

**EFFECTS ON SOIL WATER RELATIONSHIPS AND PHYSICAL PROPERTIES
OF SELECTED SOIL TYPES USING BIOCHAR AS SUBSTRATES**

ROB REINER P. MENDOZA

An Undergraduate Thesis Submitted to the Faculty of the Department of Environmental
Science, College of Arts and Sciences, Central Luzon State University,
Science City of Muñoz, Nueva Ecija, Philippines
in Partial Fulfillment of the Requirements
for the Degree of

**BACHELOR OF SCIENCE IN AGRICULTURE AND
BIOSYSTEMS ENGINEERING
(Land and Water Resources Engineering)**

JUNE 2023

TABLE OF CONTENTS

TITLE	PAGE
BIOGRAPHICAL SKETCH	iii
ACKNOWLEDGEMENT	iv
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF APPENDIX TABLES	ix
LIST OF APPENDIX FIGURES	x
ABSTRACT	xi
INTRODUCTION	1
Background of the Study	1
Statement of the Problem	3
Objectives of the Study	3
Significance of the Study	4
Scope and Limitation of the Study	4
REVIEW OF RELATED LITERATURE	5
Biochar	5
Substrates for Biochar Production	6
Soil Structure	7
Soil Texture	7
Soil Porosity	8
Soil Moisture	8
Plant Available Water	9
Properties of Rice Husk and Bamboo Biochar	9
Process to Improve Soil Porosity and Soil Moisture	10
Amount of Biochar per Kilograms of Soil	11
METHODOLOGY	12
Conceptualization of the Study	12
Materials and Instrument	14
Collection and Preparation of Raw Materials	14

Data to be Gathered	15
Determination of Physical Properties	15
Soil Structure	15
Soil Texture	16
Soil Porosity	18
Soil Moisture	20
Plant Available Water	21
Experimental Layout and Design	21
Methods of Data Analysis	22
RESULTS AND DISCUSSION	23
Physical Properties of Soil with Biochar	23
Soil Texture	23
Treatment 1: Clay loam soil with Rice Hull Biochar	23
Treatment 2: Sandy clay loam soil with Bamboo Biochar	24
Treatment 3: Clay Loam Soil with Bamboo Biochar	25
Treatment 4: Sandy clay loam soil with Rice Hull Biochar	26
Soil Structure	27
Soil Porosity	28
Effects of Biochar on Soil Water Relationships	31
Soil Moisture Content	31
Available Water	33
SUMMARY, CONCLUSIONS AND RECOMMENDATION	36
Summary	36
Conclusions	38
Recommendation	39
LITERATURE CITED	40
APPENDICES	43
Appendix Table	44
Appendix Figures	50

LIST OF TABLES

TABLE		PAGE
1	Materials and Tools used in Production of Biochar Substrates	14
2	Arrangement of Biochar Substrates with Respect to Soil Texture and Shape	15
3	Soil Separates of Treatment One after the Hydrometer Method	23
4	Soil Separates of Treatment Two after the Hydrometer Method	24
5	Soil Separates of Treatment Three after the Hydrometer Method	25
6	Soil Separates of Treatment Four after the Hydrometer Method	26
7	Soil Separates in Relation with Soil Structures.	27
8	Percent Porosity after the Pycnometer and Paraffin Clod Method	29
9	Soil Moisture Content as affected by Bamboo and Rice husk biochar	31
10	Plant Available Water as affected by Biochar Mixtures (Razzaghi et al, 2020).	34

LIST OF TABLES

TABLE		PAGE
1	Materials and Tools used in Production of Biochar Substrates	14
2	Arrangement of Biochar Substrates with Respect to Soil Texture and Shape	15
3	Soil Separates of Treatment One after the Hydrometer Method	23
4	Soil Separates of Treatment Two after the Hydrometer Method	24
5	Soil Separates of Treatment Three after the Hydrometer Method	25
6	Soil Separates of Treatment Four after the Hydrometer Method	26
7	Soil Separates in Relation with Soil Structures.	27
8	Percent Porosity after the Pycnometer and Paraffin Clod Method	29
9	Soil Moisture Content as affected by Bamboo and Rice husk biochar	31
10	Plant Available Water as affected by Biochar Mixtures (Razzaghi et al, 2020).	34

