produktiviti tanaman cili untuk penanaman kaedah secara tanpa tanah.

Kata Kunci: Kompos EFB, kandungan klorofil, Fv/Fv, habuk sabut kelapa, kaedah media tanpa tanah.

**Corresponding author:*
Mohd Fauzihan Karim
Kulliyyah of Science,
International Islamic University Malaysia
Email: mfauzihan@iium.edu.my

Introduction

Capsicum annum, commonly referred to as chilli is a member of the Solanaceae family. Its origin may be traced back to Mexico, where it was first cultivated. Subsequently, Spanish and Portuguese explorers carried chilli to other continents (Tripodi et al., 2021). According to the latest data in 2021, India has emerged as the leading exporter and producer of chilli, accounting for around 43% (1.98 million tonnes) of the global chilli harvest, followed by China and Thailand (FAO, 2023). The consumption of chilli on a daily basis exhibited variability between the years 2016 and 2019. As of 2020, the global export value of chilli was recorded at 25.18 million USD (Sundari et al. 2023).

The phytochemical research conducted on chilli revealed the presence of several advantageous substances with potential health benefits for humans, including flavonoids, carotenoids, and capsaicinoids (Batiha et al., 2020; DeVilliers et al., 2016). Capsaicin, a constituent of the capsaicinoids group, is the primary bioactive molecule accountable for the sensory attributes of pungency and spiciness exhibited by chilli. Furthermore, the pharmacological study on chilli has unveiled their therapeutic potential due to the presence of capsaicin, which exhibits antioxidant, antidiabetic, and anti-carcinogenic attributes (Brown et al., 2023; Zimmer et al., 2012). According to a study conducted by Kantar et al. (2016), it was shown that chilli contain a diverse range of vitamins including vitamins A, B2, B3, C, and E.

In recent times, the agricultural sector has seen a shift towards adopting sustainable practises in order to effectively tackle various environmental concerns. According to Yevich and Logan (2003), the emission of potent greenhouse gases has been exacerbated by improper management of agricultural waste. The annual production of empty fruit bunches (EFB) in Malaysia is aprroximately 20 million tonnes (Nasrin et al., 2017), as oil palm is the country's most important agricultural product. This EFB, which is the fresh oil palm's biomass, is frequently disposed by decomposition or combustion, which simultaneously emits methane and carbon dioxide gases (Adu et al., 2022). Consequently, the implementation of sustainable practises such as composting has reduced 76% of greenhouse gas emissions from landfills (Krishnan et al., 2017).

According to Yi et al. (2019), the application of EFB as an organic fertilizer has the potential to enhance soil fertility and physical properties. It has been observed to release macronutrients that are readily absorbed by plants, enhance soil moisture retention, elevate soil pH levels, and raise the cation exchange capacity (CEC) of growth media (Adam et al., 2016; Hafeez et al., 2002). EFB also has a positive effect on the soil biota given that it is an ideal nutrient source for microbes, thereby fostering the feeding activity of fauna (Tao et al., 2018). Moreover, in a study of cereals and maize, Adu et al. (2022) reported that incorporating EFB as a soil amendment enhanced crop growth by 42.9% compared to untreated soil. In this study, the incorporation of EFB into coconut dust-based media was evaluated in terms of the physiology and yield of chillies cultivated in soilless culture.

Materials and Methods

Field experiment

Chilli seeds (*Capsicum annuum* vs Kulai) were germinated on a germination tray filled with peat moss and raised until the development of 4 leaves . The seedlings were then transplanted into 20 cm x 20 cm polybags with a mixture of growing medium comprising either of i) 100% coconut dust; ii) 3:1 v/v of coconut coir dust and EFB compost. The plants were

fertigated daily with modified Cooper nutrient formulation with electrical conductivity (EC) of 1.5 - 2.5 dSm^{-1} (Cooper, 1976).

Yield and Physiological study

Chilli were harvested when the colour turned from green to intermediate reddish. The fruits were subsequently measured to determine their total fresh weight and total fruit number. Relative total chlorophyll content was measured on fully developed leaves using SPAD 502, MINOLTA Camera Ltd. Japan. Data was recorded at four different growth stages (vegetative, early flowering, fruiting and mature) in the early morning between 8.30 am-9.30 a.m. Meanwhile, the maximum quantum yield of Photosystem II was measured as Fv/Fm by a portable photosynthetic efficiency analyzer (PEA) (model Handy-PEA, Hansatech Instrument Ltd., Norfolk, UK).

Statistical analysis

All analysis was performed using GraphPad Prism software package Version 9.4.1 (http://www.graphpad.com). Significant difference among treatments was compared using a Student's T-Test at 5% level. The level of significance was accepted at $p \leq 0.05$.

