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EFFECT OF OIL PALM WASTE BIOCHARS ON FCV TOBACCO PRODUCTIVITY IN LIGHT TEXTURED ALFISOLS

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The sandy/ sandy loam Alfisols supporting FCV tobacco in Northern light soils (NLS) region of Andhra Pradesh have low native soil nutrient reserves and nutrient leaching problems require soil amendment like biochar that holds nutrients and meet the crop nutrient requirement. Oil palm plantations generate huge quantity of ligno-cellulosic biomass waste comprising oil palm empty fruit bunches (OEFB), oil palm fronds (OF) and oil palm trunks (OT) during oil extraction and cultivation that pose a major disposal problem. In general, these biomass generated from plantations are either unutilized or under-utilized. Conversion of this oilpalm biomass waste into a biochar, a carbon – rich product, is an effective waste management approach for carbon sequestering, soil health improvement and enhancing crop productivity and soil quality. A field experiment with flue cured tobacco (*Kanchan*) was conducted for two consecutive years during *rabi* 2018-20 at CTRI-RS Jeelugumilli in NLS region. Pooled analysis results indicated that all the three biochars applied along with the 100% RDF significantly increased the yield compared to 100 % RDF alone. The highest green leaf yield (GLY) and cured leaf yield (CLY) was recorded with 100 % RDF + OEFB Biochar 1 t ha^{-1} with 12,409 kg ha^{-1} and 2,227 kg ha^{-1} GLY and CLY, respectively over 100 % RDF alone with 11268 kg ha^{-1} GLY and 2019 kg ha^{-1}CLY. Application of OEFB Biochar has improved the potassium uptake and soil available potassium content. All the chemical quality parameters *viz.*, nicotine, reducing sugars and chlorides were within the acceptable limits. Hence, oilpalm waste can be effectively converted into biochar and can be used as a soil amendment for FCV tobacco growing light textured Alfisols for improving the nutrient use efficiency thereby productivity, nutrient uptake and soil available potassium.

INTRODUCTION

Agriculture over the past decades has been depending heavily on the chemical fertilizers that are not only very expensive but also have adverse effect on soil quality in prolonged use. In light textured soils with poor nutrient retention capacity, fertilizer nutrients are often subjected to losses through leaching process leading to low fertilizer use efficiency in crop production on these soils. Some of these environmental issues associated with intensive use of fertilizers have generated a great deal of interest in development and promotion of alternative soil management practices. Improving soil fertility and enhancing use efficiency of applied fertilizers are very critical for ensuring sustainability of soil health and crop productivity.

Tobacco *(Nicotiana tabaccum L.)* is an important high value commercial crop in India, grown in an area of 4.5 lakh ha with an annual production of 804 million kg cured leaf. Among different types cultivated in India, FCV tobacco occupies approximately 30 percent of tobacco production, which is mainly used for cigarette purpose. FCV tobacco is mainly cultivated in Andhra Pradesh and Karnataka in five distinct production ones. Among the different production zones, the best quality FCV tobacco is preferentially grown on light textured soils. FCV tobacco is produced in the Northern light soils (NLS) region of Andhra Pradesh under irrigated condition, on sandy/ sandy loam Alfisols having low native soil nutrient reserves and are subjected to nutrient leaching loses which require soil amendment like biochar that holds

Key words : Oil palm biochar, Productivity, OEFB Biochar

nutrients to meet the crop nutrient requirement by enhancing nutrient use efficiency. Biochar improve soil fertility and productivity by improving nutrient use efficiency is considered essential to sustainable soil management. Soil amendment like biochar helps to gradually release nutrients at rates that can closely match nutrient demand by plants, while potentially reducing nutrient losses to the environment through leaching, volatilization, and runoff. Biochar performs well in soil improvement as a fertilizer slow-release carrier and carbon sequestration agent (Gupta *et al.,* 2020). International Biochar Initiative (IBI), 2013 defines biochar as: A solid material obtained from thermo chemical conversion of biomass in an oxygen-limited environment. Carbonaceous material obtained from the pyrolysis of biomass under zero or limited supply of oxygen and at relatively low temperature, usually below 700^0C (Lehmann and Joseph , 2009). With a high cation exchange capacity (CEC) and adsorption capacity, biochar delays the release of fertilizer nutrients in the soil and improves the utilization rate of fertilizer nutrients (Gao *et al.*, 2016, Kharel *et al.*, 2019). Biochar also has a pore structure and high adsorption ability for water and fertilizer, which provide a good habitat for soil microorganisms and thereby promotes the propagation and activity of beneficial microorganisms (Palansooriya *et al.*, 2019). Biochar has been widely applied as a soil amendment to increase soil carbon retention, improve soil quality, and enhance nutrition utilization efficiency. Adding biochar may increase exchangeable potassium (K) levels in soil through both the addition of K which is in the ash fraction of the biochar and by reducing losses of K through leaching (Laird *et al.,* 2010). The effect of biochar on soil nutrient retention can also be indirect, through changes in soil chemical and physical properties such as pH and electric conductivity. It is well known that soil pH can strongly influence the availability of both anions and cations such as P, Ca, and K (Chan *et al.,* 2008).

