

The Effect of Bio-Fertilizer, Magnetized Water and Soil Coverage on the Ratio of NPK Elements in The Leaves, Microbial Community and Measure the Basal Phosphatase Enzyme in The Maize Soil

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Abstract

A factorial experiment was carried out according to the randomized complete block design (RCBD) with the split-split-plot arrangement with three replications during the season of 2020 to study the effect of three factors are the irrigation (non- magnetized water, magnetized water), the coverage (non-coverage soil and coverage soil), Bio and chemical fertilizers on NPK elements percentage in leaves, microbial community and measure the basal phosphatase enzyme in the maize soil. The results showed the interaction between magnetized water and the soil coverage and bio-fertilizer + a half dose of phosphate fertilizer led to significantly increased in the nitrogen and phosphorus content in the leaves 1.99 % and 0.46% respectively, and in the bacteria and fungi numbers in the soil, where recorded the highest value 15.43 and 9.23 cfu g⁻¹ dry soil respectively after 45 days, and it gave a significant increase in the basal phosphatase enzyme, where recorded the highest value 96.62 and 103.12 IU/L after 45 and 60 days respectively.

Keywords: Magnetized water, the coverage and the bio-fertilizer

1. Introduction

Maize *Zea mays* belongs to graminiae family, it comes after wheat and rice ranking among the cereals [1]. Bio-fertilizers are living microorganisms which colonize the rhizosphere zone and play important role in facilitating uptake of the essential nutrients required by the plant. [2]. Bio-fertilization is a promising alternative in reducing the use of chemical fertilizers and reducing pollution sources by adding biological vaccines to the soil, seeds or seedlings as a supplement to chemical and organic fertilizers, Vesicular Arbuscular Mycorrhizae (VAM) is one of the most widespread and important mycorrhizal species, because it infects most economic crops such as wheat, barley, corn, cotton and vegetable crops, its inability to grow in industrial medium, due to its saprophytic nutrition on organic matter, so it cannot grow in the absence of the plant host (Al-Samarrai and Al-Tamimi, 2018). Mycorrhizal fungi play an important role in plant nutrition through their continuous supply to most the macro and micro nutrients for plants [3]. Soil enzymes play an important role in the cycle of supplying elements, and the enzyme effectiveness indicates to the soil fertility [4]. The phosphatase enzyme participates in the phosphorous cycle and reveals the behavior of phosphorous-dissolving organisms in soil [5]. Irrigation with magnetized water may change water structure, reduce surface tension, raising dissolvability of minerals and providing nutrients for plants [6]. Magnetic water has many benefits such as decreasing the solubility of salts, the amounts of irrigation water, conductivity, and pH as well as increasing the growth of shoot and root systems, rate of germination, number of fruits, development of inflorescence and fruiting

yield [7]. Nutrients in the soil system are exposed to many interactions that lead to their transformation from available to unavailable form due to the influence of soil moisture and vice versa, the use of mulches, which is a layer of materials covering the surface of the earth, where the importance of mulching is reducing the water evaporation from the soil surface, protects the soil from drying out by direct sunlight and wind, and uses in weed control (Alan F. Parker, 2019). Excessive use of chemical fertilizers not only affects fruit quality, but also causes environmental pollution. [8]. Using bio-fertilizers to reduce the use of chemical fertilizers that pollute the environment and are economically costly, and to provide a suitable environment for the activity of microorganisms. The aim of this study is to evaluate the effect of the magnetized irrigation water, soil coverage and bio-fertilizer on NPK elements percentage in leaves, microbial community and measure the basal phosphatase enzyme in the maize soil.

2. Materials and Methods

The experiment was carried out in a field at the College of Agriculture / University of Diyala, affiliated with the Department of Soil Sciences and Water Resources for maize cultivation (Drachma Hybrid first generation) on (27/7/2020). The field was prepared for cultivation by plowing twice, and leveling the soil, planting the plants in lines, with the distance between lines 0.75 m and between plants 20 cm with irrigation system with stripe drip (T-tape), soil samples were taken from the field at a depth of 0-0.15 m randomly from different areas of the field before planting and dried aerobically and then passed through a sieve with a hole diameter of 2 mm, and physical, chemical and biological

analyses were conducted in the laboratory according to the results in Table (1)

The field experiment was arranged as factorial experiment based on randomized complete block design with the split-split-plot arrangement with three replications, the experiment included 16 treatments that resulted from the interaction of three factors, first factor was the irrigation (non- magnetized water, magnetized water), the second factor was the coverage (non-coverage soil and coverage soil), where the soil was covered by using a black plastic cover, third factor was Bio and Chemical fertilizers (a full dose of phosphate fertilizer without mycorrhizal fungus, a half dose of phosphate fertilizer with mycorrhizal fungus , a quarter dose of phosphate fertilizer with mycorrhizal fungus and only mycorrhizal fungus).

