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Impact of Biochar and Biofertilizer on Guar Plant (*Cyamopsis tetragonoloba L. Taub*) Growth and Sandy Soil Fertility

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ABSTRACT

Two pot experiments were performed during the two continuous summer seasons of (2013&2014) at the wire proof greenhouse associated in Sakha Agricultural Research Station, Sakha, KafrEl-Sheikh governorate, Egypt. The experiment targeted to evaluate the effects with adding different rates of biochar(w/w) (C_0=without biochar, C_1=0.2%biochar and C_2=0.4%biochar) with nitrogen fertilizer rates (N_0=without nitrogen, N_1=30 kgN.fed^{-1}, N_2=45 kgN.fed^{-1} and N_3=60 kgN.fed^{-1}) on guar plant (*Cyamopsis tetragonoloba L.Taub*) inoculated with Rhizobium isolate AZ_2. Different attributes such as N-uptake, yield, yield components of guar and the residual impact on some biochemical properties associated with sandy soil were examined. The experiments were carried out in a complete randomized block design with three replicates. Results indicated that nitrogen, phosphorus and potassium contents of guar plants after sixty days from transplant significantly increased by typically the addition of 0.4%biochar+30 kgN.fed^{-1} (T_{11}) in sandy soil compared to the control (without biochar+without nitrogen fertilization+without inoculation=T_1). The identical trend was observed using N,P and k% in guar plant seeds at harvesting stage. Furthermore, amount of nodules, nodules dry weight, dry weight of plant after 60 days and seeds dry weight increased with (T_{11}) compared with control (T_1). In respect to high quality parameters of guar for instance protein% in seeds and leg-hemoglobin, T_{11} seemed to be the best treatment. Available nitrogen and phosphorus content of soil increased substantially with T_{13} (0.4%biochar+60 kgN.fed^{-1}) compared with control, while available potassium increased along with T_{11}. Also, catalase activity as a parameter regarding microbial activities gave typically the highest values with T_{11}.

Keywords: biochar, biofertilizer, guar plant, sandy soil, nitrogen fertilizer.

INTRODUCTION

Guar has been grown successfully in a wide range of soils. The most excellent performance is noticed on the fertile medium to light sandy loam soil with pH values ranging from 7.5 to 8.0. Guar can be used as a green manure crop in newly cultivated areas in Egypt (Ghanem, 1990).

Soil fertility increased very regularly with the application of mulches, composts, and manures. On the other hand, under tropical conditions organic matter is often mineralized extremely rapidly (Tiessen *et al*., 1994) and later a smaller portion of the used organic compounds will end up being stabilized inside the soil throughout the long term, nevertheless successively released to atmosphere as CO_2 (Fearnside, 2000). An alternative solution is the employ of more stable substances such as carbonized components or their extracts. Several investigations (Glaser 1999; Glaser *et al*., 2000, 2001) showed that carbonized components from the incomplete burning of organic material (i. e. black C, pyrogenic C, charcoal) are accountable for maintaining high amounts of Soil organic matter and available nutrients within soil ecosystem.

Biochar is the residue of pyrolysis under wide range of heating temperatures which ranging from 400 and 500°C (giving the process the name “low-temperature pyrolysis”), so we need to know more about this by-product and whether it would be valuable when be added to soil. Two aspects of biochar make it valuable for this purpose: (1) its high stability against decay and (2) its superior ability to retain nutrients compared to other forms of soil organic matter. Three environmental benefits arise from these properties: (1) mitigation of climate change, (2) enhancement of soils characteristics, and (3) reduction of environmental pollution. (Pessenda *et al*. 2001, Bridgwater 2003, Czernik and Bridgwater, 2004).

The mineralization of biochar in soil occurred much more slowly than other sources of soil organic matter. This confirms that biochar is very stable in soil and can resist microbial degradation by its inherent chemical stability (Bruun and El- Zehery, 2012).

As a result of long residence time within soil and the beneficial effects on soil qualities, addition of black carbon or biochar, since this is called in this particular connection, have been suggested as a way to enhance soil quality and sequester carbon from the environment (Lehmann *et al*.,2006). Higher nutrient retention in addition to nutrient availability were identified after biochar additions to soil, related to increased exchange capacity, surface area and direct nutrient enhancements several aspects of the charcoal management remain uncertain, such as the role of microorganisms in oxidizing charcoal surfaces and liberating nutrients and the possibilities to further improve charcoal properties throughout production under field conditions. Several

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research needs have been identified, such as field testing of charcoal creation in tropical agroecosystems, the particular investigation of surface qualities of the carbonized components in the soil environment, and the evaluation regarding the agronomic and economical effectiveness of soil managing with biochar (Glaser *et. al*., 2002).