Andhra Pradesh has been the leading palm oil producing state in India contributing approximately 85 per cent of country's production followed by Kerala (10 per cent), Karnataka (2 per cent). Other oil palm producing states include Orissa, Tamil Nadu, Goa and Gujarat (Rao, 2013). Production of biochar from various biomass resources and its application to low fertility soils are attracting significant attention globally due to its unique potential to improve soil nutrient retention capacity, water holding capacity and act as stable carbon sink to mitigate climate change and reduce greenhouse gas (GHG) emissions (Lehman and Joseph, 2015). The oil palm plantations produce a significant amount of biomass residues concomitant to the production of palm oil, with pruned trunks and fronds remaining in *situ* and oil palm empty fruit bunches (OEFB) as a by-product at the processing plant. The oil palm plantation of ten-year-old produces 59.62 ton of biomass/ ha under irrigated and 36.53 ton of biomass/ha under rain fed conditions in India. Oil Palm produces about 24 leaves/palm/ year which is equivalent to 10.50 t/ha /year on dry matter basis and replacement of old plantation for new planting generates huge amount of trunk biomass. In general, these biomass generated from plantations are either unutilized or under-utilized. Conversion of biomass waste into biochar, a carbon – rich product, is an effective waste management approach for carbon sequestering, soil health improvement and enhancing crop productivity and soil quality. In this context oilpalm biomass waste *viz.,* Oil palm fronds (OF), Oil palm trunk (OT) and Oil palm empty fruit bunches (OEFB) have been effectively utilized to produce biochar and tested their efficacy to improve the productivity of FCV tobacco.

MATERIALS AND METHODS

Oil palm biomass waste used as a novel feedstock for biochar production using Annual core biochar reactor of ICAR-CIAE, Bhopal. Oil palm fronds biochar (OF Biochar) oil palm trunk biochar (OT Biochar) and oil palm empty fruit bunches biochar (OEFB Biochar), wereprepared at different preparation variables i.e heating temperature (300- 500 ^{0}C) and holding time (60- 90 min). Oil Palm biochars also had relatively high proportion of total organic carbon and thereby indicating its suitability as soil amendment for improving the soil physical environment. (Poorna Bindu *et al.*, 2019). A field experiment with flue cured tobacco (*Kancha*n) was conducted for two consecutive years during *rabi* 2018-20 at CTRI-RS Jeelugumilli in NLS region (17 11' 30" N and 81 07' 50" E at 150 m above mean sea-level), West Godavari district in Andhra Pradesh under semi-arid tropical climate. The soil was sandy loam with pH 6.50

(1:2.0) and EC 0.20 dS/m (1:2.0). To evaluate the efficacy of different oil palm biomass waste biochars viz., OEFB Biochar, OF Biochar and OT Biochar prepared from different oil palm biomass wastes OEFB Biomass , OF Biomass, OT Biomass, respectively. The treatments included 3 oil palm biochars (1 t ha^{-1} OEFB Biochar), (1 t ha^{-1} OF Biochar) and (1 t ha^{-1} OT Biochar) along with 100% RDF, 3 oil palm biochars (1 t ha^{-1} OEFB Biochar), (1 t ha^{-1} OF Biochar) and (1 t ha^{-1} OT Biochar) along with 75% RDF. One 100 % RDF alone, and one un amended un fertilized control. The 8 treatments in all were tested in a RBD with 3 replications. Plant and soil samples were processed and analyzed for the nutrient status as per the standard procedures. X and L Position leaf lamina samples were tested for different quality parameters *viz.*, nicotine, reducing sugars and chloride content. Data were subjected to statistical analysis as per the standard methods.

