Journal of Engineering and Applied Sciences 14 (Special Issue 3): 6072-6076, 2019
ISSN: 1816-949X

Effect of Biochar from Oil Palm Waste on Sweet Corn Yield

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Abstract: The cultivation of mature and immature palm trees covers a total of 5.64 million hectares representing 52% of the total area (10.9 million hectares) designated for agriculture and 17% of overall Malaysian territory (Ministry of Plantation Industries and Commodities). However, oil palm industries produce lignocellulosic biomass from oil palm trunks, Empty Fruit Bunches (EFB), Oil Palm Fronds (OPF), palm pressed fibres and shells. Oil palm waste was detected to have considerable amounts of carbon (43-51 wt.%) and fixed carbon (30-39 wt.%) showing potential to be converted into carbon-rich biochar. In view on this, we conducted this study to determine and evaluate the effects of biochar from oil palm frond and EFB on sweet corn yield. The experimental site was located at Farm Unit, UiTM Samarahan, Sarawak Branch. The experiment consisted of 5 treatments, each treatment consisting of 80 plants, replicated 3 times which gave a total of 1200 sweet corn plants laid out in a Randomized Complete Block Design (RCBD) arrangement from April-July 2018. Parameters measured at harvest 85 DAT included the fresh and dry biomass, the number of cobs and cobs grade. The number of cobs produced on each plant was counted, weighed and graded, according to scale: grade A (>200 g per cob), grade B (100-200 g per cob) and grade C (<100 g per cob). All of the recorded data were compared by the Analysis of Variance (ANOVA) using SAS 9.4 (2013). The result indicated treatment T5 (EFB biochar+foliar fertiliser) was the best treatment combination for both biomass and cobs weight with the value of 149.28 and 316.12 g, respectively ($p<0.0001$) as compared to control. T4 (EFB biochar 100%) produce lower yield as compared to T5 probably due to the application of foliar spray. EFB biochar+foliar fertiliser can be recommended to boost sweet corn yield.

Key words: Oil palm waste, biochar, sweet corn yield, OPF, carbon, parameters

INTRODUCTION

Agricultural wastes are source of organic matter to soil agro-ecosystem to provide essential plant nutrients. These wastes have the potential as an opportunity to produce biochar as a sustainable soil amendment. The use of biochar has an ability to reduce further reduction of soil organic carbon (Gaskin *et al*., 2008; Goh *et al*., 2010; Liew *et al*., 2018) and reduce the chemical fertilizer-use (Widowati and Asnah, 2014). These wastes provide a beneficial impact to the country and have a commercial value as it has a potential to be converted into biochar and biomass. The application of compost residues into the soil may cause rapid decomposition for nutrients release and emissions of greenhouse gases such as carbon dioxide. This method requires frequent application of the organic material to the soil to maintain fertility. The alternative to sustain the organic residue onto soil is conversion of crop residues into biochar for application. Biochar is a product of an organic substance at a temperature of 300-1000°C to produce few products such as oil, synthetic gas and biochar (Gul *et al*., 2015). It is which generally had alkaline pH were found to significantly affect the productivity on soils through increased phyto-availability of essential nutrients for plant growth (Biederman and Harpole (2013); Verheijen *et al*., 2010). The soil fertility is improved with primarily manifested in higher pH in acidic soils and an increase in organic carbon content (Oleszczuk *et al*., 2013; Gul *et al*., 2015). Biochar is also useful to

