Original Article

https://napass.org.ng

Effect of Co-Application of Biochar and *Pseudomonas aeruginosa* on *Corchorus olitorius* yield

Ilusanya Olusolape Afolake Favour, [1] **Osobamiro Temitope Monsurat** [2] **Adesetan Titilayo Oyeronke,** [1] **Olajumoke Oluwasegun Iroughene,**[1] **Agbarakwe, Stanley Peter,** [2] **Senjobi Comfort Titilayomi** [3] **and Egberongbe, Haneefat Olabimpe**[1]

[1]Department of Microbiology, Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria.
[2]Department of Chemical Sciences, Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria.
[3]Department of Plant Science, Olabisi Onabanjo University, Ago-Iwoye, Ogun State. Nigeria.

OPEN ACCESS

Correspondence:

E-mail:
ilusanya.olusolape@oouagoiwoye.edu.ng

Specialty Section;This article was submitted to Sciences a section of NAPAS.

Submitted: *15th April, 2024*
Accepted: *15th June, 2024*

Citation: *Ilusanya Olusolape Afolake Favour, Osobamiro Temitope Monsurat, Adesetan Titilayo Oyeronke, Olajumoke Oluwasegun Iroughene, Agbarakwe, Stanley Peter, Senjobi Comfort Titilayomi and Egberongbe, Haneefat Olabimpe (2024) Effect of Co-Application of Biochar and Pseudomonas aeruginosa on Corchorus olitorius yield*

Effective Date: vol7(2), 19-27

Publisher:cPrint,Nig.Ltd
Email:cprintpublisher@gmail.com

Abstract

This study investigated the effect of co-applying of Christmas melon (Adenopus beviflorus) seeds derived biochar and Pseudomonas aeruginosa on Corchorus olitorius yield . Soil samples were collected from an agricultural farmland in Ago-Iwoye. Adenopus breviflorus (Christmas melon) seeds were collected from farms in Ago-Iwoye and subjected to pyrolysis to produce biochar which were modified with acid and base respectively. The experiment employed 18 pots in a completely randomized manner. Treatments included control, acidic biochar (BA), co-application of acidic biochar and Pseudomonas aeruginosa (BAPS), basic biochar (BB), co-application of basic biochar and Pseudomonas aeruginosa (BBPS), and Pseudomonas aeruginosa only. The seeds of Jute plant were planted for the period of 30 days in each of the experimental buckets after which the shoots, roots and biomass were analyzed to determine yield. Results showed that the BBPs treatment exhibited the highest shoot yield, with a mean value of 44.92 cm, and the Pseudomonas (Ps) treatment had the highest root yield, with a mean value of 21.18 cm. Biomass analysis revealed that the BBPs treatment had the highest fresh and dry biomass, with mean values of 4.37 g and 3.04 g, respectively. The biochar and Pseudomonas treatments resulted in significantly higher plant yields compared to the control, indicating a positive impact on plant growth and productivity.

Keywords: Heavy metal, biochar, Pseudomonas aeruginosa, bioremediation, Corchorus olitorius

1 Introduction

The global demand for food continues to rise alongside population growth, highlighting the critical need to enhance agricultural productivity sustainably (Alexandratos & Bruinsma, 2017). *Corchorus olitorius*, commonly known as jute mallow, stands out as a significant leafy vegetable extensively cultivated in tropical and subtropical regions (Padmavathi *et al*., 2018). Its nutritional richness, rapid growth rate, and adaptability to diverse environmental conditions make it a pivotal crop for ensuring food security and supporting the livelihoods of smallholder farmers (Rahman *et al*., 2020).

In recent years, biochar has emerged as a promising tool in agricultural practices due to its ability to enhance soil fertility, improve water retention, and increase nutrient availability (Aup-Ngoen & Noipitak, 2020). Biochar, a carbon-rich material derived from the pyrolysis of organic waste, offers unique benefits for soil health and crop productivity. Furthermore, the selection of biochar feedstock plays a crucial role in determining its properties and potential agricultural benefits Narzari *et al*., 2015). *Adenopus breviflorus*, commonly referred to as Christmas melon or short-flowered adenopus, presents itself as a sustainable and renewable feedstock for biochar production. The seeds of *Adenopus breviflorus* possess several advantageous characteristics, including ready availability, renewability, and high carbon content, making them an attractive choice for biochar production (Singh *et al*., 2017).