The number of experimental units became (48) units, the plant samples were taken in the stage of the emergence of the male inflorescence after approximately 45 days and in the stage of emergence of the corn cobs after 60 days, the nitrogen fertilizer (urea) was added in three doses (0, 45, 60) days according to the dose recommended by the Ministry of Agriculture, phosphate fertilizer was added scattered with cultivation in the form of super phosphate fertilizer at a rate of 80 kg P₂O₅/ha and according to the type of treatments and levels of addition with the bio-fertilizer, while the potassium fertilizer of the type (K₂SO₄) was added to all treatments at a rate of 50 kg K₂O/ha with the first irrigation water, the commercial product included bio-fertilizer NEUDORFF of German origin and contains the fungus Microrhiza Rhizophagus intraradices, which was recently named instead of the old common name Glomus intraradices, where was added at 50 g/m² with sowing the seeds (figure 1). A device of water magnetizing was installed at the beginning of the drip irrigation lines with magnetic flux density of 1500 Gauss and the water was pumped through the drip irrigation system.

Table 1. The physical and chemical properties of soil		
Measurements	Value	Unit of measurement
Ph	7.3	
Ec	3.25	ds.m ⁻¹
N	1.3	mg. kg ⁻¹
P	2	mg. kg ⁻¹
K	260	mg. kg ⁻¹
Organic matter	1.4	g. kg ⁻¹
Caco ₃	25.5	g. kg ⁻¹
Sand	26.61	g. kg ⁻¹
Silt	30.19	g. kg ⁻¹
Clay	43.2	g. kg ⁻¹
Texture of soil	Clay	
density	1.5	g.cm ³
total bacteria	2.3x10 ⁶	Cfu ⁻¹ dry soil
total fungi	1.7x10 ⁶	Cfu ⁻¹ dry soil



Figure 1. The bio-fertilizer (mycorrhizal fungus)

Laboratory measurements

Estimation of available elements in plants

The plant samples (leaves) were taken randomly from each experimental unit, dried by air, and then placed in an oven at a temperature of 65 °C until the weight was stable, then the samples were ground and 0.2 g was taken for extraction using concentrated sulfuric acid, then a mixture of sulfuric acid and pyrochloric acid (1:1) [9] was added to estimate (nitrogen, phosphorous, potassium), as nitrogen was estimated using the Kjeldahl apparatus described by Bremner [10], as for phosphorous, it was estimated using a spectrophotometer at a wavelength of 340 nm according to Olsen et al. [11]. Potassium was estimated in the same way as phosphorous was estimated using a spectrophotometer at a wavelength of 578 nm according to the method of Jackson [12].

Estimation of the total numbers of bacteria and fungi in the rhizosphere of plants

The numbers of bacteria and fungi was estimated from the soil in the rhizosphere area of the maize plant by dilution method, 1 ml was taken from the dilution 10⁻⁶ and placed in a petri dish with two replications containing the culture medium Nutrient Agar (NA), which was sterilized at a temperature of 121 °C and a pressure of 15 pounds /inch² using the autoclave for a period of 20 minutes, and moved the dish in a circular way to ensure homogeneity [13] and the dishes were incubated at a temperature of 28 °C for 2-3 days and the bacterial colonies were counted, whereas the fungi were estimated using the culture medium Martins Medium (MM), and the same procedure was used to count the bacteria.

Soil enzymes

The basal phosphatase enzyme was evaluated according to the method presented by Bremner [10]:

Using MUB (Modified universal buffer) (PH)11 phosphate (P-nitrophenyle) using a spectrophotometer at a wavelength of 440 nm.

The experimental design

The results were analyzed using the SAS statistical program and the averages were compared according to Duncan's test at a probability level of 0.05 [14].

3. Results and Discussion

Effect of irrigation water, the coverage and bio-fertilizer on nitrogen, phosphorus and potassium percentage in maize leaves

The results of Table (2,3 and 4) showed that superior the mean of magnetized water, mean of the coverage and mean of bio-fertilizer + a half dose of phosphate fertilizer in increase of nitrogen percentage in the plant leaves, which reached 1.80 %,1.70 % and 1.72 %, and phosphorus percentage 0.39%,0.39% and 0.35%, and potassium percentage 3.64%, 3.45% and 3.25% respectively as compared with non- magnetized water, non-coverage soil and adding bio-fertilizer + a quarter dose of phosphate fertilizer.

The interaction between the irrigation water and the coverage was significantly affected on the nitrogen, phosphorus and potassium content in the leaves, which reached the highest value 1.86%, 0.44% and 3.68% respectively when using magnetized water, with coverage soil, while it decreased when using non- magnetized water, with non-coverage soil 1.26%,0.23% and 1.91% respectively.

The effect of the interaction between the irrigation water and bio-fertilizer was significant in the nitrogen, phosphorus and potassium content in the leaves, the highest value was 1.91%, 0.42% and 3.85% respectively when treated with magnetized water, with bio-fertilizer + half a dose of phosphate fertilizer and the lowest value in treatments of non- magnetized water, with bio-fertilizer + a quarter dose of fertilizer phosphate 1.28%,0.27% and 2.34% respectively.

The interaction between the coverage and the bio-fertilizer gave a significant increase in the nitrogen, phosphorus and potassium content in the leaves, where the coverage soil, with bio-fertilizer + a half dose of phosphate fertilizer recorded the highest value 1.86%, 0.40% and 3.58% respectively, while it decreased in the non-coverage soil, with bio-fertilizer + a quarter dose of phosphate fertilizer, which amounted to 1.43%,0.26% and 2.59% respectively.

