www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(12): 2186-2189

www.thepharmajournal.com
Received: 12-09-2023
Accepted: 16-11-2023

Ishwarya laxmi V
Ph. D Scholar, Department of Agronomy, S.V. Agricultural College, ANGRAU, Tirupati, Andhra Pradesh, India.

Dr. Y Reddi Ramu
Principal Scientist and Coordinator, AATTC, Chittor, Andhra Pradesh, India

Dr. V Sumathi
Principal Scientist (Agronomy), Perumallapalle, Tiripati, Andhra Pradesh, India

Dr. MVS Naidu
Associate Dean, Agricultural College, Pulivendula, Andhra Pradesh, India

Dr. P Sudhakar
Controller of Examinations, ANGRAU, LAM, Guntur, Andhra Pradesh, India

Dr. V Chandrika
Professor and Head, Department of Agronomy, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

Corresponding Author:
Ishwarya laxmi V
Ph. D Scholar, Department of Agronomy, S.V. Agricultural College, ANGRAU, Tirupati, Andhra Pradesh, India.

Physico-chemical characterization of redgram stalk biochar

Ishwarya laxmi V, Dr. Y Reddi Ramu, Dr. V Sumathi, Dr. MVS Naidu, Dr. P Sudhakar and Dr. V Chandrika

Abstract
The field experiment was conducted during *rabi,* 2021 and 2022 at Sri Venkateswara Agricultural College Dryland Farm, Tirupati, Andhra Pradesh. The experimental soil was sandy loamy in texture, neutral in soil reaction, low in organic carbon and nitrogen, high in available phosphorous and medium in available potassium. Experiment was conducted in split plot design with three replications. Three main plots, treatment consisted of levels of biochar *viz*., control (No biochar) (B_1), Biochar 2.5 t ha^{-1} (B_2) and Biochar 5 t ha^{-1} (B_3) and six sub plots consisting of real time nitrogen management practices viz., RDN (240 kg N ha^{-1}) (N_1), based on LCC value < 5 (N_2), based on SCMR value <50 (N_3), Based on NDVI value (N_4), based on SSNM nutrient expert (N_5) and based on soil test value (STBR) (N_6). This study focuses on the characterization of redgram stalk biochar produced through heap method of pyrolysis, studied for their Physico-chemical and spectral properties. pH of the biochar was 9.12, 9.17 and electrical conductivity value of biochar were 2.57, 2.56 and CEC of biochar ranges 45, 47 during 2021 and 2022 respectively. The nutrient composition of biochar indicates that biochar is rich in nutrients *viz.*, nitrogen, phosphorous, potassium and mainly carbon. The unique nature of biochar typical honey comb like structures present in the redgram stalk biochar analysed through SEM micrographs revealed the relatively porous nature of biochar. The biochar has the potential to enhance soil fertility and contribute to environment sustainability in agricultural system.

Keywords: Biochar, pH, CEC, bulk density, spectral properties

Introduction
Climate change possess a serious threat on productivity cereals. It is a fact that in India around 91.14 mt of crop residues are produced annually which have surplus biomass and are subjected to farm burning this unidentified loss of nutrients from biomass leads to global warming on the other hand maintenance of a threshold level of organic matter in the soil is crucial for maintaining physical chemical and biological integrity of the soil (Venkatesh *et al*., 2015) [16] and also for the soil to perform its agricultural production and environmental function (Izaurralde *et al*., 2001) [4].

Hence conversion of organic waste to produce biochar using pyrolysis process is potentially viable agricultural practice that improves physical and chemical properties of the soil, reduces greenhouse gas emissions and improves the microbial health of soil. Biochar, a highly stable, porous substance and recalcitrant form of organic material produced by heating biomass in an oxygen limited condition and high temperature usually above 250 °C. pyrolysis of biomass is the feasible method and its incorporation into soils has a potential role in sequestrating carbon (Lehmann *et al*., 2006) [8]. This practice can recover 190-230 Tg of carbon from atmosphere (Srinivasarao *et al*., 2013) [15] and sequester more than 50% of the carbon in a highly stable form in the soil.

