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RESEARCH ARTICLE

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Influence of Biochar Application and AMF Inoculation on Root Colonization and Selected Soil Chemical Properties

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ABSTRACT

Screen house experiment was carried out in 2013-2014 at Federal University of Agriculture, Abeokuta. to investigate the effects of biochar application and arbuscularmycorrhizal (AM) inoculation to tomato genotype on 1) AM root colonizationand 2) selected soil chemical properties The experiment was laid out in a 2 × 5 × 2 factorial, fitted into a completely randomized design with three replications. The studies factors included tomato genotypes (Ex-Lafia and Ex-Lokoja), biochar application (0, 5, 10, 15 and 20 t ha-1) and AMF (with and without AMF).Data were subjected to analysis of variance and significant means separated using Duncan's Multiple Range Test (P<0.05). Mycorrhizal inoculation influenced AM root colonization, and the addition of mycorrhizal had higher values (51.33%) when compared with non mycorrhizal pots (10.17%). Mycorrhizal inoculation had little or no influence on soil pH, organic carbon and available P. Biochar application generally increased AM root colonization, soil pH and available P when compared with control. The 20 t ha-1 of biochar application had improved soil properties as compared to other biochar rates. It is concluded that AMF inoculation in biochar amended soil is important. It is therefore, recommended that field studies should be done to upscale the current screen house conclusion to the field condition, and quantitatively confirm the optimum application rate for enhanced AM root colonization and soil chemical characteristics.

Keywords: AMF, Tomato genotypes, Soil pH, Organic carbon, Available P

INTRODUCTION

Biochar is carbon rich by-product of pyrolysis of the biomass like wood, manure, stalk, cob, leaves etc. and is regarded as a chemically- and biologically-stable C pool [1]. Biochar can have an influential role in many soil properties by changing soil pH and hence has the potential to influence soil physical, chemical and biological processes [2]. Dume reported that addition of biochar improved, pH, organic carbon (OC) and available phosphorous of the soil. Soil with higher pH increases nutrient availability and decreases the quantity of Al^{+3} and H^{+} ions residing in cation exchange sites, which can efficiently increases base saturation [3]. Recent studies indicate that biochar amendments to soils can increase AM colonization in roots of plants [4-6].

Despite the potential usefulness of biochar for soil management applications, our knowledge of how biocharinfluence on soil chemical and biological processes is limited compared to other soil amendments [7]. On the other hand, AMF are thought to be one of the most important soil micro-organisms in the context of modern organic agricultural practices [8] and land bioremediation. AMF are regarded as bio-fertilizers since they increase mineral influx. Nutrient availability can have major effect on AM colonization. Invariably, the association may be affected by many environmental factors such as soil amendments such as biochar, inorganic fertilizers, organic manure and pH adjustments, which may in turn affect the outcome of the symbiosis by modifying soil properties and fungal responses. Therefore, this experiment aims to study the effect of biochar application and arbuscularmycorrhizal inoculation on AM root colonization and selected soil properties in pot experiment [8-11].

MATERIALS AND METHODS

Experimental site, biochar and inoculation

The screen house experiment was conducted at Federal University of Agriculture, Abeokuta, Ogun State, Nigeria, in 2013-2014. The area is located in the south western Nigeria in the transitional zone. The area lies between Latitude 7°12' N and Longitude 3°20'E. The rainfall ranges between 1100 mm and 1300 mm annually while the daily temperature ranges between 24°C and 30ºC.

Maize-cob was used to produce biochar by gasification method after which the product was ground and sieved with 2 mm laboratory mesh diameter. Biochar was incorporated into 10 kg sterilized top soil 2 weeks before transplanting at the rate of 0, 5, 10, 15, 20 t h^{-1}. The AMF inoculants (Glomusmosseae) obtained from IITA, Ibadan was inoculated or not inoculated to the soil during the nursery planting at the rate of 80 g of inoculants per 5 kg of sterilized top soil to two tomato genotypes (Ex-Lafia obtained from Lafia and Ex-Lokoja obtained from Lokoja) in the screen house. The nursery was maintained for 4 weeks after which the tomato seedlings were transplanted. The experiment was conducted in the screen house for three months and laid out in a 2 × 5 × 2 factorial arrangement fitted in completely randomized design and replicated three.

Soil and root sampling

Soil samples for analyses were taken before planting and after harvest. The rhizosphere soils along with tomato roots from each bucket were dug out at a depth of about 0-20 cm for AMF root colonization studies. Another set of soil samples from each bucket were collected at a depth of about 0-20 cm to evaluate for soil pH, organic carbon and available P. The root samples were stored in 50% ethanol until processing.