The triple interaction between the irrigation water, the coverage and the bio-fertilizer gave a significant increase in the nitrogen and phosphorus content in the leaves, where recorded the highest value 1.99 % and 0.46% respectively when treated with magnetized water and the coverage soil and bio-fertilizer + a half dose of phosphate fertilizer, while it decreased in the non- magnetized water, non-coverage soil, and bio-fertilizer + a quarter dose of phosphate fertilizer, which amounted to 1.23 % and 0.20% respectively.

Effect of irrigation water, the coverage and bio-fertilizer on the total number of bacteria in the rhizosphere of plants

The results of Table (5 and 6) showed that the mean of magnetized water, mean of the coverage and mean of bio-fertilizer + a half dose of phosphate fertilizer were significantly superior in the increase of the bacteria numbers in the soil, which reached 7.05 ,7.83 and 10.93 cfu g⁻¹ dry soil after 45 days, and 10.02, 8.85 and 12.59 cfu g⁻¹ dry soil after 60 days respectively as compared with

non- magnetized water, non-coverage soil and only phosphate fertilizer 5.59, 4.80 and 2.70 cfu g⁻¹ dry soil after 45 days, and 6.17, 7.33 and 5.00 cfu g⁻¹ dry soil.

The interaction between the irrigation water and the coverage was significantly affected in the increase of the bacteria numbers in the soil, which reached the highest value 9.33 cfu g⁻¹ dry soil after 45 days when using magnetized water, with coverage soil, whereas reached 10.15 cfu g⁻¹ after 60 days when using magnetized water, with non-coverage soil, while it decreased when using non- magnetized water, with non-coverage soil 4.84 and 4.52 cfu g⁻¹ dry soil after 45 and 60 days respectively.

The effect of the interaction between the irrigation water and bio-fertilizer was significant in the increase of the bacteria numbers in the soil, the highest value was 12.93 and 17.63 cfu g⁻¹ dry soil after 45 and 60 days respectively, when treated with magnetized water, with bio-fertilizer + half a dose of phosphate fertilizer and the lowest value in treatments of non- magnetized water, with only mycorrhizal fungus 2.28 and 3.13 cfu g⁻¹ dry soil after 45 and 60 days respectively.

The interaction between the coverage and the bio-fertilizer gave a significant increase in the bacteria numbers in the soil, where the coverage, with bio-fertilizer + half a dose of phosphate fertilizer recorded the highest value 12.96 and 14.51 cfu g⁻¹ dry soil after 45 and 60 days respectively, while it decreased in the non-coverage, with only phosphate fertilizer, which amounted to 4.76 cfu g⁻¹ dry soil after 60 days.

The triple interaction between the irrigation water, the coverage and the bio-fertilizer gave a significant increase in the bacteria numbers in the soil, where recorded the highest value 15.43 cfu g⁻¹ dry soil after 45 days, when treated with magnetized water and the coverage soil and bio-fertilizer + a half dose of phosphate fertilizer, also it recorded the highest value 17.73 cfu g⁻¹ dry soil after 60 days, when treated with magnetized water and non-coverage soil and bio-fertilizer + a half dose of phosphate fertilizer, while it decreased in the non- magnetized water, non-coverage soil, and only mycorrhizal fungus, which amounted to 2.23 cfu g⁻¹ dry soil after 45 days, and it decreased in the non- magnetized water, coverage soil, and only mycorrhizal fungus which amounted to 3.03 cfu g⁻¹ dry soil after 60 days.

Effect of irrigation water, the coverage and bio-fertilizer on the total number of fungi in the rhizosphere of plants

The results of Table (7 and 8) showed that the mean of magnetized water, mean of the coverage soil and mean of bio-fertilizer + a half dose of phosphate fertilizer were significantly superior in the increase of the fungi numbers in the soil, which reached 5.74 ,3.95 and 5.38 cfu g⁻¹ dry soil after 45 days, and 7.89 , 7.71 and 7.71 cfu g⁻¹ dry soil after 60 days respectively as compared with non-magnetized water, non-coverage soil and bio-fertilizer + a quarter dose of phosphate fertilizer 1.72 , 3.50 and 2.52 cfu g⁻¹ dry soil after 45 days respectively, also as compared with non- magnetized water, non-coverage soil and only phosphate fertilizer 4.77 , 4.95 and 3.63 cfu g⁻¹ dry soil after 60 days respectively.

The interaction between the irrigation water and the coverage was significantly affected in the increase of the fungi numbers in the soil, which reached the highest value 5.98 and 8.39 cfu g⁻¹ dry soil after 45 and 60 days respectively, when using magnetized water, with coverage soil, while it decreased when using non-magnetized water, with non-coverage soil 1.50 and 2.51 cfu g⁻¹ dry soil after 45 and 60 days respectively.

The effect of the interaction between the irrigation water and bio-fertilizer was significant in the increase of the fungi numbers in the soil, the highest value was 8.91 and 10.53 cfu g⁻¹ dry soil after 45 and 60 days respectively, when treated with magnetized water, with bio-fertilizer + half a dose of phosphate fertilizer and the lowest value in treatments of non-magnetized water, with only mycorrhizal fungus 1.91 cfu g⁻¹ dry soil after 45 days, also the lowest value in treatments of non-magnetized water, with only phosphate fertilizer 3.30 cfu g⁻¹ dry soil after 60 days.