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improve the physical, chemical and biological properties of soil in agriculture activities (Curaqueo *et al*., 2014; Prendergast-Miller *et al*., 2014). The addition of biochar has also been found to have a positive influence on the soil content of N, P, K and Mg and higher grain yields (Farrell *et al*., 2014). Masulili (2010) reported that biochar could boost yield under problematic soils also such as acidic soils. It is used as amendment in degraded tropical soils (Lehmann and Joseph, 2009). Due to resistance of microbial decomposition it ensures long term benefit for soil fertility (Gaskin *et al*., 2008). Biochar helps to improve the soil structure, assist in enhance the organic matter content in the soils, thus, the crop production and yield also increase due to the increase of the soil fertility in field (Rehman and Razzaq, 2017). As a result, application of biochar can increase agricultural sustainability, especially, in areas with low rainfall and in inherently low fertile soils. Agricultural by-products such rice husk, bagasse, coconut shell, coir pith etc. are available in large quantities (Sugumaran and Sheshadri, 2010) and can be utilized in biochars production. Jeffery *et al*. (2011) reported that high crop yields were obtained by amending the soil with biochar produced from wood, paper pulp, wood chips and poultry litter. Suppadit *et al*. (2012) studied the effect of quail litter biochar on soybean yield attributes and yield in pot experiment in sandy soil and reported significant that yield increase with biochar application. Uzoma *et al*. have also reported increased maize yield by application of cow manure biochar. Yield increase in cowpea by 100% has been reported by Glaser *et al*.. This study was conducted to study the effects of biochar made up from oil palm waste to the sweet corn as the indicator. The potential benefits that biochar offers are to improve soil fertility and crop yields and it can give greater farm profitability to farmers and it also help in term of fertilizer use efficiency (Anonymous, 2016).

Experimental site: A field experiment was conducted at Farm Unit, Universiti Teknologi MARA to evaluate the effect of biochar along with different biochar rates on sweet corn yields. In a Randomized Complete Block Design (RCBD), five treatments in three replicates were used with two different sources of plant residue which were Oil Palm Fronds (OPF) and Empty Fruit Bunches (EFB). Field was ploughed and prepared before the sweet corn seeds were sown to the planting site.

MATERIALS AND METHODS

Sweet corn seedling preparation: The pre-germinated seeds were planted using compost medium in the seedling trays in nursery. Sweet corn seedlings were nursed in nursery for 7 days old before field transplanting into the various beds, according to experimental design. Each planting point were transplanted with one sweet corn seedling. The soil used were that of red-yellow podzollic soil. There were five treatments set up to study the application of biochar from two different source of plant residue; 72 kg OPF biochar, 48 kg EFB biochar and 24 kg foliar spray used to conduct this experiment.

Treatment classification: There were five treatments were prepared for soil amendment accordingly. The biochar rate was determined based on percentage to be incorporated with soil. Foliar spray was used as an additional supplement in treatment five:

- Treatment 1 = Control
- Treatment 2 = OPF biochar 50%
- Treatment 3 = OPF biochar 100%
- Treatment 4 = EFB biochar 100%
- Treatment 5 = EFB biochar 50%+Foliar spray 50%

Biochar application: Biochar was applied to sweet corn seedling at planting site, according to treatments. It was applied with 100 g on 14 Day After Transplanting (DAT) and another 100 g on 45 DAT at field planting site. The biochar was broadcasted about 5 cm from the plants collar region and plowed to incorporate with soil. Watering was carried out before biochar application to reduce the soil heat and prevent biochar lost by the wid.

Perimeter reading: After achieving 85 DAT, the cob weight of sweet corn for each plant was collected and weight were recorded at harvest by using weight balance. The cobs graded as grade A≥200 g, grade B = 100<200g, grade C≤100 g. After all cobs were harvested, the plants were cleared for fresh biomass collection. The fresh biomass was measured by weighting the plant using digital scale. After that the fresh biomass was arranged thoroughly under the sun for drying in transparent shade house for 2 days to get biomass dry weight measures. Weight of biomass included all parts of sweet corn plant from the shoots to the roots.

RESULTS AND DISCUSSION

Biomass: Result indicates that treatment 1 (Control) and applying OPF biochar 50% (treatment 2) were not significant at 96.18 and 96.55 g on the growth of sweet corn, respectively. However, the increment of biochar rate intreatment 3 which were applied with higher rate at 100% of OPF biochar had showed the significant different of biomass dry weight. Liu *et al*. (2013) reported that both bamboo biochar and rice straw biochar (RB) significantly increased soil pH and soil organic carbon compared to control whereas their effects on total N were either very small or non-significant. The study by Milla *et al.* (2013) supported the significant of the used of biochar where the effect of rice husk biochar on plant growth parameters had significantly higher number of leaves, leaf width, number of stems and root size. On the other hand, treatment 4 (100% of EFB biochar) had showed no significant different with treatment 3. That shows that was no different of the source of biochar from plant residues of OPF and EFB with similar biochar rate at 100% application. Treatment 5 (EFB biochar 50%+foliar spray) showed highest mean biomass weight at 149.28 g. The foliar spray was believed as Nitrogen (N) supply directly to the plants leave as nutrient supplement for the vegetative growth that was reflecting biomass weight (Table 1).