LIST OF FIGURES

FIGURE		PAGE
1	Conceptual Framework of the Study	13
2	Soil Separates after the Hydrometer Method	23
3	Soil Separates after the Hydrometer Method	24
4	Soil Separates after the Hydrometer Method	25
5	Soil Separates after the Hydrometer Method	26
6	Percentage Porosity after Pycnometer and Paraffin Clod Method	30
7	Soil Moisture Content after the Gravimetric Method	33

LIST OF APPENDIX TABLE

APPENDIX TABLE		PAGE
1	Comparison among means of treatment 1 using DMRT.	44
2	Comparison among means of treatment 2 using DMRT.	44
3	Comparison among means of treatment 3 using DMRT.	44
4	Comparison among means of treatment 4 using DMRT.	45
5	Analysis of Variance on percent sand, silt, and clay.	45
6	Comparison among means of Sand using DMRT.	46
7	Comparison among means of Silt using DMRT.	46
8	Comparison among means of Clay using DMRT.	47
9	One-way Analysis of Variance for soil moisture.	47
10	One-way Analysis of Variance for soil porosity.	48
11	Comparison among means of soil moisture using DMRT.	48
12	Comparison among means of soil porosity using DMRT.	49

LIST OF APPENDIX FIGURES

APPENDIX FIGURE		PAGE
1	Production Rice Husk Biochar	50
2	Production of Bamboo Biochar	51
3	Gathering Soil Sample from A7- ANSCI A for expected Sandy Clay Loam soil.	52
4	Gathering Soil Sample from A4 RM- CARES	52
5	Getting Soil Texture of A7- ANSCI A soil and RM CARES soil	52
6	Identifying the Soil Moisture of A7 ANSCI A and A4 RM- CARES soil	53
7	Identifying the Particle and Bulk Density to get the Soil Porosity of Clay Loam soil and Sandy Clay Loam soil	53
8	Sieving Rice Hull and Bamboo Biochar into 2mm size to mix well in soil	54
9	Mixing 41.5 grams of Biochar in 5 kilograms of Soil	54
10	After 1 week of incubation the soil will air dry for 4 days	55
11	Getting soil texture of TR1, TR2, TR3, TR4 with Biochar	55
12	Getting soil moisture of TR1, TR2, TR3, TR4 with biochar	56
13	Identifying the Particle and Bulk Density to get the Soil Porosity of TR1, TR2, TR3, TR4	56

ABSTRACT

MENDOZA, ROB REINER, P., Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippines, **JANUARY 2023, EFFECTS ON SOIL WATER RELATIONSHIPS AND PHYSICAL PROPERTIES OF SELECTED SOIL TYPES USING BIOCHAR AS SUBSTRATES.**

Adviser: Theody B. Sayco, Ph. D.

This study presents the result of locally produced biochar from rice husk and bamboo using the pyrolysis process and the effects of it in terms of Physical properties and soil water relationships of two types of soil such as clay loam soil and sandy clay loam soil.

The laboratory experiment results, however, demonstrate that biochar had no impact on the soil's texture because the soil's separates remained clay loam and sandy clay loam, and its soil structure remained blocky and granular. The soil porosity of clay loam soil with rice hull biochar increased to 28% from 24%, while sandy clay loam soil with bamboo biochar increased the soil porosity to 32% from 22% of the soil porosity. Clay loam soil with bamboo biochar increases to 37.33% from 24% soil porosity, and sandy clay loam soil with rice hull biochar increases to 33.33 from 22%.

The soil moisture of clay loam soil with rice hull biochar, increases to 4.58% from 2.04% of the soil moisture of soil without biochar. In comparison, sandy clay loam soil with bamboo biochar, increases the soil moisture to 3.84% from 1.01% of the soil moisture without biochar. Clay loam soil with bamboo biochar, increases to 4.99% from 2.04% soil moisture, sandy clay loam soil with rice hull biochar, increases to 3.12% from 1.01%.

Biochar amendment increase the water contents at field capacity and the permanent wilting point, but with a larger increase in field capacity, so the plant-available water overall also increases (Abel et al., 2013).

