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THE EFFECT OF INOCULATION BY BIOFERTILIZERS, ADDITION HUMIC ACID AND THE INTERACTION OF THEM ON THE GROWTH, YIELD AND PERCENTAGE OF TOMATO ROOTS INFECTION BY MYCORRHIZA FUNGI

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Abstract

This experiment was carried out at the open field of Horticulture - College of Agriculture - the University of Diyala from 15/12/2017 to 15/7/2018 season. It aims to study the effect of the bio-fertilizers with Mycorrhiza (*Glomus mosseae*), *Trichoderma harzianum* and organic fertilizer (Humic acid) on the growth, yield and percentage of Tomato roots by (*Glomus mosseae*) of the tomato's plant (Genan), A factorial experiment included (8) treatments, according to randomized complete block design (R.C.B.D) with three replications. The experiment included two variables, bio-fertilizers with Mycorrhiza (*Glomus mosseae* 30g, *Trichoderma* 5g), Humic acid (1.5 mL^{-1}) and in addition to the control treatment (spraying with water). Results showed there is significant increase of the inoculation with Mycorrhiza 30 g in the plant high (16.4%), Dry weight of vegetable and root (16.3%, 12.6 %), T.S.S, Total acid, Vitamin C (23.6%, 24.0 %, 9.46%). Earlier and Total yield is (20.1 %, 23.0 %). Results showed significant increase of inoculation with *Trichoderma* 5g in the plant high, dry weight of vegetable and root, T.S.S, Total acid, Vitamin C, Earlier and Total yield (18.5%, 20.2%, 14.7%, 24.6%, 31.6%, 11.0 %, 23.5%, 27.3%). Results indicated significant increase of the inoculation with M+T in the plant high (32.7%),dry weight of vegetable and root (38.7%, 26.0 %), T.S.S, Total acid, Vitamin C (26.2%, 37.8%, 18.1%) Earlier and Total yield (31.8%, 27.8%). Results showed significant increase of Humic 1.5mL^{-1} within the plant high, dry weight of vegetable and root, T.S.S, Total acid, Vitamin C, Earlier and Total yield (20.9%, 24.7, 15.0 %, 27.7 %, 33.8%, 12.0%, 23.4.%, 28.8%). Results showed significant superiority of inoculation with M+H 5g in the plant high, dry weight of vegetable and root, T.S.S, Total acid, Vitamin C, Earlier and Total yield (28.8%, 31.3%, 28.1%, 29.0%, 36.9%, 17.7%, 42.0 %, 31.2.%). Results showed significant increase of (T+ H) within the plant high, dry weight of vegetable and root, T.S.S, Total acid, Vitamin C, Earlier and Total yield (36.7.%, 39.2%, 29.2%, 30.9%, 37.8%, 16.3%, 44.7%, 42.9%). The Results in table 3 show that the inoculation with Mycorrhiza individually, (M+T), (M+H), (M+T+H) respectively caused an increase in the Tomato roots infection At the end of the season, 52.6 %, 54.4%, 64.6%, 76.6%. The interaction between the two variables was significant for all the studied traits. This indicated that the response of Tomato to the first variable is related to the second one. Thus, the research has concluded that the combination of two variables; Bio-fertilizers with Mycorrhiza (*Glomus mosseae*), *Trichoderma harzianum*, and organic fertilizer (Humic acid) increases the growth, fruits nutrient value and the yield of Tomato plant.

Key words: Tomato plant, Biofertilizer, Humic acid, Growth, and Yield.

