Journal of Advanced Zoology

ISSN: 0253-7214

Volume 44 Issue S-3 Year 2023 Page 270:281

The Effect of Biological and Organic Fertilization and Spraying with Manganese on The Readiness and Concentration of Some Elements in The Soil and The Wheat Plant (*Triticum Aestirum L.*)

Tamar Maitham Al-Asadi[1], Mumtaz Sahib Muhammad[2], Sabah Lateef Assi[3]

[1,2,3]Researchers in Soil and Water Technologies, Musayyib Technical College, Al-Furat Al-Awsat Technical University, Babylon, Iraq, 51001

**Corresponding author's E-mail: Tamarmaitham98@gmail.com*

Article History

Received: 06 June 2023
Revised: 12 September 2023
Accepted:04 October 2023

Abstract

In order to investigate the impact of biological and organic fertilizer and manganese spraying, as well as the interaction between these factors, on the readiness and concentration of some elements in the soil and wheat plants (Barcelona variety), a field experiment was conducted in the Tafail area/Al Sahlan village, located 25 kilometers south of the center of Al Hilla/Babil Governorate, during the 2022-2023 agricultural season. All of the features of the investigated were impacted by biofertilization and organic fertilization, however spraying treatment with manganese at a dosage of (80 mg. L-1) was particularly effective at raising element concentrations in the plant.

Keywords: *Biological Fertilizer, Organic Fertilizer, Manganese Spraying*

1. Introduction

In addition to protecting plants from diseases and drought, biofertilizers replenish the soil's fertility and reduce environmental impact [1]. In addition to enhancing yield and quality, this technique boosts the plant's uptake of both macro- and micronutrients, as well as the production of growth hormones including gibberellins and auxins. When it comes to boosting plant growth and nutrient availability, biofertilizers are among the most promising solutions. Recently, its application has grown throughout several places in the Arab world thanks to the incorporation of helpful and effective microorganisms, which are used as bacterial or fungal fertilizers, or both [2].

Organic fertilizer (poultry and sheep manure) is an important part of organic and sustainable soil management since it contains numerous components necessary for plant growth and development in addition to increasing soil fertility. Adding organic material to the soil is an important step in optimizing soil conditions. It's also important because it helps the soil retain water, air, and nutrients by improving its physical and chemical characteristics and activating particular enzymes [3].

Researchers have been focusing on cutting-edge agricultural practices like foliar feeding in recent years. The use of synthetic organic acids sparked the first interest in foliar nutrition, and further study has demonstrated that 85 percent of a plant's demands may be met by foliar application [4]. In order to feed the plant and increase growth and output, it is sprayed on at very low quantities as organic molecules. It helps lessen the damage done to the environment by the overuse of chemical fertilizers [5].

Another sprayed nutrient, manganese, is involved in many key processes inside the plant, including the regulation of osmotic potential of plant cells. It helps build chlorophyll and is involved in the Krebs cycle, in addition to being essential in the production of proteins and lipids. To assist the plant, take in more nitrogen, it activates a group of enzymes involved in oxidation and reduction processes [6, 7].

Wheat (Triticum aestirum L.), a member of the Poaceae family and a staple grain in many diets around the world, is the most valuable crop in Iraq and the world as a whole because of its contribution to national and global food security. One of the most important advantages that made it important in food is a good balance between proteins and carbohydrates in its grains; hence, the name "king of crops" [8]. It ranks high among field crops in terms of cultivated area and production because it is a staple food for most people around the world. For 2019, Iraq's overall output was 4,343,000 megagrams, while the planted area was 6,331,000 dunums and the average yield was 686.1 kilograms per hectare per year (dunum) [9].

2. Materials And Methods

To investigate the impact of biological and organic fertilizer and manganese spraying, as well as their interaction, on the maturity and concentration of some Elements, as well as the growth and yield of wheat plants (Barcelona variety) in a Clay Loam soil as in Al Hilla, Babil Governorate, 32.37°N 44.32°E during the agricultural season 2022-2023, a field experiment was conducted in the Tafail area / Al Sahlan village. Three variables and three repetitions were used in a randomized block design (CRBD) for the experiment. The first involves incorporating bacterial fertilizer (Azotobacter SPP. and Azospillum) into the soil at two different intensities (B0 without adding, B1 with adding biofertilizer). After pollination is complete, wheat seeds are mixed with bacterial biofertilizer in a plastic container for half an hour with the addition of gum Arabic to guarantee the attachment of the pollen to the seeds [10]. The second variable is the use of organic fertilizers (sheep dung), with OM0 indicating no application, OM1 indicating 20 Meg.ha-1, and OM2 indicating 40 Meg.ha-1. The properties of the fertilizer applied are listed in Table (2). Finally, spraying with manganese at three different concentrations (Mn0 = 0 mg. L-1), Mn1 = 40 mg. L-1, and Mn2 = 80 mg. L-1) using hydrated manganese sulphate (MnSO4.H2O) (Mn32%). It is sprayed during the branching, elongating, and endothelial phases of development. It's best to spray first thing in the morning before the temperature rises too high, and some bubblegum may help get the leaves well soaked and boost the efficacy of the spray.

