

EVALUATING THE EFFECT OF BIOFERTILIZATION IN IMPROVING GROWTH AND PRODUCTIVITY OF SOYA BEAN UNDER QANTRA SHARQ CONDITIONS

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Sustainable clean production of soy bean in sandy soils be in need of biofertilizers efficient to reduce or replace mineral fertilizers that have environmentally unfriendly effects on soil, plants, environment and human health. The study conducted to investigate the effects of some biofertilizers individually or in combination. *Bradyrhizobium japonicum* was used in all treatments, *Azotobacter chroococcum*, *Bacillus megterium*, and arbuscular mycorrhizal fungi (AMF) were used individually or in a mixture of all, with or without a nutrients solution as mixture of 2% humic acid and marine algae extract. The application of biofertilizers improved soil biota, increased *Azotobacter* and *Bradyrhizobium* count and plant height, shoot dry weight, root dry weight, number of branches, number and dry weight of nodules, nitrogen content and ethylene production of nodules, dry weight of seeds, total lipids, total saturated fatty acids, total sugars and total carbohydrates over the control. Adding nutrients to the microbial treatments had no positive effects on total microbial count (except the mixture with nutrient treatment), phosphate dissolving bacteria (PDB), *Bradyrhizobium*, plant height, shoot dry weight, root dry weight, number and dry weight of nodules, nitrogen content of nodules, nodules ethylene production, total saturated fatty acids and total carbohydrates. However, adding nutrients to the microbial treatment significantly increased number of branches, weight of seeds and total lipid and almost doubled the content of total unsaturated fatty acids over the control. The results could serve as a constructive approach, for supplementary research in the integrated plant-microbe interaction in agriculture.

Keywords: soybean, biofertilizer, mycorrhiza, nutrients, *Bradyrhizobium*

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is one of the most dominant agricultural crops all around the world, United States, Argentina, Brazil, India, and China command the production of soybean across the board. Soybean dry rough is rich in nutrients and grown for humans and livestock feeding globally. The isoflavones (an estrogen-like substance) content of soybean as a health conservation are being studied as rich in antioxidant, anti-inflammatory, antiviral and anticancer functions in humans and animals (Al-Tawaha et al., 2007). Edamame (branched bean, stem beans or hairy bean), a preparation of immature soybeans in the pod, contains about 38% protein, rich in calcium, vitamin A, and phytoestrogens. Edamame is famous in East Asia cuisines, pods are boiled or steamed and served with salt or other condiments (Konovsky et al., 1994).

Extravagant use of chemical fertilizers in a relatively long periods has unexpected influence on environment (Dacko et al., 2016), and soil quality, causing fertility reduction, organic matter drop, and decreasing soil physical ability to hold water and nutrients (holding capacities) (Baligar et al., 2001 and He et al., 2005). Moreover, transform soil microbiota varieties, amount, and the activity as well as the inhabitants of symbiotic fungi (Fulton, 2011).

Stresses catastrophically affect soybean yield. Soil microbes are significantly affecting the production of soybean. Rhizobia and mycorrhizal fungi are some of the most essential criteria connected to the production of soybean, which is the only kind of leguminous can be connected with rhizobia and arbuscular mycorrhizal fungi (AMF), with prospects to be further utilized (Pagano and Miransari, 2016).

Rhizobia play an important role in biological nitrogen fixation that reduces the need for chemical nitrogen fertilizers (Stacey et al., 2006 and Bhullar and Bhullar 2013). Legumes are symbiotic with rhizobia to obtain nitrogen by air nitrogen fixation. Rhizospheres' microorganisms play a regulatory role in rhizobia–soybean symbiosis (Han et al., 2020). Co-inoculation of rhizobia with other bacteria on legumes, sometimes, inhibits symbiosis with rhizobia, especially in soybean (Hashami et al., 2019). It is important that using biofertilizers for legume plants does not inhibit symbiosis between rhizobium and plants.

