The Effect of Biological Inoculation of Azotobacter chroococcum and Glomus mosseae on Growth and Yield of Zea mays L. under Different Levels of Water Stress

Tabarak Rahim Shuppar1 and Jawad Abdl-Kadhim Kamal1

1College of Agriculture, University of Al-Qadisiyah, Iraq.

Email: jawad.alshabbany@qu.edu.iq

Abstract

This study aimed to investigate the effect of inoculation with the bacteria *Azotobacter chroococcum* and the fungus *Glomus mosseae* on the growth and yield of *Zea mays* L. variety (Baghdad 3) under different levels of water stress. The field trial was conducted in the fall season of 2020 in Diwaniyah Governorate - Afak county fields. The experiment was designed according to the Randomized Complete Block Design (R.C.B.D) design with three replications. The treatments were distributed randomly. Three levels of irrigation were used in the experiment, namely (I4) irrigation every four days, (I7) irrigation every seven days, (I10) irrigation every ten days, and inoculation levels. Biological inoculation with the bacteria at two different levels (B1) inoculation with bacteria *A-chroococcum*, (B0) without inoculation. Fungal inoculation with *G-mosseae* at two inoculation levels (F1) and without inoculation with (F0). In addition to the overlapping treatment between fungus and (B1F1) bacteria. The treatments’ means were compared using the least significant difference (L.S.D) test at a probability level of 5%. The results present that the treatments inoculated with fungi or bacteria, or both, and for a seven-day irrigation period, significantly increased the values of the traits of (dry weight of the root mass, leaf area, chlorophyll concentration, and total yield). The highest means values were (5739) g.Plant\(^{-1}\), (18.04) cm\(^2\).plant\(^{-1}\), (58.93) SPAD, and (9.104) tons.ha\(^{-1}\), respectively, compared to the treatments (no application + irrigation every ten days) that gave (13.75) g.Plant\(^{-1}\), (2539) cm\(^2\).plant\(^{-1}\), (3.921) SPAD, and (29.07) tons.ha\(^{-1}\).

Keywords: Maize, Azotobacter chroococcum, Glomus mosseae, Bio-fertilizers.

1. Introduction

*Zea mays* L. is an essential crop around the world. North America its origin because there are a lot of variations [1]. Maize is crucial and is used as food and fodder for animals with all its grains and vegetative parts. It also has a role in paper manufacturing and extracting various oils from its seeds and starch. It is a concentrated feed because it contains carbohydrates, proteins, and oil (81, 10.6, and 2) %. It is grown in two seasons globally and is characterized by its adaptability to different environmental conditions. It occupies third place in terms of productivity after wheat and barley [2,3]. The cultivated area in the world for the year 2012 is (182) million hectares, with a grain yield of (824) million/tons. The average production is (4527.50) kg.ha\(^{-1}\). The cultivated area in Iraq of the crop is (125,000) hectares in 2012 [4].

Bio vaccines are one of the essential fertilizers used in agricultural systems. They are organic fertilizers that contain many microorganisms that can provide the plant with the necessary needed elements and provide the necessary nutrients for the plant in an available and accessible manner. Thus, it reduces or avoids the use of chemical fertilizers, which reduces pollution and avoids the use of mineral fertilizers and chemical pesticides, which leads to lower agricultural costs [5].

