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Poineering Biochar in Soil and Crop Improvement

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Introduction

Agriculture has to address three intertwined challenges at the same time: ensuring food safety through increased income and productivity, adapting to climate change and contributing to climate change mitigation. The motivation to study biochar came from the soil possibility to remedy many of the challenges fronting the today's world *viz*., waste administration, renew-able energy, soil declination, and climate change. Bio char production includes ranges of biomass types which allows to give the product different physical and chemical properties. In recent years, considerable research has focused on bio char, its nature, and its properties to explore its potential benefits and negative impacts, particularly for applying to agriculture field as amendments.

Characteristics and significance of biochar

The biochar is the carbon products, gained while the raw materials, like forest, animal compost, and plant residues, is heated in a closed storage place without air. In many technical and clearer standards, biochar is created by seeming thermal decomposition of organic substance below incomplete supply of (O_2) oxygen, and at comparatively low temperature (<700˚C).

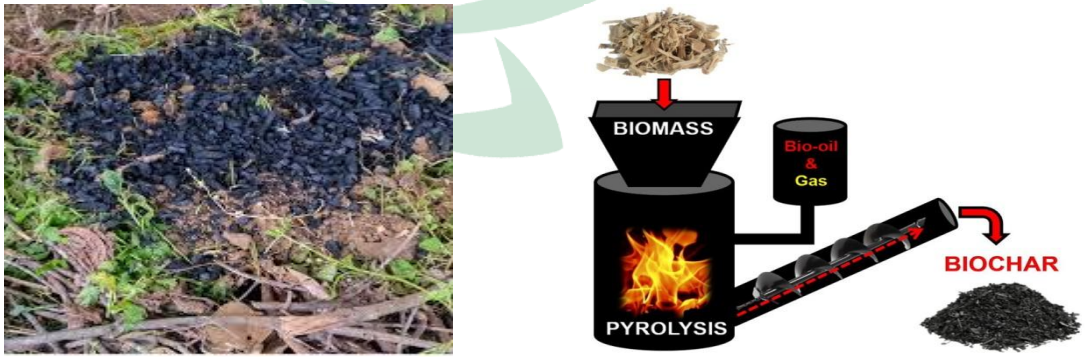

Fig 1. Biochar production process from feedstock type to biochar generation

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Bio char is a solid product obtained in pyrolysis of biomass. It is a carbon-rich and porous material which can be used for a wide range of applications among which soil improvement, remediation and pollution control take the most important roles. As the bio char differs from charcoal, which is produced in low temperature that containing high volatile matter. In higher temperature the chemical properties of biomass changes and significantly reduced the carbon content. In contrary to charcoal, bio char is also not phytotoxic.

Historical perspective

The bio char history traces back to an ancient methods of Amazon civilization used to change in fertile sandy soil into rich and sustainable fields, also noticed as distinctive dark colored soils. These soils were found to show significantly higher fertility and are described in many pieces of literature due to its exceptional richness and impact on increasing the crop yield. Today, the bio char added values are more and more often explored in then industrial scale, allowing to generate this natural soil nutrient by safe, low-emitting and resource efficient technologies.

Agricultural Advantages

The characteristics of bio char and its potential benefits when applied to land are both influenced by the specific material of the bio char and the processing technique used. When applied as soil amendments, bio char are known to improve soil physical and chemical properties such as increasing soil fertility and productivity. Bio char can retain applied fertilizer and nutrients and release them to agronomic crops over time. It has the ability to retain water and nutrients in the surface soil horizons for long periods, it benefits agriculture by reducing nutrients leaching from the crop root zone, potentially improving crop yields, and reducing fertilizer requirements. Thus using bio char in production agriculture should improve yields and reduce negative impacts on the environment.

Bio-char as a Soil Amendment

The effect of bio-char on soil physicochemical properties and its positive outcome on soil fertility and crop productivity have been documented extensively for tropical agriculture. In a global-scale meta-analysis it is reported that bio-char raised soil pH via a liming effect, which in response increased soil fertility and crop yield. Bio-char benefits on ecosystem services follows the order: C sequestration > N_2O emissions > NO_3 leaching > available water > soil biology > soil fertility > crop yields >runoff. However, benefits depends on

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different factors such as bio-char feedstock, pyrolysis temperature, application rate, properties of bio-char and soil, and climatic conditions. Other biochar agronomic benefits includes usage as a carrier material for microbial inoculants, agrochemicals (fertilizers and pesticides), or bio-fertilizers. It may also enhance the resilience of cropping systems against extreme climate events such as drought events, although this effect might only be only evident in specific years for which longer-term field studies are required.