AMF represent symbiotic relationships that affect the plant nutrition, growth and productivity with a wide range of agricultural crops including the significances like soybean, rice and maize (Berruti et al., 2016; Adeyemi et al., 2019 and 2020). AMF inoculations help in reducing the need for fertilizers to boost plant growth and yield. The host plant supplies the AMF with carbohydrates, in return the plant taking away immobilized nutrients including nitrogen and phosphorus from the fungus (Smith and Read, 2008). It helps in the reducing of phosphorus fertilizer whereas reach a big crop yield (Bender et al., 2016 and Silva et al., 2016). AMF may help in reducing the salinity and

drought effect (Evelin et al. 2009 and Yamato et al. 2009) and the stability of soil aggregation (Verbruggen et al., 2013).

Azotobacter produces active phytohormones beside nitrogen fixation, resulting an increase in soil fertility, plant growth, and yield (Hindersah et al., 2019). The stimulation of plant growth depending on gibberellins, cytokinins, and indole acetic acid, which produced by *Azotobacter* (Jnawali et al., 2015). *Azotobacter* energizing useful soil biota and protect plants against root pathogens (Ewusi-Mensah et al., 2019). Inoculation of *Azotobacter* combined with organic matter reduced chemical fertilizer (Hindersah et al., 2018), beside other effects like exopolysaccharides production and plant protection by producing hydrolytic enzymes (Romero-Perdomo et al., 2017) are able to degrade fungal pathogen cell wall (Jadhav and Sayyed, 2016).

Phosphorus is an important component to increase biomass of soybean. Nodule formation, number and mass and nitrogenase activity in symbiotic nitrogen fixation are high phosphorus demanding processes (Aise et al., 2011). Soy plants in nitrogen fixation inquire ATP for nodules development and function and membrane biosynthesis (Thakur et al., 2011). *Bradyrhizobium* is economically important for soybean, giving a notable increase in phosphorus uptake, nitrogen fixation and uptake, beside plant growth, nodulation and seed yield (Htwe et al., 2019). Phosphorus nutrition depends mainly on the ability of the plant to produce an extensive healthy root can approach the maximum from the soil phosphorus, as well as soil ability to restore phosphorus in the soil solution when crops remove it. (Akpalu et al., 2014).

Bacillus is able to retain viability and keep up stresses. *Bacillus megaterium* has a high potential for plant growth promotion, effective in phosphate mineralization, solubilizes phosphorus and produces siderophores (Miljaković et al., 2022). *Bacillus megaterium* has an antagonistic activity, able to solubilize nutrients, produces indole acetic acid and takes part in the biosynthesis of auxins and cytokinins (Haque et al., 2020 and Nascimento et al., 2020). The aim of this study was to determine the appropriate biofertilizers for improving the production and quality of soybean.

MATERIALS AND METHODS

The experiments were carried out during the two successive seasons (2019-2020), in newly cultivated sandy soil at Desert Research Center (DRC) experimental station in El-Qantra Sharq. The effect of biofertilizers (*Azotobacter chroococcum*, *Bacillus megaterium* and Mycorrhizae) and nutrient (2% humic acid + marine algae extract) on the production of soybean was investigated. Recommended practice including rates of minerals and organic manure were adhered.

Physical and chemical properties of the experimental soil were determined according to Page and Huyer (1984) as shown in Table (1).

Table (1). Some chemical properties of the experimental soil.

pH	E.C. (d.s/m)	Soluble anions and cations (meq/l)							
		K ⁺	Na ⁺	Mg ⁺²	Ca ⁺²	CO ₃ ⁼	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁼
8.7	0.64	0.27	4.29	0.84	0.85	0.0	4.3	0.78	1.17

Seeds of soybean were obtained from Agricultural Research Center (ARC), Giza, Egypt. These seeds were washed and immersed for 30 min in liquid culture of the specific bacteria to be tested. Carboxymethyl cellulose (CMC 0.5%) was used as an adhesive agent. Seeds were then dried at room temperature for two hours. Fresh liquid cultures 48 h old containing pure local strains of *Bradyrhizobium* (Br), *Bacillus megaterium* var. *phosphaticum* (PDB), *Azotobacter chroococcum* and Mycorrhizae, previously isolated from the rhizosphere of soils of Qantra Sharq region were used for seed treatment and applied to soil after month of sowing at a concentration of 2 liter /fed. These had been purified and identified according to Krieg and Holt (1984). They were used as biofertilizers in the form of single and mixed inoculations at the rate of $\sim 10^8$ cfu/ml.