Table (1). The chemical, physical and biological characteristics of the soil studied before planting

Unit	Value	Adjective	
	8.0	pH	
$dS.m^{-1}$	3.2	Ec_e	
$Cmol.L^{-1}$	*20*	Cation Exchange Capacity (CEC)	
%	1.1	Organic Matter	
$mg\ kg^{-1}$ soil	8.9	$CaCO_3$	
	15.1	$CaSO_4.2H_2O$	
$Meq.L^{-1}$	10.22	Calcium	Dissolved Positive Ions
	7.66	Magnesium	
	16.28	Sodium	
	3.15	)$HCO3^-$(	Dissolved Negative Ions
	10.53	Sulfites	
	20.55	Chlorine	
Ppm	29.39	)$N^+ – NH_4$(	Available Nutrients
	11.24	Phosphorous	
	178.66	Potassium	
	1.35	Manganese	
$Cfu\ gm^{-1}$ soil	$4.5*10^9$	Azotobacter SPP.	
	$3*10^5$	Azospirllum	
$meg.m^{-3}$	1.21	bulk density	
$gm.\ Kg^{-1}$ Soil	436	Sand	Soil Particle Size Analysis
	184	Silt	
	380	Clay	
Clay Loam		soil texture	

Table (2) Some characteristics of the sheep manure fertilizer used in the experiment

Unit	Value	Adjective
	8.03	)pH(
dS.m-1	*13.13*	EC
	15.82	C/N
gm. Kgm-1	221.56	Organic carbon
gm. Kgm-1	14.0	Total nitrogen
gm. Kgm-1	12.23	Total phosphorus
gm. Kgm-1	5.32	Total potassium
gm. Kgm-1	399.40	Organic matter

3. Results and Discussion

The effect of biological and organic fertilization, spraying with manganese, and their interaction on the availability of elements in the soil

Effect on the amount of availability nitrogen in the soil (mg.kg^{-1})

Table (3) shows that when comparing the effect of the studied factors on soil nitrogen readiness (mg.kg-1), there are statistically significant differences between the vaccinated treatment (B1) and the unvaccinated treatment (B0), with the former yielding the highest average (21.93 mg.kg-1) and the latter yielding the lowest average (21.08 mg.kg-1). Also, compared to the control treatment (OM0), which produced the lowest average (19.68 mg.kg-1), the organic fertilization treatment (OM2) performed very well, producing the highest average (27.74 mg.kg-1). The use of manganese spray as a treatment had little results. The average was found to be 24.09 mg.kg-1 higher with Mn0.

According to Table 3, the dual interaction treatment between biological and organic fertilization was significant in this trait if the interaction treatment (B1OM2) significantly outperformed the control treatment (B0OM0) and produced the highest average amounting to (30.79 mg.kg-1). Treatment (B1Mn0) resulted in the greatest mean value (22.41 mg.kg-1), whereas the interaction treatment between biofertilization and manganese spraying had no discernible impact. The condition that received neither organic or biological fertilization but was sprayed with manganese (OM2Mn0; 27.87 mg.kg-1) yielded the highest average. While the double interaction of biological and organic fertilization and manganese spraying (B1OM2Mn0; 27.86 mg.kg-1) did considerably outperform the control treatment (B0OM0Mn0), the former did not.

Table (3). The effect of biological and organic fertilization, spraying with manganese, and their interaction on the availability of nitrogen in the soil (mg.kg^{-1})

Average	Mn			OM	B
	Mn2	Mn1	Mn0		
18.40	18.40	18.40	18.42	OM0	
20.14	20.15	20.13	20.15	OM1	B0
24.69	24.70	24.68	24.70	OM2	
20.96	20.25	20.23	22.38	OM0	
27.82	27.80	27.80	27.86	OM1	B1
30.79	31.02	30.33	31.03	OM2	
	23.72	23.59	24.09	Average	
B*OM=0.951	B*OM*Mn=1.648, Mn=0.673			LSD0.05	
	OM * Mn				
19.68	19.33	19.32	20.40	OM0	
23.98	23.98	23.96	24.01	OM1	
27.74	27.86	27.51	27.87	OM2	
OM=0.673	OM*Mn=1.165			LSD0.05	
	B * Mn				
21.08	21.08	21.07	21.09	B0	
21.93	21.70	21.68	22.41	B1	

B=0.549	B*Mn=0.951	LSD0.05

Table 3 shows that when bacterial fertilizer (Azotobacter SPP.) is added to soil, the amount of available nitrogen increases. This is because Azotobacter SPP. bacteria fix atmospheric nitrogen symbiotically at a high efficiency of up to 20 mg air/g sugar consumed [11]. Biological fixation of atmospheric nitrogen has been shown in certain experiments to return to the soil more than 90% of the available nitrogen (Taha, 2007). Soil microorganisms release nitrogen from organic fertilizer (sheep dung) through the decomposition and oxidation processes [12]. This results in a greater quantity of available nitrogen in the soil.

Effect on the amount of availability phosphorus in the soil (mg.kg^{-1})

As can be seen in Table 4, there was a large difference between the average values of soil phosphorus availability (mg.kg-1) produced by the various treatments, with B1 (vaccination) producing the highest average value (29.86 mg.kg-1) and B0 (no vaccination) producing the lowest average value (27.25 mg.kg-1). Organic fertilization (treatment OM2) resulted in the highest average yield (36.92 mg.kg-1), whereas no fertilization (treatment OM0) resulted in the lowest yield (25.88 mg.kg-1). An ineffective treatment was to spray manganese on the wounds. A larger average amount (32.26 mg.kg-1) was produced by the treatment (Mn0) compared to the control group without spraying.