One of the vital vaccines used is *Azotobacter*. This bacterium belongs to the family *Azotobacteraceae*, whose members are free-living, compulsive, heterotrophic, found in neutral basal soils, and their number rarely exceeds (104,105) cells [5]. *A-chroococcum* bacteria use some organic acids, sugars, and alcohol derivatives as a carbon source: glucose, sucrose, fructose, methyl, and formate. These bacteria are found in soil, water, and on plant root surfaces to benefit from the root secretions of sugars, amino acids, and vitamins [6]. The German researcher Frank used the word microscopic (mushroom + root) for the first time in 1885 to describe the symbiotic relationship between mushrooms and roots.
Mycorrhizae live in symbiosis with most plant roots. About 90% of the known families are within the aquatic, brackish, and desert plants, except for the cruciferous family. The mycorrhizal fungus affects clusters’ formation because of its symbiosis that causes significant changes in the root, where the fungus has a mycelium of extended strings that increase soil aggregation and stability. Mycorrhizae fungus increases the amounts of the growth regulators released in the growth medium (cytokinin, gibberellin, and auxin), which have an active role in the growth of root hairs [7]. The relationship between the fungus and the plant is symbiotic because it benefits the fungus and the plant and the fungus’s role in preparing the plant with major and minor elements. It also plays a role in protecting the plant from pathogens present in the soil and its role in increasing plants’ ability to withstand stress and drought conditions [8]. Several studies have indicated that water stress leads to many phenotypic and physiological changes in plants. It works to reduce plant height and leaf area and reduce the chlorophyll content of leaves and their relative content, which leads to a reduction in the rates of photosynthesis and accumulation of dry matter present in the plant [9].

Irrigation periods are essential in plant growth and productivity and are reflected in the field plant characteristics, thus affecting the yield components. Literature has shown that the flowering periods and the end of the season are susceptible to water stress due to the decrease in photosynthesis outputs, which affects the growth and formation of arbors due to part of the male and female inflorescence [10,11]. Similarly, the lack of water directly affects hormones and enzymes' effectiveness in the ovaries, where fertilization reduces the number of grains, then the final grain yield [12].

This study aimed to:
1. Study the effect of *Azotobacter chroococcum* bacteria on growth and yield of yellow maize.
2. Investigate the effect of *Glomus mosaeae* fungus on drought resistance, growth, and yield of maize.
3. Study the effect of irrigation periods on growth and yield of yellow maize.
4. Study the interaction between *Glomus mosaeae* and *Azotobacter chroococcum* and the irrigation periods on maize growth and yield.

2. Methods and materials

A field experiment was conducted in loam sandy soil to cultivate the yellow corn crop *Zea mays*. L of the cultivar (Baghdad 3) in the fall season of 2020 in Qadisiyah Governorate/Afak county. The field soil has good qualities and is suitable for cultivation. Samples were taken from the soil's surface horizon randomly to more than one site in the field to obtain a homogeneous soil sample for testing. Soil's physical, chemical, and biological properties before planting, the soil was air-dried and sifted with a sieve with a diameter of (2) mm aperture. The physical, chemical, and biological properties were then estimated.

2.1. Seeds preparation and inoculation for planting

Maize seeds *Zea mays*. L (Baghdad 3) were used for cultivation in the field experiment. The Mycorrhizae inoculation consisting of (spores, infected roots, and dry soil) was used. *Glomus mosaeae* was obtained from the Agricultural Research Service, Ministry of Science and Technology, Zafarania. *Azotobacter chromium* inoculation was also used. The seeds were inoculated with the bacterial vaccine *A. chroococcum* after seeds surface sterilization with mercury chloride and 95% alcohol. Seeds were washed several times with distilled water to get rid of alcohol and suspended matter. They were air-dried and then dipped in prepared gum arabic in a ratio of 1:10 (gum-water) for eight minutes to ensure the adhesion of the bacterial inoculum to the washed seeds. Inoculated with previously prepared bacterial inoculum by mixing 50% of the liquid culture *A. chroococcum* and left for (15) minutes to ensure seed pollination [13]. The uninoculated seeds were sown first to avoid contamination, which done in the shade, away from the sun. Seeds were left uninoculated as a comparison treatment. Preparation of the fungal vaccine: *Glomus mosaeae* (spores, infected roots, and dry soil) was applied by adding it to the seedbed before the sowing.