On another front, *Pseudomonas aeruginosa*, a plant growth-promoting rhizobacteria (PGPR), has garnered significant attention for its beneficial effects on plant growth, health, and stress tolerance (Alkorta *et al*., 2019). *Pseudomonas* spp. have been shown to enhance nutrient uptake (Liu *et al*., 2017), induce systemic against pathogens by activating plant defense mechanisms (Beneduzi *et al*., 2015), and alleviate abiotic stress like drought and salinity through various mechanisms (Yang *et al*., 2016). However, the exploration of synergistic effects resulting from the co-application of biochar and *Pseudomonas aeruginosa* remains limited, particularly concerning their impact on crop yield, such as *Corchorus olitorius*.

This study seeks to delve into the intricacies of the combined application of *Adenopus breviflorus*-derived biochar and *Pseudomonas aeruginosa* and its influence on the growth and yield of *Corchorus olitorius*. By elucidating the potential synergistic interactions between biochar and *Pseudomonas aeruginosa* and their effects on crop productivity, this research aims to contribute valuable insights into sustainable agricultural practices and crop yield optimization.

Materials and Methods

The fruits Christmas melons (*Adenopus beviflorus*) were gotten from local farms in Ago-Iwoye town. They were washed and carefully opened to obtained the seeds. Biochar production involved slow pyrolysis under a furnace according to the methods of Huang *et al*., 2019 and Ji *et al*., 2019. The acidic modification of the biochar was achieved by placing the biochar produced in a beaker containing 2.0M of H_2SO_4 and agitated for 5 hours then allowed to dry at room temperature (Hemavathy *et al*., 2020) while for the alkali, the same process was repeated, but with NaOH (Liu *et al*., 2020).

Farm soil was collected from Olabisi Onabanjo University College of Agricultural Sciences Tree Crop Nursery Development Project located in

Ago-Iwoye, Ogun State, Nigeria between Latitudes 6°55' and 7°00N and between Longitudes 3°45 and 4°05E. Soil samples were taken at random using soil auger from 8-10 places at a depth of 0-15 cm. The soils were bulked put into sterile polythene bags and transported to the laboratory and greenhouse for laboratory analysis and pot experiment respectively. Plant materials and other debris present were removed by hand and the soil was air-dried and sieved using a 2.0 mm mesh to remove other smaller plant debris and stones.

The bacterium used in this study was isolated from Olabisi Onabanjo University College of Agricultural Sciences Tree Crop Nursery Development Project farm in Ago Iwoye ,Ogun State Nigeria. Based phenotypic and molecular characterization, the strain was identified as *Pseudomonas aeruginosa*.

The seeds of *Corchorus olitorius* with the accession ID NHJM 0029 were sourced from the National Horticultural Research Institute (NIHORT) Ibadan, Oyo State, Nigeria. The planting of the seeds of the plant was done using the procedure reported by Larnayo and Atitsogbui, 2020 and the guidelines provided by the Genetic Resources Unit of the National Horticultural Research Institute in Ibadan, Nigeria. Before planting, the jute seeds were kept in a clean white cloth and treated with boiled de-ionized in order to aid its fast germination and uniform growth. The treated seeds were then dried at room temperature. Thereafter, the jute seeds were pre-planted in a bowl and left for 14 days in order to obtain uniform sizes and growth, before introducing into the experimental pots.