Although a positive effect of biochar amendments on crop yields was already known in ancient cultures (Glaser, 2007), yet little is known about the effects of biochar addition on soil microorganisms and consequently on the soil carbon balance. Biochar is used with increasing frequency as a soil amendment because of its potentially beneficial effects on soil carbon sequestration, crop yield, nutrient leaching and greenhouse gas emissions (Koide *et al*., 2011).

Consequently, adding biochar combining fertilizer and carbon storage performance in soils would stimulate the microbial community ultimately causing nutrient release and fertilization and would add to the decadal soil C pool (Steinbeiss *et al.*, 2009). It is often observed throughout several studies that biochar addition to soils enhanced soil fertility and therefore increased crop yields upon agricultural lands (Marris, 2006; Chan *et al.*, 2007). This specific fertilizer effect could become the result of stimulation of soil microbes that resulted in the increased recycling of nutrients trapped in biomass residues. The fertilizer function is definitely likewise supported by a good increased in water retention in addition to cation exchange capacity in the soils caused by typically the huge area of biochar. Inoculation might enhance crop yield by improving the capacity of crops to obtain nutrients of which are relatively immobile within the soil for instance phosphorus (Rhodes, 1980; Jansa *et al*., 2003). Biochar can easily act as a soil conditioner enhancing plant progress by supplying and, most importantly, retaining nutrients and simply by providing other services like as improving soil physical and biological properties (Lehmann and Rondon, 2005).

The aim of this study is to investigate the effect of biochar associated with different doses of nitrogen fertilizer with inoculation of Rhizobium isolate AZ2 with guar plant on chemical and biochemical properties of soil and on guar yield components.

MATERIALS AND METHODS

Two pot experiments were conducted using guar plant (*Cyamopsis tetragonoloba L. Taub*) on 15 May, 2013 and 2014 summer growing seasons at a wire proof greenhouse of Sakha Agricultural Research Station, Sakha, Kafr El-Sheikh governorate, Egypt to study the effect of different nitrogen fertilizer doses, inoculation with a selected Rhizobium isolate AZ2 and biochar on nutrients uptake, yield, yield components of guar and the residual effect on some biochemical properties of sandy soil. The experiment aimed to evaluate effect of interaction of different concentrations addition of biochar (C0= without biochar, C1= 0.2% biochar and C2= 0.4% of biochar) with different nitrogen fertilizer levels (N0=without nitrogen fertilizer, N1=which equals 30 kg N/fed, N2= which equals 45 kg N/fed and N3= which equals 60 kg N/fed) on guar plant inoculated with Rhizobium isolate AZ2. The experiments were conducted in a complete randomized block design with three replicates.

Pots of 30 cm diameter and 35 cm height filled with 5 kg of sandy soil were fertilized with the recommended dose of potassium and phosphorus that was added to all pots at rate of 150 kg super phosphate/fed as calcium super phosphate (6.76% P), 50 kg potassium sulphate (41% K) and four rates of nitrogen fertilizer 0, 30, 45 and 60 kg/fed as urea (46%N). The amount of biochar was added as a percentage of soil weight per pot. Some characteristics of the biochar used in the experiment during two seasons were C content 600 ($g.kg^{-1}$) and N content 15.3 ($g.kg^{-1}$).

Data in Table (1) show some physical, chemical and microbiological properties of sandy soil before planting. Soil samples were sieved, then particle size distribution was carried out using international pipette method according to Klute (1986). Soil reaction pH in (1:2.5) soil-water suspension was determined and also electrical conductivity (EC), $dS.m^{-1}$, at 25 C° in soil paste extract (Hesse, 1971). Soluble ions were determined. Available N was determined using Kjeldahl method, Jackson (1967). Available phosphorus was determined calorimetrically, available potassium was estimated by using flame photometer, organic matter percentage was determined by modified Walkly and Black method according to (Jackson, 1967). Total calcium carbonate was determined using volumetric calcimeter method and cation exchange capacity according to Page (1982). Soil microbiology measurements were determined by counting total count of bacteria, actinomycetes and fungi according to Allen (1959).