The table shows that the average value generated by the B1OM2 treatment was 41.92 mg.kg-1, significantly higher than the value produced by the B0OM0 treatment (21.96 mg.kg-1). This indicates that the interaction between biological and organic fertilization was important in this regard. Interaction treatment between biofertilization and manganese spraying showed no effect, whereas treatment (B1Mn0) produced the highest average amount (30.79 mg.kg-1). Similarly, combining organic fertilizer and manganese spraying did not improve yields; the highest average yield was found in treatment (OM2Mn0), at 37.58 mg.kg-1.

The average manganese concentration in the interaction treatment (B1OM2Mn0) was 42.12 milligrams per kilogram, whereas in the comparison treatment (B0OM0Mn0), it was only 22.07 milligrams per kilogram.

Table (4) The effect of biological and organic fertilization, spraying with manganese, and their interaction on the availability of phosphorus in the soil (mg.kg^{-1})

Average	Mn			OM	B
	Mn2	Mn1	Mn0		
21.96	22.07	21.75	22.07	OM0	
27.89	27.34	27.01	29.33	OM1	B0
31.91	32.67	30.02	33.03	OM2	
29.79	30.02	29.33	30.02	OM0	
36.82	36.67	36.78	37.02	OM1	B1
41.92	41.77	41.88	42.12	OM2	
	31.76	31.13	32.26	Average	
B*OM=0.664	B*OM*Mn=1.151, Mn=0.470			LSD0.05	
		OM * Mn			
25.88	26.04	25.54	26.04	OM0	
32.36	32.01	31.89	33.18	OM1	
36.92	37.22	35.95	37.58	OM2	
OM=0.470	OM*Mn=0.814			LSD0.05	
		B * Mn			
27.25	27.36	26.26	28.14	B0	
29.86	30.01	28.79	30.79	B1	
B=0.384	B*Mn=0.664			LSD0.05	

Table 4 shows that when bacterial fertilizers (Azotobacter SPP.) are added to the soil, the amount of available phosphorus increases. This is because bacterial biofertilizers can release organic acids like Fumeric acid and Acetate acid, which have the property of liberating phosphate ions from insoluble phosphorus and converting them into dispersible forms. Bacteria's production of organic acids allows them to dissolve phosphorus. Soil phosphorus availability rises after being supplemented with organic fertilizer (sheep dung). This agrees with the findings of [14], who confirmed that increasing the soil's organic matter content increased the soil's availability phosphorus. They attributed this to the organic matter itself containing high concentrations of availability phosphorus, or to the decomposition of organic matter itself, which mineralizes the organic phosphorus into mineral phosphorus that the plant can use. That organic matter is a major source of phosphorus [15] and that adding organic matter to the soil increased available phosphorus.

Effect on the amount of availability potassium in the soil (mg.kg^{-1})

The effect of the studied factors on potassium readiness in the soil (mg.kg-1) varies significantly between treatments, as shown in Table (5). The vaccination treatment (B1) was significantly better, yielding the highest average of (151.99 mg.kg-1), whereas the treatment without vaccination (B0) yielded the lowest average of (148.42 mg.kg-1). Also doing extremely well was the organic fertilization treatment (OM2), which produced an average of 169.37 mg.kg-1 compared to the control treatment's meager 143.17 mg.kg-1. Spraying manganese as part of treatment didn't work. During treatment (Mn0), the mean was 155.45 mg.kg-1, which was the highest of any group.

The table shows that the B1OM2 treatment generated the greatest average value (179.71 mg.kg-1) compared to the B0OM0 treatment's value (137.82 mg.kg-1). This suggests that the interaction between biological and organic fertilization is extremely relevant for this feature. Biofertilization and manganese spraying were both unaffected by treatment (B1Mn+Mn), whereas the treatment (B1Mn0) produced the highest average amount (152.00 mg.kg-1). Organic fertilizer and manganese spraying did not combine to produce the highest-averaging treatment, which had an equivalent of (169.39 mg.kg-1).

The average manganese concentration in the interaction treatment (B1OM2Mn0) was 179.73 mg.kg-1, whereas in the comparison treatment (B0OM0Mn0), it was only 137. mg.kg-1 due to the lack of biological and organic fertilization and the absence of manganese spraying.

Table (5) The effect of biological and organic fertilization, spraying with manganese, and their interaction on the availability of potassium in the soil (mg.kg^{-1})

Average	Mn			OM	B
	Mn2	Mn1	Mn0		
137.82	137.83	137.79	137.83	OM0	B0
148.42	148.43	148.39	148.43	OM1	
159.03	159.03	158.99	159.06	OM2	
148.51	148.52	148.49	148.53	OM0	B1
159.11	159.12	159.09	159.13	OM1	
179.71	179.72	179.69	179.73	OM2	
155.43	155.44	155.41	155.45	Average	
B*OM=0.033	B*OM*Mn=0.057, Mn=0.023			LSD0.05	
		OM * Mn			
143.17	143.18	143.14	143.18	OM0	
153.77	153.78	153.74	153.78	OM1	
169.37	169.38	169.34	169.39	OM2	
OM=0.023		OM*Mn=0.041		LSD0.05	
		B * Mn			
148.42	148.43	148.39	148.44	B0	
151.99	151.99	151.96	152.00	B1	
B=0.019		B*Mn=0.033		LSD0.05	

If you look at Table (5), you'll see that when you add biofertilizer in the form of bacterial fertilizer (Azotobacter SPP.), the amount of available potassium in the soil rises. This is likely because these bacteria help break down organic materials in the soil and convert them into stable organic materials, which can then release additional amounts of potassium. In turn, the addition of organic fertilizer (sheep dung) increases the soil's available potassium because the breakdown of organic matter releases the potassium that had been locked up in the organic matter. In scientific terms, we refer to this as "potassium mineralization." Consequently, plants may take advantage of increased soil potassium availability and utilize it to their advantage [17].

