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Growth, yield and fibre quality of kenaf (Hibiscus cannabinus L.) varieties as influenced by biochar

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A study on growth, yield and fibre quality of kenaf (Hibiscus cannabinus L.) varieties as influenced by biochar was conducted to determine optimum rate of biochar for better quality of kenaf fibres. The experiment was conducted during the 2023 cropping season at two locations; Faculty of Agriculture Research Farm, Federal University Dutse and Bauchi State University, Gadau. The experiments were laid in randomized complete block design (RCBD) with three replications. Biochar was applied at 5 and 10 tons/ha and incorporated into ridges at sowing. The results showed that biochar applied at the rate of 10 tons/ha had higher plant height (147.5 cm and 137.5 cm), number of leaves (119.6 and 118.5), fibre yield per plant (923 g and 839 g), fibre yield per hectare (5.50 t/ha and 4.68 t/ha) and dry weight of leaves (158.4 g and 161.9 g) respectively in Dutse and Gadau. Kenaf white variety (yar fara) had higher plant height (166.6 g and 137.6 g), number of leaves (116.9 g and 114.8 g) and attained 50 % flowering earlier than black variety (yar baka). Higher leaves fresh weight (360 and 357 g), dry weight of leaves (155 and 157 g), fibre yield per plant (911 g and 825 g) and fibre yield per hectare (5.29 t/ha and 4.79 t/ha) were obtained from the black kenaf variety (yar baka) respectively in Dutse and Gadau. Biochar rates did not show any significant effect on moisture content and dry matter content. Application of 10 tons/ha biochar is recommended for production of maximum kenaf quality in the study area.

Keywords: Biochar, kenaf, optimum rate, variety, fibre

INTRODUCTION

Kenaf (Hibiscus cannabinus L.) is a fast-growing annual crop from the malvaceae family that has both economical and nutritional importance. Kenaf is thought to have originated in Africa (Western Sudan) as early as 4000 BC and several varieties and cultivars are commonly cultivated (Kobayashi et al., 2003; Cheng et al., 2004; Mostofa et al, 2013). Kenaf is cultivated for its edible leaves, seeds and fibre which is used in producing twine, rope and sack cloth (Le Malieu et al., 1991). It is an erect annual shrub that grows to a height of 1- 4 meters with a well-developed tap root, straight leaves and slender stems. It has huge cream-coloured blooms with reddish-purple necks. Kenaf is adaptable to a variety of soil types, but it thrives in well-drained, sandy loam soils rich in humus with a pH of 5 to 7 and it is planted throughout a wide geographic range. It requires much moisture at its early stage of growth and a rainfall of approximately 600 mm distributed across the growing season of 4-5 months (NAERLS, 2019). The Food and Agriculture Organisation (FAO) reports that kenaf, originating from Africa, is commercially farmed in over 20 countries, primarily China and India. Despite its origins in Africa, kenaf’s fibre is used in various industries, including cordage fibre, paper pulp, rexin, lubricants, biofuels and automobile parts. Despite its low output, kenaf production from China, Bangladesh, Thailand and Myanmar contribute to over 95% of global production. Food security in the natural environment relies on healthy soil, which is crucial for plant growth and yield in kenaf production, requiring sustainable remediation techniques for environmental sustainability (Gregory et al., 2014; Ren et al., 2016; Saffeullah et al., 2021; Ullah et al., 2021).

MATERIALS AND METHODS

Experimental site

The experiment was conducted during the 2023 cropping season at two locations; Faculty of Agriculture Research Farm, Federal University Dutse (latitude 11°70’ N, and longitude 9°34’ E, and 460 m above sea level) and Bauchi State University, Gadau (latitude 11º 40' 27" N and longitude 10º 16' 30" E, and 1200 m above sea level).

Varieties

Black variety (yar baka) which grows from 2-5 m, has an oxblood or maroon stem colour and matures in about 120 days. The white variety (yar fara): which grows up to 2-5 m with green or light green stem and palmate leaf structure and matures in about 120 days.