Determination of AM root colonization

One cm root length ((having approximately 20 root hairs) was chosen randomly from each tomato plant in each of the bucket for AMF colonization studies. The root samples were washed with 50% ethanol thoroughly and then placed in 10% KOH and heated in water bath for 15 min and rinsed. The root samples were then stained with a mixture of 1:1:1 of glycerol, lactic acid and distilled water and 0.05% methyl blue solution and heated for 5 minutes and then rinsed again. 50% Glycerol was added to preserve the root samples and mounted on compound microscope slides for visualizing the fungal structure. Determination offungal colonization was done on the basis of the presence or absence of arbuscules, hyphae or vesicles and the percentage was quantified as follows:-

MATERIALS AND TREATMENTS

Seed of maize (Kissan-92 cv.) and FYM were obtained from The Agricultural Research Farm of The University of Agriculture, Peshawar Pakistan. The experiential treatments were 5, 10 and 15 tons FYM ha^{-1} incorporated alone and/or combined with 50 or 100 kg N ha^{-1}. A control plot without any fertilizer or manure was also included in each replication. A total of 10 treatments were trailed in Randomized Complete Block design having 3 replications. The plot area was 3 × 5 m having 4 rows 75 cm apart with 5 m length. The FYM was well decomposed and incorporated in the soil 40 days before sowing. Urea (46% N) was applied in a split application, half at sowing and the other half just after first irrigation. Phosphorus and potash were applied to the field at the rate 60 kg ha^{-1} each as single super phosphate (18% P_2O_5) and sulphate of potash (60% K), respectively as a basal dose. All agronomic and cultural practices including irrigation, weeding and hoeing, etc. were carried out uniformly for all the treatments in each replication [12-18].

$$Root\ colonization\ (\%) = \frac{\text{Number of roots colonised}}{\text{Total number of roots examined}} \times 100$$

Physicochemical analysis of the soils

Soil samples were analyzed for some physicochemical properties such as soil pH in 1:1 soil-water suspension [10], organic carbon by the Walkley-Black oxidation method [19], total nitrogen (N) by micro-Kjeldahl distillation method [18], available P by Bray 1 method, exchangeable K and Na by the flame photometer method, Ca and Mg by EDTA titration method,. Particle size analysis was done using Bouyoucos [12] hydrometer method. All the analyses were carried out at Soil Science and Land Management Laboratory, FUNAAB [20-23].

Data analysis

Data obtained from this study were subjected to separate ANOVA using PROC GLM in SAS (SAS Institute, 2001) to compute mean squares of each of the experimental treatments. Means were separated using Duncan's Multiple Range Test DMRT at 5% level of significance [24-26].

RESULTS AND DISCUSSION

Soil and biochar characteristics

The chemical properties of the soil showed that pH was neutral with loamy sand soil texture. The OC content was moderate, % N and available P were medium. The soil was also observed to have moderate, very low and high contents of exchangeable magnesium (Mg^{2+}), calcium (Ca^{2+}) and sodium (Na^{+}), respectively. However, exchangeable potassium (K^{+}) was found to be moderate (Table 1). Biochar was found to have high total P, very high OC, N, with very strongly alkaline pH. Biochar was also observed to have very low and very high exchangeable Mg^{2+} and K^{+}, respectively (Tables 1 and 2).

Table 1: Physicochemical properties of the soils and chemical characteristics of biochar used for this study (OC=Organic Carbon, N=Nitrogen, P=Phosphorus, Na=Sodium, K=Potassium Mg=Magnesium, Ca=Calcium, Fe=Iron).

Properties	Soil	Properties	Biochar
(1:1)	7.2	(1:1)	10.12
Sand g kg^{-1}	83.8	-	-
Clay g kg^{-1}	11.4	-	-
Silt g kg^{-1}	4.8	-	-
Textural class	Loamy sand	-	-
O C %	1.04	OC %	14.4
N %	0.22	N %	1.94
Available P (mg kg^{-1})	9.96	Total P ($mgkg^{-1}$)	31
Exchangeable Bases (cmol kg^{-1})	-	-	-
K	0.58	K %	2.29
Ca	1	-	-
Mg	2.2	Mg %	0.022
Na	0.74	-	-
-	-	Fe %	0.13

Table 2: Effects of genotype, biochar and AMF inoculation on AM root colonization, soil pH, organic carbon, and available P content in the screenhouse (Means within the same column with the same letters are not significantly different according to Duncan's New Multiple Range Test at ($P<0.05$). ns-not significant at $P<0.05$. (-) uninoculated, (+) inoculated, OC=Organic Carbon, P=Phosphorous) [27-29].

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CONCLUSION AND RECOMMENDATION

AMF increased AM root colonization, whereas biochar improved soil pH and available P. However, the shift in soil pH was not high enough to be havoc on soil properties. Hence, AMF inoculation in biochar amended soil is important. It is therefore, recommended that field experiment should be done to confirmed the optimum application rate for enhanced AM root colonization and soil chemical characteristics.

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