A pot experiment was carried out in the green house of Department of Plant Science, Olabisi Onabanjo University, Ago-Iwoye, Ogun State. The dimension of each pot was (22cm x 25cm x 18cm). Two kilogram (2 Kg) dried soil was used to fill each pot. The following treatments were used: H_2SO_4 modified biochar only (BA); NaOH modified biochar only (BB); H_2SO_4 modified biochar and *Pseudomonas aeruginosa* (BAPs); NaOH modified biochar and *Pseudomonas aeruginosa* (BBPs); *Pseudomonas aeruginosa* only (Ps) and Control, Without biochar and microorganism (Ctrl). Each treatment was carried out in triplicate making a total of 18 pots arranged in a complete randomized design; Each of these treatments was mixed thoroughly with the soil. Six (6) Jute plants were transferred into each of the experimental buckets. The soil moisture was stabilized at 70% of the field water holding capacity (Zhang *et al.,* 2014). Routine management was carried out for 30 days until the plant grew to maturity.

Harvested jute mallow plants were divided into their roots, and shoots. Using a meter rule, the shoot and root lengths were measured to get the growth length yield. To determine the biomass yield, each pot's shoot fresh biomass was measured using a weighing balance, and the shoot dry biomass was measured using samples that were heated in an oven to a consistent weight. The roots from each pot were individually rinsed with tap water and then distilled water, weighted using a balance to get the fresh weight of the roots, and then placed in an electric oven to maintain a consistent weight to determine the dry weight of the roots.

The SPSS 18.0 Statistical Package Program (SPSS Institute, USA) was used to perform the statistical analysis of the data produced. The level of significance was set at $P<0.05$, and one-way analysis of variance (ANOVA) and Tukey's test was performed to evaluate the statistical differences between the treatments.

Results

The effect of different treatments on the shoot and root yield length of *Corchorus olitorius*, is presented in Fig 1. The highest mean shoot length yield was observed in the soil treated with *Pseudomonas aeruginosa* (Ps) (44.38 cm), followed by B_BP*s* (38.88 cm) while the lowest mean shoot length of 30.63 cm was obtained from the plants in the control soil. Similarly, P*s* treatment also recorded the highest mean root length value (10.50 cm), while BA treatment had the lowest root yield (7.75 cm). The lowest yields amongst the treated groups were seen in the $B_A$and B_APs treatments.

Presented in Fig 2 is the effect of the treatments on the fresh biomass of *Corchorus olitorius.* The plants from the control pots had a significantly lower fresh biomass compared to the treated plant. The fresh shoot and root biomasses for the control were of 2.05 g and 0.28 g respectively while the highest mean fresh biomass were obtained from the BBPs treated plants with 4.37 g for the shoot and 0.77 g for the roots..

Fig 3 showed that the highest dry shoot and root biomass was seen in same BBPS treatment soil with 3.04 g and 0.23 g respectively, while the lowest mean dry biomass of shoot and root was seen in the control soil with 0.54 g and 0.09 g respectively.

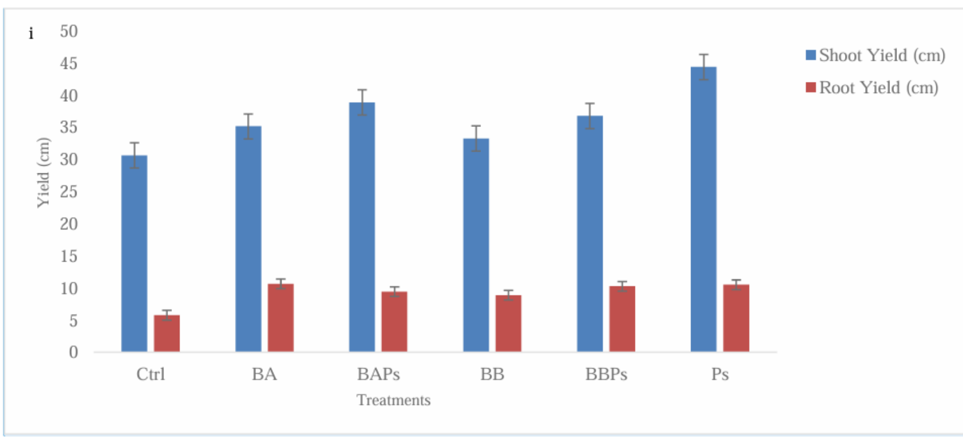

Fig. 1: Effect of treatments on *Corchorus olitorius* yield length. Treatments Key: Ctrl: Control, BA: Acidic Biochar, BAP_S: Acidic Biochar and *Pseudomonas*, BB: Basic Biochar, BBP_S: Basic Biochar and *Pseudomonas*, P_S: *Pseudomonas.*