Results and Discussion

This research was conducted to determine the effects of applying palm oil empty fruit bunch (EFB) compost on the yield and physiology of chilli grown in soilless culture media. Figure 1 demonstrates that the addition of EFB compost to coconut dust significantly increased the fruit fresh weight ($p \leq 0.01$). The total harvest in EFB compost amended media increased approximately 35.7% more than coconut dust alone, suggesting the benefit of adding EFB compost in helping to improve yield. In addition, the number of fruits harvested followed the same pattern, with a significantly greater number observed in media amended with EFB compost (23,5%) compared to the control (Figure 2). The correlation analysis performed to determine the relationship between fruit fresh weight and fruit number reveals that both parameters are significantly and positively correlated (Figure 3). EFB compost contain highly important nutrients and naturally act as slow release fertiliser. The incorporation of EFB compost with mineral fertilisers, according to Adu et al. (2022), could increase plant growth and yield by 30.9% compared to unamended soil. It was proposed that this could be the function of EFB to enhance soil structure, increase the number of beneficial microorganisms, and increase soil moisture content (Radin et al., 2018). Furthermore, coconut dust-grown plants were also at risk of experiencing water deficiency. Despite its high water absorption, coconut dust reportedly has limited water retention (Abad et al., 2005) and could lead to a water limited situation.

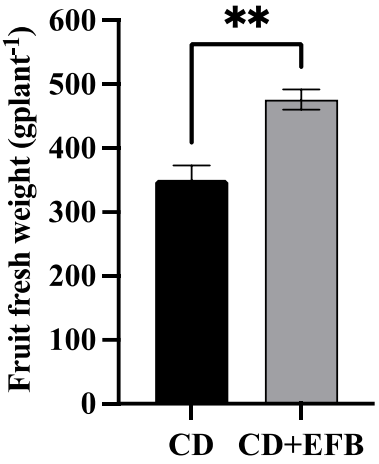

Figure 1: Effect of EFB compost amendment on fruit fresh weight of chilli at harvesting. Data was analysed using a Student's T-Test to compare the means between two groups. Values are given as mean±S.E (n=4). Values with superscript (**) differ significantly at p≤0.05.

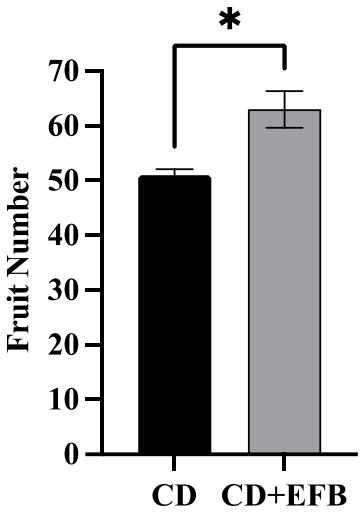

Figure 2: Effect of EFB compost amendment on fruit number of chilli at harvesting. Data was analysed using a Student's T-Test to compare the means between two groups. Values are given as mean±S.E (n=4). Values with superscript (*) differ significantly at p≤0.05.

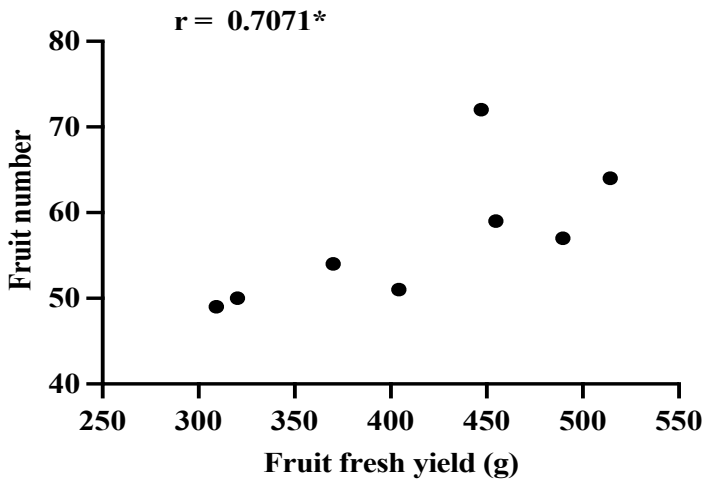

Figure 3: Pearson correlation analysis between fruit fresh weight and fruit number.

Meanwhile, the quantification of chlorophyll concentration serves as a valuable indicator for assessing the ongoing photosynthetic processes within plants. In this study, measurements were taken at four different growth stages (vegetative, early flowering, fruiting, and mature) to determine the effect of EFB compost on chlorophyll status. In general, both treatments exhibit increases in chlorophyll content from the vegetative stage to maturity, as shown in Figure 4. However, the magnitude of the increase between treatments varied. During the vegetative and early flowering stages, there was no significant difference in relative chlorophyll content between EFB-amended media and the control. During the fruiting and mature stages, the CD+EFB media has a higher chlorophyll content than the control by 9.5% and 13.4%, respectively. Chlorophylls are the nitrogen and magnesium rich molecules (Durret and Welti, 2021). Therefore, adequate supplementation of these two nutrients is essential during the formation of chlorophylls.

