

Tobacco stalk Biochar as a soil amendment

Complete Details of Technology:

The tobacco stalk biochar (TS Biochar) was produced from tobacco stalk biomass (TS Biomass) through the process of pyrolysis. The TS Biochar production parameters (heating temperature and duration) were optimized at ICAR-CIAE, Bhopal, India. The TS Biochar used in this investigation was produced by pyrolysing TS Biomass at a temperature of 500 °C and holding time of 90 minutes (giving a biochar yield of 40%). and analyzed for important characteristics. Laboratory and field experiments were conducted to assess the effectiveness of TS Biochar vis-à-vis other amendments viz., untreated TS Biomass and synthetic zeolite (SZ). A laboratory leaching experiment was conducted in duplicate to study the N and K leaching losses as affected by tobacco stalk biochar (TS Biochar) and synthetic zeolite (SZ) as soil amendments. The treatments included: T1: N+K, T2: N+K+TS Biochar, T3: N+K+SZ, T4: N+K+TS Biochar + SZ, T5: TS Biochar and T6: Control. The leachate samples were collected after every leaching event and analyzed for pH, ammonium and potassium contents.

The dynamics of soil pH, N and K fertility of an Alfisol amended with different organic and inorganic soil amendments were assessed in a 90- day incubation experiment in two factor completely randomized block design with eight treatments, eight different days of incubation and with three replications. The soil amendments tested were tobacco stalk biochar (TS Biochar), tobacco stalk biomass (TS Biomass) and synthetic zeolite (SZ). The treatments for incubation experiment included: T1 (100% RDF), T2 (100 % RDF+1 t ha⁻¹ TS Biochar), T3 (100 % RDF+ 250 kg ha⁻¹ SZ), T4 (100 % RDF+1 t ha⁻¹ TS Biochar+250 kg ha⁻¹ SZ), T5 (100 % RDF +0.5 t ha⁻¹ TS Biomass), T6 (1 t ha⁻¹ TS Biochar+250 kg ha⁻¹ SZ), T7 (1t ha⁻¹ TS Biochar) and T8 (Control). The sub-samples of soils were drawn eight times at pre-decided intervals (1, 7, 15, 30, 45, 60, 75 and 90 days) during the course of incubation and analysed for soil properties. Fertilizer nutrients, especially N and K, once applied to light textured sandy soils are vulnerable to losses through leaching. A field experiments with flue cured virginia (FCV) tobacco as a test crop was conducted at ICAR-CTRI, Rajahmundry, Andhra Pradesh. It was laid in randomized block design with eight treatments and three replications.

The treatments included 2 organic amendment treatments (1 t ha⁻¹ TS Biochar) and (0.5 t ha⁻¹ TS Biomass) combined with 100% RDF, inorganic amendment (250 kg ha⁻¹ SZ) with 100% RDF, adjusted dose of N and K + 1 t TS Biochar ha⁻¹, combination of both organic (1 t ha⁻¹ TS Biochar) and inorganic (250 kg ha⁻¹ SZ) soil amendments with 100 % RDF, 100 % RDF alone, combination of TSB and SZ alone, and the control. The 8 treatments in all were tested in a RBD with 3 replications. Growth parameters like plant height no. of leaves and leaf area index were recorded at 60 DAT. Plant samples collected at 60, 75 DAT and harvest were assessed for their nutrient content. Tobacco leaf yields and leaf

quality (in terms of nicotine, reducing sugars and chlorides) were recorded. Nutrient uptake and use efficiency parameters were calculated. Final soil samples were collected depth wise and analyzed for soil properties. Experimental results revealed that optimum conditions for complete charring of tobacco stalk biomass were attained at a temperature of 500°C and holding time of 90 minutes with the yield recovery of 40%. Biochar yield tended to decrease with increase in reactor temperature and holding time.

