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The Interacting effect of sulphur oxidizing bacteria *Thiobacillus thioparus* and organic matter on the growth and yield of wheat (*Triticum aestivum* L.)

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Abstract

The biological study experiment included the effect of inoculation with sulphur-oxidizing bacteria *T. thioparus* and its interaction with levels of organic matter. In addition, a biological vaccine for *T. thioparus* and the second factor is the organic matter at three levels control by without adding (0%, 0.5%, 1 %) the results of the statistical analysis showed that the biological Inoculation.

T. thioparus treatment gave the highest levels of grain yield, numbers of *T. thioparus* bacteria, soil content of available nitrogen and soil content of available sulphur (4.74 $mg.h^{-1}$, 0.22×10^4 CFu gm^{-1} soil, 54.27 mg N kg $soil^{-1}$, 3131.39 mg S kg $soil^{-1}$) respectively.

While treatment with the second level of organic matter 1% gave the highest levels of the numbers of *T. thioparus* bacteria and the nitrogen content available in the soil and the sulphur content available in the soil (0.23×10^4 CFu gm^{-1} soil, 5163 mg N kg $soil^{-1}$, 2796 mg S kg $soil^{-1}$) respectively.

In addition to the interactive treatments of biological inoculation of *T. thioparus* and organic matter of B_1O_2 of *T. thioparus* numbers, nitrogen content available in soil and soil sulphur content available (0.24×10^4 CFu gm^{-1} soil, 59.40 mg N kg $soil^{-1}$, 3326.87 mg S kg $soil^{-1}$) respectively.

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Key words: *Thiobacillus thioparus*, organic matter, wheat.

Introduction

The Iraqi soil is generally characterized by a low content of organic matter and, consequently, a weak activity of microorganisms in it and a high degree of soil interaction with high rates of carbonate minerals. Excessively chemical, as the trend of the world recently is to use several safe alternatives to improve soil properties and its content of phosphorous and nitrogen (Osip et al, 2000). Al-Samarrai et al (2006) have shown that bio fertilizer releases hormones and substances that encourage growth. Also, the bio-fertilizer works to absorb the nutrients and water present in the soil by the plant and works to improve the properties of sandy soil by collecting its granules due to the secretion of sugary substances (Al-Balkhi, 1990). As Klopper et al (1986) pointed out that agricultural progress requires better use of the effectiveness of microorganisms and their biological use in the soil to provide the plant with some nutrients as a cheap source and an environmentally safe alternative compared to chemical fertilizers. To live effectively in the rhizosphere soil of the plant. Devai and Delaun (2000) indicated that there are large numbers of microorganisms that have the ability to oxidize the nutrient sulphur, including the autotrophic sulphur oxidizing organisms that belong to the genus Thiobacillus, and some of the trophic sulphur bacteria that are responsible for the oxidation of sulphur.

The most important and necessary role of organic matter in the soil comes through the product of its decomposition, as the addition of organic fertilizers from animal or plant wastes has a high decomposition activity compared to the competition of microorganisms in the soil, and here highlights the role of adding organic matter by preserving the chemical properties of soil And physical and fertility, which works on similar agricultural production by feeding the plant with nutrients that stimulate growth Mabuhay et al , 2006. Wheat is considered one of the most important cereal crops (Uppal and Sriinivas, 2004), where 80% of the daily diets of peoples enter, as the wheat crop is grown in almost most parts of the world, and it is one of the four

important crops grown in the world (Guthrie, 1989).

Material and methods

A biological experiment was designed to study the effect of inoculation with bacterial isolates of *T. thioparus* and their interaction with levels of organic matter, in addition to studying the effect of adding a bio-bacterial pollen by collecting and inoculating wheat seeds with it. The experiment was designed according to the design of randomized complete sectors (RCBD) and cultivation was carried out at the second agricultural research and experiment station of the College of Agriculture-University of Al-Muthanna after ploughing the Soil in a perpendicular manner, after which the processes of levelling and smoothing were carried out and then the land was divided into experimental units and the area of each experimental unit was 3 square meters (2m×1.5m) and then the cultivated by Cultivated by Lines on 26/11/2020 using two factors for the experiment, the first factor adding the bacterial cultivated by B at two levels B_0=without addition and B_1=adding the Bacterial inoculation of *Thiobacillus thioparus*. As for the second factor, adding organic matter O at three levels: O_0= Control, O_1=adding 0.5% of organic matter and O_2=adding 1% of organic matter. The soil was planted with wheat Seeds inoculated with different Inoculation according to the above-mentioned treatments, at a rate of 5.14g Seeds per line on 2020-2021. Fertilizers were added according to the treatments with a complete fertilizer recommendation for each of the nitrogen fertilizers in the form of urea (46%N), in two batches, the first at planting and the second at the elongation stage, noting that the fertilizer recommendation is 100% NH^{-1}Kg, and phosphate fertilizer was added in one batch before planting on Triple superphosphate fertilizer (20%P), noting that the fertilizer recommendation is 75% P^{-1}Kg and the potassium fertilization process was carried out in one batch when planting in the form of potassium sulphate (50%K2O), noting that the fertilizer recommendation is 100% K Kg ha^{-1}, and a level of 0.5% was added and 1% level of organic matter, the crop was harvested after completion of maturity on 04/30/2021.