Introduction

Tomato plant (*Lycopersicon esculentun* L) belongs to the Solanaceae family (Boras, *et al.*, 2011). It is the first important crop of the Solanaceae's family, Tomato is grown in most parts of Iraq, cultivation area is reached to 69686 ha in 2018 with a yield 467579 tons (CSO, 2018). The usual period of its growth in Iraq at open fields at the beginning of spring, and in protected agriculture at the beginning of Fall. Many researchers are interested in improving the growth, production, and nutrition value of this crop. It is one of the important vegetable crops and

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man's health such as carbohydrates, Protein, Fats, Vitamin C, A, in addition to nutrient elements Ca, P, Fe (Rao and G. Rao, 2007; Park and Kaura, 2012). Macro and micro element are an important and necessary for the growth and reproduction of plants to complete its life's cycle, the absence of this element or lack of its available make plant die before the completion of its life's cycle from seed to seed. It has a great role in the physiological process. Bio-fertilizers (Mycorrhiza, *Trichoderma*) have an important role in soil properties, stabilization of nitrogen element air, increase and easy support of absorption of macro nutrients (N, P, K) micro elements and improve the nutrition of stats of the plant. The technology of Bio-fertilizers is a successful alternative in reducing the use of chemical fertilizers. Besides, the application of an organic farming system helps to create a state of balance between the nutrients' content in the soil and the quantity and quality of yield. (Klefield and Chet. 1992; Al- Shaibani and Abd, 2005; Smith and Read. 2008; Cimen and Pirinc, 2010; Heil, 2011) Several studies have pointed out the role of organic fertilizers in the characteristics of vegetable growth and crop. Humic acid is a complex substance derived from organic material decomposition. Humic acid improves the physical and chemical characteristics of the soil and soil structure, increases the availability of nutrients absorbed in the soil. Agricultural humic acid is reputed to enhance nutrient uptake, especially phosphorous, sulfur and nitrogen, seed germination, and overall plant performance, stimulate shoot growth, promoted the accumulation of N, P, B, Mg, K.Ca, Zn,Cu and Fe, (Lee and Bartlette 1976; Ertan, 2007; Al- Sinbol, 2012; Hussein and Allawi. 2017). So this study aims to investigate the effect of the bio-fertilizers and humic acid and interaction between them in growth, the nutrition value of fruits, yield, and root infection by Mycorrhiza Fungi.

Materials and methods

This experiment was carried out at the open field of Horticulture - College of Agriculture - the University of Diyala - from 15/12/2017 to 15/7/2018. It aims to study the effect of inoculation with bio-fertilizers (Mycorrhiza, *Trichoderma*), and the addation of organic fertilizer by the Humic acid and the interaction of them in the plant hight, Dry weight of vegetable and root, Total T.S.S, total acid and vitamin C, Earlier and Total yield, and root infection with mycorrhiza of the tomato plant (Genan) which is characterized by the strong growth, the, weight of the fruits and total yield. The field experiment included the cultivation stage of Tomato's seed under plastic tunnels of (1kg) weight with addition 750g of soil 250g of beta-mosses fertilizer for each bag, inoculated by 30g of Mycorrhiza (dried soil + infection roots + sports), *Trichoderma* 5g and addition organic fertilizer Humic acid 1.5 mL^{-1}, and in addition to the control treatment. The seedlings transferred to the field on 25/2/2018. Humic acid added three times on 10/3/2018, 25/3/2018, and 10/4/2018. The experiment was performed in R.C.B.D with three replications. It consisted of 24 experimental units and each unit contained 15 plants with 6 m in length, 2.5* 1.75 m width, and 0.4 m space between two plants. After 30 days, 10 plants from each experimental unit, are randomly collected to study structural features, such as the height of plant (cm $plant^{-1}$), dry weight of vegetative (g $plant^{-1}$), dry weight of roots (g $plant^{-1}$). At the end season, 10 plants from each experimental unit, are randomly collected to study the structural features, such as T.S.S%, total acid %,.Vitamin C (mLg/100 ml^{-1} earlier and total yield ton ha^{-1} and the percentage of Tomato roots infection by Mycorrhiza (*Glomus mosseae*). The SAS system was used under Windows 2009 for statistical analysis, the mean was compared by using a less significant difference (L.S.D 5%) (Kadhim and Abed, 2017).

