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A **Effect of Biochar in Arbuscular Mycorrhiza Fungi (*Glomus Mosseae*) Activity and Growth of Sweet Corn Plant**

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ABSTRACT

The impacts of three levels of biochar (1 , 3 , 5)% on Arbuscular Mycorrhiza (AM) fungi *Glomus mosseae* activity was tested , On the other hand the effect of interaction between biochar and AM fungi on some growth parameters of sweet corn plant which growth under greenhouse conditions was studied .the results showed positive effects of biochar on AM fungi activity , The plant which treated with 5 % of biochar give highest increased in the percentage of mycorrhiza colonization and mycorrhizal root weight which were (96.67 % , 122.93 gm) Respectively, while the treatment with 3% of biochar recorded highest increased in spores number that (1980) spores , and there was no significant increased in mycorrhizal dependency . as well as the results showed positive effect of interaction between biochar and AM fungi on growth of sweet corn plant , the treatment of 3% of biochar + AM fungi recorded significant increased in plant height , fresh and dry weight of shoot , leaf area , fresh and dry weight of root which were (80.76 cm , 20.36 gm , 4.136 gm , 150.74 cm^2 , 12.603 gm and 1.28 gm) Respectively , for root length the treatment with 1% of biochar + AM fungi showed highest increased which was (54.93) cm . The result showed a negative effect of increased biochar level on sweet corn plants growth , but AM fungi activity was not affected..

Introduction

The continuous population growth needs to double agricultural production but there are many problems that must be solved (1) However Heavy agriculture reduces soil fertility in the long term (2) Adding Biochar to soil is a promising option to improve soil fertility (3).

Biochar is produced by hydrothermal carbonization process under high temperatures and low oxygen conditions from a wide range of biomass sources including agricultural residues and animal manures (4). Several studies suggested that addition of biochar to soil have positive effects, The biochar application to agricultural

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soils lead to physical and chemical changes in soil properties for example increase water holding capacity, increased ability to cations exchange by addition of cation exchange sites , reduced soil leaching and improve soil structure (5) . Other studies on biochar have reported positive effect on plant growth by increasing the availability of micronutrients , minimize the damage of heavy metals on the plant , Biochar may be beneficial to microbial populations (6 , 7) . The addition of biochar to soil also contributes to improving the climate by reducing emissions of CO2, some study showed that addition biochar to the soil reduces emission of CO2 in rate 12% (8).

Both Biochar and Arbuscular mycorrhiza fungi (AM) have a significant role in improving physical and chemical soil properties, improving plant growth, reducing carbon dioxide emissions to the atmosphere (9) However, the nature of the relationship between them are still under consideration . some studies have indicated the positive role of Biochar in AM fungi activity through : altered levels of nutrient availability and/ soil physicochemical parameters (10) , alterations with effects that are beneficial or detrimental to other soil microbes (11) , alters plant–mycorrhizal fungi signaling processes or detoxifies allelochemicals (12) , Biochar serves as a refuge for hyphal (13). We sought to determine if biochar alters plant interactions with mycorrhizal fungi at three levels of Biochar , On the other hand, this study aimed at determining the effect of these concentrations of Biochar in the growth of sweet corn plant .

Material and methods

- Plant seeds , Arbuscular Mycorrhiza inoculum and Biochar production.

Sweet corn (Zea mays) seeds was obtained from a local market , The seeds were surface-sterilized with 10 % sodium hypochloride for 5 min, then wash with sterilized distilled water for 3- 4 times, blotted on a sterile filter paper, dried and kept for further use. mycorrhizal fungi *G. mosseae* were used after growing on white corn plant, the mycorrhizal Inoculum which consisted of (spores + hypha + heavily infected root fragments) .

Eucalyptus branches used for production Biochar which heated in a furnace type PLF 110/10 at 500 °C for 5 hours (14). The Biochar was allowed to cool overnight before removing then biochar was grounded to small granules and pass through 2mm sieve .