RESULTS AND DISCUSSION

Effect of oil palm biochars on FCV tobacco productivity

Application of oil palm waste biochars significantly increased the tobacco green leaf yield (GLY) and cured leaf yield (CLY). All the three oil palm biochars applied along with the 100% RDF significantly increased the yield compared to 100 % RDF alone. The highest GLY and CLY was recorded with 100 % RDF + Oil palm empty fruit bunch biochar (OEFB Biochar) 1 t ha^{-1}) with 12,409 kg ha^{-1} and 2,227 kg ha^{-1} GLY and CLY, respectively over 100 % RDF alone with 11268 kg ha^{-1} GLY and 2019 kg ha^{-1}CLY.Treatments with 75 % RDF along with oil palm waste biochars were at a par with 100 % RDF alone (Table 1). Apart from the positive effects in both reducing emissions and increasing the sequestration of green house gases, the production of biochar and its application to the soil will deliver immediate benefits through improved soil fertility and increased crop production, improves the soil fertility and crop yield (Stavi and Lal, 2013). Xu *et al.*, 2015 reported that biochar significantly improved peanut biomass and pod yield up to 2- and 3-folds respectively in red ferrosol and redoxi-hydrosol. Biochar application also improved the availability of soil nutrients, which is critical in improving peanut performance, especially on infertile redoxi-hydrosol. Akhtar *et al.*, 2014 reported that addition of biochar increased the soil moisture contents in deficit irrigation (DI) and plant root deficit (PRD), which consequently improved physiology, yield, and quality of tomato as compared with the non-

Table 1: Effect of oil palm biochars on yield (kg ha^{-1}) of FCV tobacco grown in light textured soils

Treatments	Green leaf yield	Cured leaf yield
T_1 - 100% RDF	11,268	2,019
T_2 - 100% RDF + 1t ha^{-1} OEFB Biochar	12,409	2,227
T_3 - 100% RDF + 1t ha^{-1} OF Biochar	11,749	2,116
T_4 - 100% RDF + 1t ha^{-1} OT Biochar	12,357	2,220
T_5 - 75% RDF + 1t ha^{-1} OEFB Biochar	11,077	1,987
T_6 - 75% RDF + 1t ha^{-1} OF Biochar	10,304	1,835
T_7 - 75% RDF + 1t ha^{-1} OT Biochar	11,245	2,019
T_8 - Un amended and unfertilized cropped control	5,348	976
SEm±	**211**	**34**
CD	**613**	**101**
Seasons		
Year 1	8167	1634
Year 2	13272	2216
SEm±	**106**	**17**
CD	**307**	**51**

biochar control. A possible mechanism for yield improvement may be due to increase of soil water holding capacity (Jeffery *et al.*, 2011). Application of biochar along with recommended dose of fertilizers will help in increasing in crop yield. Results are in aggrement with dual application of biochar and KCl fertilizer application, which increased maize production by 29 % (Widowawiti and Asanah, 2013). Uzoma *et al.* 2011, reported that maize yields were significantly improved in sandy acid soils by application of 20 t ha^{-1} cow manure biochar in green house experiment.

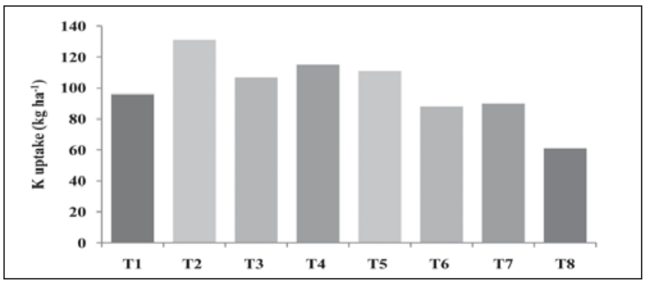

Fig. 1: Effect of oil palm biochars on potassium uptake (kg ha^{-1})

T_1 - 100% RDF; T_2 - 100% RDF + 1t ha^{-1} OEFB Biochar; T_3 - 100% RDF + 1t ha^{-1} OF Biochar; T_4 - 100% RDF + 1t ha^{-1} OT Biochar; T_5 - 75% RDF + 1t ha^{-1} OEFB Biochar; T_6 - 75% RDF + 1t ha^{-1} OF Biochar; T_7 - 75% RDF + 1t ha^{-1} OT Biochar T_8 - Un amended and unfertilized cropped control