Result and discussion

Vegetative traits:

the results in table 1 indicate that the inoculation with Mycorrhiza individually caused a significant increase in plant height, dry weight of the vegetative and dry weight of root, 16.4 %, 16.3 %, 12.6 % respectively, compared to the control treatment. This due to Mycorrhiza fungi that caused the availability of macro nutrients in the soil such as nitrogen, phosphorus, potassium, and micro nutrients that led to absorption by the plant which is reflected in the increase of the plant growth parameters, also encourages the plant to absorb nutrients and water, and produce some growth regulators, increase biological activity in the roots zone, this is reflected by the increase in plant growth such as a leaf area, number of branches, flowering, and fruits. The results in (Table 1), show that the inoculation with *Trichoderma harzianum* individually caused a significant increase in plant height, dry weight of the vegetative and dry weight of root, 18.5%, 20.2.%, 14.7% respectively, as compared to the control treatment. This due to *Trichoderma harzianum* fungi which caused the availability of nutrients in the soil that are essential for plant, and that may be due to the ability of this fungus to produce growth regulators such as Auxin IAA, Gibberellin GA_3 which play an important role in the internal organization of the growth activity. The Results of the inoculation between (M+T) in table 1 caused a significant increase in plant height, dry weight of the vegetative and

dry weight of root, 32.7%, 38.7%, 26.0% respectively, as compared to the control treatment. (Zehra, *et al.*, 2012; Allawi, 2013; Alzubaidy, *et al.*, 2014). In regards to the treatment of Humic acid individually caused a significant increase in plant height, dry weight of the vegetative and dry weight of root, 20.9 %, 24.7 %, 15.0 % respectively, compared to the control treatment. The due to Hamic acid that improves the physical and chemical characteristics of the soil, chelate soil nutrients, improve nutrient uptake, especially phosphorous, sulfur and nitrogen. Act as storehouse of N, P, K, S, Fe and Zn, stimulate soil biological activity. (Ertan, 2007; Al- Sinbol, 2012). While the interaction treatments between inoculation Mycorrhiza and the addition of Humic made a significant increase in height 28.8%, dry weight of vegetative 31.3%, and dry weight of root 28.1%, as compared to the control treatment. The interaction between Humic acid and *T. harzianum* Showed an increase in plant height, dry weight of the vegetative and dry weight of root, 36.7 %, 3.39 %, 29.2 % respectively, compared to the control treatment, The interaction of treatments between inoculation with bio-fertilizers (Mycorrhiza. *T. harzianum*) and Humic acid resulted in an increase in plant height, 46.2%, dry weight of the vegetative 45.5 % and dry weight of root 36.2%, respectively compared to the control treatment. These results were in agreement with some previous studies (Celik, *et al.*, 2004; Smith, and Read. 2008; Zehra Khan, *et al.*, 2012; Allawi, 2013; Alzubaidy, *et al.*. 2014).

Fruits Nutritional Value traits:

The Results in (Table 2) showed that the inoculation with Mycorrhiza individually caused a significant increase in T.S.S, 23.6 %, total acid, 24.0 % and Vitamin C, 9.46 %, as compared to the control treatment. This is because Mycorrhiza fungi caused the availability of macro nutrients in the soil such as nitrogen, phosphorus, potassium, and micronutrients which led to absorption by the plant; that was reflected by the increase of the plant growth parameters, also encouraged the plant to absorb nutrients and water, and produce some growth regulators, increased biological activity in the roots zone, this was reflected by the increase in plant growth such as the leaf area, a number of branches, flowering, and fruits. The Results in (Table 2) individual application shows that the inoculation with *Trichoderma harzianum* individually caused a significant increase in T.S.S Total acid and Vitamin C, 24.6 %, 31.6 %, 11.0 % respectively, compared to the control treatment, The Results in Table: 2 gave that the inoculation between (M+T) caused a significant increase in T.S.S, Total acid and Vitamin C, 26.2 %, %, 37.8 %, 18.1 % respectively, compared to the control treatment. For the treatment of Humic acid individually, the results in table 2 showed an increase in T.S.S, 27.7 % total acid, 33.8.5%, and Vitamin C, 12.0 %, compared to the control treatment. While the interaction of treatments between inoculation Mycorrhiza and addition Humic gave a significant increase in T.S.S, Total acid and Vitamin C. 29.0 %, 36.9 %, 17.7 %, respectively compared to the control treatment. The interaction between Humic acid and *T. harzianum* Showed an increase in T.S.S. 30.9 % Total acid, 37.8 % and Vitamin C, 16.3 % compared to the control treatment respectively. While the interaction of treatments between inoculation with bio-fertilizers (Mycorrhiza, *T. harzianum*) and Humic acid resulted in an increase in T.S.S, Total acid and Vitamin C, 34.0 %, 40.5 %, 19.4 % respectively These results were in agreement with some previous studies (Klefield and Chet, 1992); Cimen, *et al.*, 2010; Allawi, 2013).

