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A Review: Synergistic Effects of FYM and Cob Biochar on the Growth and Yield of Sweet Corn (*Zea mays* L. *saccharata*)

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ABSTRACT: Production of sweet corn generates massive agricultural wastes, particularly corncobs, which are usually incinerated, resulting in environmental and health issues. Converting wastes into biochar through slow pyrolysis offers an environmentally friendly option. Biochar is a carbon-rich by-product that improves soil properties such as pH, nutrient status, water retention, and microbial activity. Farmyard manure (FYM), a traditional soil conditioner, also improves soil fertility through the introduction of organic matter and nutrients. Current studies show that the mixing of biochar with FYM has complementary impacts, significantly improving soil structure, nutrient absorption, and yield of crop. This combined strategy enhances sweet corn cultivation through sustainable farming, reduction of environmental stress, and soil sustainability. Application of FYM in combination with sweet corn waste for the production of biochar is a viable method of efficient waste management and climate-resilient agriculture.

Keywords: Pyrolysis, cob biochar, pervious, farmyard manure, fertilizers, sustainable agriculture.

INTRODUCTION

Sweet corn (*Zea mays* L. *saccharata*) or the sugar corn is gaining popularity, as the cob is tender and flavor, is accepted for straight consumption. Sweet corn cultivation is found highly rewarding and can be cultivated throughout the year with successful yield. Sweet corn is quickly becoming popular among all the segments of population because it is highly nutritive and rich in protein and fibre (Lal *et al.*, 2018). Its use at young stage as boiled and roasted ears is a common practice since the kernels are sweet, tender, creamy, and crunchy and checks nearly shell-less. Owing to its additional sweetness of taste and softness, sweet corn growing is the priority of the farmers particularly in agriculture. After corn stalks and leaves are harvested, a vast amount of agricultural waste is left behind. Corn cob is a byproduct that remains after all the kernels have been removed. Mostly farmers use burning as a means of getting rid of this farm waste. But this is not good as it leads to local air pollution issues, soil degradation, and impacting human health. To prevent the burning of biomass, it is vital to determine how this waste can be used. This issue can be addressed in agriculture by using slow pyrolysis to produce biochar from the corncob trash (Gabhane *et al.*, 2020). Biochar is a fine grained, carbon dense, pervious residue left after plant biomass has undergone thermo-chemical conversion process (pyrolysis) under conditions of little or no oxygen (Devika *et al.*, 2018). Physico-chemical properties like bioavailability of nutrients, cation exchange capacity, pH, strength of soil, and water holding capacity can be altered in the soil with the biochar application (Khan *et al*., 2024). Biochar enhances crop root development and nutrient uptake by ameliorating soil structure, moisture retention, and nutrient availability (Hussain *et al.*, 2017). Even though biochar has a lot of potential, it's essential to remember that FYM is a classic agrarian practice. Because of its high organic matter content, FYM ameliorates soil structure, provides nutrients, and encourages favorable microbial activity (Balda and Giri 2023). A steady supply of nourishment to plants occurs when the gradual release of nutrients takes place with the breakdown of organic matter. The benefit of FYM and biochar is they work together to create a synergistic interaction. Results from applying these modifications together are greater than those being applied alone (Arif *et al.*, 2012). Biochar has also proven to enhance the soil microbial activity. FYM promotes microbial diversity, enriches organic matter, and is a great nutritional supplementation in the short term. Hence, the combined use of biochar and FYM may represent a holistic strategy that maximizes the soil fertility, improves climate resilience and eventually promotes sustainable agriculture practices in sweet corn.

Properties and Benefits of FYM: FYM is a heterogeneous product of animal excreta and bedding materials like urine soaked litter developed by anaerobic decomposition. Organic matter, microbial biomass, moisture level (50%-70%) and inorganic mineral components are the main constituents of FYM. The supplement material of FYM varies with the support of animals, type of animals, harvesting techniques and capacity levels. Properly composted FYM provides easily available nutrients N, P, and K along with necessary supplements (Bayu *et al.,* 2006). FYM also serves as a source of organic carbon when it breakdown in the soil.