Bradyrhizobium spp.: Locally isolated *Bradyrhizobium japonicum* were maintained at 4°C on yeast extract mannitol agar (YEMA) used as base application for all treatments and control.

1. Biochemical Activities of Bacterial Isolates

The ability of the tested microbial isolates to produce biochemical activities was evaluated under *in vitro* conditions, through determination of their efficiency for growth regulators production (Rizzolo et al., 1992), nitrogen fixation (Page and Collinson 1982) and enzymes (Barrow and Veltham, 1993).

2. Purification and Maintenance of Bacterial Cultures

Fresh liquid culture of *Azotobacter chroococcum* and *Bacillus megaterium* were used for soil applications single or in combination at the rate of (10^8 cfu/ml). The inoculum of each strain was prepared by growing them in 500 ml flasks containing selective media, Ashby's Nitrogen-free selective media for *Azotobacter* and nutrient agar for *Bacillus*, flasks incubated at 30°C for 48 h under shaking, the suspension containing 10^8 cfu/ml used for inoculation.

3. Isolation and Identification of Arbuscular Mycorrhizal Fungi (AMF)

Mycorrhizal spores were isolated from rhizosphere by wet sieving and decantation method (Gerdemann and Nicolson, 1963). The spores of the isolated mycorrhizae identified microscopically according to the morphological characteristics described by Schenck and Perez (1987 and

1990), by the site of International Collection of Vesicular and AMF (<http://invam.caf.wvu.edu>) and the original species descriptions.

4. Preparation of Mycorrhizal Inoculum

Multiplication of mycorrhizal fungi was carried out by pot culture; the AM inoculate was mixed with pure sand and kept in the refrigerator to be used in the inoculation.

5. Nutrient Preparation

A mixture of 2% humic acid + marine algae extract was prepared and used as a foliar spray.

6. Collection of Algae

Fresh marine algae were collected from coastal region of Mediterranean Sea. They were hand-picked, washed thoroughly with seawater, hard brushed to remove macroscopic epiphytes and sand particles and then washed with tap water to remove adhering salt. Samples were air-dried (26°C) for 2–4 days followed by thermostat dry at 60 °C for 12 h.

7. Preparation of Marine Algae Extract (MAE)

Dried marine algae were hand crushed or cut into pieces and then grounded. The coarse powder was mixed with distilled water in a ratio of 1:20 (w/v). Boiled for 60 min and filtered through four folds of white cloth. The filtrate was collected and stored. The nutrients were used as foliar spray (0.25 mM/l).

Humic acid: Potassium humate (12.5% K₂O) was used at a concentration of 2%.

8. Field Experiment

The experiments included 10 treatments where *Brady rhizobium japonicum* was used as a base treatment. The treatments were: Control, *Azotobacter chroococcum*, *Bacillus megaterium*, mycorrhiza, mixture, nutrients, *Azotobacter chroococcum* with nutrients, *Bacillus megaterium* with nutrients, mycorrhiza with nutrients and the mixture with nutrients. Samples were taken after 35, 70 and 105 days after cultivation. The determination of growth parameters, yield and its components (plant height, shoot and root dry weight, number of branches, number of nodules /5 plants, dry weight of nodules) were measured. Nitrogen % was calculated according to Page and Collinson (1982).

Ethylene determination: Nodules were placed in 10 ml gas-tight glass vessels and incubated at room temperature for 14 h. One ml sample of gas was removed and analyzed with a gas chromatograph (Balestrasse et al., 2004). Soil carefully washed away with water, leaving the roots and nodules. The nodules were removed from the roots, counted, and both fresh and dry weights were determined.

9. Counting of Bacteria

Rhizosphere soil samples were collected for total count of microorganisms by plate count method according to Clark (1965), counting and growing phosphate dissolving bacteria using Pikovskaya's agar medium (PVK) according to Nautiyal (1999) and for counting and growing Azotobacters using modified Ashby's medium according to Abd-el-Malek and Ishac (1968).

10. Chemical Analysis

After 105 days, dry weight of soybean seeds was determined as gram per plant and seeds were ground to analyze the percentage of total lipids, total saturated fatty acids, total unsaturated fatty acids, total sugars and total carbohydrates. For dry weight measuring: whole, ungrounded soybean seeds were dried at 103 °C for 72 h.