Seeds of guar were surface sterilized as mentioned by (Vincent, 1970) and inoculated with the isolate of (AZ2) as combined Rhizobium isolate. At harvest, each pot contained 3 plants which were cut at about 3 cm above the soil surface and separated into shoots and seeds whereas root samples were taken using sieves and water stream to separate soil away from root before being dried. Seeds were separated from bods. Straw yield was recorded. Biological yield (dry weight of straw and seed yield), was recorded, and some chemical analyses of plant were determined. Protein yield was calculated in seeds by multiplying N% by 6.25.

Log viable counts, catalase activity, the leghaemoglobin content of fresh, bold and pink nodules were determined, as outlined by Johnson and Temple (1964) and readjusted by El-Essawi (1973) for the determination of catalase activity in sandy soil. Data obtained from experimental treatments were subjected to the analysis of variance and treatment means were compared using the L.S.D. method according to Steel and Torrie (1980).

Table 1. Some physical, chemical and microbiological properties of the experimental soils.

OM %	Soluble anions, meq/L				Soluble cations, meq/L				Available macro-nutrients (mg.kg^{-1})			pH 1:2.5 soil suspension	EC, ($dS.m^{-1}$) In soil paste extract
	SO_4^{-2}	Cl^-	HCO_3^-	CO_3^{-2}	Na^+	K^+	Mg^{2+}	Ca^{2+}	P_2O_5	N	K		
0.3	13.2	13.3	3.5	0.0	19.0	0.3	6.2	4.5	6.2	13.1	280	7.4	2.8

Texture grade	Particle size distribution				CEC (cmolc kg^{-1})	Total $CaCO_3$ (%)	Total count of bacteria, as cfu/g dried soil	Total Fungi count/g dried soil	Total Actinomycetes count/g dried soil
	Clay %	Silt%	C.sand %	F.sand %					
Sandy	1.7	6.4	37.1	54.8	7	0.5	45 x 10^4	36 x 10^3	49 x 10^3

RESULTS AND DISCUSSION

Results given in Table (2) show nodule dry weights significantly responded to nitrogen fertilizer levels and biochar addition. The highest value was 299.33 and 300.33 mg/plant obtained with T11 (0.4% biochar+30 kg N/fed) in the 1st and 2nd season, respectively. The dry weight of nodules and dry weight of plants above ground after 60 days of guar planting gave the same trend with T11 in both seasons. These results were significantly responded to nitrogen fertilizer levels and inoculation with (Rhizobium inoculation) in both seasons compared with uninoculated treatment (T1) biochar had a superior effect in increasing dry weight of plant in T11 treatment, it gave 18.23 and 18.27 g/plant in both seasons. These results are in accordance with Glaser *et al.* (2002), Lehmann *et al.* (2006) who showed that crop yields can be enhanced even more compared to control soils if charcoal amendments are applied together with inorganic or organic fertilizers.

Results in Table (3) show that N-content in guar plant (shoot) significantly responded to nitrogen fertilizer levels and biochar addition in both seasons. The highest value was 2.54% as a result of adding 30 kg N/fed +0.4% biochar (T11) in both seasons. The increasing percentages of N-content in shoot due to applying T11 treatment were 44.49 and 42.13 compared to control without inoculation and with inoculation respectively. Also, the same trend was exhibited with phosphorus and potassium contents. Results in Table (3) indicate that the positive effect of microbial inoculation on N, P and K percentage in guar plant was probably due to the beneficial association between biochar and applied fertilizers under inoculation conditions, which improve the nutrients content. These results are in harmony with the findings of Kimetu *et.al.* (2008) who reported positive yield effects from biochar addition.

Table 2. Effect of nitrogen fertilizer, inoculation and biochar additions on number of nodules, nodules dry weight, dry weight and leghemoglobin of guar shoot plants after 60 days of planting