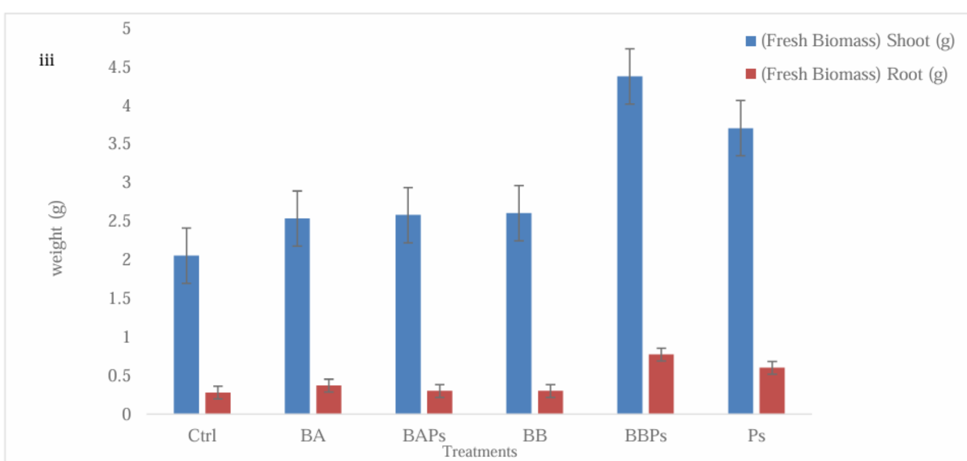

Fig. 2: Effect of treatments on Corchorus olitorius fresh biomass.Treatments Key: Ctrl: Control, BA: Acidic Biochar, BAPS: Acidic Biochar and Pseudomonas, BB: Basic Biochar, BBPS: Basic Biochar and Pseudomonas, PS: Pseudomonas.

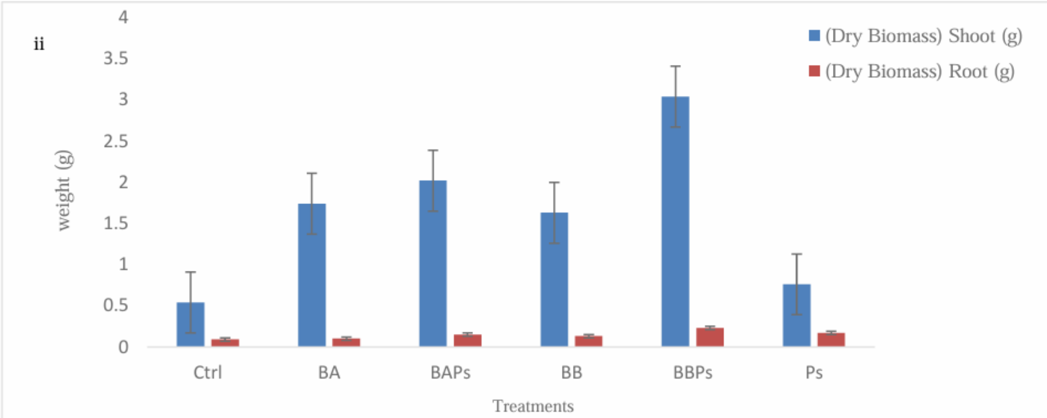

Fig. 3: Effect of treatments on Corchorus olitorius dry biomass. Treatments Key: Ctrl: Control, BA: Acidic Biochar, BAPS: Acidic Biochar and Pseudomonas, BB: Basic Biochar, BBPS: Basic Biochar and Pseudomonas, PS: Pseudomonas.