Table 1. Properties of Bio-char

Properties	Values
pH	9.7
CEC (cmol (P^+) kg^{-1})	12.54
Carbon (g/kg)	30.80
C : N ratio	39.4
N (g/kg)	0.97
P (g/kg)	1.06
K (g/kg)	12.60

Effects of bio-char in various crop improvement and growth parameters

Bio char is enriched with nitrogen is tested and analyzed statistically. The results in rice, confess that the growth parameters like leaf area, plant height, chlorophyll content, tiller numbers, stomatal conductance, and yield attributes was higher than control. Applying biochar to paddy fields is a helpful approach that potentially increases rice production and nitrogen use efficiency (NUE) to ensure food security and protect the ecological environment. Biochar application increases rice yield and NUE by 10.73% and 12.04%, respectively.

In Maize, low dosage biochar (4 tons/ha) in combination with precision farming had a strong effect on maize yield, in sandy, acidic soils where physical and chemical soil characteristics are improved by the amendment of biochar where it is concentrated in basins close to plant roots. Biochar application has a pronounced effect on maize grain yields where higher application rates (5 t/ha) showed superior performance to 2.5 t/ha. Biochar

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amendments significantly increased maize production however decreased GHGs. Also biochar application increased soil pH and soil organic carbon positively improved.

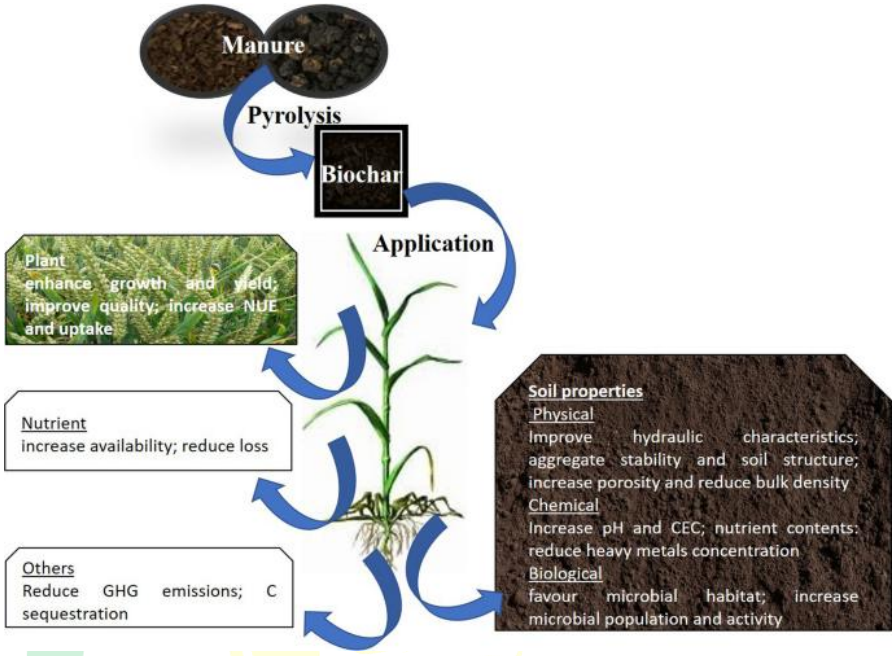

Fig 2. Biochar nutrient dynamics in soil and plant

Biochar-based controlled release nitrogen fertilizers (BCRNFs) successfully enhanced the yield (~ 16.6%) and NUE (~ 58.79%) of rape by slowly releasing N and modulating the abundance of functional microbes through increased soil nitrification and reduced denitrification, as compared with Urea treatment. Application of bio char at the rate of 12-18 ton per ha improved pod number per plant and seed number per pod in garden pea. In groundnut, Biochar neutralized the acid soil, significantly raising soil pH from 5 to 7.15 and increasing cation exchange capacity by 75%. Biochar amended at 1 and 2%, increased groundnut dry matter yield by 28%.

Conclusion

The different physical properties of the soil such as bulk density, porosity and the chemical properties (pH, N, P, K, organic carbon) of soil were improved due to application of bio char. Due to application of bio char the growth parameters of various crops had shown improvement, which indicates bio char irrespective of type is a beneficial soil amendment improves the yield in eco-friendly way.