Treatments	Number of nodules.plant^{-1}		Nodules dry weight, mg.plant^{-1}		Dry weight of plant, g.plant^{-1}		Leghemoglobin, mg.g nodules f.w.$^{-1}$	
	Seasone1	Season2	Seasone1	Season2	Seasone1	Season2	Seasone1	Season2
T_1= C_0N_0	6.00 f	4.33 f	42.00 j	42.67 i	5.93 k	5.81 i	21.48 f	19.27 g
T_2= C_0N_0	11.00 e f	11.67 f	53.67 i	59.67 h	8.67 j	8.33 h	23.18 f	21.25 g
T_3= C_0N_1	14.33 e	15.33 e	76.00 h	79.33 g	11.30 i	11.33 g	26.83 e	26.08 f
T_4= C_0N_2	21.33 d	24.33 e	92.67 g	78.67 g	12.63 h	13.70 ef	29.92 cd	29.08 cdef
T_5= C_0N_3	31.00 abc	31.67 d	108.33 f	114.33 f	13.90 f g	13.77 ef	28.83 cde	28.67 def
T_6= C_1N_0	25.33 c d	30.67 b c	122.67 e	123.33 f	12.90 g h	12.87 f	29.75 cd	30.42 cd
T_7= C_1N_1	32.67 a b	37.67 b c	154.67 d	154.33 e	16.13 c d	16.33 b	31.67 bc	32.00 bc
T_8= C_1N_2	33.33 a b	31.67 a	234.67 b	231.67 c	17.70 a b	16.87 b	37.13 b	34.26 b
T_9= C_1N_3	32.67 a	29.00 c d	235.33 b	236.67 c	14.77 e f	15.17 cd	29.99 cd	29.18 cde
T_{10}= C_2N_0	37.67 a	35.33 a b	207.00 c	210.33 d	15.17 d e	14.83 de	28.53 de	26.92 ef
T_{11}= C_2N_1	30.33 b c	30.33 b c	299.33 a	300.33 a	18.23 a	18.27 a	39.75 a	40.58 a
T_{12}= C_2N_2	37.00 a b	35.67a b	245.00 b	246.67 b	16.97 b c	16.60 b	34.15 b	33.50 b
T_{13}= C_2N_3	34.33 a b	37.33 a	216.00 c	218.33 d	16.17 c d	16.17 bc	29.67 cde	29.19 cde
F. Test	**	**	**	**	**	**	**	**
LSD at 0.05	6.8	5.34	10.69	9.85	1.15	1.16	2.89	3.02

C0= without biochar, C1= 0.2% biochar and C2= 0.4% biochar
N_0=without nitrogen fertilizer, N_1=30 kg N .fed^{-1}, N_2=45 kg N .fed^{-1} and N3=60 kg N .fed^{-1}
T1 without inoculation T2:T13 inculcated with rhizobium isolate adopted with guar

Table 3. Effect of nitrogen fertilizer, inoculation and biochar additions on percentage of nitrogen, phosphorus and potassium in guar shoot plants after 60 days of planting.

Treatments	N% in plant		P% in plant		K% in plant	
	Seasone1	Season2	Seasone1	Season2	Seasone1	Season2
T_1= C_0N_0	1.41 g	1.40 h	0.01 i	0.01 g	1.94 d e	1.96 j
T_2= C_0N_0	1.48 f g	1.46 h	0.02 h i	0.02 g	2.01 c d	2.07 hij
T_3= C_0N_1	1.59 f	1.57 g	0.02 g h	0.02 f g	1.46 e	2.10 ghi
T_4= C_0N_2	1.77 e	1.76 e f	0.03 e f	0.02 f	2.19 bcd	2.22 e fg
T_5= C_0N_3	2.07 c d	2.12 c	0.03 d e	0.03 f	2.15 bcd	2.19 fg h
T_6= C_1N_0	1.74 e	1.70 f	0.02 f g	0.02 f	2.06 c d	2.04 i j
T_7= C_1N_1	2.12 e	2.15 c	0.05 c	0.05 d	2.36 abcd	2.40 c d
T_8= C_1N_2	2.35 b	2.37 b	0.06 a b	0.06 b	2.67 a b	2.65 b
T_9= C_1N_3	1.97 d	1.96 e f	0.04 d	0.04 e	2.23 bcd	2.29 d e f
T_{10}= C_2N_0	1.84 e	1.81 e	0.03 e f g	0.03 f	2.12 c d	2.11 g h i
T_{11}= C_2N_1	2.54 a	2.54 a	0.06 a	0.07 a	2.80 a	2.82 a
T_{12}= C_2N_2	2.31 b	2.32 b	0.06 b	0.05 c	2.47 abc	2.46 c
T_{13}= C_2N_3	2.04 c d	1.99 d	0.04 c	0.04 e	2.33 abcd	2.32 d e
F. Test	**	**	**	**	**	**
LSD at 0.05	0.12	0.11	0.007	0.006	0.53	0.13

C0= without biochar, C1= 0.2% biochar and C2= 0.4% biochar
N_0=without nitrogen fertilizer, N_1=30 kg N .fed^{-1} , N_2=45 kg N .fed^{-1} and N3=60 kg N .fed^{-1}
T1 without inoculation T2:T13 inculcated with rhizobium isolate adopted with guar