Treatments and experimental design

The experiment consisted of two rates of biochar (5 tons/ha and 10 tons/ha) and two varieties of kenaf [black (yar baka) and white (yar fara)].

The experiment was laid in a Randomized Complete Block Design (RCBD). The experimental field was cleared, ploughed, harrowed and ridged to create favourable condition for plant establishment. Plots of 3.75 m × 1.50 m dimensions were marked and each plot was made up of 5 rows (0.75 m apart). The first and fifth rows were the border rows. The second and fourth rows were used as sampling rows. The third row (middle) row was used for final yield assessment (net plot). There was an alley of 1.0 m between plots and 1.5 m between replications.

Agronomic practices

Three (3) seeds per hole were sown, at an intra-row spacing of 25 cm and inter-row spacing of 75 cm on 15th July, 2023 and 22nd July, 2023 at Dutse and Gadau respectively and thinned to 2 stands, first weeding was carried out manually at 3 WAS (Weeks after seeding) and subsequent weedings were carried out when due (IART, 2021).

Data Collection

Parameters were assessed by tagging five (5) plants randomly from the second and fourth rows. Data collected included plant height, number of leaves, and day to 50% flowering other data were fresh and dry leaf weight, fibre yield per plant and hectare.

Quality parameters

These include ash, moisture and dry matter contents that were determined using standard procedures (AOAC, 2005).

Data Analysis

Data collected were subjected to analysis of variance using GenStat 16th edition and significant means were separated using Fisher's protected least significance difference.

RESULTS

The physico-chemical characteristics of the experimental soil at Dutse and Gadau are shown in Table 1. The soils at both locations had moderate amount of nitrogen and available phosphorus. Organic carbon, calcium, magnesium, potassium, sodium and cation exchange capacity were at moderate levels at both locations. The pH ranged from 6.2 to 6.4 across the two locations and is slightly acidic.

Plant Height

There was significant difference ($p<0.001$) in plant height between the levels of biochar applied at both locations across all sampling periods. Application of biochar at 10 t/ha had higher plant height across all the sampling periods at both locations. There were significant differences ($p<0.05$) between the varieties across all sampling periods at Dutse. White variety (yar fara) kenaf had taller plants across all the sampling periods while kenaf at Gadau had significant difference between the varieties at 8 and 10 weeks after sowing. No significant interaction between the factor at both locations (Table 2).

Number of Leaves per Plant

Biochar significantly showed difference ($p<0.05$) at both locations except for Gadau at 12 and 14 WAS. Application of 10 t/ha had significantly higher number of leaves at both locations across all the sampling periods. No significant differences were observed among the varieties at both location across all sampling periods (Table 3).

Number of Days to 50 % Flowering

The amounts of biochar applied at the two locations did not differ significantly in terms of flowering. At both locations, significant differences ($p<0.001$) were found between the varieties. 50 % days to flowering were significantly higher in white variety (yar fara) (Table 4).

Fresh Weight of Leaves

No significant difference was observed among the levels of biochar applied, although application of 5 t/ha of biochar had higher weight of fresh leaves at both locations. There were significant differences ($p<0.05$) between the varieties at both locations, and the black variety (yar baka) produced highest fresh leaves weight (Table 5).

Dry Weight of Leaves

No significant difference in dry weight of leaves was observed among varieties at both locations (Table 6).

Fibre Yield per Plant

Significant differences were observed ($p<0.05$) for fibre yield per plant among the levels of biochar applied at both locations. Application of 10 t/ha had higher fibre yield per plant at both locations. There was significant difference ($p<0.001$) among the varieties at Dutse, and Black variety (yar baka) had higher fibre yield per plant at Dutse. No Significant difference was observed among the varieties at Gadau (Table 7).

Fibre Yield per Hectare

At Dutse, significant differences ($p<0.05$) were observed among the biochar levels and application of 10 t/ha biochar produced the highest yield of fibre. Among the varieties at both locations, black variety (yar baka) had higher fibre yield at both locations. There were no significant interactions observed between the factors biochar and variety at both locations (Table 8).