Effect on the amount of manganese available in the soil (mg.kg-1)

Table (6) shows that when comparing the effect of the studied factors on manganese soil readiness (mg.kg-1), there are statistically significant differences between the vaccinated treatment (B1) and the unvaccinated treatment (B0), with B1 yielding the highest average (1.66 mg.kg-1) and B0 yielding the lowest average (1.60 mg.kg-1). Similarly striking was the performance of the organic fertilization treatment (OM2), which produced the highest average yield of (1.89 mg.kg-1) and the lowest yield of (1.65) compared to the control treatment (OM0). Spraying manganese as part of treatment didn't work. With treatment (Mn0), the mean was 1.77 mg.kg-1.

If the average yield increases from the interaction treatment (B1OM2) to the control treatment (B0OM0) by 1.56 mg.kg-1, then the dual interaction treatment between biological and organic fertilization is significant for this trait, as shown in the table. Biofertilization and manganese spraying had no effect on the average yield of 1.68 mg.kg-1 from the treatment (B1Mn0). Since the highest average yield was obtained from the treatment (OM2Mn0), the interaction between organic fertilization and manganese spraying had no effect.

Compared to the control treatment (B0OM0Mn0), which resulted in the lowest average yield (1.56 mg.kg-1), the interaction treatment (B1OM2Mn0) between biological and organic fertilization and manganese spraying resulted in the greatest average (2.18 mg.kg-1).

Table (10). The effect of biological and organic fertilization and spraying with manganese and their interaction on the availability of manganese in the soil (mg.kg^{-1})

Average	Mn			OM	B
	Mn2	Mn1	Mn0		
1.56	1.56	1.57	1.56	OM0	B0
1.59	1.59	1.58	1.62	OM1	
1.65	1.63	1.65	1.67	OM2	
1.75	1.75	1.72	1.77	OM0	B1
1.80	1.78	1.81	1.82	OM1	
2.12	2.10	2.08	2.18	OM2	
	1.73	1.74	1.77	Average	
B*OM=0.017	B*OM*Mn=0.029, Mn=0.012			LSD0.05	
OM * Mn					
1.65	1.66	1.65	1.66	OM0	
1.70	1.68	1.69	1.72	OM1	
1.89	1.86	1.87	1.93	OM2	
OM=0.012	OM*Mn=0.021			LSD0.05	
B * Mn					
1.60	1.59	1.60	1.61	B0	
1.66	1.65	1.65	1.68	B1	
B=0.010	B*Mn=0.017			LSD0.05	

Table (6) shows that increasing the amount of biofertilizer in the form of bacterial fertilizer (Azotobacter SPP.), has the role of these organisms in increasing the amount of available manganese in the soil, which may be due to the ability of these bacteria present in biofertilizers to convert inaccessible manganese in the soil into its available form that plants can easily absorb [18].

Several factors contribute to the increased bioavailability of minerals after organic fertilizer (sheep manure) is added to the soil, including the destruction that releases various materials, including manganese trapped in organic materials, and makes it available for plants to absorb, and the increased bioavailability of minerals. This procedure improves manganese availability and facilitates its uptake by plants [19].

The effect of biological and organic fertilization and spraying with manganese and their interaction on the concentration of elements in wheat plants

Effect on nitrogen concentration in plants (%)

Table (7) shows that the influence of the analyzed variables on the nitrogen content (%) in wheat plants varies significantly. Treatment B1, which included pollination, yielded the greatest average of (1.54%), whereas treatment B0, which did not include pollination, yielded the lowest average of (1.39%). The organic fertilization treatment (OM2) fared the best overall, yielding an average of 1.87 percent, whereas the control group (OM0) averaged just 1.45 percent. The therapy (Mn2) that included manganese spraying was the most effective and yielded the greatest average (1.73%), whereas the control treatment (Mn0) yielded the lowest average (1.57%).

All of the binary interaction coefficients between biological and organic fertilization and manganese spraying were significant in the table, if the intervention treatment (B1OM2) significantly outperformed the interaction treatment (B0OM0), which yielded the lowest average (1.22%), in this characteristic. Also, much better than the interference treatment (B0Mn0), which produced the lowest average (1.31%), was the interference treatment (B1Mn2), which produced the highest average (1.58%). The interference treatment with OM2Mn2 resulted in the greatest average (1.97%) and performed much better than the interference treatment with OM0Mn0, which resulted in the lowest average (1.37%).

Treatment B1OM2Mn2 (which combines biological and organic fertilization with manganese spraying) significantly outperformed the control treatment B0OM0Mn0 (which combines none of these factors), yielding an average of 2.35 percent.