Discussion

This study investigated the effects of co-application of biochar and Pseudomonas aeruginosa on the yield of *Corchorus olitorius*. Our findings demonstrated that both biochar and *Pseudomonas aeruginosa* treatments significantly enhanced the shoot and root yield of *C. olitorius* compared to the control. Notably, the co-application of *Pseudomonas aeruginosa* (Ps) treatment resulted in the highest mean shoot and root yields (44.38 cm and 12.50 cm, respectively), highlighting the potential synergistic effects of this combined approach. The positive impact of biochar application on *C. olitorius* yield aligns with previous studies investigating the beneficial effects of biochar on plant growth (Liu *et al*., 2018). Biochar can improve soil fertility by enhancing nutrient retention and promoting beneficial soil microbial communities (Lehmann & Joseph, 2015). In this study, we employed biochar derived from *Adenopus breviflorus* seeds, a readily available and renewable feedstock.

These findings support the well-established role of *Pseudomonas aeruginosa* as a plant growth-promoting bacterium (PGPR) (Alkorta *et al*., 2019). The observed increase in yield with *Pseudomonas aeruginosa* treatment (Ps) is likely due to its various plant growth-promoting mechanisms, including nutrient solubilization through phosphate solubilization and siderophore production, as well as inducing systemic resistance against pathogens (Beneduzi *et al*., 2015; Liu *et al*., 2017). Our findings are also consistent with the study by Zhao *et al*. (2014) which demonstrated positive effects of *Pseudomonas aeruginosa* on tomato plant growth.

The most significant yield improvement was observed in the co-application treatment of basic biochar and *Pseudomonas* (BBPs), suggesting a potential synergistic effect between biochar modified with an alkali and *Pseudomonas aeruginosa*. While the exact mechanisms underlying this synergy require further investigation, it is possible that biochar provides a favourable habitat for the beneficial bacteria like *Pseudomonas aeruginosa*, enhancing their colonization and persistence in the rhizosphere (Lehmann & Joseph, 2015).

The co-application of acid and alkali modified *Adenopus breviflorus* seed-derived biochar and

Pseudomonas aeruginosa has shown promising results in improving *Corchorus olitorius* yield. *Pseudomonas aeruginosa*, a beneficial soil bacterium, contributes to the degradation of organic matter and the release of plant growth-promoting substances, thereby enhancing soil fertility. The co-application of alkali modified biochar with *Pseudomonas aeruginosa* demonstrated the potential for a holistic and sustainable approach of improved soil health in agricultural soils.

References

Abdelhafez, A. A., Shaheen, S. M., Sayed, M., & AbdEl-Salam, N. M. (2014). Assessing the of different biochars in improving sandy soil quality and sorghum yield. *Soil and Tillage Research*, 138, 9-16.

Adesodun, J. K., Atayese, M. O., Agbaje, T. A., Osadiaye, B. A., Mafe, O. F., & Soretire, A. A. (2010). Phytoremediation potentials of sunflowers (Tithonia diversifolia and Helianthus annuus) for metals in soils contaminated with zinc and lead nitrates. *Water, Air, & Soil Pollution*, 207(1-4), 195-201.

Ajayi, S. A., Adeyeye, E. I., Ali, H., & Sajad, M. A. (2017). Assessment of heavy metal concentrations in soil and vegetables grown around dumpsites in Lagos State, Nigeria. *Journal of Environmental and Public Health,* 2017, 5630817.

Alexandratos, N., & Bruinsma, J. (2017). World agriculture towards 2030/2050: The revised FAO long-term perspective. *Food and Agriculture Organization of the United Nations (FAO)*. https://www.fao.org/3/a0607e/a0607e00.htm

Alkorta, I., Garbisu, C., Llama, M. J., & Serra, J. L. (2019). Bioremediation: A Sustainable Approach for Soil and Water Cleanup. In *Comprehensive Biotechnology* (Third Edition) (pp. 141-154). *Elsevier*.