Results and Discussion

(1) Plant Height (cm):

The results of the statistical analysis in Appendix (1) indicated that there was no significant effect of the treatments of biological vaccines and levels of organic fertilizer and the interaction between them on plant height (cm).

Table (1): Effect of bio pollen and levels of organic matter and the interaction between them on plant height (cm):

The average	O_2	O_1	O_0	Transactions
107.7	**108.2**	**112.5**	**102.4**	**B_0**
110.0	**111.8**	**108.2**	**109.9**	**B_1**
	110.0	**110.4**	**106.2**	**The average**
	B*O	**O**	**B**	
	N.S	**N.S**	**N.S**	**L.S.D. 0.05**

2. Grain yield ($mg.h^{-1}$):

Table (2) shows that the results of the effect of the biological vaccine on grain yield showed a significant difference as the single biofilm treatment of *T. thioparus* outperformed the control treatment, as it recorded rates of 4.74 $mg.h^{-1}$ It reached 3.19 $mg.h^{-1}$, and the reason for this may be due to the role of the biofilm in providing an ideal environment for microorganisms by increasing the secretion of organic acids by the microorganisms that make up it, which helps in increasing the mineralization of nutrients and this is consistent with what was found (Seneviratne et al, 2005).

The results of Table (2) also showed a significant superiority of the bilateral interaction treatments between the bacterial bio inoculum and levels of organic matter (B_0O_1, B_0O_2, B_1O_2, B_1O_1, B_1O_0) over the comparison treatment, as the grain yield rates were recorded (4.85, 4.74, 4.64, 3.82, 3.57) $mg.h^{-1}$ sequentially, while the comparison treatment recorded the lowest rate of 2.17 $mg.h^{-1}$, and this may be due to the contribution of biological fertilization that provides part of

the nutrients and in turn directly or indirectly affects plant growth during the growing season and increases the efficiency of operations The vitality of the plant, which increases the growth of the root and vegetative total of the plant, and this makes the plant more vital in absorbing nutrients and then transporting them to their storage places, which are grains, and this is consistent with what was found by (Buddhika et al,2012).

Table (2): The effect of the bio-vaccine and the levels of organic matter and the interaction between them on the grain yield ($Mg.h^{-1}$):

The average	O_2	O_1	O_0	Transactions
3.19	**3.82**	**3.57**	**2.17**	**B_0**
4.74	**4.64**	**4.74**	**4.85**	**B_1**
	4.23	**4.15**	**3.51**	**The average**
	B*O	**O**	**B**	
	1.427	**N.S**	**0.824**	**L.S.D. 0.05**

3. Preparation of *T. thioparus* ($\times 10^4$ CFu gm^{-1} soil):

The results in Table (3) showed that there were significant differences between the fertilization treatment with the biological vaccine and the comparison treatment in the character of the numbers of *T. thioparus* bacteria, where a rate of 0.22×10^4 CFu gm^{-1} soil was recorded, with an increase of 16% from the comparison treatment, which recorded the lowest rate of 0.19×10^4 CFu gm^{-1} soil, and the results showed the superiority of the two treatments The level of organic fertilization O_2, O_1 sequentially in the character of bacteria numbers *T. thioparus* they recorded rates of 0.23×10^4 CFu gm^{-1} soil and 0.22×10^4 CFu gm^{-1} soil sequentially with an increase of 38%, 44% compared to the comparison treatment that recorded the lowest rate of 0.16×10^4 CFu gm^{-1} soil . It increases bacterial activity by secreting enzymes, organic matter, temperature and biological balance, and it is one of the most important factors that contribute to the spread, distribution and activity of sulphur-reducing bacteria, and

this is consistent with what was stated (Westrich and Berner, 1988).

The results of fertilization with bacterial inoculum and organic matter showed significant differences (B_1O_2, B_1O_1, B_0O_2, B_0O_1, B_1O_0) at rates reaching (0.24, 0.24, 0.23, 0.20, 0.17) $\times 10^4$ CFu gm^{-1} soil sequentially with the comparison treatment that recorded the lowest rate of 0.14×10^4 CFu gm^{-1} soil .