The interaction between the coverage and the bio-fertilizer gave a significant increase in the fungi numbers in the soil, where the coverage, with bio-fertilizer + half a dose of phosphate fertilizer recorded the highest value 5.76 and 9.98 cfu g⁻¹ dry soil after 45 and 60 days respectively, while it decreased in the coverage soil, with bio-fertilizer + a quarter dose of phosphate fertilizer, which amounted to 1.90 cfu g⁻¹ dry soil after 45 days, and also it decreased in the non-coverage soil, with only phosphate fertilizer 2.83 cfu g⁻¹ dry soil after 60 days.

The triple interaction between the irrigation water, the coverage and the bio-fertilizer gave a significant increase in the fungi numbers in the soil, where recorded the highest value 9.23 and 11.63 cfu g⁻¹ dry soil after 45 and 60 days respectively, when treated with magnetized water and the coverage soil and bio-fertilizer + a half dose of phosphate fertilizer, while it decreased in the non-magnetized water, coverage soil, and bio-fertilizer + a quarter dose of phosphate fertilizer, which amounted to 1.10 cfu g⁻¹ dry soil after 45 days, and it decreased in the non-magnetized water, non-coverage soil, and only mycorrhizal fungus which amounted to 1.06 cfu g⁻¹ dry soil after 60 days.

Effect of irrigation water, the coverage and bio-fertilizer on measure the basal phosphatase enzyme IU/L in the field

The results of Table (9 and 10) showed that superior the mean of magnetized water, mean of the coverage and mean of bio-fertilizer + a half dose of phosphate fertilizer in increase the basal phosphatase enzyme, which reached 86.70, 86.45 and 88.37 IU/L after 45 days, and 91.95, 91.65 and 92.03 IU/L after 60 days as compared with non-magnetized water, non-coverage soil and bio-fertilizer + a quarter dose of phosphate fertilizer, amounted to 78.52, 78.77 and 76.94 IU/L after 45 days, and 80.67, 80.97 and 81.78 IU/L after 60 days.

The interaction between the irrigation water and the coverage was significantly affected on the basal phosphatase enzyme, which reached the highest value 86.75 and 93.00 IU/L after 45 and 60 days respectively, when using magnetized water, with coverage soil, while it

decreased when using non-magnetized water, with non-coverage soil 70.89 and 71.03 IU/L after 45 and 60 days respectively.

The effect of the interaction between the irrigation water and bio-fertilizer was significant in the basal phosphatase enzyme, the highest value was 95.25 and 100.56 IU/L after 45 and 60 days respectively, when treated with magnetized water, with bio-fertilizer + half a dose of phosphate fertilizer, and the lowest value in treatments of non-magnetized water, with bio-fertilizer + a quarter dose of fertilizer phosphate 74.37 and 75.37 IU/L after 45 and 60 days respectively.

The interaction between the coverage and the bio-fertilizer gave a significant increase in the basal phosphatase enzyme, where the coverage soil, with bio-fertilizer + a half dose of phosphate fertilizer recorded the highest value 93.44 and 98.62 IU/L after 45 and 60 days respectively, while it decreased in the non-coverage, with bio-fertilizer + a quarter dose of phosphate fertilizer, which amounted to 74.12 IU/L after 45 days, and it decreased in the non-coverage, with only phosphate fertilizer, which reached 77.44 IU/L after 60 days.

The triple interaction between the irrigation water, the coverage and the bio-fertilizer gave a significant increase in the basal phosphatase enzyme, where recorded the highest value 96.62 and 103.12 IU/L after 45 and 60 days respectively, when treated with magnetized water and the coverage soil and bio-fertilizer + a half dose of phosphate fertilizer, while it decreased in the non-magnetized water, non-coverage soil, and bio-fertilizer + a quarter dose of phosphate fertilizer, which amounted to 67.75 and 67.87 IU/L after 45 and 60 days respectively.

The results indicate that the treatments of magnetized water were significantly superior on the treatments of non-magnetized water in the ratios of NPK in the plant, the reason may be attributed the magnetized water has an effect on the soil, where it improves the effectiveness of phosphorous dissolution, in addition to increasing the available nitrogen in the soil layers (Al-Mawsili, 2021). The superiority of magnetized water in the measurements of basal phosphatase enzyme in field soil due to the ability of magnetized water to increase the solubility of elements, especially the increase in the solubility of phosphorous, and thus increase the phosphatase enzyme, and this is consistent with Radhakrishnan et al. [15], where the results indicated an increase in the activities of acid and base phosphatase in soil using magnetized water. The coverage treatments was a significantly superior in the percentage of NPK due to the coverage soil increases the availability of water in the root area and increases the moisture content by reducing evaporation from the surface of the soil, which encourages the roots to absorb water and nutrients and thus increase the content of the plant from nutrients and this is consistent with the results of Fakher et al. [16], where the results showed that the coverage treatments led to an increase in the dry weight of the vegetative part of the plant and an increase in the absorbed amount of nitrogen and phosphorous. [17] reported that the coverage led to an increase in the available phosphorous content and thus ease of absorption by the plant. The bio-fertilizer + a half