Fig. 1. Farmyard manure.

Hydraulic conductivity was enhanced to a great extent, and bulk density was reduced by applying farmyard manure under deep tillage (Khan *et al.,* 2010). Desta (2015) performed a field experiment at the Antra catchment of Chilga to investigate the effect of natural and chemical fertilizers on soil properties under maize and identified that the integrated application of natural and inorganic fertilizers improved soil pH, organic carbon, and cation exchange capacity when compared to the control. The advantageous impact of FYM on yield-contributing characters was the main reason behind increased grain yield at the enhanced level of FYM. FYM provides all macro and micro nutrients required for plant growth and also activates microbial population and physical condition of soil, thereby affecting yield-contributing characters (Bhat *et al.,* 2013). The impact of integrated application of natural and chemical fertilizers on soil microbes reported that natural fertilizers had a significant effect on microbial and parasitic populations, where microbial (8.24 log cfu g^{-1} soil) and fungi (3.89 log cfu g^{-1} soil) richness was greater under integrated application of fertilizers (Kumar *et al.,* 2017). The most feasible technique for enhancing the count of actinomycetes and bacteria was to use FYM with NPK fertilizer (Jagathjothi *et al.,* 2008). Sustainable improvement in soil's physical environment, carbon sequestration, raised productivity, and efficient use of water and nutrients can be achieved by implementing integrated application of inorganic fertilizers at optimum levels and farmyard manure in every wheat crop season (Meena *et al*., 2018).

Cob Biochar Production: A carbon-rich residue of heating biomass in a confined area with little oxygen is called biochar (Panwar *et al.,* 2019). Pyrolysis is a low-cost and straightforward process that has been employed to make biochar. The most pivotal factor in pyrolysis is temperature because all of the basic physical changes depend on it. Low temperatures and extended residence times are preferred for the solid biochar product, while higher temperatures and shorter residence times are preferred for the liquid biochar product (Shariff *et al.,* 2016). After being gathered from the field, the feedstocks should be sun-dried for two days until all of the humidity has faded (Anika *et al.,* 2022). To lower the humidity content to a safe level for processing and storage, the cobs are needed to be dried. Drying can be accomplished naturally with the sun or air, or with mechanical dryers. Maize cob farm waste was pyrolysed in a resistance box muffle furnace for the purpose of getting a biochar at various temperatures (300–500°C) (Adekanye *et al.,* 2022). When temperatures rise, the quantum of biochar produced diminishes because of either the primary breakdown of feedstocks or the secondary breakdown of biochar residues (Shariff *et al.,* 2016). The resulting biochar was successfully characterizeised by varying the physico-chemical and structural characteristics of the biochar (Adekanye *et al.,* 2022). A slower rate of heating has proven to yield better results when compared to faster rate of heating (Bartoli *et al.,* 2022). Compared to other temperatures, maize cob biochar generated at 600°C has a higher fixed carbon concentration (Shariff *et al.,* 2016). A yield of roughly 34% was attained by slow pyrolysis of corncobs at 500°C for 60 minutes of residence time and pyrolysis temperature (Rattanaphaiboon *et al.,* 2022). The biochar was crushed to a fine powder and sieved following the pyrolysis process (Rekaby *et al.,* 2021).

Fig. 2. Corn cob and Corn cob biochar.