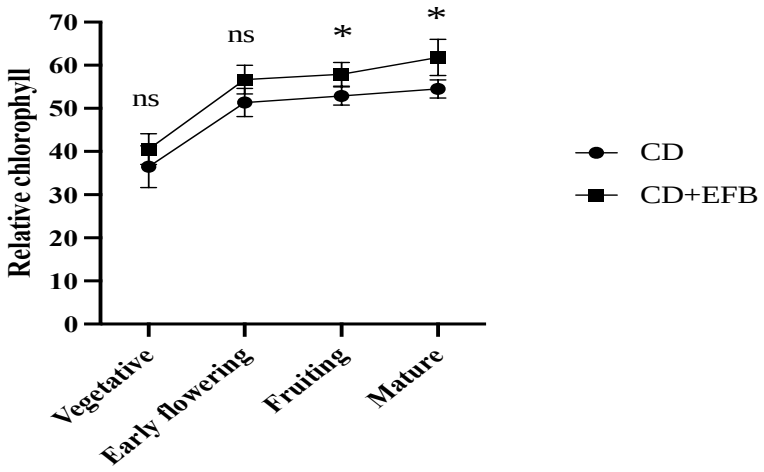

Figure 4: Effect of EFB compost amendment on relative chlorophyll content at different growth stages. Data was analysed using a Student's T-Test to compare the means between two groups within the same growth stage. Values are given as mean±S.E (n=4). Values with superscript (*) differ significantly at $p \leq 0.05$

In addition to chlorophylls, the homologous proteins D1 and D2 are also present in Photosystem II (Knoppová et al., 2022). Maintaining the process of electrons' excitation to a higher energy level is dependent upon the health of these proteins, specifically the D1 protein. Maximum quantum yield of PSII (Fv/Fm) is measured as the ratio of variable to maximum fluorescence after dark adaptation and value in the range of 0.79 to 0.84 is the approximate optimal value for many plant species, with lowered values indicating plant stress (Maxwell and Johnson, 2000). This experiment revealed that the Fv/Fm ratio fell within the expected range, suggesting that the introduction of EFB did not cause any photoinhibition. In fact, the value was slightly better than that of the control. This could suggest that EFB compost may have a positive effect on photosynthesis, the fundamental process of plant growth.

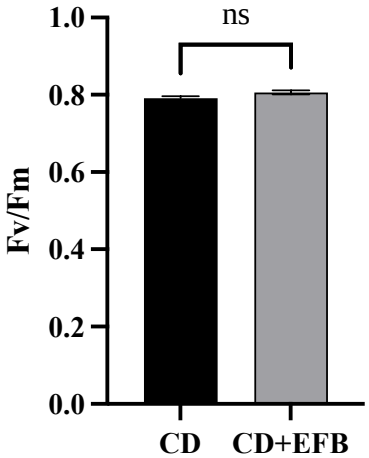

Figure 5: Effect of EFB compost amendment on Fv/Fm at early flowering stage. Data was analysed using a Student's T-Test to compare the means between two groups. Values are given as mean±S.E (n=4). Values with superscript(*) differ significantly at $p \leq 0.05$.

Although the control plants also received the same number of fertilisers, coconut dust was found to have a significantly lower cation exchange capacity (CEC) (Landis et al., 2014). This could result in rapid nutrient leakage from the polybags. In contrast, EFB-derived produce naturally has a higher CEC value, which affects the soil's capacity to retain essential nutrients and acts as a buffer against soil acidification (Ab-Aziz et al., 2015). In fact, the use of coconut dust with more than 50% of the media was reported to reduce plant growth due to high C:N ratio and high microbial immobilization (Arenas, et al., 2002).

Conclusion

The incorporation of EFB compost into coconut dust media has been observed to have a beneficial impact on the yield and physiology of chilli plants cultivated in soilless culture. Adding the EFB compost resulted in an increased fruit fresh weight and a higher total number of fruits. The physiology of plants including relative chlorophyll content also improved with EFB amendment. This suggest EFB compost is beneficial not only for field-grown crops, but also for soilless cultivation techniques. Additionally, a slight rise in chlorophyll fluorescence was also observed. This enables the potential for implementing more environmentally sustainable farming practises by substituting chemical fertilisers with organic amendments, as EFB constitute a significant waste source within the oil palm industry. Furthermore, this methodology could serve as a viable method for

promoting improved agricultural production practise in response to the worldwide concern around climate change.

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