dose of phosphate fertilizer led to significantly increased in the ratios of NPK in the leaves, this may be due to the role of the mycorrhizae in increasing the availability of phosphorus in the soil and increasing its uptake by the plant, these results are consistent with Al-Samarrai et al. (2007) who stated that the Mycorrhizal fungus led to an increase in phosphorous uptake and a positive interaction between phosphorous and nitrogen elements, and their effect on increasing the content of corn grains of macronutrients NPK. This is consistent with Galvez et al. [18] and Matrood et al. [19] who reported the use of mycorrhizal fungi led to increase the efficiency of phosphorous use at different stages of growth of maize plants and agrees with [20, 21], where the results showed that inoculation with mycorrhizal fungus in maize plant led to a significant increase in the percentage of NPK elements. [22] showed that inoculation with mycorrhizal fungus increased phosphorous uptake and consequently an increase in root elongation. The bio-fertilizer + a half dose of phosphate fertilizer led to significantly increased in the values of basal phosphatase enzyme in the soil and the increase in the density of micro-organisms in the soil because an addition the bio-fertilizer gave the highest

activity of the phosphatase enzyme and the highest density of micro-organisms in the soil, this agrees with Dar et al. [23] who indicated that inoculation with the mycorrhizal fungus gave the highest activity of the phosphatase enzyme in bean roots compared to non-inoculated plants. Matrood et al. [19] explained that the uptake of phosphorus by the mycorrhizal fungus is carried out by several mechanisms, including the secretion of an enzyme phosphatase by the fungus hyphae, which dissolves organic phosphorous, as well as the secretion of Hydroxycids, which hold the calcium, iron and aluminum and leave the associated phosphorous element dissolved in the soil solution.

4. Conclusion

The magnetized water and the coverage of soil and adding the bio-fertilizer, with a half dose of phosphate fertilizer had a clear effect in increase of nitrogen, phosphorus and potassium percentage in the plant leaves, increase of the bacteria and fungi numbers in the soil, and increase the basal phosphatase enzyme in the field soil.

Table 2. Effect of irrigation water, the coverage and bio-fertilizer on nitrogen percentage in maize leaves

Irrigation	Covering	Bio-fertilizer				Interaction between irrigation and covering	Irrigation Mean	Covering mean
		Control only phosphate fertilizer	A half dose of phosphate fertilizer with mycorrhizal fungus	A quarter dose of phosphate fertilizer with mycorrhizal fungus	Only mycorrhizalfungus			
Non magnetizedwater	Uncoveringsoil	1.17 k	1.32 i	1.23 j	1.32 i	1.26 d		
	Coveringsoil	1.45 h	1.73 e	1.33 i	1.68 f	1.54 c		
Magnetizedwater	Uncoveringsoil	1.76 d	1.83 c	1.63 g	1.74 de	1.74 b		
	Covering soil	1.83 c	1.99 a	1.72 e	1.89 b	1.86 a		
Irrigation	Non magnetizedwater	1.31 f	1.52 d	1.28 g	1.50 e		1.40 b	
	Magnetizedwater	1.80 b	1.91 a	1.67 c	1.82 b		1.80 a	
Covering	Uncovering soil	1.46 f	1.58 d	1.43 g	1.53 e			1.50 b
	Coveringsoil	1.64 c	1.86 a	1.53 e	1.78 b			1.70 a
Bio-fertilizer mean 3		1.55 c	1.72 a	1.48 d	1.66 b			

Table 3. Effect of irrigation water, the coverage and bio-fertilizer on phosphorus percentage in maize leaves

Irrigation	Covering	Bio-fertilizer				Interaction between irrigation and covering	Irrigation Mean	Covering mean
		Control only phosphate fertilizer	A half dose of phosphate fertilizer with mycorrhizal fungus	A quarter dose of phosphate fertilizer with mycorrhizal fungus	Only mycorrhizalfungus			
Non magnetizedwater	Uncoveringsoil	0.26g	0.23h	0.20i	0.22h	0.23c		
	Coveringsoil	0.33ef	0.33e	0.35d	0.33e	0.33b		
Magnetizedwater	Uncoveringsoil	0.34de	0.38c	0.32f	0.34de	0.34b		

	Covering soil	0.45a	0.46a	0.40b	0.46a	0.44a	
Irrigation	Non magnetizedwater	0.29d	0.28e	0.27e	0.28e		28.0b
	Magnetizedwater	0.39b	0.42a	0.36c	0.40b		0.39a
Covering	Uncovering soil	0.30c	0.31c	0.26e	0.28d		0.29b
	Coveringsoil	0.39a	0.40a	0.37b	0.40a		0.39a
Bio-fertilizer mean		0.34b	0.35d	0.35d	0.34b		

Table 4. Effect of irrigation water, the coverage and bio-fertilizer on potassium percentage in maize leaves

Irrigation	Covering	Bio-fertilizer				Interaction between irrigation and covering	Irrigation Mean	Covering mean
		Control only phosphate fertilizer	A half dose of phosphate fertilizer with mycorrhizal fungus	A quarter dose of phosphate fertilizer with mycorrhizal fungus	Only mycorrhizal fungus			
Non magnetizedwater	Uncoveringsoil	2.06i	2.00i	1.82j	1.78j	1.91b		
	Coveringsoil	3.29g	3.31fg	2.86h	3.48cd	3.23a		
Magnetizedwater	Uncoveringsoil	3.47cd	3.84a	3.37fe	3.74b	3.61a		
	Coveringsoil	3.54c	3.85a	3.41de	3.90a	3.68a		
Irrigation	Non magnetizedwater	2.67d	2.66d	2.34e	2.63d		2.57e	
	Magnetizedwater	3.50b	3.85a	3.39c	3.82a		3.64a	
Covering	Uncovering soil	2.77f	2.92e	2.59g	2.76f		2.76b	
	Coveringsoil	3.41c	3.58b	3.14d	3.69a		3.45a	
Bio-fertilizer mean		3.09b	3.25a	2.87c	3.22a			