Experimental setup

The experiment was carried out in the green house of Soil department / agriculture college in University of Gukrova, Turkey . we were used plastic pots size 2 kg contain sterilized soil by Autoclave at 121 °C and pressure 1.2 kg/cm^2 for 30 minute the . Mycorrhizal inoculum were applied at rate 10 gm / pot , one gram of mycorrhizal inoculum contains 12 spore of *G. mosseae* . As for Biochar applied at rates (0, 1, 3, 5) % of total soil weight in pots which was 2 kg for each pot . The experiment consist of 16

treatments with three replicated for each treatment, three seeds of sweet corn was sown in each pot and after germination plants were thinned to two plants per pot. The plant were harvested after 45 day to take all measurements.

- **Mycorrhizal and plant parameters**

Mycorrhizal parameters: Number of *G. mosseae* spores in soil that was calculated by using the wet sieving and decanting method (15), the following equation was used to calculate the spores number of mycorrhiza (16):

Spores number in 10 g / soil = Rate of spore number in 1 ml × final size of dilution To assay the percentage of mycorrhizal colonization the root staining with Ink according (17), the Percentage of mycorrhizal colonization determination according to (18):% Mycorrhizal colonization = (Number of colonized root segments/ Total number of root segments) × 100

Weight of mycorrhizal roots calculated based on (19) and assess of mycorrhizal dependency (MD) Calculated by (20):

Weight of mycorrhizal roots = % Mycorrhizal infection × Dry weight of roots Mycorrhizal Dependency (MD) = Dry weight of mycorrhizal plant – Dry weight of Untreated plants / Dry weight of mycorrhizal plant

Plant parameters: Different parameters of growth were taken at the end of the experiment which were shoot length , fresh and dry weight of shoot , leaf area , root length and fresh and dry weight of root .

- **Statistical Analysis**

The experiment were conducted and analyzed as factorial experiment. Pots were arranged in completely randomized design (RCD). Data were analyzed using SPSS software program version 17; the mean values were compared by using LSD test at probability of 5 % ($p \leq 0.05$).

Result and Discussion

1- Effect of biochar in Arbuscular Mycorrhiza parameters.

- Percentage of Mycorrhiza colonization and spores number: The results in table (1) showed that the percentage of mycorrhizal colonization and spores number are significantly affected under three levels of biochar which were (1, 3, 5) % . sweet corn plant which treated with 5 % of biochar showed maximum percentage of mycorrhiza colonization that 96.67 % , while the plant that treated with (1 , 3) % of biochar recorded (55.56% , 93.33%) respectively comparative with non-treated plant (mycorrhiza only) which was 50 % .

The number of mycorrhiza spores was significantly increased as a result of biochar treatment , the highest number of spore recorded in treatment with 3 % of biochar which was 1980 spore ,while in plant which treated with (1% , 5 %)of biochar recorded (1280 , 1120) spores

respectively . While in non-treated plant with biochar spores number was 340 spores .

Mycorrhizal root weight and mycorrhizal dependency: The table (1) showed positive effect of three levels of biochar (1, 3, 5) % in Mycorrhizal root weight and mycorrhizal dependency on sweet corn plant. For the mycorrhizal root weight treatment with 5 % of biochar gave maximum weight which was 122.93 gm while plant that treated with (1, 3) % of biochar (73.176, 119.65) gm respectively. Non treated plant gave 41.6 gm . As for the Mycorrhizal Dependency, The result showed no significant effect of all levels of biochar but it had increased with no statistical significant difference among treatment.

Table (1) Effect of biochar on Arbuscular Mycorrhiza parameters of sweet corn grown under greenhouse conditions.