Quality Yield:

The Results in table 3 showed that the inoculation with Mycorrhiza individually caused a significant increase in the Earlier crop with Total yield, 20.1 %, 23.0 %, compared to the control treatment. This due to Mycorrhiza fungi that caused the availability of macro nutrients in the soil such as Nitrogen, Phosphorus, Potassium, and Micronutrients (Fe, Mn, Zn) which led to absorption by the plant, that is reflected by the increase in the plant growth parameters, also encourages the plant to absorb nutrients and water, and produce some growth regulators, and increase biological activity in the roots zone, this is reflected by the increase in plant growth such as leaf area, a number of branches, flowering, and fruits. The results in table 3 that the inoculation with *Trichoderma harzianum* individually caused a significant increase in the Earlier crop and total yield, 23.5 %, 27.3 % respectively, compared to the control treatment. This due to *Trichoderma harzianum* fungi to increase the availability of nutrients in soil (N, P, K, Fe, Mn, Zn) and produce growth regulators such as Auxin IAA, Gibberellin GA_3 which play an important role in the internal organization of the growth activity. This is reflected by the increase in plant growth such as leaf area, a number of branches, flowering, and fruits. The Results in the table 3 showed that the inoculation between (M+T) caused a significant increase in the Earlier crop, 31.8 %, Total yield 27.8 %, compared to the control treatment (Smith, and Read. 2008; Yousif, 2011; Allawi, 2013). As for the treatment of Humic acid individually, the results in table 3 increase in the Earlier crop. 23.4 %, Total yield 28.8 %, compared to the control treatment. The due to Hamic acid that improves the physical and chemical characteristics of the soil, solubilize

minerals, chelate soil nutrients, improve nutrient uptake, especially phosphorous, sulfur and nitrogen. Act as storehouse of N, P, K, S, Fe and Zn, stimulate soil biological activity improve water holding capacity for better drought resistance and reduction in water usage, improve soil structure, this is reflected by the increase in plant growth such as leaf area, a number of branches, flowering, and fruits (- Ertan, 2007; Al- Sinbol, 2012; Hussein and Allawi. 2017). While the interaction treatments between inoculation Mycorrhiza and addition Humic make a significant increase in the Earlier crop with 42.8 %, Total yield 31.2 %. compared to the control treatment. The interaction between Humic acid and *T. harzianum* Showed an increase in the Earlier crop and Total yield, 44.7 %, 42.9 %, respectively, compared to the control treatment, While the interaction treatments between inoculation with bio-fertilizers (Mycorrhiza. *T. harzianum*) and Humic acid increased the Earlier crop by 50.0%, Total yield by 49.7%, compared to the control treatment respectively. These results were in agreement with some previous studies).

Percentage of Tomato roots infection by Mycorrhiza fungi:

The Results in (Table 3) show that the inoculation with Mycorrhiza individually caused an increase in the Tomato roots infection At the end of the season, 52.6 %, as compared to the control treatment. While the interaction of treatments between inoculation Mycorrhiza and addition Humic make an increase in the Tomato roots infection to 64.6 %. compared to the control treatment. As for the treatment of (M+T. *T. harzianum*), the results in table 1 displayed an increase in Tomato roots infection with 56.4 %, compared to the control treatment. While the interaction of treatments between inoculation with bio-fertilizers (Mycorrhiza. *T. harzianum*) and Humic acid increased the infection of Tomato roots to 76.0 %, compared to the control treatment. These results were in agreement with some previous studies (Smith and Read. 2008; Yildiz, 2010; Yousif, 2011).