Table 5. Effect of irrigation water, the coverage and bio-fertilizer on the total number of bacteria in the rhizosphere of plants after 45 days (cfu g⁻¹ dry soil*10⁶)

Irrigation	Covering	Bio-fertilizer				Interaction between irrigation and covering	Irrigation Mean	Covering mean
		Control only phosphate fertilizer	A half dose of phosphate fertilizer with mycorrhizal fungus	A quarter dose of phosphate fertilizer with mycorrhizal fungus	Only mycorrhizal fungus			
Non magnetizedWater	Uncoveringsoil	2.53gh	7.36e	7.23e	2.23h	4.84c		
	Coveringsoil	2.76fgh	10.50c	9.76d	2.33h	6.34b		
MagnetizedWater	Uncoveringsoil	3.23f	10.43c	2.33h	3.06fg	4.76c		
	Covering soil	2.26h	15.43c	2.40h	17.23a	9.33a		
Irrigation	Non magnetizedwater	2.65ef	8.93c	8.50d	2.28f		5.59b	
	Magnetizedwater	2.75e	12.93a	2.36ef	10.15b		7.05a	
Covering	Uncovering soil	2.88f	8.90c	4.78e	2.65f		4.80b	
	Coveringsoil	2.51f	12.96a	6.08d	9.78b		7.83a	
Bio-fertilizer mean		2.70d	10.93a	10.93a	6.21b			

Table 6. Effect of irrigation water, the coverage and bio-fertilizer on the total number of bacteria in the rhizosphere of plants after 60 days (cfu g⁻¹ dry soil*10⁶)

Irrigation	Covering	Bio-fertilizer				Interaction between irrigation and covering	Irrigation Mean	Covering mean
		Control only phosphate fertilizer	A half dose of phosphate fertilizer with mycorrhizal fungus	A quarter dose of phosphate fertilizer with mycorrhizal fungus	Only mycorrhizal fungus			
Non magnetizedwater	Uncoveringsoil	3.93h	3.60i	7.33f	3.23j	4.52d		
	Covering soil	7.63e	11.50b	9.10d	3.03jk	7.81c		
Magnetizedwater	Uncoveringsoil	5.60g	17.73a	9.60c	7.66e	10.15a		
	Covering soil	2.86k	17.53a	9.50c	9.66c	9.89b		
Irrigation	Non magnetizedwater	5.78f	7.55e	8.21d	3.13h		6.17b	
	Magnetizedwater	4.23g	17.63a	9.55b	8.66c		10.02a	
Covering	Uncovering soil	4.76h	10.66b	8.46d	5.45f		7.33b	
	Coveringsoil	5.25g	14.51a	9.30c	6.35e		8.85a	

Bio-fertilizer mean	5.00d	12.59a	8.88b	5.90c		
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Table 7. Effect of irrigation water, the coverage and bio-fertilizer on the total number of fungi in the rhizosphere of plants after 45 days (cfu g⁻¹ dry soil*10⁶)

Irrigation	Covering	Bio-fertilizer				Interaction between irrigation and covering	Irrigation Mean	Covering mean		
		Control only phosphate fertilizer	A half dose of phosphate fertilizer with mycorrhizal fungus	A quarter dose of phosphate fertilizer with mycorrhizal fungus	Only mycorrhizal fungus					
Non magnetized water	Uncovering soil	1.40 hi	1.40 hi	1.70 gh	1.53 ghi	1.50 d	1.72 b	3.50 b		
	Covering soil	2.03 fg	2.30 fe	1.10 i	2.30 ef	1.93 c				
Magnetized water	Uncovering soil	4.26 c	8.60 b	4.60 c	4.53 c	5.50 b				
	Covering soil	3.13 d	9.23 a	2.70 de	8.86 ab	5.98 a				
Irrigation	Non magnetized water	1.71 de	1.85 d	1.40 e	1.91 d				5.74 a	
	Magnetized water	3.70 c	8.91 a	3.65 c	6.70 b					
Covering	Uncovering soil	2.83 cd	5.00 b	3.15 c	3.03 c					3.95 a
	Covering soil	2.58 d	5.76 a	1.90 e	5.58 a					
Bio-fertilizer mean		2.70 c	5.38 a	2.52 c	4.30 b					

Table 8. Effect of irrigation water, the coverage and bio-fertilizer on the total number of fungi in the rhizosphere of plants after 60 days (cfu g⁻¹ dry soil*10⁶)