Effect of oil palm biochars on Potassium uptake and leaf quality

Result showed that the uptake of potassium by FCV tobacco was significantly influenced with the application of different types of oil palm biochars. Application of oil palm biochars along with recommended dose of fertilizers has increased the potassium uptake over 100% RDF. Among the oil palm biochars OEFB biochars 1 t ha^{-1} along with 100 % RDF has recorded maximum potassium uptake with 131 kg ha^{-1} when compared to 100 % RDF with 96 kg ha^{-1}(Fig.1). The highest K uptake of 100 % RDF along with OEFB biochar applied plots could be due to the increase in K content in tobacco plant was related to the high concentration of total K in the OEFB biochars. Poorna Bindu *et al.*, 2019 reported that among the oil palm biomass wastes biochars, OEFB biomass and biochar recorded maximum 2.88 and 6.07 % potassium content, respectively. Julie, (2009) reported that biochar reduces leaching of critical nutrients, creates a higher crop uptake of nutrients, and provides greater soil availability of nutrients. Impact of oil palm waste biochars on quality of FCV tobacco was studied in terms of nicotine, reducing sugars and chloride content. All the quality parameters were within the acceptable limits (Table 2) (Gopalachari, 1984).

Table 2: Effect of oil palm biochars on quality parameters of FCV tobacco grown in light textured soils

Treatments	Nicotine(%)		Reducing Sugars(%)		Chlorides(%)	
	X	L	X	L	X	L
T_1 - 100% RDF	2.42	2.75	12.71	15.22	0.46	0.40
T_2 - 100% RDF + 1t ha^{-1} OEFB Biochar	2.33	2.19	16.69	16.67	0.56	0.49
T_3 - 100% RDF + 1t ha^{-1} OF Biochar	2.52	2.11	16.96	16.50	0.58	0.51
T_4 - 100% RDF + 1t ha^{-1} OT Biochar	2.71	2.91	13.27	16.12	0.79	0.59
T_5 - 75% RDF + 1t ha^{-1} OEFB Biochar	1.79	2.53	17.26	18.34	0.61	0.48
T_6 - 75% RDF + 1t ha^{-1} OF Biochar	2.25	2.79	18.36	18.93	0.55	0.47
T_7 - 75% RDF + 1t ha^{-1} OT Biochar	1.92	3.18	18.07	18.23	0.80	0.65
T_8 - Un amended and unfertilized cropped control	2.11	2.10	17.17	16.97	0.90	0.65
CD (p=0.05)	NS	NS	0.11	0.03	NS	NS
SEM ±	0.29	0.29	0.04	0.08	1.05	0.87

Table 3: Effect of oil palm biochars on Soil properties

Treatments	Soil pH (1:2.5)	Available K kg ha^{-1}
T_1 - 100% RDF	5.38	130.50
T_2 - 100% RDF + 1t ha^{-1} Oil Palm Empty Fruit Bunch Biochar (OEFB Biochar)	5.89	176.67
T_3 - 100% RDF + 1t ha^{-1} Oil Palm Fronds Biochar (OF Biochar)	5.52	130.00
T_4 - 100% RDF + 1t ha^{-1} Oil Palm Trunk Biochar (OT Biochar)	5.92	136.00
T_5 - 75% RDF + 1t ha^{-1} OEFB Biochar	5.28	161.00
T_6 - 75% RDF + 1t ha^{-1} OF Biochar	5.64	151.00
T_7 - 75% RDF + 1t ha^{-1} OT Biochar	6.00	151.00
T_8 - Un amended and unfertilized cropped control	5.90	141.33
CD (p=0.05)	0.11	8.00

Effect of oil palm biochars on soil properties

Application of oil palm waste biochars increased soil pH probably due to the alkaline nature of biochar (Table 3). Poorna Bindu *et al.*, 2019 reported that oil palm waste biochars were slightly alkaline (pH 8.0), and can reduce the soil acidity. A similar trend was observed with 20 and 40 t ha^{-1} of Empty Fruit Bunch Biochar (EFBB), which may partly be due to the saturation effect of the high pH of EFBB added. Therefore, soil pH fluctuations showed a similar trend irrespective of the biochar addition rate. Hence, biochar has the potential to substitute lime materials as to increase the pH of acidic soil (Bakar et al., 2015). Oil pam waste biocahar application has significantly improved the soil available nutrient such as potassium (Table 3) which might be due to reduction in leaching losses. Biochar amendments had signicantly improved soil nutrient content (Liard *et al.*, 2010) is partly due to direct addition of nutrients such as P and K (Enders *et al.* 2012) and partly because reduction in runoff and leaching. (Liard *et al.*, 2010). Yu xue Liu, 2015, reported that available P and K contents were significantly greater in soils amended with biochar especially in rice biochar than in control soils.

Oilpalm waste can be effectively converted into biochar and can be used as a soil amendment for FCV tobacco growing light textured Alfisols for improving the nutrient use efficiency thereby productivity, nutrient uptake and soil available potassium.

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