Physico-Chemical Properties of Cob Biochar: Corncobs, which are exclusively utilized as agrarian waste, can be converted into biochar; a more valued functional product. The biochar can enhance the C, N, Ca, Mg, K, and P availability to plants because the biochar is a reservoir of nutrients having a long-term effect on microbial development upon release in the soil solution. The quantum of potassium (K) and silicon (Si) in biochar influences its thermal stability (Anika *et al.,* 2022). When the pyrolysis temperature increased, the biochar's carbon content increased from 45.5% to 64.5%, but the oxygen content dropped at the same time which indicates carbonization was enhanced with rising pyrolysis temperature (Rafiq *et al.,* 2016). Studies indicate that a higher temperature could affect in a larger fixed carbon product for the maize cob (Adekanye *et al.,* 2022). Biochar can be used to manage nitrogen losses because it increases cation exchange capacity (Liang *et al*., 2006), decreases nitrous oxide emissions, and retains nitrogen (Chan *et al.,* 2008). Corncob-derived biochar has a pH of 8.59 due to pyrolysis's impact on the organic material's separation from alkaline salt (Rattanaphaiboon *et al.,* 2022). Although the temperature is raised from 300°C to 500°C, the porous structure of the biochar made from maize cobs can expand because of thermal cracking brought on by the release of volatile matter, the biochar is not porous at 300°C (Adekanye *et al.,* 2022). After pyrolysis, corncob biochar showed more porosity, with internal holes that were usually between 0.5 and 3 µm (Rattanaphaiboon *et al.,* 2022). The unstable matter and dampness substance of the corncob biochar were decreased to 1.78% and 33.05%, individually, and the fiery remains and settled carbon were raised to 59% and 6.13%, separately (Rattanaphaiboon *et al.,* 2022). Elimination of phenol in aqueous solution was done by using modified biochar, which was created by chemically activating biochar made from corncob pyrolysis (Wang *et al.,* 2020). Biochar surface area of maize cob grew with pyrolysis temperature to 199 m²/g at 300 °C, 231 m²/g at 400 °C, and 291.8 m²/g at 500°C, with maximum surface area recorded at 500 °C owing to the temperature factor (Adekanye *et al*., 2022). By improving the physico-chemical and biological properties of soil, corn cob biochar can promote nutrient uptake, healthy plant roots, and plant growth. An rise in the efficiency of dry matter, carotenoid, chlorophyll, and nutrient consumption demonstrates that the cob biochar has significantly improved the condition of soil (Rekaby *et al.,* 2021). Corn cobs can be converted into biochar to improve the characteristics of highland acidic soil, promote soil adaptation, and decrease carbon loss from agrarian waste (Nurida *et al.,* 2023). Besides being a good absorber of nutrients and agrarian chemicals, corn cob biochar has the implicit to be a significant soil supplement since it retains the maturity of the mineral nutrients set up in corn remainder and may store carbon.

Table 1: Difference between Farmyard manure and Corn cob biochar.

Feature	Farmyard manure	Corn cob biochar
Origin	Decomposed animal excreta (urine, dung) along with bedding materials such as straw, crop residues, and other organic wastes.	Pyrolysis of corncobs
Production	Decomposition process	Pyrolysis process
Soil Structure	Enhances soils structure which is less effective than cob biochar	Improves soil structure ,more effective than FYM
Nutrient Availability	Rich in easily accessible nutrients, such as N, P and K	lower availability of nutrients, mainly serving as a soil amendment
Water Holding Capacity	Increases water holding capacity which is less compared to cob biochar	Increases water holding capacity which is more compared to FYM.
Carbon content	Contains organic carbon and adds to the organic matter in the soil.	High carbon content, promotes carbon sequestration over time in soil.
Longterm Effects	Decomposes quickly in the soil	Can last for many years in the soil
Potential Environmental Benefits	Reduces the use of synthetic fertilizers and improves soil health condition	Reduces dependence on synthetic fertilizers and helps in mitigation of climate change