Incorporation of biochar in the soil is reported to alter various soil physical, chemical and biological properties such as soil structure, pore size distribution, pH, CEC etc. and have positive implications on soil aeration, water holding capacity and plant growth (Downie *et al*., 2009) [3]. The increased surface area, porosity, and lower bulk density in mineral soil with biochar leads to better water retention, soil aggregation, and availability of nutrients. biochar may not provide a significant source of plant nutrients but they can improve the nutrient assimilation capability of crops by positively influencing the soil environment by acting as a adhesive material by which it increase the capacity of soils to adsorb and store nutrients makes it all available to the plant. Hence study was conducted to characterize the redgram stalk biochar for its physico-chemical properties.

Materials and Methods

The experiment was conducted in Field No. 139 during *rabi* 2021 and 2022 at Sri Venkateswara Agricultural College Dryland Farm, Tirupati campus of Acharya N.G. Ranga Agricultural University which is geographically situated at 13.5°N latitude, 79.5°E longitude and at an altitude of 182.9 m above mean sea level in the Southern Agro-climatic Zone of Andhra Pradesh. According to Trolls classification, it is under Semi-Arid Tropics (SAT). The experimental soil was sandy loamy in nature, neutral in soil reaction, low in organic carbon and nitrogen, high in available phosphorous and medium in available potassium. Experiment was conducted in split plot design with three replications. There were three main plots consisting of levels of biochar *viz*., control (No biochar) (B_1), biochar@ 2.5 t ha^{-1} (B_2) and biochar@5 t ha^{-1} (B_3) and six sub plots consisting of real time nitrogen management practices viz., RDN* (240 kg N ha^{-1}) (N_1), LCC value < 5 (N_2), SCMR value <50 (N_3), based on NDVI value (N_4), based on SSNM nutrient expert (N_5) and based on soil test value (STBR) (N_6). Heap method is used for preparation of biochar by using slow pyrolysis process at 350 ºC to 400 ºC temperature range. In this method of biochar preparation, a pyramid like (earth kiln) heap will be made with clay soil and red gram crop stalks are placed inside for making biochar and it is sealed with mud paste for maintaining anaerobic conditions. Some vents will be opened from top to bottom of the heap to allow the combustion process. Further, when no relative smoke is released, the heap is covered with a layer of moist earth as a stack. The staking makes the cooling of burnt material in two to three days. Then earth is removed and biochar separated from surrounding portion of the heap. The prepared biochar was grounded and passed through 2 mm sieve for subsequent laboratory analysis.

The pH of biochar was determined using pH meter in 1:20 (biochar: water) ratio suspension after shaking for 1 hour. (Jackson 1973) [5]. The EC of the biochar was determined using electrical conductivity meter (Jackson 1973) [5]. Cation exchange capacity of biochar measured by modified ammonium acetate method suggested by Yuan *et al*. (2011) [17] sample was leached with 1N sodium acetate followed by washing with alcohol and again leached with 10 % KCl and the Na+ on the exchangeable sites of the biochar was displaced by 20 mL of 1 M NH4–acetate. Na in the leachate was estimated using flame photometry. Physical properties of biochar like bulk density, particle density, water holding capacity were measured by using Keen's cup method. (Keen and rackzowski., 1921) [6]. The porosity (%) was calculated by using the formula:

$$\text{Porosity (\%)} = (1- (BD / PD)) \times 100$$

The ash content in the biochar obtained from the thermo-conversion process was determined as outlined by Yuan *et al.* (2011) [17]. Ground biochar (1-mm sieve) heated at 200 °C for one hour and then at 500 °C for an additional 4 h in a muffle furnace. After the furnace was cooled to room temperature, the sample are weighed, and these were used as the weight of ash.

The ash content was determined by the following equation:

$$\text{Ash (\%)} = (\text{Wt. ash} / \text{Wt. biochar}) \times 100$$

Total nitrogen in red gram stalk biochar was determined by macro Kjeldahl digestion cum distillation method as outlined by Chopra and Kanwar (1976) [2] was expressed in %.