In respect to nitrogen% in seed of guar plant, results in Table (4) indicate that there is a significant effect of biochar and nitrogen fertilizer on increasing N in seed especially with the T11 treatment, the highest values were 5.31 and 5.30% as a result of adding 30 kg N/fed + 0.4% biochar in the 1st and 2nd seasons, respectively. Also phosphorus and potassium percentages in seeds significantly responded to nitrogen fertilizer levels and biochar in both seasons. The highest values of phosphorus were 0.35 and 0.37% obtained with T11 treatment in the 1st and 2nd seasons, respectively. Whereas, with potassium content the highest values of potassium were 1.7 and 1.66% obtained as a result of adding T11 treatment in the 1st and 2nd season, respectively. These results indicate the effect of biochar on retaining nutrients compared to sandy soil which its CEC did not exceeded than 7 cmolc.kg^{-1} soil as mentioned in Table 1 and so it would increase soil fertility and release of mineral nutrients from fertilizers which retained on biochar surface this is corresponding with (Czernik and Bridgwater, 2004).

Results in Table (5) show that seed dry weight and seed protein % significantly responded to nitrogen fertilizer levels and biochar additions in both seasons. The highest values of seed dry weight were 10.87 g/plant and 10.53

g/plant obtained as a result of adding 30 kg N/fed and 0.4% of biochar (T11) in the 1st and 2nd seasons, respectively. Increasing percentages of seed protein due to T11 treatment were 34.04% and 34.63% compared to the control without inoculation (T1) in the 1st and 2nd seasons, respectively. This might be due to increasing available nutrients in soil as illustrated in Figs (1,2 and 3) and also due to the interaction between biochar and inoculation and the enhancement of this interaction on nitrogen fixation, as well as increasing CEC due to biochar increased exchangeable nutrients which prevents nutrients from losses and fixation. The results from the current study agree with Chan *et.al.* (2007) who reported positive response to biochar in combination with fertilizer in pot trials, and Yamato *et. al.* (2006) who stated that maize and peanut yields were enhanced when charcoal (biochar) was applied in combination with N fertilizer.

Table 4. Effect of nitrogen fertilizer, inoculation and biochar additions on percentage of nitrogen, phosphorus and potassium of seeds in guar plant at harvesting.

Treatments	N% in seed		P% in seed		K% in seed	
	Seasone1	Season2	Seasone1	Season2	Seasone1	Season2
$T_1= C_0N_0$	3.50 i	3.47 g	0.03 h	0.03 f	1.26 h	1.22 h
$T_2= C_0N_0$	3.54 h i	3.49 g	0.03 h	0.04 f	1.26 h	1.26 h
$T_3= C_0N_1$	3.56 h i	3.47 g	0.03 h	0.04 f	1.25 h	1.25 h
$T_4= C_0N_2$	3.77 f g	3.85 e	0.15 g	0.16 d e	1.34 e f	1.33 f g
$T_5= C_0N_3$	3.92 e f	3.86 e	0.15 g	0.14 e	1.32 e f g	1.32 f g
$T_6= C_1N_0$	3.75 f g	3.75 e f	0.05 h	0.05 f	1.29 f g h	1.28 g h
$T_7= C_1N_1$	4.33 d	4.32 c	0.21 e f	0.23 c	1.46 c	1.42d
$T_8= C_1N_2$	4.92 b	4.76 b	0.33 a b	0.34 a	1.58 b	1.59 b
$T_9= C_1N_3$	4.06 e	4.04 d	0.25 d e	0.26 b c	1.38 d e	1.37 d e f
$T_{10}= C_2N_0$	3.72 g h	3.67 f	0.18 f g	0.19 d	1.37 d e	1.35 e f
$T_{11}= C_2N_1$	5.31 a	5.30 a	0.35 a	0.37 a	1.70 a	1.66 a
$T_{12}= C_2N_2$	4.55 c	4.39 c	0.30 b c	0.28 b	1.52 b	1.52 c
$T_{13}= C_2N_3$	4.27d	4.24 c	0.28 c d	0.29 b	1.42 c d	1.39 d e
F. Test	**	**	**	**	**	**
LSD at 0.05	0.18	0.15	0.038	0.039	0.06	0.057

C0= without biochar, C1= 0.2% biochar and C2= 0.4% biochar
N_0=without nitrogen fertilizer, N_1=30 kg N .fed^{-1} , N_2=45 kg N .fed^{-1} and N3=60 kg N .fed^{-1}
T1 without inoculation T2:T13 inculcated with rhizobium isolate adopted with guar

Table 5. Effect of nitrogen fertilizer, inoculation and biochar additions on dry weight of seeds and protein% in guar plant at harvesting.