Treatments	*Mycorrhiza colonization (%)*	*Spores number*	*Mycorrhizal root weight (gm)*	*Mycorrhizal dependency (%)*
Control (AM only)	46.67±5.77	340±10	41.6±8.02	77.156±24.77
AM + 1% biochar	55.56±19.24	1280±10	73.176±49.88	79.023±27.41
AM + 3% biochar	93.33±5.77	1980±10	119.65±14.10	85.506±15.195
AM +5% biochar	96.67±5.77	1120±10	122.93±11.37	83.946±16.94
LSD at p ≤ 0.05	20.421	18.828	50.529	NS

Effect of biochar and Arbuscular Mycorrhiza in plant growth:

Shoot growth : The table (2) showed that treated with three levels of biochar caused significant increased in plant heights especially in the treatments of interaction of biochar with AM fungi , the maximum of plant height in treatment 3 % of biochar and AM fungi which was 80.76 cm comparative with 50.96 cm in control treatment and 71.43 cm in the treatment of AM fungi only, and the image (1) Showed the effect of interaction of biochar with AM fungi in sweet corn growth under greenhouse conditions .

In the same table, the results showed significant Increasing in shoot fresh weight among the sweet plant that treated with 3% biochar and AM fungi recorded highest increases, which was 20.36 gm comparative with 4.576 gm in control treatment and 14.523 gm in the treatment of AM fungi only. For dry weight of shoot, the highest dry weight of shoot in treatment of 3% biochar and AM fungi that 4.136 gm comparative with 0.62 gm in control treatment and 3.103 gm in the treatment of AM fungi only.

For leaf area the result showed significant increasing in sweet corn plant especially in interaction treatment when were compared with biochar only or AM fungi only, the highest leaf area was noticed in the treatment of 3% of biochar and AM fungi which was 150.74 cm2 compared with 58.083 cm2 and 135.229 cm2 in the treatment of AM fungi only , and the result showed no significant differences between treatments of three levels of biochar or there interaction with Am fungi .

Root growth :

The Table (3) showed significant effect of biochar and AM fungi or there interaction in root length , fresh and dry weight of root , the result showed in above root growth parameters , root length significant increased under three level of biochar and AM fungi , among these sweet corn plant which treated with 1% of biochar and AM fungi showed highest increased that 54.93 cm comparative with 38.93 cm in control treatment ,the minimum root length was recorded in plant treated with 1% biochar which was 52.93 cm .

Table (1) Effect of biochar, Arbuscular Mycorrhiza fungi (AM) and there interaction on plant shoot of sweet corn grown under greenhouse conditions.

Treatments	Shoot height (cm)	Fresh weight (gm)	Dry weight (gm)	leaf area (cm^2)
Control	50.96±6.45	4.576±0.10	0.620±0.67	58.083±9.31
1% biochar	53±12.14	5.346±0.84	1.176±0.47	68.494±13.84
3% biochar	54.7±6.10	5.203±0.71	1.290±0.03	63.654±4.22
5% biochar	52.9±4.39	5.766±0.93	1.326±0.28	68.947±6.79
AM only	71.43±5.30	14.523±1.76	3.103±0.47	135.229±8.20
AM + 1% biochar	79.46±4.25	19.843±5.33	3.866±1.04	140.837±33.81
AM + 3% biochar	80.76±0.11	20.360±4.92	4.136±0.20	150.75±29.66
AM + 5% biochar	78.66±3.38	17.546±0.25	3.756±0.15	141.98±21.46
LSD at $p \leq 0.05$	4.152	2.33	0.448	15.592

Table (2) Effect of biochar , Arbuscular Mycorrhiza fungi (AM) and there interaction on plant root growth of sweet corn grown under greenhouse conditions.