Total phosphorus was determined by using di acid (9:4 mixture of nitric acid and perchloric acid) mixture. The digested material was transferred to 100 ml volumetric flask and made up to 100 ml with distilled water. From this 5 ml was used for phosphorus determination by developing vanadomolybdo-phosphoric yellow colour method with Barton's reagent. The intensity of yellow colour was determined by using UV-VIS 7500 spectrometer at 420 nm (Piper, 1966) [10]. The content was expressed in %. Total potassium was determined by using di acid (9:4 mixture of nitric acid and perchloric acid) mixture. From this solution potassium was determined by using ELICO flame photometer and expressed as % (Piper, 1966) [10]. Total carbon concentration in the biochar was determined by the dry combustion method using Carbon analyzer (Elementar) at 950 ºC temperature (Nelson and Sommers, 1982) [9].

Results and Discussion

A. Chemical properties of biochar

The results pertaining to chemical properties of redgram stalk biochar during both the years of experiment were presented in the table 1. The pH of the redgram stalk biochar was 9.12 and 9.17 during both the years respectively. The alkaline nature of redgram stalk biochar was attributed to organic and inorganic functional groups and the -coo- and -o- group in biochar are involved in deprotonation of acidic groups results in conjugation of bases and leads to alkaline pH of biochar (Ronsse *et al.*, 2013) [11]. EC of the biochar used in experiment during both the years was 2.57 and 2.56 these EC values of biochar might be due to water soluble K^+, Mg^{+2} and Ca^{+2} the values are within appropriate range and suitable for soil application.

Table 1: Physical, chemical properties and nutrient composition of redgram stalk biochar

S. No	Characters	Red gram stalk biochar values	
		2021	**2022**
1.	pH	9.12	9.17
2.	EC (dSm^{-1})	2.57	2.56
3.	CEC (%)	45	47
4.	Bulk density (Mg m^{-3})	0.40	0.36
5.	Particle density (Mg m^{-3})	0.74	0.72
6.	Porosity (%)	46	50
7.	Water holding capacity (%)	270	280
8.	Total ash (%)	15.6	15.4
9.	Carbon (%)	41.6	42.1
10.	Nitrogen (%)	0.86	0.85
11.	Phosphorous (%)	0.43	0.41
12.	Potassium (%)	0.82	0.81
13.	C:N ratio	48.4	49.5

The cation exchange capacity (CEC) of pigeon pea biochar was 2.57 and 2.56 high cation exchange capacity of biochar might be due volatile matter(VM) present in biochar and relatively higher CEC indicating that greater potential in holding more nutrients and be made available to the the crop (Das *et al*., 2018) [12].

B. Physical properties of biochar

The biochar prepared from redgram stalk biochar recorded the lower bulk density (0.40 and 0.36) compared to the soil (1.48

and 1.47) and partical density of biochar was 0.74 and 0.72 during both the years of experiment. Porosity of the biochar was 46 and 50. water holding capacity was recorded in redgram stalk biochar was 270 and 280 during two years of experiment. Lower bulk density and higher water holding capacity of biochar might be due to porous nature of biochar material which inturn enhances the soil aeration, water holding capacity and improves physical properties of the soil. Total ash content in the biochar during both the years was found 15.6 and 15.4. the ash content in the biochar produced through heap method is in the range of acceptability and suitable for soil application. The similar observation was also made by Kinney *et al.* (2012) [7] and Venkatesh *et al*, (2013) [14].

C. Nutrient composition of the biochar

The results pertaining to nutrient composition of the redgram stalk biochar is presented in the table 1. The redgram stalk biochar contained 0.86 and 0.85 percent of nitrogen during two years of experiment respectively. while the corresponding phosphorous was 0.43, 0.41 and potassium was 0.82 and 0.81 during 2021 and 2022 respectively. similarly carbon content in the redgram stalk biochar was 41.6 and 42.1. The higher amount of nutrients in biochar is due to the greater solubility of associated minerals in biochar formed during pyrolysis process (Bera *et al.*, 2014) [1].

D. Spectral properties of biochar

To achieve successful visual and morphological characterization and pore properties of red gram stalk biochar. SEM images taken at different resolution (500,100, 20 and 10) were illustrated in Fig 1. Redgram stalk biochar SEM micrographs vividly show the distinctive porous and honeycomb-like structure. The architecture of the feedstock material employed is inherited by the porous tubular structures of biochar (Sohi *et al*., 2010) [13]. The macro and micro porous structures of biochar (pore size approximately 1 mm diameter) are possibly relevant for water holding capacity and nutrient adsorption capacity in soil systems (Bera *et al*., 2014) [1]. The capillary transport of dissolved minerals in soil solution happens by diffusion and mass flow through these tubular structures.