Treatments	Dry weight of seed g.$plant^{-1}$		Protein in seed %	
	Seasone1	Season2	Seasone1	Season2
$T_1= C_0N_0$	5.83 h	5.57 g	21.88 i	21.67 g
$T_2= C_0N_0$	5.97 h	6.23 f g	22.13 h i	21.81 g
$T_3= C_0N_1$	7.07 f g	6.80 e f	22.23 h i	21.67 g
$T_4= C_0N_2$	7.33 e f g	7.43 d e	23.54 f g	24.06 e
$T_5= C_0N_3$	7.70 d e f	8.23 c d	24.50 e f	24.15 e
$T_6= C_1N_0$	6.70 g h	6.60 e f	23.46 f g	23.42 e f
$T_7= C_1N_1$	8.23 c d	8.60 c	27.04 d	26.98 c
$T_8= C_1N_2$	10.07 a	9.70 a b	30.73 b	29.77 b
$T_9= C_1N_3$	8.10 c d e	8.10 c d	25.38 e	25.23 d
$T_{10}= C_2N_0$	6.93 f g	6.77 e f	23.25 g h	22.96 f
$T_{11}= C_2N_1$	10.87 a	10.53 a	33.17 a	33.15 a
$T_{12}= C_2N_2$	8.90 b c	8.83 b c	28.42 c	27.46 c
$T_{13}= C_2N_3$	9.17 b	8.77 c	26.67 d	26.52 c
F. Test	**	**	**	**
LSD at 0.05	0.89	0.93	1.13	0.96

C0= without biochar, C1= 0.2% biochar and C2= 0.4% biochar
N_0=without nitrogen fertilizer, N_1=30 kg N .fed^{-1} , N_2=45 kg N .fed^{-1} and N3=60 kg N .fed^{-1}
T1 without inoculation T2:T13 inculcated with rhizobium isolate adopted with guar

Concerning to the weight of 100 seed, data in Table (6) show that it was increased to be 3.3 and 3.13 g/plant in T11 treatment, while the same trend was observed with leghameoglobin (Table 2) and catalase activity, whereas they significantly responded to nitrogen fertilizer levels and biochar addition in both seasons. Regarding the catalase activity, the maximum values, 140.13 and 140.23 µ moles H_2O_2 g^{-1} soil 15 min^{-1} were recorded by the application of 30 kg N/fed and 0.4% biochar in the 1st and 2nd seasons, respectively. These results are in accordance to each other due to that leghameoglobin and catalase activity represent the activity of nodules and legume plant to fix nitrogen and increase effective biomass in the soil. These results agree with the findings of El-Essawi *et al*. (1988) and Abd-Elkader, (1998). Also, Ishii and Kadoya (1994) reported an increase in the root amount and soil water retention after the application of charcoal (Piccolo *et al*. 1996) and the gaseous phase (Ezawa *et al*. 2002), such amelioration of the soil physical and chemical properties could be effective in enhancing root growth. The enhancement of root growth may account for the stable crop production.

Table 6. Effect of nitrogen fertilizer, inoculation and biochar additions on weight of 100 seeds, and catalase activity in guar plant at harvesting

Treatments	weight of 100 seed(g)		Catalase activity (µ moles H_2O_2 g^{-1} soil.15 min^{-1})	
	Seasone1	Season2	Seasone1	Season2
$T_1= C_0N_0$	2.25 i	2.27 g	57.53 i	59.57 h
$T_2= C_0N_0$	2.32 h i	2.31 f g	68.18 h	69.63 g
$T_3= C_0N_1$	2.34 h i	2.32 f g	75.25 g	72.25 g
$T_4= C_0N_2$	2.57 e f	2.57 d e	108.97 d	112.30 d
$T_5= C_0N_3$	2.65 d e	2.64 c d	114.63 c	115.26 d
$T_6= C_1N_0$	2.38 g h i	2.39 f	82.10 f	82.13 f
$T_7= C_1N_1$	2.81 c	2.75 c	125.00 b	122.30 b c
$T_8= C_1N_2$	3.03 b	2.95 b	126.60 b	125.00 b
$T_9= C_1N_3$	2.46 f g h	2.51 e	115.27 c	116.83 c d
$T_{10}= C_2N_0$	2.49 f g	2.52 e	91.13 e	91.93 e
$T_{11}= C_2N_1$	3.30 a	3.13 a	140.13 a	140.23 a
$T_{12}= C_2N_2$	2.75 c d	2.90 b	126.30 b	124.88 b
$T_{13}= C_2N_3$	2.75 c d	2.71 c	118.87 c	122.63 b c
F. Test	**	**	**	**
LSD at 0.05	0.14	0.11	5.34	6.47