Table (3): Effect of biofilm and levels of organic matter and the interaction between them on the preparation of *T. thioparus* x 10^4 CFu gm^{-1} soil:

The average	O_2	O_1	O_0	Transactions
0.19	**0.23**	**0.20**	**0.14**	**B_0**
0.22	**0.24**	**0.24**	**0.17**	**B_1**
	0.24	**0.22**	**0.16**	**The average**
	B*O	**O**	**B**	
	0.06506	**0.04600**	**0.03756**	**L.S.D. 0.05**

4: Ready nitrogen content in soil (mg N kg $soil^{-1}$):

The results shown in Table (4) showed that the addition of the bio-vaccine had a significant effect on the nitrogen concentration in the soil, as the results indicated the superiority of the bio-vaccine treatments over the comparison treatment, regardless of the type of inoculum. Live vaccine, and with no significant differences between vaccination treatments, where the B_1 treatment scored the highest rate of 54.27mg N kg $soil^{-1}$, an increase of 46% over the comparison treatment that scored 37.24mg N kg $soil^{-1}$ (Shafer et al., 2014).

On the other hand, the results of Table No (4) showed the effect of adding organic matter on the quality of the ready nitrogen content in the soil. The results indicated that the level of organic fertilization (O_1, O_2), which was recorded (51.63, 45.88) mg N kg $soil^{-1}$ sequentially compared to the treatment of no addition O_0, which scored 39.75mg N kg $soil^{-1}$, and this is attributed to the reason for the plant's uptake of nitrogen, which is the function of ready nitrogen in the soil and this is consistent with what was found (Cooper, 2008).

As for the superiority of the coefficients of adding biological vaccine and organic materials (B_0O_1, B_0O_2, B_1O_0, B_1O_1, B_1O_2) significantly outperformed the rest of the treatments as it scored (59.40, 54.07, 49.33, 43.87, 37.70)mg N kg $soil^{-1}$ sequentially while the comparison treatment (B_0O_0) recorded the lowest rate

of 30.17mg N kg soil^{-1} and this increase may be due to the fact that The use of a double inoculum may lead to root colonization and increased soil acidity, with the secreted H^+ concentration up to four times that compared to the single inoculum (Senerivatne et al, 2009) and increased acidity at micro-sites near the root hairs leading to an increase in NH^{+4} concentration in Soil solution (Xu et al, 1997).

Table (4): The effect of the bio-vaccine and the levels of organic matter and the interaction between them on the content of ready nitrogen in the soil (mg N kg soil^{-1}):

The average	O_2	O_1	O_0	Transactions
37.24	**43.87**	**37.70**	**30.17**	**B_0**
54.27	**59.40**	**54.07**	**49.33**	**B_1**
	51.64	**45.89**	**39.75**	**The average**
	B*O	**O**	**B**	
	2.117	**1.497**	**1.222**	**L.S.D. 0.05**

5: Concentration of ready sulphur in soil (mg S kg soil^{-1}):

The results of Table (5) showed that the bacterial bio-inoculation had a significant effect on the content of ready sulphur in the soil compared to not adding it. The results of the table indicated the superiority of the B1 treatment, as the highest rate of sulphur content in the soil was recorded at 3131.39 mg S kg soil^{-1} with an increase of 48.7% of the comparison treatment, which recorded 2106.27 mg S kg soil^{-1}, and the reason may be due to the fact that inoculation with sulphur oxidizing bacteria leads to an increase in the availability of sulphur in the soil, as it oxidizes incompletely oxidized sulphur compounds to sulphate (Soaud et al, 2011).

The results also showed in Table (5) the clear effect of the levels of organic fertilizers on the sulphur content in the soil, as significant differences were obtained between the levels of the added organic fertilizers starting from the comparison treatment O_0 to the highest level of O_2, as the treatment of organic fertilizer at the third level recorded an average rate of 2796.86 mg S kg soil^{-1} with a percentage of An increase of 13% from

the control treatment, and the level of the second organic fertilization O_1 outperformed the O_0 treatment, as it recorded an average of 2591.51 mg S kg soil^{-1} Microscopic.

On the other hand, it is clear from the table that there are significant differences between the bilateral interaction treatments between bio-vaccine and organic fertilizer in the character of sulphur content in the soil (B_1O_2, B_1O_1, B_1O_0, B_0O_2, B_0O_1) The highest rates were (3327, 3123, 2945, 2266, 2060) mg S kg soil^{-1} from the comparison treatment that recorded the lowest rate of 1992.49 mg S kg soil^{-1}.

Table (5): Effect of bio-vaccine and organic matter levels and the interaction between them on the content of ready sulphur in soil (mg S kg soil^{-1}):

The average	O_2	O_1	O_0	Transactions
2106.27	**2266.84**	**2060.48**	**1992.49**	**B_0**
3131.39	**3326.87**	**3122.54**	**2944.75**	**B_1**
	2796.86	**2591.51**	**2468.62**	**The average**
	B*O	**O**	**B**	
	88.8	**62.8**	**51.3**	**L.S.D. 0.05**

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