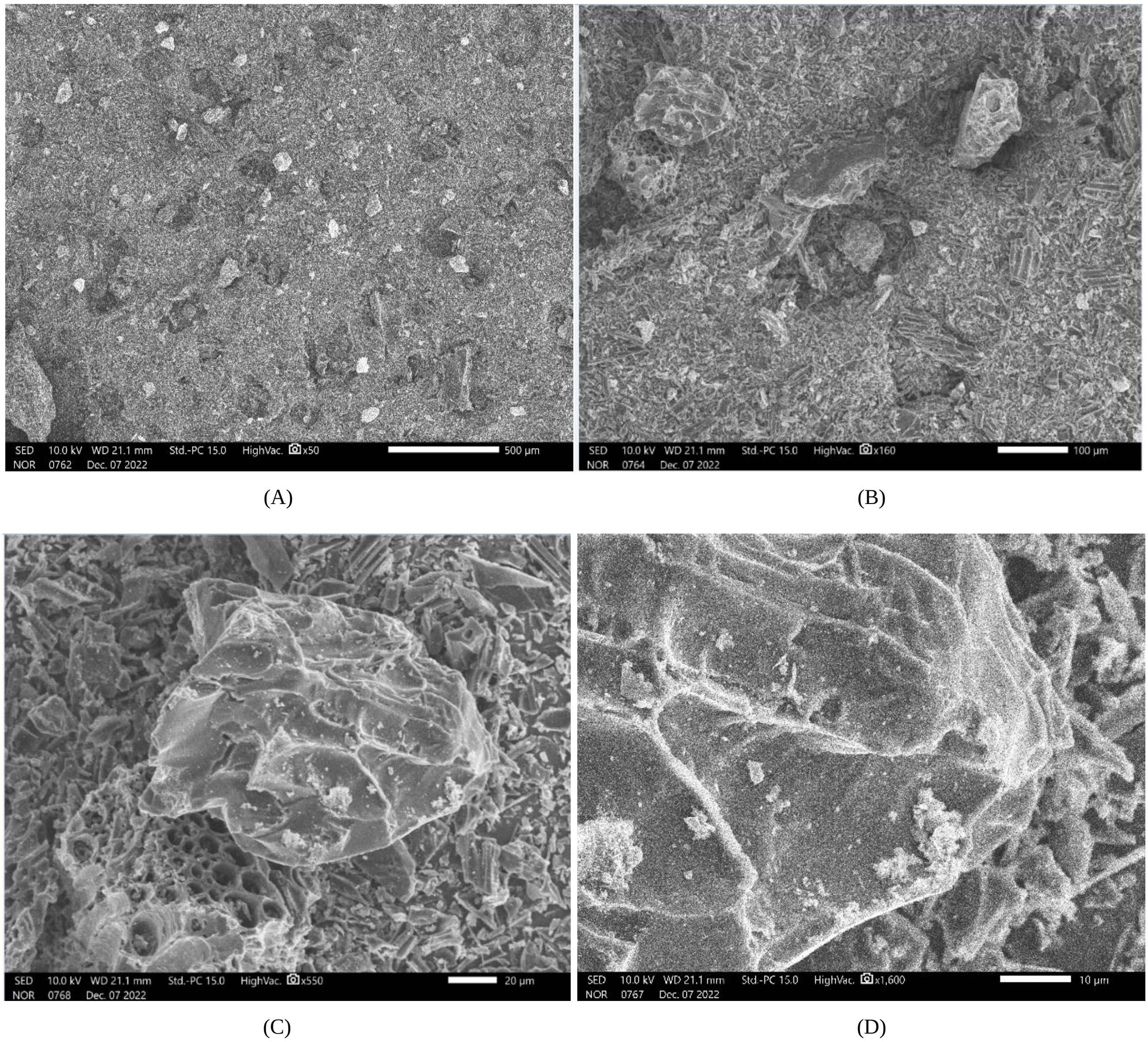

Fig 1: Scanning electron micrographs (SEM) (A) Pigeonpea biochar at 1.0 k magnification; 500 µm resolution (B)100 µm resolution (C) 20 µm resolution (D)10 µm resolution

