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Influence of using Mycorrhizae (MH) with Vermicompost (VRF) on Soil Properties, Soybean (*Glycine max* L.) Growth and Yield

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ABSTRACT

The research team conducted pots experiment in a Silty clay loam soil to investigate the effect of inoculation with Mycorrhizae (MH), Vermicompost fertilizer (VRF) and chemical fertilization (CF) on the growth and yield of soybean (*Glycine max*) and some soil properties after cultivation, The team used complete randomized design CRD experimental system of three replications. Experimental treatments were; control (zero addition) (T_1), the addition of CF alone as a complete recommendation (100 N, 160 P_2O_5, 80 K_2O kg.ha^{-1}) (T_2), addition of MH fungi (10 g.pot^{-1}) (T_3), MH + half of the CF recommendation (T_4), VRF (2 tons.ha^{-1}) (T_5), VRF + half of the CF recommendation (T6), VRF + MH (4 ton.donm^{-1}) (T_7), and finally MH + VRF + half CF recommendation (T_8), in addition to interactions among these parameters. The seeds of the soybean were inoculated with specialized rhizobia (RHZ). Then, they were implanted on May 5, 2019. After maturity of the pods, they were harvested on 1st September, 2019. The important plant, yield, and some soil properties were analyzed post cultivation. The results indicated that (T8) was the best in improving the growth and yield properties and gave significant differences compared to T_2, T_3, and T_4, as this treatment gave the maximum height of the plant (PLH) (89.8 cm. plant^{-1}), the best leaf area (LA) of (68.4 dcm^2.plant^{-1}), the maximum green total weight (GTW) of (58.6 gm.plant^{-1}), The highest dry weight of roots (DRW) (12.8 gm plant^{-1}), the highest number of pods (NPP) of (195.6 pods.plant^{-1}), the highest number of grains per pod (NGP) of (2.96 grain. pod^{-1}) and the highest total yield (TY) of 110.8 gm plant^{-1}. Regarding soil properties after cultivation, The T8 treatment recorded the least values of soil pH and EC, as it decreased to 7.25 and 2.26 dS.m^{-1}, respectively, while the number of active root nodules (ARN) and O.M of soil increased to 60.3 nodes.plant^{-1} and 2.96%, respectively. The T_8 treatment recorded the maximum soil nutrition content (SNC) after cultivation for total N and available PK which were (198.2%, 28.7 mg.kg^{-1}, and 188.2 mg,kg^{-1}) respectively. While the other treatments were in the following order $T_7 > T_4 > T_6 > T_3 > T_5 > T_2 > T_1$.

Keywords: Vermicompost; mycorrhiza; soybean; growth; yield; soil properties.

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INTRODUCTION

Mycorrhizae is a group of fungi that establish a symbiotic relationship with various plant roots under natural conditions, which represents a beneficial and nonpathogenic relationship and thus improves growth, physiological and qualitative characteristics, its resistance to diseases and environmental factors increases as well. This relationship looks like that of root nodules bacteria (Rhizobium) in legumes. There are three main types of mycorrhizae: external, internal and external internal, the internal mycorrhizae, which are called vesicular-arbuscular mycorrhizae (VAM) the most important of the three types is that they Infect most economic crops and are not specialized on a particular plant, but there is some advantage in infection for some the plants, It also lives in a wide environmental range, as it can affect plants in the Arctic and tropical regions, as well as in water environments and desert areas, Among the most important determinants of its spread is its inability to grow in industrial settings, as it is obligatory to feed on living matter, Thus, it cannot grow in the absence of the plant host and this determines the possibility of producing large quantities of vaccine for industrial production (Siddiqui *et al*., 2008 and Marzban *et al*. 2017), the most famous and effective genera, as well as the most present in Iraqi soils, is the genus *Glomus*, especially *G. mosseae*.

Vermicompost fertilizer, a fertilizer produced by breeding Earthworms on the waste of homes, farms and markets, is an important organic fertilizer in agriculture, It enriches the soil with nutrients necessary for plant growth, such as nitrogen, phosphorus, potassium, and microelements such as iron, manganese, zinc, copper, iodine, and molybdenum, in addition to its production of growth regulators and enzymes. It also improves the physical properties of the soil and provides a safe environmental system for production, thereby reducing chemical fertilizers and pesticides that are harmful to public health and environmental pollution, as well as the production of natural crops that are not contaminated and have an excellent taste, and more importantly, it works to increase the microbial activity in the soil in general, such as bacteria and fungi in particular, mycorrhizae. That is the aim of our study (Alireza *et al*., 2014).