Aup-Ngoen, K., & Noipitak, M. (2020). Effect of carbon-rich biochar on mechanical properties of PLA-biochar composites. *Sustainable Chemistry and Pharmacy*, 15, 100204.

Beneduzi, A., Ambrosini, A., & Montesinos, E. (Znce/articles/10.3389/fpls.2022.923880/full Chairat, C., Prompue, P., Khokiattiwong, S., & Sangthong, C. (2018). Phytoremediation potential of *Bacillus subtilis* inoculated on Pb contaminated soils in mustard plants. *Journal of Environmental Management,* 209, 20-25.

Chen, Y., & Lin, Q. (2020). Effects of soil amendments on the growth and heavy metal accumulation of plants in contaminated soils: a review. *Journal of Soils and Sediments*, 20(2), 687-704.

Dahunsi, S. O., Owolabi, A. A., Oranusi, S. U., & Adesulu-Dahunsi, A. T. (2018). Pyrolysis of *Adenopus breviflorus* seed biomass for biochar production: optimization using response surface methodology. *Bioresources and Bioprocessing*, 5(1), 6.

Gupta, D. K., Nicoloso, F. T., & Schetinger, M. R. (Eds.). (2015). Heavy Metal Stress in Plants: From *Biomolecules to Ecosystems*. Springer

Hassan, M. M., Mohamed, I. A., Abo-Amer, A. E., & Abdel-Razek, A. S. (2020). Bioremediation of Organic Pollutants Using *Pseudomonas* spp. In Microbial Biotechnology: *Basic Research and Applications* (pp. 93-114). Springer.

Hemavathy, J., Sandhya, S., and Ganesan, V. (2020). Influence of acid and alkali modification on the physicochemical characteristics and adsorption capacity of biochar derived from Cassia auriculata seeds, *Arabian Journal of Chemistry*, 13(12), 2020, 8472-8480.

Huang, H., Tang, J., Wu, S., Zhou, Y., & Chen, Y. (2019). Basic modification of biochar for enhancing its phosphate adsorption capacity. J*ournal of Environmental Management,* 231, 395-402.

Ji, X., Liu, X., Zhang, H., Cai, J., & Xu, Y. (2019). Preparation and characterization of biochars from different feedstocks and their potential application for heavy metal removal in landfill leachate. *Bioresource Technology*, 272, 555-562.

Jiajun, L., Lin, C., Qiming, W., Shunli, L., D ongfang, H., & Jianjun, W. (2020). Influence of biochar and phosphate-solubilizing bacteria on soil cadmium availability and uptake by rice plants. *Environmental Science and Pollution Research,* 27(4),3810-3819.

Khan, S., Cao, Q., Zheng, Y. M., Huang, Y. Z., & Zhu, Y. G. (2008). Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. *Environmental Pollution*, 152(3), 686-692.

Liang, Y., Sun, W., Zhang, S., Wang, H., & Wang, X. (2017). The role of biochar amendment in alleviating soil heavy metal contamination. *Chemosphere*, 142, 105-113.

Liu, L., Luo, Y., Li, Y., Christie, P., & Zhang, J. (2017). Plant growth-promoting effects of endophytic bacterium *Pseudomonas fluorescens* ZDY-1 isolated from rape and its mechanisms of action. *Microbial Biotechnology*, 10(3), 709–721. https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2017.02538/full

Liu, Y., Zeng, G., and He, X., (2020). Biochar for environmental management: An overview, *Environmental Science and Pollution Research,* 27(19), 22967-22987.

Liu, Z., Jiang, H., Li, L., Laird, D. A., & Yuan, H. (2018). Impact of biochar application on jute (*Corchorus olitorius L.*) growth and soil properties in a chromium-contaminated soil. *Environmental Science and Pollution Research*, *25*(1), 704-713. https:// www. researchgate.net/ publication /247158390_The_Impact_of_ Biochar_ Application_on_Soil_Properties_and_Plant_Growth_of_Pot_Grown_Lettuce_Lactuca_sativa_and _ Cabbage_ Brassica _chinensis

Lu, K., Yang, X., Shen, J., Robinson, B., Huang, H., Liu, D., & Liu, T. (2017). Effect of bamboo and rice straw biochars on the mobility and redistribution of heavy metals (Cd, Cu, Pb and Zn) in contaminated soil. *Journal of Environmental Management*, 186, 285-292.