TS biochar showed the enrichment of the carbon and nutrients owing to mass reduction by 2.5 times. The FTIR spectrum of TS Biomass indicated the lignocellulosic nature coupled with various polar functional groups, while that of TS Biochar showed degradation of broad peak around $WN\ 3340\ cm^{-1}$ (resulting in degraded broad peak around $WN\ 3030\ cm^{-1}$) thereby indicating dehydration of biomass structure and cleaved of phenolic groups at high temperature (500 °C). Vibration in the frequency range of $WN\ 1100\ cm^{-1}$ to $WN\ 1500\ cm^{-1}$ represented peaks for carbonate and carbonate-carboxyl, and $WN\ 1660\ cm^{-1}$ to $WN\ 1670\ cm^{-1}$ showing the peaks for carboxylic acid. Peaks at $WN\ 1555$ & $WN\ 1613\ cm^{-1}$ represented basic groups such as quinones.

Effect of soil amendments on soil pH indicated that among all the treatments maximum increase in pH was recorded in T6 (1 t ha⁻¹ TS Biochar+250 kg ha⁻¹ SZ) followed by T7 (1 t ha⁻¹ TS Biochar). These results clearly demonstrated that TS Biochar serves as a very effective liming agent for acid Alfisols. Results on leaching experiment indicated that treatments including TS Biochar recorded higher pH values of the leachates than the treatments without TS Biochar. The per cent inhibition of leaching of applied ammonium and potassium by tobacco stalk biochar was 28.10 and 25.28%, respectively. Field experiment with FCV tobacco grown on an Alfisol under irrigated conditions revealed that the application of TS Biochar + 100% RDF and TS Biochar + SZ + 100% RDF resulted in a significant increase in tobacco leaf yield compared to the 100% RDF. The relative yield obtained with soil amendments ranged from 92 to 123%.

The highest uptake of nitrogen (84.56 kg ha⁻¹) and potassium (122.73 kg ha⁻¹) by tobacco was observed in T2 (100% RDF+1 t ha⁻¹ TS Biochar). Recovery efficiency of N and K applied was greater in tobacco stalk biochar soil amendment with 50.78 and 77.83 per cent as against 100 % RDF alone with 32.83 and 49.64 per cent, respectively, indicating that the tobacco stalk biochar can serve as soil amendment for minimizing nutrient leaching losses in light textured Alfisols. All treatments with TS biochar also improved the soil quality as evident from increased nutrient availability, soil organic carbon content and relatively greater carbon management index (CMI).

Brief Description of Technology Including Salient Features:

Among different soil amendments organic soil amendment tobacco stalk biochar was rich in total organic carbon content. Per cent inhibition of leaching losses of ammonium and potassium from sandy soils was observed in case of TS Biochar soil amendment. Tobacco stalk biochar was characterized by rich carboxylate functional groups. Among the treatments, 100% RDF with 1 t ha⁻¹ TS Biochar in FCV tobacco showed improvement in nutrient availability, growth, yield, yield attributes, uptake, use efficiency, quality and soil properties.

Tobacco stalk biochar also improved the soil quality which is evidenced from increased soil total organic carbon content and high carbon management index. From the research findings it was well understood that organic soil amendment TS Biochar prepared from TS Biomass can be used as soil amendment for improving the nutrient holding capacity of sandy soils. From the research findings it was also understood that application of TS Biochar along with recommended dose of fertilizer improved growth, yield, yield attributes, nutrient uptake and quality of tobacco. It acted as soil amendment and also an additional source of nutrients and there by increased the nutrient content, uptake and use efficiency of crop. Hence, from the study it can be concluded that application of tobacco stalk biochar (1 t ha⁻¹) along with 100% RDF can be recommended to improve yield and yield attributes of tobacco.

Benefits/Utility

Application of TS Biochar along with recommended dose of fertilizer improved growth, yield, yield attributes, nutrient uptake and quality of tobacco. It acted as soil amendment and also an additional source of nutrients and there by increased the nutrient content, uptake and use efficiency of crop. Hence, application of tobacco stalk biochar (1 t ha⁻¹) along with 100% RDF can be recommended to improve yield and yield attributes of tobacco and it will have implications for improving nutrient use efficiency particularly of N & K under conditions of NLS and thereby reduce the cost of production.