Soybeans (*Glycine max* (L.) merr) ranks first among the oilseed crops in terms of cultivated area and global production, as its seeds contain a high protein content of 40% and a percentage of oil in the range of 14-24%, and it is of great importance In human nutrition because it contains all the essential amino acids and some important minerals and vitamins and unsaturated fatty acids, which makes it easy to use by body cells, especially for people with heart and liver diseases, atherosclerosis and diabetes patients, in addition to using it as concentrated feeds for poultry, fish, animal feed, and soil properties and increases Its fertility as legumes crop (Chia-Chien, *et al* 2017 and Pireh *et al*. 20127).

This study aimed to find out the effectiveness of the vesicular-arbuscular mycorrhizae (VAM) fungus when used with vermicompost fertilizer in influencing the growth and yield of Soybean and some soil properties.

MATERIALS AND METHODS

The research team carried out this pot experiment (20 kg soil capacity) to determine the effect of both mycorrhiza, vermicompost, chemical fertilizers and their interactions on the growth and yield of soybeans as well as the soil properties after cultivation. Silty clay loam soil samples were taken from an agricultural area belonging to Al-Fallujah district. Table 1 shows some chemical and physical properties of the soil, a complete randomized design CRD with three replicates was used as experiment system. The experiment consisted of eight treatments revealed from interaction between two factors: inoculation with mycorrhiza, the addition of vermicompost as described in Table 2 and the fertilizer recommendation for soybeans as follows:

1. T1: Control treatment (without any addition) (CT).
2. T2: Fertilizer recommendation for soybean using (100 N, 160 P_2O_5, 80 K_2O kg ha^{-1}) (CF).
3. T3: Mycorrhizae treatment only (MH).
4. T4: Mycorrhizae + half of the fertilizing recommendation (MH+CF).
5. T5: vermicompost (4 tons. ha^{-1}) (VRF).
6. T6: vermicompost + half of the chemical fertilizer recommendation (VRF+CF).
7. T7: Mycorrhizae + vermicompost (4 tons. ha^{-1}) (MH+VRF).
8. T8: Mycorrhizae + vermicompost (4 tons. ha $^{-1}$)+ half of the fertilizer recommendation (MH+VRF+CF).

The pots were filled with 20 kg of soil and sowed with soybean seeds (*Glycine max* L. *merr*). The seeds were inoculated with special soybean rhizobia (RHZ) inoculant (Rhizobium japonicum), with 3 seeds in each pot, thinned to one plant for each pot after germination. The vermicompost and chemical fertilizers were mixed with the soil and were added before the cultivation process according to the treatments requirements, As for the inoculation of mycorrhiza, it was added by 10 g for each pot directly, while sowing of seeds was at May 20, 2019 according to treatments, Irrigation was carried out after cultivation within the limits of field capacity F.C.. Soil moisture was preserved at the limits of F.C. throughout experiment period. After the end of the experiment on September 1, 2019, the plants were harvested. Then the properties of plants were measured that consist: plant height (PLH), leaf area (LA), total green weight (GTW), number of pods per plant (NPP), number of grains per pod (NGP) and total yield (TY). The soil properties were measured after harvesting which were: pH, EC, O.M, total N, available P, available K and the number of active root nodules (ARN) after month and a half from cultivation.

Table 1: Pre cultivation chemical and physical properties of the soil

No	Properties	Value	Unit
1	Electrical conductivity (EC)	2.58	ds. m^{-1}
2	pH	7.73	-
3	Cation exchange capacity CEC	23.7	$Cmole.kg^{-1}$
4	Organic matter (O.M)	1.14	%
5	Total nitrogen (N)	91.4	mg kg^{-1}
6	available phosphorous (P)	12.1	mg kg^{-1}
7	available potassium (K)	108.7	mg kg^{-1}
8	Sand	145	g. kg^{-1}
9	Silt	470	g. kg^{-1}
10	Clay	385	g. kg^{-1}
11	Soil texture	Silty clay loam	-

Table 2: some properties and elements contained in vermicompost

EC dS.m^{-1}	pH	%						C / N	mg.kg^{-1}			
		C	N	P	K	Ca^{++}	Mg^{+}		Fe	Zn	Mn	$Cu^{=}$
5.2	7.1	24	1.9	1.4	0.9	1.8	0.6	12.6	850	87	135	38