Cob weight: Table 2 shows that treatment 1 (Control) and treatment 2 (OPF biochar 50%) had no significant different of cobs weight at 185.59 and 211.71 g, respectively. However, with higher rate biochar application at 100% of OPF (treatment 3) had significantly different higher of cob weight compared to treatment 1 at mean different of 44.93 g. This indicates the higher rate of biochar application could increase the soil fertility with soil organics and soil characters improvements. Besides that treatment 4 (EFB biochar 100%) also showed significant different compare to treatment 1 (Control) and treatment 2 (OPF biochar 50%). However, there was no significant different with treatment 3, although, the source of plants residue was different. According to Blackwell *et al*. (2010) and Farrell *et al*. (2014) confirmed the beneficial effect of biochar amendment on common wheat grain yield. Increased crop yields after biochar application may result both from an improvement in the soil structure (Lehmann and Joseph 2009) and from reduced nutrient leaching (Yanai *et al*., 2007). Major *et al*. (2010) reported that in maize application of biochar at 20 tons/ha significantly increased maize grain yield by 98% compared to the control. In treatment 5 (EFB biochar 50%+foliar spray) the weight of cobs was significantly higher compared to treatment 1-4. It was understood the additional of foliar spray with Nitrogen (N) could supply enough nutrient for plant growth and fruits formation. This result was supported by Asai *et al*. (2009) that biochar application resulted in higher grain yields at sites with low P availability and enhanced the response to N and NP fertilizer treatments but reduced leaf SPAD values, possibly through a reduction in available N indicating that biochar application should be coupled with N fertilization in soils with low N supply. In addition, Venkatesh *et al*. (2010) reported that higher agronomic nitrogen use efficiency (91.0 kg grain/kg N) was recorded with application of biochar (6.0 t/ha) coupled with NPK.

Table 1: Dry weight of sweet corn plants

Treatment	Dry weight (g)
1	096.18±9.990c
2	096.55±8.590c
3	104.63±5.290b
4	119.28±13.29b
5	149.28±18.53a

Table 2: Cobs weight for each treatment

Treatment	Cobs weight (g)
1	185.59±7.280c
2	211.71±7.810c
3	230.52±4.700b
4	287.80±10.75b
5	316.12±14.94a

a-c significant values

Cobs grades: Figure 1 shows the percentage of sweet corn cob according to the cob weight. The sweet corn cobs grade was classified based on cobs weight. All the sweet corn cobs were classified as grade A and B at 805 (67.08%) cobs and 395 (32.92%) cob, respectively.