Synergistic Effects of FYM and Cob Biochar on Sweet corn Productivity: The increase in biological yield of maize through the combined use of farmyard manure, biochar, and nitrogen fertilizer can be attributed to soil fertility advancements, higher nutrient contents, and larger carbon stores, promoting to crop growth, productivity (Agegnehu *et al*., 2017) and quality parameters. Cumulatively, organic amendment and biochar application would delay the silking tasseling and increases grain protein and oil content (Ali *et al*., 2017). Soil carbon after maize harvest was significantly higher when 50 t BC was combined with 10 t FYM per hectare compared to just 5 t FYM (Ali *et al*., 2018). Organic amendments like FYM and biochar enhances grain yield in addition to enhancing the structure of soil, water holding capacity, and nutrient supply (Singh *et al*., 2022). Biochar when applied along with nitrogenous fertilizer promotes the nutrient uptake by plant which leads to an increase in yield attributes and yield (Naeem *et al*., 2018). Biochar enhances the flow of water and nutrients through the soil, improves carbon content and microbial population and improves the maize grain yield because of its pervious nature and immense surface area (Ali *et al*., 2021). Higher yield occurs in maize due to improved nutrient uptake, root development, and effective distribution of carbohydrates from leaves to reproductive parts (Nagaveni *et al*., 2024). Farmyard manure, biochar, and nitrogenous fertilizers in combination plays a significant role in augmenting the condition for maize growth by increasing soil organic matter and cation exchange capacity, conserving nutrients, and provides good environment for microbial growth (Arif *et al*., 2012). It also improves the microbial activity and nutrient utilization efficiency in soil (Song *et al*., 2019). Application of biochar along with fertilizer can increase crop yield far beyond employing biochar to treat the soil (Ali *et al*., 2018). Regulation of nutrients and boosting soil retention and nitrogen use in maize farming were found with the application of N fertilizers with the appropriate type of biochar (Li *et al*., 2023).Yield and yield components of corn can be increased with conglomerate application of biochar, FYM and inorganic fertilizers (Arif *et al*., 2012).

CONCLUSIONS

The conglomerate application of farmyard manure (FYM) and biochar with inorganic fertilizers has exhibited promising results in enhancing the soil quality, productivity and quality of sweet corn. FYM improves the soil organic carbon and encourages microbial growth, leading to improved physical and biological status of soil. Likewise, biochar produced from corncobs enriches the physico-chemical properties of soil, carbon sequestration, nutrient availability and retention, lowered bulk density, and stimulates microbial activity because of its porous nature and nutrient-dense content. The FYM releases nutrients quickly into the soil, which may not be available for utilization by plants, whereas the biochar releases the nutrients slowly into the soil and improves the soil structure and fertility in the long run. The FYM is prone to volatilization losses quickly, whereas biochar has good nutrient retention capacity and reduces leaching losses. Therefore, application of FYM and cob biochar will complement eachother's benefits and improve soil physicochemical properties and increase the grain yield when compared to sole application of either FYM or cob biochar. Hence, integrated nutrient management using FYM, cob biochar, and inorganic fertilizers is the best way to promote sustainable sweet corn production which improves physicochemical and biological properties of soil in long run.

FUTURE SCOPE

The combined application of FYM and cob biochar has an immense effect on the yield of sweet corn. It promotes sustainable agriculture. Future research should focus on improving crop production and soil fertility as well as discovering the correct combinations of FYM, cob biochar, and inorganic fertilizers that work well under different agro-climatic conditions. It is necessary to make cost-benefit and economically feasible combinations of FYM and biochar so that small farmers can adopt them. Studies should need to be carried out in assessing the impact of FYM, cob biochar, and their combinations on carbon sequestration, nutrient availability, and microbial population in the soil.

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Conflict of Interest. None.

REFERENCES

Adekanye, T., Dada, O. and Kolapo, J. (2022). Pyrolysis of maize cob at different temperatures for biochar production: Proximate, ultimate and spectroscopic characterisation. *Research in Agricultural Engineering, 68*(1), 27–34.

Agegnehu, G., Srivastava, A. K. and Bird, M. I. (2017). The role of biochar and biochar-compost in improving soil quality and crop performance: A review. *Applied Soil Ecology, 119*, 156–170.

Ali, K., Arif, M., Islam, B., Hayat, Z., Ali, A., Naveed, K. and Shah, F. (2018). Formulation of biochar based fertilizer for improving maize productivity and soil fertility. *Pakistan Journal of Botany, 50*(1), 135–141.

Ali, K., Arif, M., Shah, F., Shehzad, A., Munsif, F., Mian, I. A. and Mian, A. A. (2017). Improvement in maize (*Zea mays* L.) growth and quality through integrated use of biochar. *Pakistan Journal of Botany, 49*(1), 85–94.

Ali, L., Manzoor, N., Li, X., Naveed, M., Nadeem, S. M., Waqas, M. R., Khalid, M., Abbas, A., Ahmed, T. and Li, B. (2021). Impact of corn cob-derived biochar in altering soil quality, biochemical status and improving maize growth under drought stress. *Agronomy, 11*(11), 2300.