3. Experimental design

The experiment was designed according to the Randomized Complete Block Design (R.C.B.D) with three replications. The trial parameters were: treatment of mycorrhiza inoculation (G), treatment of inoculation with *A. azotobacter*, treatment of overlap between fungi and bacteria (A + G), comparison treatment for (C0), with three irrigation periods of (4, 7, and 10) days. The treatments were distributed randomly on the experimental units. The field was divided into three replications of (36) experimental units. The area of one experimental unit is (4 x 4 = 16) m², leaving (1.5) m between each experimental unit and the other and (2) m between each replicate and another to control the irrigation process. The experimental unit was divided into (5) lines. The distance among lines is (75) cm and between plants within a line is (25) cm. The field soil was prepared for planting from plowing, smoothing, and leveling.
Mycorrhizae inoculation was applied and distributed under the seeds, (5) cm wide and (5) cm thick, with the seeds being inoculated with the *Azotobacter bacteria* an hour before planting to ensure the adhesion of the largest number of bacterial cells to the seeds. The planting date took place on the 29th of July 2020. Three seeds were placed in one seedbed with a grafting process a week after planting to compensate for the loss. Crop service and manual weeding were also carried out to get rid of the bushes continuously.

4. The studied plant traits

4.1. Field traits

1. Plant height (cm): Four plants were picked randomly from each treatment and measured their height with a tape measure from the plant's site with the soil surface to the plant's highest peak and extracted the average plant height.
2. Chlorophyll ratio: The chlorophyll percentage of four leaves from four plants was measured randomly by the SPAD device.
3. Leaf area (cm².Plant⁻¹): The leaf area was measured at the end of the season, and the rule was applied to leaf length x width x 0.75, and the average was obtained.
4. The dry weight of the vegetative total (g.plant⁻¹): The plants were taken at the end of the season. The vegetative part was separated from the roots and dried in an electric oven at a temperature of (65) °C until the weight stabilized, then the dry weight of the vegetative total was measured for each experimental unit.
5. The dry weight of the root group (g.plant⁻¹): After separating the root system from the vegetative, it was washed with running water to get rid of the soil attached to it, then it was dried in an electric oven at (65) °C until the weight stabilized, then the dry weight of the running total was measured for each experimental unit.
6. The length of the corn ear (cm): After harvesting the crop, the sprouts' length was measured with a tape measure of four spears from four plants randomly for each experimental unit.
7. Total yield (tons.ha⁻¹): The yield of (5) plants from each experimental unit was taken randomly and weighed to obtain one plant's yield from the ears.

| Trait             | Value | Unit          |
|-------------------|-------|---------------|
| PH                | 7.71  | --------------|
| EC                | 2.28  | DesiSmens.M⁻¹ |
| CEC               | 10.17 | Cml.charge.kg⁻¹.soil |
| Soil texture      |       | Sandy Loam    |
| Sand              | 296   | g.kg⁻¹Soil    |
| Clay              | 34.7  | Mg.kg⁻¹Soil   |
| Silt              | 199.7 | g.kg⁻¹Soil    |
| Organic matter O.M| 8.7   |                |
| N                 | 26.36 |                |
| P                 | 11.34 | Mg.kg⁻¹Soil   |
| K                 | 100.95|                |
| Ca                | 1.2   | Cmol⁻¹.L⁻¹    |
| mg                | 0.7   |                |
| Na                | 4.7   |                |
| CO₃⁻              | 0     | CFU .g⁻¹ dry soil |
| HCO₃⁻             | 1.8   |                |
| SO₄²⁻             | 1.5   |                |

*A-chrococcum* 1.1×10⁶
5. Results and discussion

The dry weight of the root system (g.plant^{-1}): Table (2) presents that A. chroococcum bacteria's application resulted in a significant increase in the root system's dry weight. The highest weight value was (12.61) g.plant^{-1} compared to the comparison treatment (no application), which gave the lowest average (9.64) g.plant^{-1}. This increase is attributed to the role of *A*-chrococcum in the secretion of plant hormones such as oxins, cytokinins, and gibberellins [14], which affect the growth and density of roots and thus increase the weight and density of the roots. This result is consistent with [15,16].