Conclusion

Biochar prepared from red gram stalks can very well be suggested as soil ameliorant for low pH soils as it is alkaline in nature. Biochar is also known to improve soil nutrients like nitrogen, phosphorus and potassium by having large CEC and low bulk density. The organic carbon content present in biochar which can be very well used for carbon sequestration studies. The spectral properties of the biochar clearly depicted the required purpose of biochar use such as honey-comb like porous structure for water holding and nutrient adsorption.

References

1. Bera T, Puarakayastha TJ, Patra AK. Spectral, chemical and physical characterisation of mustard stalk biochar as affected by temperature. Clay Research. 2014;33(1):36-45.
2. Chopra S, Kanwar JS. Analytical agricultural chemistry. 1976.
3. Downie A, Crosky A, Munroe P. Physical properties of biochar. In Lehmann, J., and Joseph, S. (Eds.), Biochar for environmental management: Science and technology. *Earth scan*, London, 2009, 13-32.
4. Izaurralde RC, Rosenberg NJ, Lal R. Mitigation of climate change by soil carbon sequestration: issues of science, monitoring, and degraded lands. Advances in Agronomy. 2001;70:1-75.
5. Jackson ML. Soil Chemical Analysis. Oxford IBH Publishing House, Bombay, 1973, 38.
6. Keen BA, Raczkowski H. The relation between the clay content and certain physical properties of a soil. Journal of Agricultural Sciences. 1921;11:441-449.
7. Kinney TJ, Masiello CA, Dugan B, Hockaday WC, Dean MR, Zygourakis K, *et al*. Hydrologic properties of biochars produced at different temperatures. Biomass and Bioenergy. 2012;41:34-43.
8. Lehmann J, Gaunt J, Randon M. Biochar sequestration in terrestrial ecosystems-a review. Mitigation and Adaptation Strategies for Global Change. 2006;11(2):403-427.
9. Nelson DW, Sommers LE. Total carbon, organic carbon, and organic matter. In: A.L. Page (ed.), Methods of Soil Analysis. Part 2. 2nd ed. Agronomy 9. American Society of Agronomy, Madison, WI; c1982. p. 539-547.
10. Piper CS. Soil and Plant Analysis. Hans Publishers, Bombay. 1966, 137-153.
11. Ronsse F, Van Hecke S, Dickinson D, Prins W. Production and characterization of slow pyrolysis biochar: influence of feed stock type and pyrolysis conditions. Global Change Biology Bioenergy. 2013;5:104-105.
12. Shaon Kumar Das, Goutam Kumar Ghosh, Avasthe RK, Manik Chandra Kundu. Preparation and Characterization of Biochars for their application as a Soil Ammendment. Indian Journal of Hill Farming. 2018;31(1):141-145.
13. Sohi SP, Krull E, Lopez-Capel E, Bol R. A review of biochar and its use and function in soil. Advances in Agronomy. 2010;105:47-82.
14. Srinivasa rao Ch, Gopinath KA, Venkatesh G, Dubey AK, Harsha Wakudkar TJ, Purakayastha Pathak H, *et al*. Use of biochar for soil health enhancement and greenhouse gas mitigation in India: Potential and Constraints. Central Research Institute for Dryland Agriculture, Hyderabad, Andhra Pradesh. 2013, p. 51.
15. Venkatesh G, Venkateswarlu B, Gopinath KA, Srinivasarao Ch, Korwar GR, Reddy BS, *et al*. Biochar production technology for conversion of cotton stalk bio-residue into biochar and its characterization for soil amendment qualities. Indian Journal of Dryland Agricultural Research and Development. 2013a;28(1):48-57.
16. Venkatesh G, Srinivasa Rao Ch., Gopinath KA, Sammi Reddy K. Low-cost portable kiln for biochar production from on-farm crop residue. Indian farming. 2015;64(12):9-12.
17. Yuan JH, Xu RK, Zhang H. The forms of alkalis in the biochar produced from crop residues at different temperatures. Bioresource Technology. 2011;102:3488-3497.