Table (7). The effect of biological and organic fertilization, spraying with manganese, and their interaction on the concentration of nitrogen in wheat plants (%)

Average	Mn			OM	B
	Mn2	Mn1	Mn0		
1.22	1.31	1.27	1.08	OM0	B0
1.40	1.44	1.40	1.35	OM1	
1.54	1.59	1.53	1.51	OM2	
1.68	1.70	1.69	1.66	OM0	B1
1.89	1.98	1.88	1.82	OM1	
2.20	2.35	2.22	2.01	OM2	
	1.73	1.67	1.57	Average	
B*OM=0.011	B*OM*Mn=0.019, Mn=0.008			LSD0.05	
		OM * Mn			
1.45	1.50	1.48	1.37	OM0	
1.65	1.71	1.64	1.59	OM1	
1.87	1.97	1.88	1.76	OM2	
OM=0.008	OM*MN=0.013			LSD0.05	
		B * Mn			
1.39	1.45	1.40	1.31	B0	
1.54	1.58	1.54	1.50	B1	
B=0.006	B*Mn=0.011			LSD0.05	

Table (7) shows that when bacterial fertilizer (Azotobacter SPP.) is added as a kind of biofertilizer, the proportion of nitrogen in the plant increases. This may be because, as proven by [20], the process of fogging atmospheric nitrogen is carried out by Azotobacter bacteria. Among the dirt. Ammonium nitrogen (NH_4^+), a form of nitrogen that plants may utilize, is produced in the soil by the action of bacterial nitrogenase enzymes from atmospheric nitrogen (N_2).

Plant roots and the soil around them get colonized with azotobacter bacteria once biofertilizer containing these bacteria is applied to the soil. Plants may benefit from the fermentation of atmospheric nitrogen by Azotobacter bacteria. Results from research by [21] that examined Azotobacter for its capacity to fix nitrogen and identified the species within the genus showed that efficient and effective species were obtained; these were then put to use as a biofertilizer.

Increasing the plant's nitrogen content is a side effect of using organic fertilizer (sheep dung). Studies have shown that there are a number of causes for this. Biological waste breakdown. Sheep dung is a rich source of organic fertilizer since it includes a wide variety of organic compounds. In the presence of this fertilizer, soil microorganisms begin the process of decomposing and digesting the organic matter, producing nitrate transfer enzymes and other nitrogenous chemicals that plants may utilise. Organic nitrogen in fertilizer is converted by nitrate transfer bacteria and other soil microbes into nitrate (NO3-), a form that is readily available to plants. Beneficial effects on soil structure, including increased organic matter and moisture due to the use of organic fertilizer. The biological processes that help transform nitrogen into a form plant can use are aided by the increased activity of microorganisms in soil that is in better condition [22].

Spraying the plant with manganese (hydrated manganese sulphate (MnSO4.H2O) (Mn32%)) helps raise the plant's nitrogen content. Some studies have suggested that this is due to the increased activity of soil microbes or enhanced soil quality after spraying with manganese. This, in turn, may aid in increasing nitrogen availability and plant uptake [23].

Effect on phosphorus concentration in plants (%)

Table (8) shows that the influence of the tested variables on the phosphorus content in wheat plants (percent) varies significantly. Treatment B1, which included pollination, yielded the greatest average of 0.45%, whereas treatment B0, which did not include pollination, yielded the lowest average of 0.41. Treatment OM2, which included organic fertilization, performed very well and yielded the greatest average (0.53%), whereas treatment OM0, which did not include fertilization, had the lowest average (0.43%). When comparing the two manganese spraying treatments (Mn2 and Mn0), the latter had the lowest average (0.41%), while the former yielded the highest (0.50%).

Each of the table's binary interaction coefficients for biological and organic fertilization and manganese spraying was statistically significant, indicating that the intervention treatment (B1OM2) was statistically superior to the interaction treatment (B0OM0), with B1OM2 producing an average yield of (0.62%) compared to (0.37%) for B0OM0. The average results for the interference therapy (B1Mn1) were (0.82%), whereas the results for the control treatment (B0Mn0) were (0.48%). And whereas the interference treatment (OM0Mn0) resulted in the lowest mathematical average (0.33%), the interference treatment (OM2Mn1) resulted in the highest average (0.58%).

The control treatment (B0OM0Mn0) produced the lowest average (0.32%), whereas the triple interaction of biological and organic fertilization and manganese spraying (B1OM2Mn2) produced the greatest average (0.64%).

Table (8) The effect of biological and organic fertilization, spraying with manganese, and their interaction on the concentration of phosphorus in wheat plants (%)

Average	Mn			OM	B
	Mn2	Mn1	Mn0		
0.37	0.41	0.39	0.32	OM0	
0.43	0.45	0.37	0.45	OM1	B0
0.44	0.34	0.55	0.42	OM2	
0.48	0.56	0.53	0.33	OM0	
0.42	0.58	0.32	0.34	OM1	B1
0.62	0.64	0.61	0.59	OM2	
	0.50	0.46	0.41	Average	
B*OM=0.033	B*OM*Mn=0.057, Mn=0.023			LSD0.05	
		OM * Mn			
0.43	0.49	0.46	0.33	OM0	

0.42	0.52	0.35	0.40	OM1
0.53	0.49	0.58	0.51	OM2
OM=0.061		OM*MN=0.041		LSD0.05
		B * Mn		
0.41	0.40	0.44	0.40	B0
0.45	0.45	0.48	0.40	B1
B=0.019		B*Mn=0.033		LSD0.05

Table (8) shows that when bacterial fertilizer (Azotobacter SPP.) is added as a biofertilizer, the concentration of phosphorus in the plant rises. Phosphate compounds are secreted by azotobacter bacteria, which may explain why they are so effective in dissolving phosphate in the soil and making it accessible to plants. Phosphorus is a crucial nutrient for plant development, and the availability of this element is increased by these compounds [24].