Table (2) also presents that the treatment of inoculation with *G*-mosseae led to a significant increase in the root system's dry weight. It reached (12.20) g.plant^{-1} compared to the comparison treatment, which gave the lowest average, as it was (10.05) g.plant^{-1}. This increase is because of the role of *G*-mosseae, which increases the surface of the exposed roots of the soil. It increases the absorption of nutrients and water and increases the absorption of nutrients with little movement in the soil—especially phosphorus and trace elements such as zinc and copper. Therefore, improving the plant's growth and development improves the plant's root growth and vegetative growth. Since the microscopic helps absorb nutrients, improve water relations, and increase the surface area of the roots [8,17,18].

There are significant differences between the treatments for irrigation periods (10, 7, and 4) days in the root total's dry weight. Irrigation treatment every (7) day produced the highest average dry weight of root total (14.37) g.plant^{-1}, by comparison with irrigation treatment every (4) day, which produced (12.33) g.plant^{-1}, then the irrigation treatment every (10) day, which made the lowest average (6.67) g.plant^{-1}.

The bilateral interaction between irrigation and biological inoculation periods was significant. Treatment B1I7 (*A*-chrococcum bacteria + irrigation every 7 days) produced the highest value of interaction (16.57) g.plant^{-1} compared to B0I10 (no bacterial inoculation + irrigation every 10 days), which gave the least value of interference (4.95) g.plant^{-1}. The decrease in the root mass's dry weight at a period of (10) days was attributed to a decrease in the root's length. This decrease is due to the severity of stress and the attainment of the (serves stress) stage, which led to the stimulation of the production of oxidative enzymes, an increase in the accumulation of abscisic acid, and a decrease in cytokines [19,20].

The effect of the triple overlap between the study factors was significant on the root system's dry weight. The treatment B1F1I7 (*A*-chrococcum + *G*-mosseae + irrigation every 7 days) achieved the highest value of interaction (18.04) g.plant^{-1} in comparison with the B0F0I10 treatment (without bio application + irrigation every 10 days) which gave the least value of interaction (3.57) g.plant^{-1}. It is because the phosphorus component contributes to the growth of all parts of the plant and increases its weight as a result of encouraging phosphorus to form a dense and deep root system that helps to absorb water and nutrients as well as the positive effect of potassium in improving plant growth and its effect in terms of increasing or encouraging nitrogen absorption by the plant [21]. The fungus *G*-mossea significantly outperformed the rest of the other biological fungi in increasing the dry weight of sunflower plants' roots.

| Bacteria (B) | Fungi (F) | Irrigation periods (I) day | Mean of Binary overlap F x B |
|--------------|----------|---------------------------|-----------------------------|
| B0           | F0       | 13.16                     | 8.88                        |
|              | F1       | 10.44                     | 10.39                       |
| B1           | F0       | 11.34                     | 11.21                       |
|              | F1       | 14.39                     | 14.00                       |
| LSD .05      | 1.42     | 0.82                      |

| Bacteria (B) | Irrigation periods (I) day | Mean (B) |
|--------------|---------------------------|----------|
| B0           | 11.80                     | 9.64     |
| B1           | 12.86                     | 12.61    |
| LSD .05      | 1.01                      | 0.58     |

| Fungi (F) | Irrigation periods (I) day | Mean (B) |
|-----------|---------------------------|----------|
| F0        | 11.20                     | 9.64     |
| F1        | 12.20                     | 12.61    |
| LSD .05   | 1.01                      | 0.58     |

Table 2. The effect of inoculation with *A*-chrococcum and *G*-mosseae under different water stress levels on the root system's dry weight (g.plant^{-1}).
5.1. Leaf area (cm².plant⁻¹)