Total lipids was determined according to a protocol adapted from Folch et al. (1957), 1 g of the ground flour samples were separately extracted in 10 ml solution of chloroform: methanol (2:1 v/v), vortexed for 2 min and allowed to stand for 30 min. Thereafter, the samples were filtered through a Whatman paper No. 1 into a weighed 50 ml Falcon tubes and the filtrate allowed to evaporate to dryness in the hood. Total extracted fats % were calculated using the following equation: $\text{initial weight of sample} \times 100 = \text{total extracted fat \%}$. The fat content and the weights were recorded (weight of the falcon tube plus fat – weight of the falcon tube).

Fatty acids were esterified according to the method of Metcalfe et al. (1966). Fatty acids profiles as relative percentage of total oil for each sample was determined by Gas Chromatography. Total sugars % was determined according to modified method of Geater et al. (2001). Total carbohydrate % was determined according to Dubios and Lacaze (1965).

11. Statistical Analysis of Data

The collected data were analyzed using analysis of variance (ANOVA) at 5% significant level and the normal (F) test and the means separation were compared by using Least Significant Difference (LSD) at the 5% level according to Snedecor and Cochran (1982).

RESULTS

1. Total Microbial Counts

Results in Fig. (1) show that all treatments except mycorrhiza with nutrients increased the total microbial count, measured as percentage per gram dry soil, compared with control. Adding nutrients to the mixture increased the total microbial count significantly ($p < 0.05$) after 105 days by 56%, while decreased or has no effect on the total count when added to each treatment individually. There was no significant effect of adding the mixture or the nutrients alone compared with control. With mycorrhiza, plants take up more

of the soil nutrients and water, this might affect the availability of water and nutrients for soil microbes, limiting metabolic activity for microbial growth, so decreased the total count number.

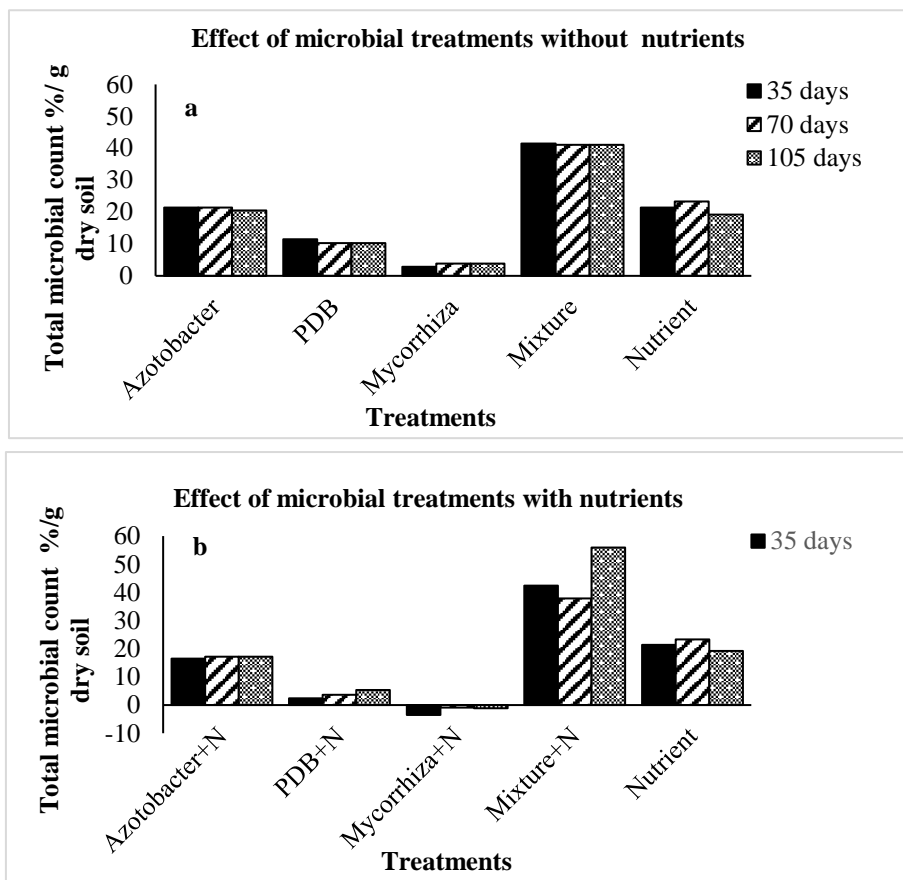


Fig. (1). Effect of microbial treatments **a.** without nutrients and **b.** with nutrients on the total microbial count % / g dry weight of soil.

