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Biochar effect on nematodes and insects population density, soil improvement and yield of okra

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Okra (*Abelmoschus esculentus* L. Moench) is an economically valuable crop in Ghana for its culinary significance and income generation potential. Agricultural production worldwide is constrained by abiotic and biotic factors. Chemical fertilizers are usually used to solve soil infertility problems. However, chemical fertilizers are expensive and when applied continuously, degrade agricultural lands (Savci, 2012; Bhattacharyya *et al*., 2015). Biotic factors such as plant parasitic nematodes (PPN) and foliar insects have been implicated as major constraints to okra production (Asare-Bediako *et al*., 2014b). The attack of root-knot nematodes (*Meloidogyne* spp.) has been reported as the most serious, widespread and alarming which causes tremendous yield losses (Hussain *et al*., 2011; Kayani *et al*., 2013; Barros *et al*., 2014). Flea beetle (*Podagrica* spp.) is the most important insect pest of okra in Ghana and Nigeria (Obeng-Ofori & Sackey, 2003; Asare-Bediako *et al*., 2014a, Mobolade *et al*., 2014). It has been estimated that insect pests attack led to great reduction in okra yield (Echezona & Offordile, 2011). Management interventions such as crop rotation, antagonistic plants, bio-control agents, host resistance, soil amendments and chemicals usage have routinely been employed to minimize plant parasitic nematodes and insects' infestation (Mukhtar *et al*., 2013). Chemical usage has been identified as the most efficient management strategy (Mall *et al*., 2018). However, the deleterious effects of chemical strategy on man and the environment discount any benefits the strategy might import. Okra does not do well on infertile soil and is highly susceptible to root-knot nematodes infection (Hussain *et al*., 2014). The use of carbonized materials such as biochar in food production could contribute to the sustainability of crop husbandry. According to Sokchea *et al*., (2013), incorporating rice husk biochar in a loam soil increased yields of rice grain by 30%.

Field trials were conducted at Kpando Torkor irrigation site and Kpeve Agric Station in the Volta region of Ghana. The locations are characterized by two rainy seasons (April to early July and September to November). The average annual rainfall ranges from 900 mm to 1,300 mm with considerable variations with the time of onset, duration and intensity over the years. The double maxima rainfall pattern experienced place the locations at comparative advantage in food production and food security bracket. The soils are mainly, savannah ochrosols and groundwater lateritic. The choice of locations was based on the extensive cropping of okra as informed by the peasant farmers.

The biochar used for the studies was obtained from two different feed stocks; rice husk and corn cob, respectively. These feed stocks were carbonized at a temperature of 650-700°C as measured with a thermocouple in a process known as Pyrolysis. Pyrolysis time was two

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days using a simplified reactor. The treatment, Corn cob at 4t/ha consistently had reduced nematodes population densities at both locations. Untreated plots had higher nematode populations during the period of experimentation (Table 1).

Six treatments: Rice husk biochar @ 4tons/ha, rice husk biochar @ 2 tons/ha, corn cob biochar @ 4tons/ha, corn cob biochar @ 2tons/ha, recommended fertilizer (150 kg NPK/ha) and control (no treatment) were tested on a local okra var. (Project Manager). The treatments were laid out in a randomized complete block design and replicated 4 times at each location. Biochar was applied in-situ at both locations. The recommended fertilizer was however applied barely two weeks after germination.

Soil samples were collected with a 5-cm diameter auger for nematode assay and physico-chemical analysis. In addition, insect population and severity of insect damage were assessed. Both rice husk and corn cob biochar were antagonistic to root-knot nematodes. Application of the biochar material resulted in significant population reductions and root galling indices which reflected in significant yield increases compared with the control treatment. Biochar addition to soil has been generally associated with crop yield increases as a result of increased nutrient availability, soil water retention properties and saturated hydraulic conductivity (Pramod Jha *et al*., 2010; Domene *et al*., 2014). Similarly, Munyua *et al*., (2015) observed reductions in the root galling caused by nematodes and increased yield of beans where biochar amendments were applied. In previous studies, again, Matsubara *et al*., (2002), demonstrated the suppressive effect of charcoal amendments on the soil borne pathogen *Fusarium* sp. Further studies have shown that biochar have positive effects on the abundance of mycorrhizal fungi (Warnock *et al*., 2007). However, this study amply demonstrated the lack of suppressive effect of biochar on *Podagrica* species.

In conclusion, biochar has the potential to decrease nematode population densities, manage soil borne insect pests, improve soil fertility and increase yield of crops. Its effect on flying insect pests is negligible.

Table 1. Nematodes population/200cm^3 soil at Kpando and Kpeve.

Treatments	**Kpando**		**Kpeve**	
	***Meloidogyne* spp.**	***P. penetrans***	***Meloidogyne* spp.**	***P. penetrans***
Rice husk 4t/ha	352	98	151	91
Rice husk 2t/ha	345	155	144	99
Corn cob 4t/ha	201	79	108	57
Corn cob 2t/ha	379	221	157	91
NPK 15:15:15	263	173	173	73
Control	496	305	274	126
Mean	339	172	168	90
LSD	166	133	98	71

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