Using organic fertilizer (sheep dung) has the unintended effect of raising the phosphorus concentration in the plant. Soil phosphorus availability increased when organic matter was added, which may explain why the plant's phosphorus concentration rose. This was explained by the abundance of phosphorus in decomposing organic materials or by the mineralization of organic phosphorus into mineral phosphorus.

Spraying the plant with manganese (hydrated manganese sulphate (MnSO4.H2O) (Mn32%)) helps boost the plant's phosphorus content. This agrees with the findings of [23].

Effect on potassium concentration in plants (%)

Table (9) shows that the tested circumstances had a wide range of effects on the potassium content (percent) of wheat plants. In general, the average yield was 2.21 percent higher in Treatment B1, which included pollination, than in Treatment B0, which did not. In terms of average yield, the organic fertilization treatment (OM2) did very well at (2.62%), whereas the control treatment (OM0) performed poorly at (1.86%). The treatment with the highest average yield (Mn2) was obviously superior than the treatment with no spraying (Mn0), which had the lowest yield (2.13 percent).

If the interaction treatment (B1OM2) is significantly better and yields a higher average of (3.04%) compared to the interaction treatment (B0OM0), which yields a lower average of (1.43%), then all the binary interaction coefficients between biological and organic fertilization and manganese spraying are significant. The interference therapy (B1Mn2) performed better than the control treatment (B0Mn0), which performed worse, by a large margin, and yielded an average of (1.79%). The interference treatment with OM2Mn2 resulted in the greatest average of 2.76 percent, whereas the interference treatment with OM0Mn0 resulted in the lowest average of 1.62 percent.

The average yield for Treatment B1, which included both biological and organic fertilization as well as manganese spraying, was 1.03 percent, whereas the average yield for Treatment B2, which included all three, was 3.31 percent.

Table (9) The effect of biological and organic fertilization, spraying with manganese, and their interaction on the concentration of potassium in wheat plants (%)

Average	Mn			OM	B
	Mn2	Mn1	Mn0		
1.43	2.13	1.15	1.03	OM0	B0
2.17	2.18	2.17	2.16	OM1	
2.19	2.21	2.18	2.18	OM2	
2.28	2.31	2.30	2.22	OM0	B1
2.35	2.39	2.33	2.32	OM1	
3.04	3.31	2.97	2.85	OM2	
	2.42	2.18	2.13	Average	
B*OM=0.029	B*OM*Mn=0.050, Mn=0.020			LSD0.05	
		OM * Mn			
1.86	2.22	1.72	1.62	OM0	
2.26	2.29	2.25	2.24	OM1	

2.62	2.76	2.57	2.52	OM2
OM=0.020	OM*MN=0.035			LSD0.05
		B * Mn		
1.93	2.17	1.83	1.79	B0
2.21	2.23	2.22	2.19	B1
B=0.017	B*Mn=0.029			LSD0.05

Table (9) shows that when bacterial fertilizer (Azotobacter SPP.) is added as a kind of biofertilizer, the proportion of potassium in the plant increases. There are a number of possible causes for this, including:

Azotobacter bacteria may enhance soil quality and plant root activity, both of which lead to increased potassium absorption from the soil. Increased root activity aids in the uptake of potassium from the soil.

Soil potassium availability may be increased with the help of Azotobacter bacteria. Plants may be able to take advantage of more potassium if the soil is healthy and contains a lot of organic matter [25].

Potassium levels in plants may be raised by the use of organic fertilizer (sheep dung). This is because the nitrogen, phosphorous, and potassium included in these fertilizers are dissolved into a form that the plant's roots can easily absorb. This agrees with the findings of [17], which revealed that plants benefited from organic fertilizer application at a rate of 30–40% for nitrogen, 60% for phosphorus, and 75–90% for potassium. When using organic fertilizer, extra quantities of organic materials are broken down into nitrogen, phosphorous, and potassium.

Spraying the plant with manganese (hydrated manganese sulphate (MnSO4.H2O) (Mn32%)) helps boost the plant's potassium content. Researchers speculate that this is because manganese stimulates the production of enzymes necessary for potassium absorption. Many plant enzymes, particularly those involved in potassium absorption and transport, need manganese to function. When potassium fertilizers are applied to the soil, manganese plays a crucial function in maximizing the plant's uptake of those nutrients [26].