Mohammadi, K., & Yousefi, N. (2021). Plant-

Associated Bacteria for Heavy Metal Detoxification: Mechanisms, Applications, and Future Prospects. *Microbial Ecology*, 1-18

Narzari, R., Bordoloi, N., Chutia, R. S., Borkotoki, B., Gogoi, N., Bora, A., & Kataki, R. (2015). Biochar: an overview on its production, properties and potential benefits. *Biology, biotechnology and sustainable development*, 1(1), 13-40.

Niazi, N. K., Bibi, I., Shahid, M., Ok, Y. S., Burton, E. D., Wang, H., & Rinklebe, J. (2017). Phytoremediation of heavy metals Concepts and applications. *Chemosphere*, 166, 746-767.

Padamvathi, T. V., Reddy, A. R., & Reddy, B. V. (2018). Jute (*Corchorus* spp.)—fibre crops. In Industrial crops: Breeding and genetics (pp. 211-232). *Springer, Singapore*. https://www.researchgate.net/publication/336536914_Jute_Corchorus_spp_Breeding

Rahman, M. M., Mondal, M. M. I., & Uddin, M. N. (2020). Profitability and economic viability of jute mallow (*Corchorus olitorius L.*) cultivation in Bangladesh. *Journal of Sustainable Agriculture and Resource Management*, 2(1), 7-12.

Rinklebe, J., & Shaheen, S. M. (2015). Metal immobilization by biochar: mechanisms and analytical tools. In *Biochar from Biomass and Waste* (pp. 207-235). De Gruyter.

Rodríguez-Vila, A., Díaz-Raviña, M., Fernández-Sanjurjo, M. J., Arias-Estévez, M., Nóvoa-Muñoz, J. C., & Álvarez-Rodríguez, E. (2015). Copper immobilisation by biochars in soil contaminated by fungicide-treated lumber. *Geoderma*, 259-260, 159-167.

Singh, H., Singh, B., Sweeney, S., Cowie, A., & Jeffery, S. (2017). Biochar effects on nitrous oxide emissions from nitrogen fertilizer under different soil moisture conditions. *Biology and Fertility of Soils*, *53*(3), 335–348. https://www.sciencedirect.com/ science/article/ pii/ S0038071713004707.

Sohi, S. P., Krull, E., Lopez-Capel, E., & Bol, R. (2010). A review of biochar and its use and function in soil. *Advances in agronomy*, 105, 47-82.

Spokas, K. A., Cantrell, K. B., Novak, J. M., Archer, D. W., Ippolito, J. A., Collins, H. P., & Amonette, J. E. (2012). Biochar: A synthesis of its agronomic impact beyond carbon sequestration. *Journal of Environmental Quality,* 41(4), 973-989.

Wang, Y., Chen, Y., Xu, H., Zhang, L., & Ma, X. (2021). The effect of feedstock type on the properties of biochar derived from pyrolysis: A review. *Chemosphere*,z 273, 129667.

Yang, J., Kloepper, J. W., & Ryu, C. M. (2016). Rhizosphere bacteria help plants tolerate abiotic stress. *Trends in Plant Science*, *21*(8), 711–721.

Yang, X., Li, T., Hu, C., Ren, G., Zhang, Y., & Chen, G. (2016). Biochar alleviates combined stress of ammonium and acid rain more than ammonium alone in fluvo-aquic soil. *Journal of Soils and Sediments*, 16(2), 530-539.

Zhao, K., Xue, C., Shang, Q., & Xue, P. (2014). Plant growth promotion and stress alleviation effects of *Pseudomonas* *aeruginosa* associated with tomato plants. *PLoS ONE*, *9*(4), e95831. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9844402/