Treatments	Root length (cm)	Fresh weight (gm)	Dry weight (gm)
Control	38.93±6.45	6.133±0.53	0.63±0.05
1% biochar	52.96±12.14	7.11±1.62	0.39±6.79
3% biochar	50.63±6.10	7.14±1.90	0.478±0.04
5% biochar	41.23±4.39	7.423±0.66	0.516±0.10
AM only	52.16±5.30	10.43±3.54	0.886±0.07
AM + 1% biochar	54.93±4.25	12.156±1.34	1.25±0.58
AM + 3% biochar	53.16±0.11	12.603±0.26	1.28±0.09
AM + 5% biochar	52.8±3.38	11.313±0.40	1.27±0.04
LSD at $p \leq 0.05$	5.329	1.421	0.185

The fresh weight of root increased among of interaction treatments of three levels of biochar and AM fungi compared to treatments with biochar only or AM fungi only. The treatment with 3% of biochar and AM fungi recorded highest increased in root fresh weight which was 12.603 gm compared with 6.133 gm in control treatment and 10.43 gm in the treatment of AM fungi only.

Either the dry weight of root the result in table (3) showed significant increased in all Mycorrhizal treatments the highest increased was

1.28 gm recorded in treatment 3% of biochar and AM fungi with no significant different between interaction treatment. This result compared with 0.36 gm in control treatment and 0.886 gm in the treatment of AM fungi only

The results above showed positive effect of biochar on AM fungi activity and growth of sweet corn plant This could be due to some mechanisms which summed up by (9) these mechanisms Includes Alteration of soil properties , detoxification of allelochemicals and indirect effects on other soil microbes . The results compatible with (21) which found that root colonized by AM fungi increased in the biochar treatment. In (22) study on wheat plant found that biochar could increase mycorrhizal colonization, plant growth and nutrient uptake (N, P, K and Zn) . The study of (23) found that soil biochar applied proved to be soybean plant more effective in mitigating drought stress and found that plant growth not effected under these conditions. another study showed the ability of biochar to increased corn plant growth which was shoot and root biomass , root length , root volume , plant height and leaf chlorophyll content . Study of (24) suggests that successive biochar amendments have the potential to enhance cotton productivity and soil fertility while reducing nitrate leaching.

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تأثير الكربون الحيوي في نشاط فطر المايكورايزا الشجيرية (*Glomus mosseae*) ونمو نبات الذرة الحلوة

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الخلاصة :

تم اختبار ثلاث مستويات من الكربون الحيوي (5,3,1) % في نشاط فطر المايكورايزا الشجيرية AM (*Glomus mosseae*) ومن جهة أخرى تمت دراسة تأثير التداخل بين الكربون الحيوي وفطر المايكورايزا في بعض معايير نمو نبات الذرة الحلوة النامي تحت ظروف البيت الزجاجي . أظهرت النتائج التأثير الإيجابي للكربون الحيوي في نشاط فطر المايكورايزا , اذ أعطت النباتات المعاملة بـ 5% كربون حيوي + فطر AM اعلى زيادة في النسبة المئوية لاستيطان المايكورايزا ووزن الجذور المايكورايزية وكانت (96.67 % , 122.93 غم) على التوالي , اما المعاملة بـ 3% كربون حيوي + فطر AM سجلت اعلى زيادة في عدد الابواغ وكانت (1980) بوغ , ولم تكن هناك زيادة معنوية في الاعتمادية المايكورايزية . كما أظهرت النتائج التأثير الإيجابي لتداخل الكربون الحيوي مع فطر المايكورايزا في نمو نبات الذرة , اذ سجلت المعاملة 3% كربون حيوي + فطر AM أعلى زيادة معنوية في ارتفاع النبات , الوزن الطري والجاف الخضري , المساحة الورقية , الوزن الطري والجاف الجذري وكانت (80.76 سم , 20.36 غم , 4.136 غم , 150.74 سم^2 , 12.603 غم , 1.28 غم) على التوالي اما اطوال الجذور فقد تفوقت معاملة 1% كربون حيوي + فطر AM معنويا وكانت (54.93) سم . أظهرت هذه الدراسة انه بزيادة تركيز الكربون الحيوي انخفض نمو نبات الذرة الحلوة بينما نشاط فطر المايكورايزا لم يتأثر بزيادة التركيز .

الكلمات المفتاحية : الذرة الحلوة , الكربون الحيوي , *Glomus mosseae* , نشاط فطر المايكورايزا , نمو النبات