Effect on manganese concentration in plants (µg. g^{-1})

Table (10) shows that when comparing the effect of the studied factors on the potassium concentration in wheat plants (g.g-1), there are statistically significant differences between the treatments. The vaccination treatment (B1) produced the highest average (666.12 g. g-1) and the treatment without vaccination (B0) produced the lowest average (599.15 g. g-1). Also, compared to the control treatment (OM0), which produced the lowest average yield (629.39 g. g-1), the organic fertilization treatment (OM2) performed extremely well, producing the maximum average (721.17 g. g-1). In terms of average manganese concentration, the sprayed treatment (Mn2) yielded the highest value (701.00 g. g-1) while the non-sprayed treatment (Mn0) yielded the lowest value (657.28 g. g-1).

All of the binary interaction treatments between biological and organic fertilization and manganese spraying were significant in this regard, with the B1OM2 treatment producing significantly higher average manganese concentrations (729.43 g.g-1) than the B0OM0 treatment (which produced the lowest average concentrations). It got up to 528.93 g g-1. Also substantially better than the interference treatment (B0Mn0), which produced the lowest average (569.62 g.g-1), was the interference treatment (B1Mn2), which produced the greatest average (678.24 g.g-1). In addition, OM2Mn2's interference treatment yielded the greatest average of (747.82 g.g-1) compared to OM0Mn0's, which yielded the lowest average of (590.98 g.g-1).

Treatment B1OM2Mn2 (a triple interaction of biological and organic fertilization and manganese spraying) significantly outperformed the comparison treatment B0OM0Mn0 (a single interaction of these three factors), yielding an average of 836.25 g.g-1.

Table (10) The effect of biological and organic fertilization, spraying with manganese, and their interaction on the concentration of manganese in wheat plants (µg.g^{-1})

Average	Mn			OM	B
	Mn2	Mn1	Mn0		
528.93	570.73	552.22	463.85	OM0	B0
618.60	638.15	613.96	603.70	OM1	

649.91	659.38	649.05	641.30	OM2	
729.84	737.18	734.22	718.12	OM0	
758.29	764.32	762.08	748.48	OM1	B1
792.43	836.25	772.78	768.25	OM2	
	701.00	680.72	657.28	Average	
B*OM=0.3	B*OM*Mn=0.520, Mn=0.212			LSD0.05	
		OM * Mn			
629.39	653.96	643.22	590.98	OM0	
688.45	701.23	688.02	676.09	OM1	
721.17	747.82	710.92	704.78	OM2	
OM=0.212	OM*MN=0.368			LSD0.05	
		B * Mn			
599.15	622.75	605.08	569.62	B0	
666.12	678.24	665.74	654.37	B1	
B=0.173	B*Mn=0.3			LSD0.05	

Table (10) shows that when bacterial fertilizer (Azotobacter SPP.) is added as a biofertilizer, the concentration of manganese in the plant increases. The addition of Azotobacter bacteria aids the plant in absorbing not only nitrogen via BNF activities, but also phosphorus and microelements like manganese, iron, and others, which is compatible with what was described [16].

Increasing the plant's intake of organic fertilizer (sheep dung) helps boost manganese levels. Natural chelating compounds with humic substances are formed during organic fertilization, which improves the nutritional status of micronutrients like manganese, iron, calcium, and others, as mentioned by [27].

Spraying the plant with hydrated manganese sulphate (MnSO4.H2O) (Mn32%) helps boost the plant's manganese content. This makes sense for a number of reasons, the most crucial being that it improves manganese absorption. The uptake of manganese from the soil may be facilitated by spraying the area with an aqueous manganese sulphate solution. This is due in part to the fact that manganese is now more concentrated and readily accessible near plant roots [28].

4. Conclusion

This study concludes that the role Bacteria play in breaking down organic fertilizers and releasing the elements in an availability form for the plant is significant in increasing the readiness of the soil content of major nutrients (N, P, K), and minor elements, including manganese (Mn) in particular. Because these components are so vital to the plant's development, they also play a function in raising the proportion of them inside the plant. The research also shown that spraying plants with manganese sulphate aids in crop yield. The importance of these elements in photosynthesis is what causes their abundance.

References:

1. Choudhary, Seema and P.C. Trivedi.2008. Biofertilizer boon for agriculture. In biofertilizer pointer publishers Jarpur 302003 (Raj) India.
2. Garcia-Fraile, Ps E. Menendez and R. Rivas (2015). Role of bacterial bio fertilizers in agriculture and forestry. J. Microbial biotechnology. 2(3):86-94.
3. Haruna, I.M. and M.S. Abimiki (2012). Yield of sesame (Sesamum indicum L.) as influenced by organic fertilizer in the southern Savanna of Nigeria. Sustain. Agric. Res, 1(1):1927-1935.
4. Al-Qaisi, Muhammad Abdel-Sattar Jaata and Aqeel Najm Aboud Al-Muhammadi (2016). The effect of humic acid and spraying with iron and zinc on the growth and yield of Datura (Datura Stranonium L.) plant, Tikrit University Journal of Agricultural Sciences 16(3).
5. Datta, J.k., A. Banerjeel. M. saha sikdar, s. Gupta and N.k. Mondal. 2009. Inpact of combined exposure of chemical, fertilizer. bio fertilizer and Compost on growth, physrology and productivity of Brassica Compestris in old alluvial soil. Journal of Environmental Biology. 30(5): 797-800.
6. Al Nuaimi, Saadallah Najm Abdullah (2000). Principles of Plant Nutrition (translated), Ministry of Higher Education and Scientific Research, University of Mosul, Iraq.
7. Taiz,L. and E. Zeiger (2010). Plant Physiology. 5th (ed.), Sianauer Associates, Sunderland, UK:pp 629.
8. Costa, R.,N. pinherio A. S-Almeida and C. Gomes. (2013). Effect of Sowing date and seeding rate on Wheat yield and test weight under Mediterranean bread Conditions J. Food Agric. 25 (12): 951-961.