The results of Table (3) indicate that inoculation with *A-chrococcum* bacteria resulted in a significant increase in the leaf area of maize plants. It produced the highest average (4636) cm².plant⁻¹ compared to the comparison treatment (no inoculation), which gave the least average (3782) cm².plant⁻¹. This increase is attributed to the role of *A-chrococcum* bacteria in fixing free atmospheric nitrogen, which enters in the water of the chlorophyll molecule, amino acids, proteins, and R.N.A., D.N.A., which may contribute to the increase in the growth of vegetative parts of the plant such as the leaf space [16,22]. This result agrees with [23]. Table (3) results present that inoculation with *G-mosseae* resulted in a significant increase in leaf area. It produced the highest average (4440) cm².plant⁻¹ compared to the comparison treatment that produced the lowest average (3977) cm².plant⁻¹.

The reason may be attributed to the fact that *Mycorrhizae* fungi can make phosphorus available from unavailable sources. Phosphorus is necessary to meet the plant's energy needs, which led to a significant increase in plant growth and production because the leaf is the plant's carbohydrate energy plant, and measuring its area has evident importance in highlighting the plant's vital capacity. It depends on the number of leaves and the speed of their appearance [24].

There were significant differences between the irrigation period's treatments (10, 7, and 4) days in the maize plant's leaf area. The irrigation treatment every (7) day produced the highest average of the leaf area (4994) cm².plant⁻¹ compared to the irrigation treatment every (4) day that achieved (4530) cm².plant⁻¹ and the irrigation treatment every (10) day that achieved the lowest average of (3103) cm².plant⁻¹. It is attributed to the role of water stress in closing the stomata and inhibiting the process of carbonization, causing a lack of absorption and plant growth, and thus a lack of leaf area [25-27].

There was significant in the maize plant's leaf area as for the bilateral overlap between irrigation periods and the application of bio inoculation. Treatment B1I7 (bacteria + irrigation every 7 days) resulted in the highest value of interference (5739) cm².plant⁻¹ compared to treatment B0I10, which made the least value of interference (2539) cm².plant⁻¹.

It was evident from the triple interaction results that applying bacteria and fungi led to an increase in the yellow maize plant leaf area in the three irrigation periods' treatments. Their application extended the irrigation period from 4 to 7 days compared to no application, which shows the integrated role of *A-chrococcum* and *G-mosseae* when applied together or separately to prepare the soil solution's nutrients and encourage the growth of the root system of the maize.

Table 3. The effect of inoculation with *A-chrococcum* and *G-mosseae* under different water stress levels on the leaf area (cm².plant⁻¹).

| Bacteria (B) | Fungi (F) | Irrigation periods (I) day | Mean of Binary overlap F x B |
|-------------|-----------|---------------------------|-----------------------------|
|             | I₄        | I₇        | I₁₀      |                          |
| B₀          | F₀        | 4081      | 3816     | 2539                  | 3479 |
|             | F₁        | 4392      | 4953     | 2912                  | 4086 |
| B₁          | F₀        | 4610      | 5466     | 3352                  | 4476 |
|             | F₁        | 5037      | 5739     | 3609                  | 4795 |
| LSD .05     | 246       | 142       | 69        |                        |

| Bacteria (B) | Irrigation periods (I) day | (B) Mean |
|--------------|---------------------------|----------|
|              | I₄       | I₇       | I₁₀      |               |
| B₀          | 4236     | 4385     | 2725     | 3782 |
| B₁          | 4823     | 5603     | 3480     | 4636 |
| LSD .05     | 174      | 100      |          |        |

| Fungi (F) | Irrigation periods (I) day | (B) Mean |
|-----------|---------------------------|----------|
|           | I₄       | I₇       | I₁₀      |               |
|           | 12.25    | 12.42    | 5.47     | 10.05 |
| LSD .05   | 1.01     | 0.58     |          |        |
5.2. Chlorophyll concentration (SPAD)