Conclusions

This present study has shown that the interaction between the two variables was significant for all the studied traits, Indicated that the response of Tomato to the first variable is related to the second one. Thus, the research has concluded that the combination of two variables; Bio-fertilizers with Mycorrhiza (*Glomus mosseae*), *Trichoderma harzianum*, and organic fertilizer (Humic acid) in the growth increasing the growth, Fruits

Table 1: Effect of inoculation by biofertilizer and addition with Humic acid and their interaction on vegetative traits in Tomato plant during 2018.

Humic acid / Biofertilizers	Plant length cm plant^{-1}		Mean of Humic acid	Dry weight of vegetative g plant^{-1}		Mean of Humic acid	Dry weight of roots g plant^{-1}		Mean of Humic acid
	Humic 0	Humic 1.5 mL^{-1}		Humic 0	Humic 1.5 mL^{-1}		Humic 0	Humic 1.5 mL^{-1}	
Control	32.0	40.5	36.2	7.90	10.5	9.20	2.55	3.00	2.77
Mycorrhiza (*Glomus mosseae*)	38.3	45.0	41.6	9.45	11.5	10.4	2.92	3.55	3.23
Trichoderma harzianum	39.3	50.6	44.9	9.90	13.0	11.4	2.99	3.60	3.29
Mycorrhiza+ *Trichoderma*	47 .6	59.5	53.5	12.9	14.5	13.7	3.45	4.00	3.72
L.S.D 5 %	5.51		3.21	0.17		0.14	0.16		
Mean of biofertilizers	39.3.	48.9		10.0	12.3		2.98	3.53	
L.S.D	3.03			0.10			0.07		

Table 2: Effect of inoculation by biofertilizer and addition with Humic acid and their interaction on fruits nutritional value traits in Tomato plant during 2018.

Humic acid / Biofertilizers	T.S.S		Mean of Humic acid	Total acid		Mean of Humic acid	Vitamin		Mean of Humic acid
	Humic 0	Humic 1.5 mL^{-1}		Humic 0	Humic 1.5 mL^{-1}		Humic 0	Humic 1.5 mL^{-1}	
Control	4.22	5.84	5.03	0.41	0.62	0.51	15.3	17.4	16.3
Mycorrhiza (*Glomus mosseae*)	5.53	5.95	5.74	0.54	0.65	0.59	16.9	18.6	17.7
Trichoderma harzianum	5.60	6.11	5.85	0.60	0.66	0.63	17.2	18.3	17.7
Mycorrhiza+ *Trichoderma*	5.72	6.40	6.06	0.66	0.69	0.67	18.7	19.0	18.8
L.S.D 5 %	1.10		0.87	0.08		0.06	1.19		1.90
Mean of biofertilizers	5.26	6.07		0.55	0.65		17.0	18.3	
L.S.P	0.18			0.04			0.98		

Table 3: Effect of inoculation by biofertilizer and addition with Humic acid and their interaction on earlier, total yield and percentage of Tomato roots infection by Mycorrhiza fungi in Tomato plant during 2018.

Humic acid / Biofertilizers	Earlier yield		Mean of Humic acid	Total yield		Mean of Humic acid	Percentage of Tomato roots by Mycorrhiza %		Mean of Humic acid
	Humic 0	Humic mL^{-1} 1.5		Humic 0	Humic mL^{-1} 1.5		Humic 0	Humic mL^{-1} 1.5	
Control	34.0	50.3	42.1	50.5	71.0	60.7	0	0	0
Mycorrhiza (*Glomus mosseae*)	42.6	58.7	50.6	65.6	73.5	69.5	54.6	59.2	56.9
Trichoderma harzianum	44.5	61.5	53.0	69.5	88.5	79.0	0	0	0
Mycorrhiza+ *Trichoderma*	49.9	68.0	58.9	70.0	101.6	85.8	68.4	76.8	72.6
L.S.D 5 %	13.6		10.3	25.9		10.7	7.8		0.94
Mean of biofertilizers	42.7	59.6		63.9	83.6		30.7	32.9	
L.S.D 5%	8.90			12.8			1.70		

Nutrient Value and the Yield of Tomato plant.

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