Anika, N., Mahardika, M., Panjaitan, J. R. H., Achmad, F., Bindar, Y., Azizah, I. N., Anggraini, R. and Ramadhani, D. A. (2022). Effect of production technique on corncob biochar quality. In: *IOP Conference Series: Earth and Environmental Science, 1038*(1), 012007.

Arif, M., Ali, A., Umair, M., Munsif, F., Ali, K., Inamullah, Saleem, M. and Ayub, G. (2012). Effect of biochar, FYM, and mineral nitrogen alone and in combination on yield and yield components of maize. *Sarhad Journal of Agriculture, 28*(2), 191–195.

Balda, A. and Giri, A. (2023). Compost formulation from different wastes to enhance the soil and plant productivity: A review. *Defence Life Science Journal, 8*(2), 149–157.

Bartoli, M., Troiano, M., Giudicianni, P., Amato, D., Giorcelli, M. and Solimene, R. (2022). Effect of heating rate and feedstock nature on electrical conductivity of biochar and biochar-based composites. *Applications in Energy and Combustion Science, 12*, 100089.

Bayu, W., Rethman, N. P. G., Hammes, P. S. and Alemu, G. (2006). Application of farmyard manure improved the chemical and physical properties of the soil in a semi-arid area in Ethiopia. *Biological Agriculture & Horticulture*, *24*, 293–300.

Bhat, R. A., Ahmad, L. and Wani, G. A. (2013). Growth, yield and economics of maize as affected by cropping sequences, rates and frequency of farm yard manure (FYM). *African Journal of Agricultural Research, 8*(27), 3632–3638.

Chan, K. Y., Van Zwieten, L., Meszaros, I., Downie, A. and Joseph, S. (2008). Using poultry litter biochars as soil amendments. *Australian Journal of Soil Research, 46*(5), 437–444.

Desta, H. A. (2015). Effects of organic and inorganic fertilizers on selected soil properties after harvesting maize at Antra Catchment, Northwestern Ethiopia. *International Inventive Journal of Agricultural and Soil Science*, *3*(5), 68–78.

Devika, O. S., Prasad, P. R., Rani, P. P. and Pathy, R. L. (2018). Nutrient status of soils influenced by the interaction of biochar and FYM with chemical fertilizers. *The Pharma Innovation Journal, 7*(6), 174–177.

Gabhane, J. W., Bhange, V. P., Patil, P. D., Bankar, S. T. and Kumar, S. (2020). Recent trends in biochar production methods and its application as a soil health conditioner: A review. *Environmental Technology & Innovation, 20,* 101095.

Hussain, M., Farooq, M., Nawaz, A., Al-Sadi, A. M., Solaiman, Z. M., Alghamdi, S. S., Ammara, U., Ok, Y. S. and Siddique, K. H. M. (2017). Biochar for crop production: Potential benefits and risks. *Journal of Soils and Sediments, 17*(3), 1-12.

Jagathjothi, N., Ramamoorthy, K. and Kokilavani, S. (2008). Effect of FYM with and without enrichment on soil microbial population, soil fertility, yield and economics. *Research Journal of Agriculture and Biological Sciences, 4*(6), 647–650.

Khan, N. I., Malik, A. U., Umer, F. and Bodla, M. I. (2010). Effect of tillage and farm yard manure on physical properties of soil. *International Research Journal of Plant Science, 1*(4), 75–82.

Khan, S., Irshad, S., Mehmood, K., Hasnain, Z., Nawaz, M., Rais, A., Gul, S., Wahid, M. A., Hashem, A., Abd_Allah, E. F. and Ibrar, D. (2024). Biochar production and characteristics, its impacts on soil health, crop production, and yield enhancement: A review. *Plants, 13*(2), 166.

Kumar, V., Saikia, J., Barik, N. and Das, T. (2017). Effect of integrated nutrient management on soil enzymes, microbial biomass carbon, and microbial population under okra cultivation. *International Journal of Biochemistry Research & Review, 20,* 1–7.