THE RESULTS AND DISCUSSION

Table 3 illustrates the effect of MH, VRF and CF treatments and their interactions on some properties of the vegetation, root, and yield for soybean. The table shows that T_8 treatment gave the highest PLH, the maximum LA and the highest GTW as (89.8 cm, 68.4 dcm^2.$plant^{-1}$ and 58.6 g.$plant^{-1}$) respectively, the differences were significant compared to the rest of the treatments, followed by T_7 treatment which recorded (85.4 cm, 64.2 dm^2 .$plants^{-1}$ and 52.4 g.$plant^{-1}$), for the same traits respectively, the next were T_6 and T_4 treatments, which had no significant differences. Also, there were no significant differences between the T_5 treatments, which represented the addition of VRF only, and T_3, which represented the addition of MH only. They followed by full CF treatment, while the comparison treatment gave the least values, recording (50.4 cm, 41.6 dcm^2. $plant^{-1}$ and 26.4 g. $plant^{-1}$). For DRW, Table 3 shows that T_8 treatment significantly outperformed all treatments in this trait where it reached 12.8 g. $plant^{-1}$, It is noticed that the MH treatments T3 significantly outperformed the DRW over the VRF treatments T_5, as well as the CF treatments alone. The treatment T_3 ((MH only)) gave 7.9 g.plant^{-1} for DRW which significantly superior to T5 (VRF) That gave 6.2 g. plant^{-1} and on the treatment T_2 (CF only) which gave 4.1 g. plant^{-1}, whereas, the Control treatment T_1 gave a very low value of 2.0 g.plant^{-1}.

Table 3 also shows the effect of MH, VRF and CF on the yield components in terms of NPP, NGP, and the TY, It was found that the T_8 treatment gave significant differences in these traits compared to the rest of treatments. It gave the highest NPP, NGP, and the best TY per plant which where (195.6 pods.plant^{-1}, 2.96 grains.pod^{-1} and 110.8 g.plant^{-1}) respectively. Treatment T_7 (gives 171.3, 2.73 and 95.6) respectively. There were insignificant differences between MH compared to VRF neither alone nor with CF treatments, The CF only (T_2) treatment gave yield properties less than the T_7 (MH+VRF) treatments individually or in combination, while the T_1 (CT) treatment gave the least values of yield properties.

The improvement of vegetal and radical properties occurring as a result of MH application is due to additional root extension of MH as well as main root of plant which led to an increase in size root to extend more in soil, thus causing an increase in water absorption and necessary nutrients by plants from more distances due to increase the mycorrhizal root extension in addition to its work of rising availability of many nutrients by increasing the solubility of compounds and materials that contain these elements and extracting them from the soil, especially phosphorous. The MH also produces growth regulators (Auxins) and some enzymes that lead to growth development. Also, the MH have an important role in biological control by supporting plant resistance ability against many fungal and bacterial pathogens. There is also a positive beneficial interaction between soybean MH and RHZ where their collaborated existence increase their both activity and thus improves the characteristics of growth and yield by improving the soil fertile status, especially increasing nitrogen stabilization (Lenin and Ravimycin 2013; Adavi and Kalantari 2014; Alireza *et al* 2014; Sarcheshmehpour *et al*. 2016; Pireh *et al*. 2017).

As for the increases due to the addition of VRF, it is because VRF works to improve the physical, chemical, fertile, and biological soil properties. It improves the physical traits by improving soil structure and increasing water holding capacity and cation exchange capacity (CEC). It's also improves chemical and fertility properties by increasing availability of soil nutrients by making them in an easier for plants to absorb, either by dissolving compounds of these elements to release them by organic acids that produced at decomposition, or by releasing them from VRF itself as a result of the decomposition of its components to spread into the soil. VRF also enhances the biological soil status by stimulating growth and activity of microorganisms and its positive effects on plant growth by stabilizing some elements such as atmospheric nitrogen or by dissolving and releasing some of precipitated or stabilized elements such as phosphorus and potassium, which led to increased vegetal and radical growth, as well as yield components of mung bean (Muhammad *et al.* 2016, Jahangiri *et al.*2016, Nia *et al.* 2017, and Kamran *et al.* 2016).

Table 3: Effect of treatments on some plant and yield properties

No	Treatments	PLH (cm)	LA (dcm^2. plant $^{-1}$)	GDW (g. Plant $^{-1}$)	DRW (g. Plant $^{-1}$)	NPP (pod.plant^{-1})	NGP (grains. Pod $^{-1}$)	TY (g. plant^{-1})
1	T1	50.4	41.6	26.4	2.0	78.3	2.12	41.2
2	T2	67.2	50.2	35.7	4.1	119.6	2.30	59.7
3	T3	72.9	55.7	42.8	7.9	136.0	2.41	71.8
4	T4	79.9	60.0	46.9	8.7	147.6	2.55	78.9
5	T5	74.6	56.3	43.1	6.2	141.0	2.44	72.3
6	T6	80.7	60.7	48.0	7.1	149.3	2.59	81.2
7	T7	85.4	64.2	52.4	10.2	171.3	2.73	95.6
8	T8	89.8	68.4	58.6	12.8	195.6	2.96	110.8
LSD 0.05		3.6	3.1	5.6	1.6	15.4	0.12	9.7