C0= without biochar, C1= 0.2% biochar and C2= 0.4% biochar
N_0=without nitrogen fertilizer, N_1=30 kg N .fed^{-1} , N_2=45 kg N .fed^{-1} and N3=60 kg N .fed^{-1}
T1 without inoculation T2:T13 inculcated with rhizobium isolate adopted with guar

The interactions between nitrogen fertilizer and biochar addition gave a highly significant increase in N-available, P-available and K-available in soil ppm (Fig 1,2 and 3 respectively) in both seasons with sandy soil. The highest values of N-available were 33.53 and 32.43 ppm with T13 and T12 in 1st and 2nd season, respectively. Whereas, the highest values of P-available were 27.93 and 27.95 ppm with T13 in both seasons. Also, the highest values of K-available were 326.6 and 327.5 ppm with T11 and T13 in 1st and 2nd seasons, respectively. These results are attributed to the added dose of mineral fertilizer, biochar addition and the role of N-fixing bacteria on guar plant. The high level of available nutrients after biochar-NPK application indicated that the application of biochar led to a high retention of nutrients in addition to their content of this elements especially the phosphorus. Inoculation may improve crop yield by increasing the capacity of plant to obtain nutrients that are relatively immobile in the soil such as phosphorus (Rhodes, 1980; Jansa et.al. 2003). Kimetu *et al.* (2008) pointed that the impacts were in part due to non-nutrient improvement to soil functioning.

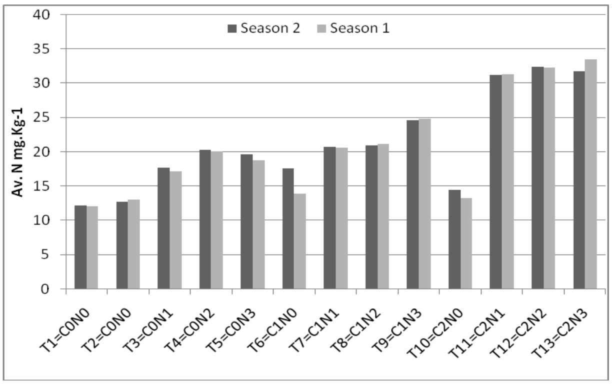

Fig. 1. Effect of nitrogen fertilizer, inoculation and biochar additions on available nitrogen in sandy soil after harvesting guar plant.

C0= without biochar, C1= 0.2% biochar and C2= 0.4% biochar

N_0=without nitrogen fertilizer, N_1=30 kg N .fed^{-1} , N_2=45 kg N .fed^{-1} and N3=60 kg N .fed^{-1}

T1 without inoculation T2:T13 inculcated with rhizobium isolate adopted with guar

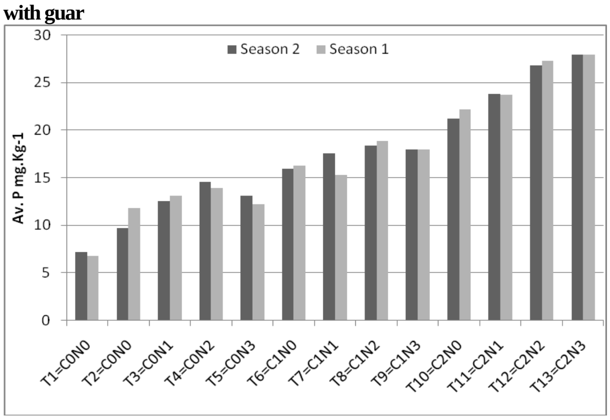

Fig. 2. Effect of nitrogen fertilizer, inoculation and biochar additions on available phosphorus in sandy soil after harvesting guar plant.