9. Central Bureau of Statistics, Directorate of Agricultural Statistics, wheat and barley production for the year 2019. Republic of Iraq.
10. Vincent,J.M. (1970).A manual for practical study of root nodules bacteria IBP. Handbook No.15. Black Well Sci. Publications, Oxford and Ed.inburg. : 125-126.
11. Al-Shahat, Taha Mohamed Ramadan (2007). Biofertilizers and organic agriculture, healthy food and a clean environment. Faculty of Agriculture - Ain Shams University. First edition - Dar Al-Fikr Al-Arabi. Cairo .
12. Cardoza YJ (2011) Arabidopsis thaliana resistance to insects, mediated by an earthworm-produced organic soil amendment. Pest Manag Sci 67(2):233–238.
13. Han, H.S. and Lee, K.D. (2005). Plant Growth Promoting Rhizobacteria effect on antioxidant status, photosynthesis, mineral uptake and growth of Lettuce under soil salinity. Research Journal of Agriculture and Biological Sciences, 1 (Suppl 3), p:210-215
14. Al-Husseini, Iyad Kazem Ali. (2010). Inheritance and development of earning potential for some soils northern Iraq. Doctoral thesis. faculty of Agriculture. Baghdad University.
15. Wandruszka, Ray Von. (2006). Phosphorus retention in calcareous soils and the effect of organic matter on its mobility. Geochemical Transactions. 7 (6): 1-8.
16. Velmourougane, K., Prasanna, R., Chawla, G., Nain, L., Kumar, A., & Saxena, A. K. (2019). Trichoderma–Azotobacter biofilm inoculation improves soil nutrient availability and plant growth in wheat and cotton. Journal of basic microbiology, 59(6), 632-644
17. Doan, T. T., T. Henry-Des-Tureaux, C. Rumpel, J. L. Janeau, and P. Jouquet. 2015. Impact of compost, vermicompost and biochar on soil fertility, maize yield and soil erosion in Northern Vietnam: A three-year mesocosm experiment. The Science of the Total Environment 514:147–54. doi: 10.1016/j.scitotenv.2015.02.005.
18. Barman, M.; S.Paul; A.G. Choudhury; P.Roy and J.Sen.2017. Biofertilizer as prospective input for sutainable agriculture in India. Int. J. Curr. Microbiol. Appl. Sci, (6):1177-1186
19. Santos CER, Andrade MMM, Stamford NP, Freitas ADS, Sousa CA, Lira JMA (2013) Effects of biofertilizer with Rev Environ Sci Biotechnol
20. Nain L, Rana A, Joshi M, Jadhav SD. 2010. Evaluation of synergistic effects of bacterial and cyanobacterial strains as biofertilizers for wheat. Plant Soil;331:217-30.
21. Ghimire, R.; Adhikari, K.R.; Chen, Z.-S.; Shah, S.C.; Dahal, K.R.2011. Soil organic carbon sequestration as affected by tillage, crop residue, and nitrogen application in rice–wheat rotation system. Paddy Water Environ., 10, 95–102.
22. Al-Tamimi, Muhammad Salal, Amal Radi Al-Quraishi, Bayader Marza Odeh, and Kifah Abdul Hussein Al-Duraie. (2016). The effect of organic fertilization and spraying with manganese on the growth and yield of wheat. Al-Furat Journal of Agricultural Sciences. 8(4): 325-331.
23. Gherardi, M. J., & Rengel, Z. (2004). The effect of manganese supply on exudation of carboxylates by roots of lucerne (Medicago sativa). Plant and Soil, 260, 271-282
24. El-Ghamry, A. M., A. M. Abd El-Hamid and A. A. Mosa (2009). Effect of farmyard manure and foliar application of micronutrients on yield characteristics of wheat grown on salt affected soil. American-Eurasian J. Agric. &Environ. Sci. 5(4):460-465.
25. Naeem, M. A., M. Khalid, M. Aon, G. Abbas, M. Amjad, B. Murtaza, W. U. D. Khan, and N. Ahmad. 2018. Combined application of biochar with compost and fertilizer improves soil properties and grain yield of maize. Journal of Plant Nutrition 41(1):112–22. doi: 10.1080/01904167.2017.1381734.
26. Al-Alusi, Youssef Ahmed Muhammad. (2002). The effect of spraying with iron and manganese in soil varying in potassium preparation on the growth and yield of wheat. Doctoral thesis, College of Agriculture - University of Baghdad. Iraq.
27. Al-Halafi, Intisar Hadi Hamidi and Mukhaled Ibrahim Falih. (2017). Response of yields of two varieties of bread wheat to mineral, biological and organic fertilizers. Iraqi Agricultural Sciences Journal. 48(6): 1661-1671.
28. Al-Khafaji, Doaa Ahmed Abdel-Razzaq and Mumtaz Sahib Hakim. 2021. The effect of biological fertilization and spraying with manganese and copper on the growth and yield of wheat plants, Master’s thesis, Al-Furat Al-Awsat Technical University.