Irrigation	Covering	Bio-fertilizer				Interaction between irrigation and covering	Irrigation Mean	Covering mean		
		Control only phosphate fertilizer	A half dose of phosphate fertilizer with mycorrhizal fungus	A quarter dose of phosphate fertilizer with mycorrhizal fungus	Only mycorrhizal fungus					
Non magnetized water	Uncovering soil	1.40 k	1.36 k	6.23 g	1.06 k	2.51 d	4.77 b	4.95 b		
	Covering soil	5.20 h	8.33 d	7.13 f	7.46 ef	7.03 c				
Magnetized water	Uncovering soil	4.26 i	9.43 c	7.40 ef	8.50 d	7.40 b				
	Covering soil	3.66 j	11.63 a	7.56 e	10.70 b	8.39 a				
Irrigation	Non magnetized water	3.30 h	4.85 e	6.68 d	4.26 f				7.89 a	
	Magnetized water	3.96 g	10.53 a	7.48 c	9.60 b					
Covering	Uncovering soil	2.83 h	5.40 e	6.81 d	4.78 f					7.71 a
	Covering soil	4.43 g	9.98 a	7.35 c	9.08 b					
Bio-fertilizer mean		3.63 c	7.71 a	7.03 b	6.93 b					

Table 9. Effect of irrigation water, the coverage and bio-fertilizer on measure the basal phosphatase enzyme IU/L in the field after 45 days

Irrigation	Covering	Bio-fertilizer				Interaction between irrigation and covering	Irrigation Mean	Covering mean		
		Control only phosphate fertilizer	A half dose of phosphate fertilizer with mycorrhizal fungus	A quarter dose of phosphate fertilizer with mycorrhizal fungus	Only mycorrhizal fungus					
Non magnetized water	Uncovering soil	71.56 h	72.75 h	67.75 l	71.50 h	70.89 b	78.52 b	78.77 b		
	Covering soil	86.50 d	90.25 c	81.00 ef	86.87 d	86.15 a				
Magnetized water	Uncovering soil	82.50 e	93.87 b	80.50 efg	89.75 c	86.65 a				
	Covering soil	78.25 g	96.62 a	78.50 Fg	93.62 B	86.75 a				
Irrigation	Non magnetized water	79.03 d	81.50 c	74.37 F	79.19 d				86.70 a	
	Magnetized water	80.37 cd	95.25 a	79.50 d	91.69 b					
Covering	Uncovering soil	77.03 e	83.31 c	74.12 f	80.62 d					86.45 a
	Covering soil	82.37 c	93.44 a	79.75 d	90.25 d					
Bio-fertilizer mean		79.70 c	88.37 a	76.94 d	85.44 b					

Table 10. Effect of irrigation water, the coverage and bio-fertilizer on measure the basal phosphatase enzyme IU/L in the field after 60 days

Irrigation	Covering	Bio-fertilizer				Interaction between irrigation and covering	Irrigation Mean	Covering mean
		Control only phosphate fertilizer	A half dose of phosphate fertilizer with mycorrhizal fungus	A quarter dose of phosphate fertilizer with mycorrhizal fungus	Only mycorrhizal fungus			
Non magnetized water	Uncovering soil	72.00j	72.87	67.87k	71.37j	71.03d	80.67b	80.97b
	Covering soil	94.12c	94.12c	82.87h	90.12e	90.31c		
Magnetized water	Uncovering soil	82.87h	98.00b	90.37e	92.37d	90.31c		
	Covering soil	84.37g	103.12a	86.37f	98.12b	93.00a		
Irrigation	Non magnetized water	83.06d	83.50d	75.37f	80.75e	91.95a		
	Magnetized water	83.62d	100.56a	88.37c	95.25b			
Covering	Uncovering soil	77.44h	85.44d	79.12g	81.87f	91.65a		
	Covering soil	89.25c	98.62a	84.62e	94.12b			
Bio-fertilizer mean		83.34c	92.03a	81.78d	88.00b			