Keywords: Biochar; Rice Husk; Bamboo; Physical Properties; Soil Water Relationships

LITERATURE CITED

- Abdullah, H., Aussieanita Mediaswanti, K., & Wu, Hongwei. (2019). Biochar as a fuel: Significant differences in fuel quality and ash properties of biochars from various biomass components of mallee trees. doi.org/10.1021/ef901435f
- Adeniyi, A.G., Ighalo, J., & Onifade V. (2021) Retort-heating carbonisation of almond (*Terminalia catappa*) leaves and LDPE waste for biochar production: evaluation of product quality. *International Journal of Sustainable Engineering*. DOI: 10.1080/19397038.2021.1886371
- Ahmed, O.H., Ch'ng H., & Majid N.H. (2015). Improving phosphorus availability, nutrient uptake and dry matter production of *Zea mays l.* on a tropical acid soil using poultry manure biochar and pineapple leaves compost. https://doi.org/10.1021/ef901435f
- Azlina, M., Mohammad, A.R., Mohd Fazzly M., Mohd, Ridzuan, M.D., Norziana, Z.Z., Nuru Ain, A.B., & Tosiah, S. (2015). Local practices for production of rice husk biochar and coconut shell biochar: Production methods, product characteristics, nutrient and field water holding capacity. *J. Trop. Agric. and Fd. Sci.*
- Bastos, A.C., Diafas, I., Jeffery, S., Van der Velde, M., & Verheijen, F. (2010). Biochar application to soils a critical scientific review of effects on soil properties, processes and functions. *JRC Scientific and Technical Reports*. DOI 10.2788/472
- Bjerk, T., Bispo, Caramao, E.B., M.D., Jacques, R., Krause, L.C., Oliveira, S., Onorevoli, B., Schena, T., Schneider, J.K., Silva Maciel, G., & Tomasini, D. (2018). Production of activated biochar from coconut fiber for the removal of organic
- Burgos, J., Caballero D., Espinosa, A., Gunasekaran, S., Marquez, J., Martinez, F., Ramirez A., & Rodriguez, S. (2020). Experimental data on the production and characterization of biochars derived from coconut-shell wastes obtained from the Colombian Pacific Coast at low temperature pyrolysis. *Data in Brief*. doi.org/10.1016/j.dib.2019.104855
- Chausali, N., Saxena, J., & Prasad, R. (2021). Nanobiochar and biochar based nanocompo sites: Advances and applications. *Journal of Agriculture and Food Research*. doi.org/10.1016/j.jafr.2021.100191.
- Chen, D.,Huang J., Li, Y., Song, Pang, X., C., & Yu, X. (2016). Effect of pyrolysis tempera ture on the chemical oxidation stability of bamboo biochar.*Bioresource Technology*. doi.org/10.1016/j.biortech.2016.07.112.

- Chen, Y., Duan D., Ling, L., Lou, L., Rukun C., & Xu T. (2012). Effect of bamboo biochar on pentachlorophenol leachability and bioavailability in agricultural soil. *Science of The Total Environment*. doi.org/10.1016/j.scitotenv.2011.11.005.
- Chen, Z., Feng, X., Rinklebe, J., Shaheen, S., Wang, J., Ying, X., & Zhang, H. (2020). Mitigation of mercury accumulation in rice using rice hull-derived biochar as soil amendment: A field investigation, *Journal of Hazardous Materials*. doi.org/10.1016/j.jhazmat.2019.121747
- Kassie, Tadele Amare. (2021). Re: Determining the exact amount of biochar to add to 5 kg of pot soil ?. Retrieved from: https://www.researchgate.net/post/Determining_the_exact_amount_of_biochar_to_add_to_5_kg_of_pot_soil/60e541e795236d1e7845bcf4/citation/download.
- Danso, Prince. (2021). Re: Determining the exact amount of biochar to add to 5 kg of pot soil ?. Retrieved from: https://www.researchgate.net/post/Determining_the_exact_amount_of_biochar_to_add_to_5_kg_of_pot_soil/60e549a311d77b3f021a7ef3/citation/download.
- Fang, H., Khorram, M.S., Fang H., Lin, D., Yu, Y., Zhang, Q., & Zheng, Y. (2017). Effects of aging process on adsorption–desorption and bioavailability of fomesafen in an agricultural soil amended with rice hull biochar. *Journal of Environmental Sciences*. doi.org/10.1016/j.jes.2016.09.012
- Guocheng, L., Hao, Z., Jiang, Z., Pan, B., Wang, Z., & Xing B.(2018). Formation and physicochemical characteristics of nano biochar: insight into chemical and colloidal stability. *Environmental Science and Technology*. doi.org/10.1021/acs.est.8b01481
- Kim, H.S., Kim, K.R., & Yang, J.E. (2017). Amelioration of Horticultural Growing Media Properties Through Rice Hull Biochar Incorporation. *Waste Biomass*. <https://doi.org/10.1007/s12649-016-9588-z>
- Park S-Y, Choi H-Y, Kang Y-G, Park S-J, Luyima D, & Lee J-H. (2020) “Evaluation of ammonia (NH₃) emissions from soil amended with rice hull biochar,” *농업과학연구*. Institute of Agricultural Science, Chungnam National University, 47(4), pp. 1049–1056. doi: 10.7744/KJOAS.20200088.
- Sukartono, S.(2011) Simple Biochar production generated from cattle dung and coconut shell. *J. Basic. Appl. Sci. Res.*. ISSN 2090-424X compounds from phenolic.