Table (4) presents that the application of A-chrococcum resulted in a significant increase in chlorophyll concentration in the maize plant. It gave the highest value (48.19) SPAD compared to the comparison treatment (no application treatment), which gave the least value (39.80) SPAD. This increase is attributed to the critical role of A-chrococcum in atmospheric fixation of the critical nitrogen in the formation of chlorophyll molecules. Nitrogen plays an essential role in increasing chlorophyll by combining it with magnesium and entering it in building cell membranes such as the plasma membrane [31]. These results are consistent with [16,32], who indicated the critical role of bacteria in increasing plants’ chlorophyll content.

The results of Table (4) show that the treatment of inoculation with G-mosseae was significantly superior and produced the highest average percentage of chlorophyll (46.63) SPAD compared to the comparison treatment that gave the least mean (41.46) SPAD. It is due to the role of the fungus G-mosseae and its ability to supply phosphorous [33]. There were significant differences between irrigation treatments (4, 7, and 10) days in the maize's chlorophyll percentage. The (7) day irrigation treatment produced the highest average chlorophyll ratio (50.21) SPAD compared to the (10) day irrigation period that produced the lowest average (34.85) SPAD. The low chlorophyll content of the maize plant, which was irrigated every ten days, is attributed to water stress in reducing the photosynthesis process due to limiting the stomata's opening [34].

The double overlap between irrigation periods and bio-inoculation was significant in the chlorophyll concentration of the maize plant. Treatment B1I7 (A-chrococcum + irrigation every seven days) gave the highest value of interference (56.67) SPAD compared to treatment B0I10 (no bacteria addition + irrigation every ten days, which resulted in the least value for overlap (31.41) SPAD. The reason is attributed to the fact that water stress leads to an increase in the formation of free radicals, R.O.S., which work to oxidize the pigments representing carbon [35,36]. This result agrees with [37], who showed that water stress leads to losing most of the chlorophyll in tissue cells.

The effect of the triple overlap between study factors was significant in the proportion of chlorophyll. The combination B1F1I7 achieved the highest value of interference (58.93) SPAD compared to combination B0F0I10, which produced the lowest value of interference (29.07) SPAD. The application of A-chrococcum and G-mosseae led to an increase in the chlorophyll concentration of yellow maize plants in treating the three irrigation periods and its application, which led to the prolongation of the irrigation period from (4 and 7) days compared to uninoculated. Its shows the integrated role of A-chrococcum and G-mosseae when applied together or separately to increase the availability of nutrients in the soil solution and encourage the root system's growth.

### Table 4. The effect of inoculation with A-chrococcum and G-mosseae under different water stress levels on chlorophyll concentration (SPAD).

| Bacteria (B) | Fungi (F) | Irrigation periods (I) day | Mean of Binary overlap F x B |
|--------------|-----------|---------------------------|-------------------------------|
| B0           | F0        | I4  | 43.29 | 38.03 | 29.07 | 36.80 |
| B1           | F1        | I7  | 51.17 | 58.93 | 40.67 | 50.26 |
| B0           | F1        | I10 | 2.47  |       |       | 1.42  |

LSD .05

| B0 | F0 | I4  | 44.54 | 43.75 | 31.41 | 39.80 |
| B1 | F1 | I7  | 49.61 | 56.67 | 38.29 | 48.19 |

LSD .05

| B0 | F0 | I4  | 1.74  |       |       | 0.42  |
| B1 | F1 | I7  | 1.77  |       |       | 0.42  |

LSD .05

| B0 | F0 | I4  |       |       |       | 0.42  |
| B1 | F1 | I7  |       |       |       | 0.42  |

LSD .05

| F0 | I4  | 4530 | 4994 | 3103 | 3680 |
| F1 | I7  | 5117 | 5893 | 4067 | 5026 |

LSD .05
5.3. Total yield (tons. ha⁻¹)

Table (5) present that inoculation with \textit{A-chrococcum} bacteria resulted in a significant increase in the plant's total yield. Its value was (7.320) tons.ha⁻¹ compared to the comparison treatment, which gave the least average (6.252) tons.ha⁻¹. This increase is attributed to \textit{A-chrococcum} bacteria's ability to secrete some growth regulators that positively affect the root system's growth and activity and absorb nutrients, and this bacteria's activity in fixing the atmospheric nitrogen [38]. These results were confirmed by [21,39,40].