References

- Amin E, Elagib M. Comparative study of organic and inorganic fertilizers on forage corn (*Zea mays* L.) grown on two soil types. 2001:21-47. Available from: <http://hdl.handle.net/10576/9832>
- Salim HA, Kadhum AA, Ali AF, Saleh UN, Jassim NH, Hamad AR, Attia JA, Darwish JJ, Hassan AF. Response of cucumber plants to PGPR bacteria (*Azospirillum brasilense*, *Pseudomonas fluorescens* and *Bacillus megaterium*) and bread yeast (*Saccharomyces cerevisiae*). *Syst Rev Pharm*. 2021;12(1):969-75.
- Gerdemann J, Trappe J. The Endogonaceae in the Pacific Northwest. *Mycologia Memoir*, no. 5. Mycol Soc Amer, New York Botanical Garden, New York. 1974:1-76.
- He L, Gao Z. Pretreatment of seed with H₂O₂ enhances drought tolerance of wheat (*Triticum aestivum* L.) seedlings. *African Journal of Biotechnology*. 2009;8(22). <https://doi.org/10.5897/AJB09.490>
- Nannipieri P, Ascher-Jenull J, Ceccherini M, Giagnoni L, Pietramellara G, Renella G. Nannipieri, P., Ascher, J., Ceccherini, MT, Landi, L., Pietramellara, G. & Renella, G. 2003. Microbial diversity and soil functions. *European Journal of Soil Science*, 54, 655–670. Reflections by P. Nannipieri, J. Ascher-Jenull, MT Ceccherini, L. Giagnoni, G. Pietramellara & G. Renella. *European Journal of Soil Science*. 2017;68(1):2-5. https://doi.org/10.1111/ejss.2_12398
- Babu V, Triveni S, Subhash Reddy R, Sathyanarayana J. Influence of Application of Different Formulations of Phosphate Solubilizing Biofertilizers on Soil Enzymes in Maize Crop. 2017;6(12):pp. 3771-8. <https://doi.org/10.20546/ijcmas.2017.612.434>
- Grewal HS, Maheshwari BL. Magnetic treatment of irrigation water and snow pea and chickpea seeds enhances early growth and nutrient contents of seedlings. *Bioelectromagnetics*. 2011;32(1):58-65. <https://doi.org/10.1002/bem.20615>
- Salim HA, Salman IS, Jasim BN. IPM approach for the management of wilt disease caused by *Fusarium oxysporum* f. sp. *lycopersici* on tomato (*Lycopersicon esculentum*). *Journal of Experimental Biology and Agricultural Sciences*. 2016;4(6, Suppl.):742-7.
- Cresser M, Parsons J. Sulphuric—Perchloric acid digestion of plant material for the determination of nitrogen, phosphorus, potassium, calcium and magnesium. *Analytica Chimica Acta*. 1979;109(2):431-6. [https://doi.org/10.1016/S0003-2670\(01\)84273-2](https://doi.org/10.1016/S0003-2670(01)84273-2)
- Bremner J. Total nitrogen. *Methods of soil analysis: part 2 chemical and microbiological properties*. 1965; 9:1149-78. <https://doi.org/10.2134/agronmonogr9.2.c32>
- Olsen S, Watanabe F, Danielson R. Phosphorus absorption by corn roots as affected by moisture and phosphorus concentration. *Soil Science Society of America Journal*. 1961;25(4):289-94. <https://doi.org/10.2136/sssaj1961.03615995002500040018x>
- Jackson M. *Soil chemical analysis. Soil chemical analysis*. 2016:930 pp.
- King EO, Ward MK, Raney DE. Two simple media for the demonstration of pyocyanin and fluorescin. *The Journal of laboratory and clinical medicine*. 1954;44(2):301-7. <https://doi.org/10.5555/uri:pii:002221435490222X>
- Al-Rawi KM, Allah A. *Design and Analysis of Agricultural Experiments* Ministry of Higher Education and Scientific Research. University of Al Mosul Dar Al-Kut for Publishing. 2000.
- Radhakrishnan R, Ranjitha Kumari BD. Pulsed magnetic field: A contemporary approach offers to enhance plant growth and yield of soybean. *Plant Physiology and Biochemistry*. 2012; 51:139-44. <https://doi.org/10.1016/j.plaphy.2011.10.017>
- Fakher S, Saleh S. Effect of Soil Surface Coverage and Irrigation Level on Behavior of Nitrogen, Phosphorus and Growth of Corn Plant (*Zea mays* L. Assiut Journal of Agricultural Sciences. 2016;47(6-2):555-68. <https://doi.org/10.21608/ajas.2016.2791>
- Liu C, Jin S, Zhou L, Jia Y, Li F, Xiong Y, Li X. Effects of plastic film mulch and tillage on maize productivity and soil parameters. *European Journal of Agronomy*. 2009;31(4):241-9. <https://doi.org/10.1016/j.eja.2009.08.004>

18. Galvez L, Douds D, Drinkwater L, Wagoner P. Effect of tillage and farming system upon VAM fungus populations and mycorrhizas and nutrient uptake of maize. *Plant and Soil*. 2001;228(2):299-308. <https://doi.org/10.1023/A:1004810116854>
19. Matrood AA, Al-Taie AH. Inhibition Activity of mycorrhizal Fungi *Glomus mosseae* and *G. intradicas* with *Trichoderma harizanum* Against *Rhizoctonia solani* in Okra Plant *Abelmoschus esculentus* (L.). *Basrah Journal of Agricultural Sciences*. 2017;30(2):72-82. <https://doi.org/10.37077/25200860.2017.48>
20. Yang R, Qin Z, Wang J, Zhang X, Xu S, Zhao W, Huang Z. The Interactions between Arbuscular Mycorrhizal Fungi and *Trichoderma longibrachiatum* Enhance Maize Growth and Modulate Root Metabolome under Increasing Soil Salinity. *Microorganisms*. 2022;10(5). <https://doi.org/10.3390/microorganisms10051042>
21. Jarosz Z, Michałojć Z, Pitura K, Dzida K, Koter M. Influence of Fertilization and Mycorrhizae on the Nutritional Status of *Rhododendron* (*Rhododendron hybridum*) in a Nursery. *Agriculture*. 2021;11(6):538. <https://doi.org/10.3390/agriculture11060538>
22. Mai W, Xue X, Feng G, Tian C. Simultaneously maximizing root/mycorrhizal growth and phosphorus uptake by cotton plants by optimizing water and phosphorus management. *BMC plant biology*. 2018;18(1):1-10. <https://doi.org/10.1186/s12870-018-1550-8>
23. Dar MH, Shahid S, Kataria N, Taqvi S. Acid Phosphatase Enzyme Activity and Various Growth Parameters of Common Bean as Influenced by Applications of Different Biofertilizers with Different Levels of Phosphorus Under Intercropping System. Available from: https://hkbpublications.com/Articles/ea6c34b7-70c6-43cc-b501-a32261a273f0_113-121.pdf