Ash content

Significant differences ($p<0.05$) were observed in ash content between levels of biochar applied at Dutse; application of biochar at 5 t/ha had the highest ash content. At Gadau, there was no significant difference in ash content between the levels of biochar applied. Also, no significant difference was observed between the varieties at both locations (Table 9).

Moisture content

No significant difference was observed in moisture content among the levels of biochar applied and varieties used at both locations. There were no significant interactions observed between the factors at both locations (Table 10). Similar results were obtained for dry matter content (Table 11). Significant interaction ($p<0.05$) was observed between varieties and biochar (Table 12).

DISCUSSION

Application of biochar had a significant effect on growth (plant height, number of leaves, chlorophyll content, and stem diameter) of two varieties of kenaf cultivated in Sahel savannah showing the ability of biochar in improve growth and yield of kenaf. This could be attributed to the beneficial role of biochar in providing soil nitrogen, phosphorus, potassium and other essential nutrients which in turn improved the overall performance of kenaf in the region as earlier reported by Jeffery et al., (2011) showing that biochar application enhances soil structure by increasing aggregate stability and pore space and promotes better root penetration and water infiltration. Also, Lehmann et al., (2003) and Major et al., (2010) had earlier asserted that biochar application can improve soil fertility through mechanisms such as increased cation exchange capacity and nutrient retention, creating a more favorable environment for fibre crop growth. When applied, biochar increases both micro and macro nutrients as well as enhances the physical and chemical properties of the soil thereby leading to high vegetative crop growth. Dademel et al., (2004) reported similar finding on okra where nitrogen content in biochar enhanced leaf production, flowering, seed and root formation and metabolic activities. The application of biochar at 10 t/ha which led to higher kenaf fibre may partly be explained by the fact that leafy plants requires higher dose of essential nutrients, especially N, P and K for growth and development and the higher doses of biochar led to significant improvement of physical and chemical properties of the soil which enhanced crop development and high yields through enhancing partitioning of photosynthates. This was earlier reported by Steiner et al. (2007) that biochar increases fertilizer use efficiency, leading to increased plant biomass. Equally, Sarah et al., (2020) reported that biochar role in ameliorating soil pH, particularly in acidic soils common to many agricultural regions thereby creating a more favorable environment for nutrient uptake and microbial activity, further improving soil fertility which subsequently increase the yield of fibre in a ramie plant.

Application of biochar showed significant differences on varieties. Differences among the kenaf varieties in terms of their growth, yield and yield components may be attributed to what Akinfasoye et al., (1997) reported that such differences in yield parameters of crops are attributed to the cultivars and its genetic capabilities. This was earlier asserted by Adeniyan et al., (2014) that variation in characters due to genetic and environmental variations and soil factors may affecting growth and yield of crops (Mader et al.,2002). Williams (2004) observed differences in yield of kenaf varieties. Such varietal differences tend to influence nutrient uptake and utilization mechanisms, particularly for essential nutrients involved in chlorophyll synthesis, such as nitrogen, phosphorus and potassium (Ahmad, 2018). Biochar did not show significant differences on quality parameters except on ash content. The nutrient levels of kenaf fibres could be influenced from nutrient status of the soils. Such observations are not uncommon as previous experiments have shown positive correlations between soil nutrients and plant tissue nutrients content (Radwan and Awad, 2002; Agyarko et al., 2006; Ouda and Mahadeen, 2008).

CONCLUSION AND RECOMMENDATION

The results of this study showed that the application of biochar at 10 t/ha significantly provided better quality and yield of fibre with the black variety (yar baka) providing better yield and quality fibre. From the above results, application of 10 t/ha of biochar and black variety (yar baka) of kenaf can be recommended to farmers in the Sudan savannah zone of Nigeria for better yield and fibre quality of kenaf.

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