Table 4 shows the effect of treatments on some soil properties after cultivation. The table showed that the MH and VRF treatments reduced soil pH. The treatments T_8 and T_7 gave the least values of soil acidity of 7.25 and 7.32, respectively that significantly superior to all treatments, while CF treatments of T_2 and T_1 gave the highest pH values of 7.62 and 7.66, respectively, The presence of MH and VRF works to reduce soil pH since the growth of MH in the soil and the decomposition of VRF work to produce some compounds and organic acids that reduce soil pH, It is also noticed from Table 4 that the addition of MH and VRF reduced soil salinity (EC) as treatments T_8 and T_7 gave the minimum soil salinity of 2.26 and 2.32 dS.m^{-1}, respectively that were significantly superior in reducing soil salinity overall treatments while the T_1 and T_2 gave the maximum soil salinity values of 2.60 and 2.53 dS.m^{-1}, respectively, MH reduces soil salinity through several mechanisms, the most important of which is increased plant growth which in turn absorbs both the macro, micro nutrients, and some salts as well during its growth period. Also by increasing the activity of antioxidant enzymes and the production of proline acid . VRF also improves the physical, chemical, and biological properties of the soil, (Mahesh *et al.*2010, Lenin and Ravimycin 2013, and Mehdi *et al.*2018).

Table 4 also shows the number of ARN of the soybean plant after 45 days of cultivation. There was an increase in the number of ARN for the MH and VRF treatments, especially in T_8 and T_7 treatments that gave the highest ARN of 60.3 and 57.6 nodules, respectively. It was followed by the rest of treatments with or without CF with an insignificant differences among them. While the T_1 and T_2 treatments gave the least ARN values of 28.3 and 22.6 knots each, successively. The presence of MH with specialized RHZ on soybeans stimulates the formation and number of root nodules, especially for the active RNs because the mycorrhizal enzyme secretes that also improve the fertile status of soil which increase the activity of the root nodules and also the number of ARNs, VRF also increases the number of ARNs as well as their activity and effectiveness by improving the fertile status of soil to release of nutrients and increase the activity of microorganism enzymes and growth regulators (Auxies), (Njunge *et al.* 2016, Samanhudi *et al.* 2018 and Kamran *et al*. 2016).

It is also evident from Table 4 that MH and VRF treatments have significantly increased OM, total N, available P, and K in the soil after cultivation, the treatment T_8 was outperformed in all of these properties over the rest of the treatments. Thus it gave 2.96% for OM 198.2% for total N, 28.7 mg.kg^{-1} for available P and 188.2 mg.kg^{-1} for available K, This was followed by treatments T_7 while the T_1 and T_2 treatments gave least values for the above mentioned traits, the both MH and VRF either individually or collectively, increase the proportion of organic matter and the concentration of available nutrients in soil through several mechanisms, such a most important of them is that MH increases the availability of nutrients and release them from their original compounds in soil, especially phosphorus, through MH extensions into soil, such a matter increases contact area of roots far from the rhizosphere, which supports the nutrients absorption by the plant. As well as that the MH produces growth regulators which improves soil, whereas VRF also increases the OM and essential nutrients in two ways: the first one, when it decomposes into its components of organic and mineral compounds to enrich soil organic content; the second is by improving soil physical and chemical status which increases the activity of microorganisms, which in turn exploits the organic carbon in VRF and then produce substances stimulates growth and enzymes necessary to mineralize some elements to make them available to plant's uptake (Alireza *et al.*2014, Jahangiri *et al.*2016, Nia *et al.*2017, Samanhudi *et al*. 2018, Dahanayake and Alawathugoda 2015).

Table 4: Effect of treatments on some soil properties after cultivation

No	Treatments	pH	EC dS m^{-1}	ARN Node. Plant^{-1}	O. M %	Totall N %	available P mg-kg $^{-1}$	available K mg-kg $^{-1}$
1	T1	7.66	2.60	22.6	1.30	81.6	9.7	101.5
2	T2	7.62	2.53	28.3	1.42	110.4	17.3	121.7
3	T3	7.44	2.46	41.6	2.26	158.9	23.8	162.5
4	T4	7.42	2.44	44.3	2.37	165.4	25.9	169.2
5	T5	7.40	2.45	41.0	2.80	168.5	18.6	156.8
6	T6	7.38	2.42	43.6	2.81	177.8	20.3	168.2
7	T7	7.26	2.32	57.6	2.91	189.0	24.8	175.6
8	T8	7.25	2.26	60.3	2.96	198.2	28.7	188.2
LSD 0.05		0.11	0.09	3.9	0.14	10.5	2.4	12.3

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