The treatment of fungus \textit{G-mosseae} resulted in a significant increase in the total yield of yellow corn plants (7.119) tons.ha⁻¹ compared to the comparison treatment, which produced the least mean (6.453) tons.ha⁻¹. This attributed to the positive role of used biochemistry. The used micro-organisms are characterized by several favorable properties that enhance plant growth, including their ability to fix atmospheric nitrogen and increase phosphorus solubility in the soil and convert unrefined images into more ready images [41]. It is consistent with what [42], stated that micro-organisms' ability to convert insoluble phosphate compounds into soluble ones is essential for plants' phosphate nutrition. The dissolution process includes the secretion of organic acids of low molecular weights, which, through their hydroxyl and carboxylate groups, chelate phosphate-bound cations, converting phosphates into the dissolved form. Soil revival is the key to phosphorous soil dynamics and the subsequent processing of phosphorous through a group of heterotrophic organisms that secrete organic acids to dissolve phosphate minerals, so phosphorus is released directly into the soil solution.

There are significant differences between the treatments for irrigation periods (4, 7, and 10) days. Every (7) day's irrigation treatment resulted in the highest average total yield (7.984) tons.ha⁻¹ compared to the treatment of irrigation every (4) days, which gave (7.773) tons.ha⁻¹ and the irrigation treatment every (10) day, which had the least average (4.600) tons.ha⁻¹. Since water stress leads to a lack of processing of photosynthesis materials, which causes abortion of the emerging grains, their number decreases, some become atrophied, and the outcome decreases.

The effect of the triple overlap between the study factors was significant in the maize plant's total yield. The treatment, B1F1I7, produced the highest value of overlap (9.104) tons.ha⁻¹ compared to the treatment B0F0I10, which gave the lowest value of overlap (3.921) tons.ha⁻¹. It appears from the results of the triple interference to the addition of \textit{A-chrococcum} and \textit{G-mosseae} in the positive effect of the interaction in improving the infection rate and numbers of spores and bacteria. It is reflected positively on the process of bio-fixation of nitrogen by the azotobacter bacteria by providing them with sufficient quantities of phosphorus needed to meet their energy needs [21,43,44]. There is a positive interaction effect on increasing bacteria's ability to secrete hormones and growth regulators of all kinds (oxins, gibberellins, and cytokinins). Therefore, encouraging the roots to absorb water and nutrients necessary to the crop production, which will positively affect the growth and production of the crop [45-48].

Table 5. The effect of inoculation with \textit{A-chrococcum} and \textit{G-mosseae} under different stress levels on the total yield (tons.ha⁻¹).

| Bacteria (B) | Fungi (F) | Irrigation periods (I) day | Mean of Binary overlap F x B |
|--------------|-----------|---------------------------|-----------------------------|
| B0           | F0        | 7.306                     | 5.814                       |
|              | F1        | 7.622                     | 6.690                       |
| B1           | F0        | 7.896                     | 7.091                       |
|              | F1        | 8.269                     | 7.548                       |
| LSD .05      |           | 0.441                     | 0.254                       |

| Bacteria (B) | Irrigation periods (I) day | (B) Mean |
|--------------|---------------------------|----------|
| B0           | 7.464                     | 6.252    |
| B1           | 8.083                     | 7.320    |
| LSD .05      | 0.312                     | 0.180    |
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