C0= without biochar, C1= 0.2% biochar and C2= 0.4% biochar

N_0=without nitrogen fertilizer, N_1=30 kg N .fed^{-1} , N_2=45 kg N .fed^{-1} and N3=60 kg N .fed^{-1}

T1 without inoculation T2:T13 inculcated with rhizobium isolate adopted with guar

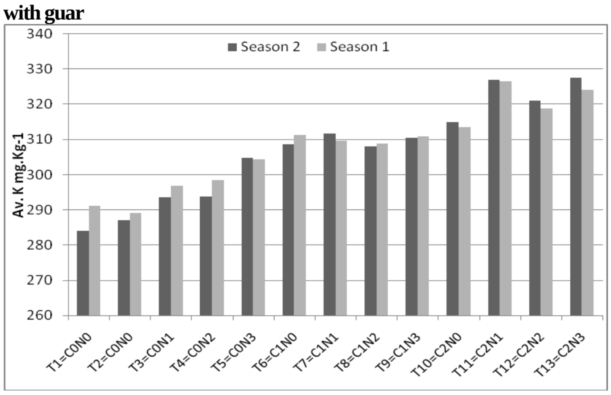

Fig. 3. Effect of nitrogen fertilizer, inoculation and biochar additions on available potassium in sandy soil after harvesting guar plant.

C0= without biochar, C1= 0.2% biochar and C2= 0.4% biochar

N0=without nitrogen fertilizer, N_1=30 kg N .fed^{-1} , N2=45 kg N .fed^{-1} and N3=60 kg N .fed^{-1}

T1 without inoculation T2:T13 inculcated with rhizobium isolate adopted with guar

CONCLUSION

Biochar is potential for countering land degradation and for improving agriculture. It persists longer in soil and retains cations better than other forms of soil organic matter. Soil analysis at harvest revealed that available N, P and K were generally higher after the application of biochar, inoculation and fertilizer than after the application of fertilizer only (NPK). So, sandy soil is quit in need of such technology to sustain and improve its fertility. Research is still needed to maximize the favorable attributes of biochar and to fully evaluate environmental risks, but this technology has the potential to provide an important carbon sink and to reduce environmental pollution by fertilizers.

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تأثير الفحم النباتى والتسميد الحيوي على نبات الجوار وخصوبة التربة الرملية

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تم إجراء تجربتى أصص خلال الموسمين الصيفيين المتتاليين لعامي 2013 و 2014 في الصوبة السلكية لمحطة البحوث الزراعية بسخا ، سخا ، محافظة كفر الشيخ ، مصر. تهدف التجربة إلى تقييم آثار إضافة مستويات مختلفة من الفحم الحيوي (وزن / وزن) (= C0 بدون فحم حيوي ، C1= 0.2٪ فحم حيوي و C2= 0.4٪ من الفحم الحيوي) مع اضافة مستويات من التسميد النيتروجيني (N0=بدون تسميد نيتروجينى، N1= 30 كجم/ فدان , N2= 45كجمN/فدان وN3 = 60 كجمN/فدان) على نمو نبات الجوار (Cyamopsis tetragonoloba l. taub) مع تلقيح بذور الجوار بالريزوبيا الخاصة به .(Rhizobium AZ2) وبعض الصفات مثل النيتروجين الممتص ومكونات المحصول والمحصول من نبات الجوار كما تم دراسة تأثير تلك المعاملات على التأثير المتبقي على بعض الخواص الكيميائية الحيوية للتربة الرملية. وأجريت التجارب في تصميم كامل العشوائية مع ثلاث مكررات. أشارت النتائج إلى أن محتوى النيتروجين والفوسفور والبوتاسيوم في نباتات الجوار بعد 60 يومًا من الزراعة زاد بشكل كبير بإضافة المعاملة T11 (0.4٪ من الفحم الحيوي + 30 كجمN/فدان) في التربة الرملية مقارنة بالكنترول T1 (بدون إضافةbiochar +بدون تسميد نيتروجينى وبدون تلقيح بكتيرى) كما لوحظ نفس الاتجاه مع N% ، P% و K ٪ في بذور الجوار في مرحلة الحصاد. كما زاد عدد العقد الجذرية والوزن الجاف لها والوزن الجاف للنبات بعد 60 يومًا وزاد الوزن الجاف للبذور عند الحصاد مع المعاملة (T11) مقارنة مع(T1) الكنترول . بينما فيما يتعلق بمعايير الجودة لنبات الجوار مثل %للبروتين في البذور والليجهيموغلوبين ، كانت المعاملة T11 هى أفضل معاملة. كذلك زاد تركيز النيتروجين والفوسفور في التربة بشكل ملحوظ مع المعاملة T13(0.4٪ الفحم الحيوي + 60 كجم N/ فدان) مقارنة مع الكنترول بينما زاد البوتاسيوم الصالح مع المعاملة T11 ،كذلك أعطى نشاط الكاتلاز المستخدم كدلالة على النشاط الميكروبي أعلى القيم مع المعاملة T11.