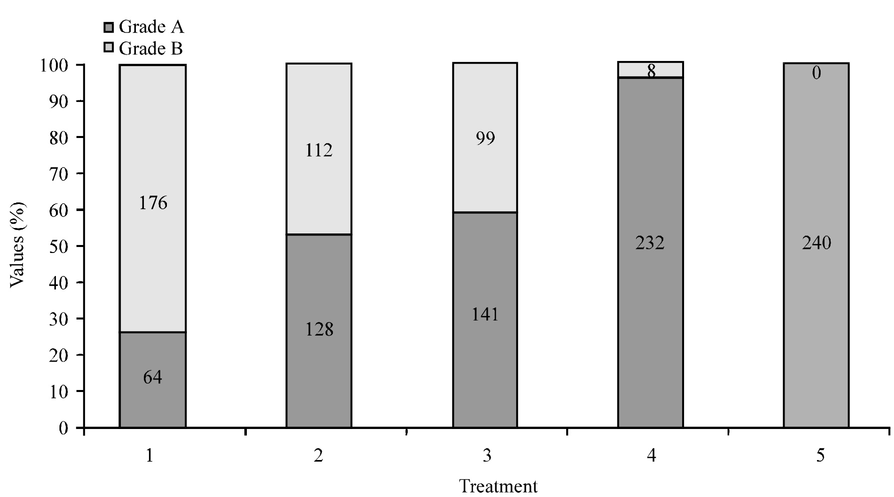

Fig. 1: Cobs grade

None of treatment produced grade C cobs during the study. Treatment 1 (Control) showed the lowest grade A of sweet corn cobs at 64 (5.33%) and highest of grade B at 176 (14.67%). Treatment 2 (OPF biochar 50%) and treatment 3 (OPF biochar 100%) had about the same of sweet corn cons classified as grade A which were 128 (10.67%) and 141 (11.75%), respectively with the meant different was 1.08%. Treatment 4 (EFB biochar 100%) and treatment 5 (OPF 50%+foliar spray) showed higher of sweet corn cobs at 232 (19.33%) and 240 (20%), respectively. However, there was no grade B cobs produce in treatment 5.

CONCLUSION

Application of biochar in sweet corn planting showed significantly improvement in plant biomass weight, cobs weigh as well as for cobs grade. However, the presence of Nitrogen (N) supply from foliar spray could increase the plants biomass that was reflecting the vegetative growth of plants. As translated in study outcome, there were positive correlation between plants biomass and sweet corn weight as yield. The plant biomass was referring the plants components included plants stem, leaves and roots which were significantly important for the formation of quality fruits set. As suggested in previous study, the rate of biochar had significantly different to improve the soil condition improvement such as physical properties, soil chemical properties and soil biological properties. Therefore, the correct amount of biochar should be considered for soil amendment to ensure it is effective for application. Besides that the additional of nutrients supply such as Nitrogen (N) must be emphasized for better outcomes in sweet corn planting. Nitrogen (N) could be supplied to plant in various form like foliar fertilizer in solution (foliar spray) and in granular nitrogen fertilizer.

REFERENCES

Anonymous, 2016. Malaysia oil palm. Ministry of Primary Industries, Putrajaya, Malaysia.

Asai, H., B.K. Samson, H.M. Stephan, K. Songyikhangsuthor and K. Homma *et al*., 2009. Biochar amendment techniques for upland rice production in Northern Laos: 1. Soil physical properties, leaf SPAD and grain yield. Field Crop Res., 111: 81-84.

Biederman, L.A. and W.S. Harpole, 2013. Biochar and its effects on plant productivity and nutrient cycling: A meta-analysis. GCB Bioenergy, 5: 202-214.

Blackwell, P., E. Krull, G. Butler, A. Herbert and Z. Solaiman, 2010. Effect of banded biochar on Dryland Wheat production and fertiliser use in South-Western Australia: An agronomic and economic perspective. Soil Res., 48: 531-545.

Curaqueo, G., S. Meier, N. Khan, M. Cea and R. Navia, 2014. Use of biochar on two volcanic soils: Effects on soil properties and barley yield. J. Soil Sci. Plant Nutr., 14: 911-924.

Farrell, M., L.M. Macdonald, G. Butler, I. Chirino-Valle and L.M. Condron, 2014. Biochar and fertiliser applications influence phosphorus fractionation and Wheat yield. Biol. Fertil. Soils, 50: 169-178.

Gaskin, J.W., C. Steiner, K. Harris, K.C. Das and B. Bibens, 2008. Effect of low-temperature pyrolysis conditions on biochar for agricultural use. Trans. ASABE, 51: 2061-2069.

Goh, C.S., K.T. Tan, K.T. Lee and S. Bhatia, 2010. Bio-ethanol from lignocellulose: Status, perspectives and challenges in Malaysia. Bioresour. Technol., 101: 4834-4841.

Gul, S., J.K. Whalen, B.W. Thomas, V. Sachdeva and H. Deng, 2015. Physico-chemical properties and microbial responses in biochar-amended soils: Mechanisms and future directions. Agric. Ecosyst. Environ., 206: 46-59.