- Swapan, S., & Shalini, G. (2017). Pyrolysis of coconut husk biomass: analysis of its bio char properties, energy sources, part a: recovery, utilization, and environmental effects. DOI: [10.1080/15567036.2016.1263252](https://doi.org/10.1080/15567036.2016.1263252)
- Wang, C., Jin, H., Li, L., & Shi, J. (2021). Biochar production by coconut shell gasification in supercritical water and evolution of its porous structure. *Journal of Analytical and Applied Pyrolysis*.
- Weber, K. & Quicker P. (2018). Properties of biochar, fuel. *Elsevier, fuel*. ISSN 0016 2361. <https://doi.org/10.1016/j.fuel.2017.12.0>
- Jun Zhang, James E. Amonette, Markus Flury, Effect of biochar and biochar particle size on plant-available water of sand, silt loam, and clay soil, *Soil and Tillage Research*, Volume 212, 2021, 104992, ISSN 01671987, <https://doi.org/10.1016/j.still.2021.104992>. (<https://www.sciencedirect.com/science/article/pii/S0167198721000623>)
- Saxton and Rawls (2006), Cornell University, USDA-NIFA, Minnesota Stormwater Manual, Soil water storage properties - Minnesota Stormwater Manual (state.mn.us)
- Carvalho, Márcia Thaís & Maia, Aline & Madari, Beáta & Bastiaans, L. & Oort, Pepijn & Heinemann, Alexandre & Da Silva, Mellissa & Petter, F. & Meinke, Holger. (2014). Biochar increases plant available water in a sandy soil under an aerobic rice cropping system. *Solid Earth Discussions*. 6. 10.5194/sed-6-887-2014.
- Jun Zhang, James E. Amonette, Markus Flury, Effect of biochar and biochar particle size on plant-available water of sand, silt loam, and clay soil, *Soil and Tillage Research*, Volume 212, 2021, 104992, ISSN 0167-1987, <https://doi.org/10.1016/j.still.2021.104992>. (<https://www.sciencedirect.com/science/article/pii/S0167198721000623>)
- Carvalho, Márcia Thaís & Maia, Aline & Madari, Beáta & Bastiaans, L. & Oort, Pepijn & Heinemann, Alexandre & Da Silva, Mellissa & Petter, F. & Meinke, Holger. (2014). Biochar increases plant available water in a sandy soil under an aerobic rice cropping system. *Solid Earth Discussions*. 6. 10.5194/sed-6-887-2014.
- Ndede, Otieno & Kurebito, Soboda & Olusegun, Idowu & Tokunari, Takeo & Jindo, Keiji. (2022). The Potential of Biochar to Enhance the Water Retention Properties of Sandy Agricultural Soils. *Agronomy*. 12. 311. [10.3390/agronomy12020311](https://doi.org/10.3390/agronomy12020311).