Lal, B. P., Babu, P. R., Prasad, P. R. K. and Lakshmi, N. V. (2018). Influence of biochar derived from maize stover and maize cobs on growth and yield of sweet corn in sandy loam soils. *The Andhra Agricultural Journal, 65*(1), 92–97.

Li, C., Zhao, C., Zhao, X., Wang, Y., Lv, X., Zhu, X. and Song, X. (2023). Beneficial effects of biochar application with nitrogen fertilizer on soil nitrogen retention, absorption and utilization in maize production. *Agronomy, 13*(1), 113.

Liang, B., Lehmann, J., Solomon, D., Kinyangi, J., Grossman, J., O'Neill, B., Skjemstad, J. O., Thies, J., Luizão, F. J., Petersen, J. and Neves, E. G. (2006). Black carbon increases cation exchange capacity in soils. *Soil Science Society of America Journal, 70*, 1719–1730.

Meena, K. B., Alam, M. S., Singh, H., Bhat, M. A., Singh, A. K., Mishra, A. K. and Thomas, T. (2018). Influence of farmyard manure and fertilizers on soil properties and yield and nutrient uptake of wheat. *International Journal of Chemical Studies, 6*(3), 386–390.

Naeem, M. A., Khalid, M., Aon, M., Abbas, G., Amjad, M., Murtaza, B., Khan, W. U. D. and Ahmad, N. (2018). Combined application of biochar with compost and fertilizer improves soil properties and grain yield of maize. *Journal of Plant Nutrition, 41*(1), 112–122.

Nagaveni, H. C., Hebsur, N. S., Kuligod, V. B., Rajkumar, S. and Nirmalanath, P. J. (2024). Impact of different sources and levels of biochar on maize growth and yield in a Vertisol. *International Journal of Plant & Soil Science, 36*(3), 234–242.

Nurida, N. L., Salma, S., and Jubaedah (2023). Corn cob biochar as agricultural waste management for increasing soil resilience and crop yield. In:. *E3S Web of Conferences, 467*, 01003.

Panwar, N. L., Pawar, A. and Salvi, B. L. (2019). Comprehensive review on production and utilization of biochar. *SN Applied Sciences, 1*(2), 168.

Rafiq, M. K., Bachmann, R. T., Rafiq, M. T., Shang, Z., Joseph, S. and Long, R. (2016). Influence of pyrolysis temperature on physico-chemical properties of corn stover (*Zea mays* L.) biochar and feasibility for carbon capture and energy balance. *PLoS ONE, 11*(6), e0156894.

Rattanaphaiboon, P., Homdoung, N. and Tippayawong, N. (2022). Production and characterization of corncob biochar for agricultural use. *AIP Conference Proceedings, 2681*, 020034.

Rekaby, S. A., Awad, M., Majrashi, A., Ali, E. F. and Eissa, M. A. (2021). Corn cob-derived biochar improves the growth of saline-irrigated quinoa in different orders of Egyptian soils. *Horticulturae, 7*(8), 221.

Shariff, A., Mohamed Noor, N., Lau, A. and Mohd Ali, M. A. (2016). A comparative study on biochar from slow pyrolysis of corn cob and cassava wastes. *World Academy of Science, Engineering and Technology: International Journal of Biotechnology and Bioengineering, 10*(12).

Singh, V. K., Malhi, G. S., Kaur, M., Singh, G. and Jatav, H. S. (2022). Use of organic soil amendments for improving soil ecosystem health and crop productivity. In H. S. Jatav (Ed.), *Ecosystem services: Types, management and benefits* (pp. 260–275). Nova Science Publishers.

Song, D., Xi, X., Zheng, Q., Liang, G., Zhou, W. and Wang, X. (2019). Soil nutrient and microbial activity responses to two years after maize straw biochar application in a calcareous soil. *Ecotoxicology and Environmental Safety, 180*, 348–356.

Wang, G., Zhang, Z., Li, W., Du, C. and Chen, T. (2020). Production and characterization of modified biochar by corn cob and its ability to absorb phenol. In: *IOP Conference Series: Materials Science and Engineering, 729*, 012070.

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