Jeffery, S., F.G. Verheijen, M. van der Velde and A.C. Bastos, 2011. A quantitative review of the effects of biochar application to soils on crop productivity using meta-analysis. Agric. Ecosyst. Environ., 144: 175-187.

Koh, L.P. and D.S. Wilcove, 2008. Is oil palm agriculture really destroying tropical biodiversity?. Conserv. Lett., 1: 60-64.

Lehmann, J. and S. Joseph, 2009. Biochar for Environmental Management: Science and Technology. Earthscan Publisher, Sterling, Virginia, London, UK., ISBN:9781844076581, Pages: 416.

Liew, R.K., W.L. Nam, M.Y. Chong, X.Y. Phang and M.H. Su *et al*., 2018. Oil palm waste: An abundant and promising feedstock for microwave pyrolysis conversion into good quality biochar with potential multi-applications. Process Safety Environ. Prot., 115: 57-69.

Liu, X., Z. Afeng, C. Ji, S. Joseph and R. Bian *et al*., 2013. Biochar's effect on crop productivity and the dependence on experimental conditions-A meta-analysis of literature data. Plant Soil, 373: 583-594.

Major, J., M. Rondon, D. Molina, S.J. Riha and J. Lehmann, 2010. Maize yield and nutrition during 4 years after biochar application to a Colombian savanna oxisol. Plant Soil, 333: 117-128.

Masulili, A., W.H. Utomo and M.S. Syechfani, 2010. Rice husk biochar for rice based cropping system in acid soil 1. The characteristics of rice husk biochar and its influence on the properties of acid sulfate soils and rice growth in West Kalimantan, Indonesia. J. Agric. Sci., 2: 39-47.

Milla, O.V., E.B. Rivera, W.J. Huang, C.C. Chien and Y.M. Wang, 2013. Agronomic properties and characterization of rice husk and wood biochars and their effect on the growth of water spinach in a field test. J. Soil Sci. Plant Nutr., 13: 251-266.

Oleszczuk, P., I. Josko and M. Kusmierz, 2013. Biochar properties regarding to contaminants content and ecotoxicological assessment. J. Hazard. Mater., 260: 375-382.

Prendergast-Miller, M.T., M. Duvall and S.P. Sohi, 2014. Biochar-root interactions are mediated by Biochar nutrient content and impacts on soil nutrient availability. Eur. J. Soil Sci., 65: 173-185.

Rehman, H.A. and R. Razzaq, 2017. Benefits of biochar on the agriculture and environment-a review. J. Environ. Anal. Chem., 4: 1-3.

Sugumaran, P. and S. Sheshadri, 2010. Biomass charcoal briquetting: Technology for alternative energy based income generation in rural areas. MSc Thesis, Shri AMM Murugappa Chettiar Research Centre, Taramani, Chennai.

Suppadit, T., N. Phumkokrak and P. Poungsuk, 2012. The effect of using quail litter biochar on soybean (Glycine max L. Merr.) production. Chil. J. Agric. Res., 72: 244-251.

Venkatesh, G., G.R. Korwar, B. Venkateswarlu, K.A. Gopinath and U.K. Mandal *et al*., 2010. Preliminary studies on conversion of maize stalks into biochar for terrestrial sequestration of carbon in rainfed agriculture. Proceedinds of the National Symposium on Climate Change and Rainfed Agriculture, February 18-20, 2010, Central Research Institute for Dryland Agriculture, Hyderabad, India, pp: 388-391.

Verheijen, F., S. Jeffery and A.C. Bastos, 2010. Biochar Application to Soils: A Critical Scientific Review of Effects on Soil Properties, Processes and Functions. Publications Office, Luxembourg, Europe, Pages: 160.

Widowati, W. and A. Asnah, 2014. Biochar effect on potassium fertilizer and leaching potassium dosage for two corn planting seasons. Agrivita J. Agric. Sci., 36: 65-71.

Yanai, Y., K. Toyota and M. Okazaki, 2007. Effects of charcoal addition on N_2O emissions from soil resulting from rewetting air-dried soil in short-term laboratory experiments. Soil Sci. Plant Nutr., 53: 181-188.