1. Azotobacter Counts

Data in Fig. (2) show that all treatments increased *Azotobacter* count, measured as percentage per gram dry soil. Increasing was significantly high ($p < 0.01$) by adding the mixture compared with the control after 35, 70 and 105 days to be 82, 64 and 54%, respectively. Adding nutrients increased the count significantly ($p < 0.05$) compared with the control. While the mixture plus the nutrients increased the count significantly compared with nutrients alone. There was no significant difference between adding the nutrients or the mixture alone.

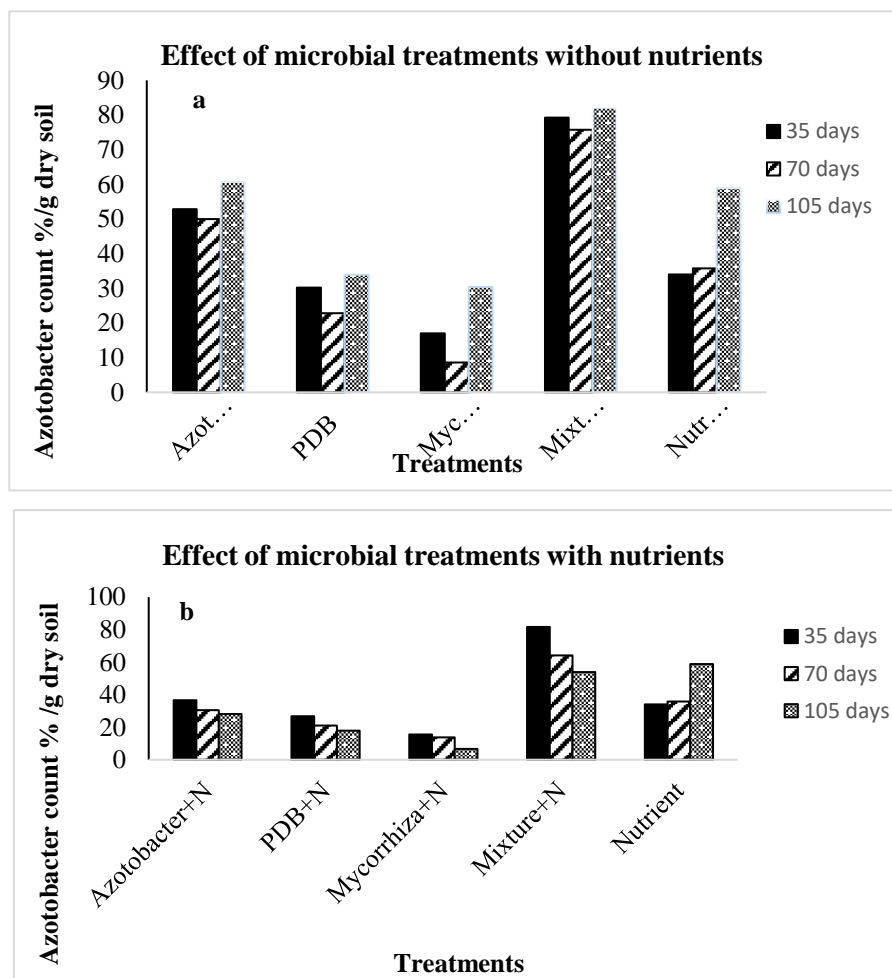


Fig. (2). Effect of microbial treatments **a.** without nutrients and **b.** with nutrients on *Azotobacter* count /g dry weight of soil.

2. Phosphate Dissolving Bacteria (PDB) Counts

In Fig. (3), most of treatments increased the number of PDB count despite the negative effect for adding nutrients to the treatments. Adding *Azotobacter*, PDB or nutrient increased the number of PDB count percentage significantly ($p < 0.05$) compared with control, while the mixture increased the number significantly high ($p < 0.01$) compared with the control. Adding the nutrient to the mixture increased the count highly significant ($p < 0.01$) compared with the nutrient alone.

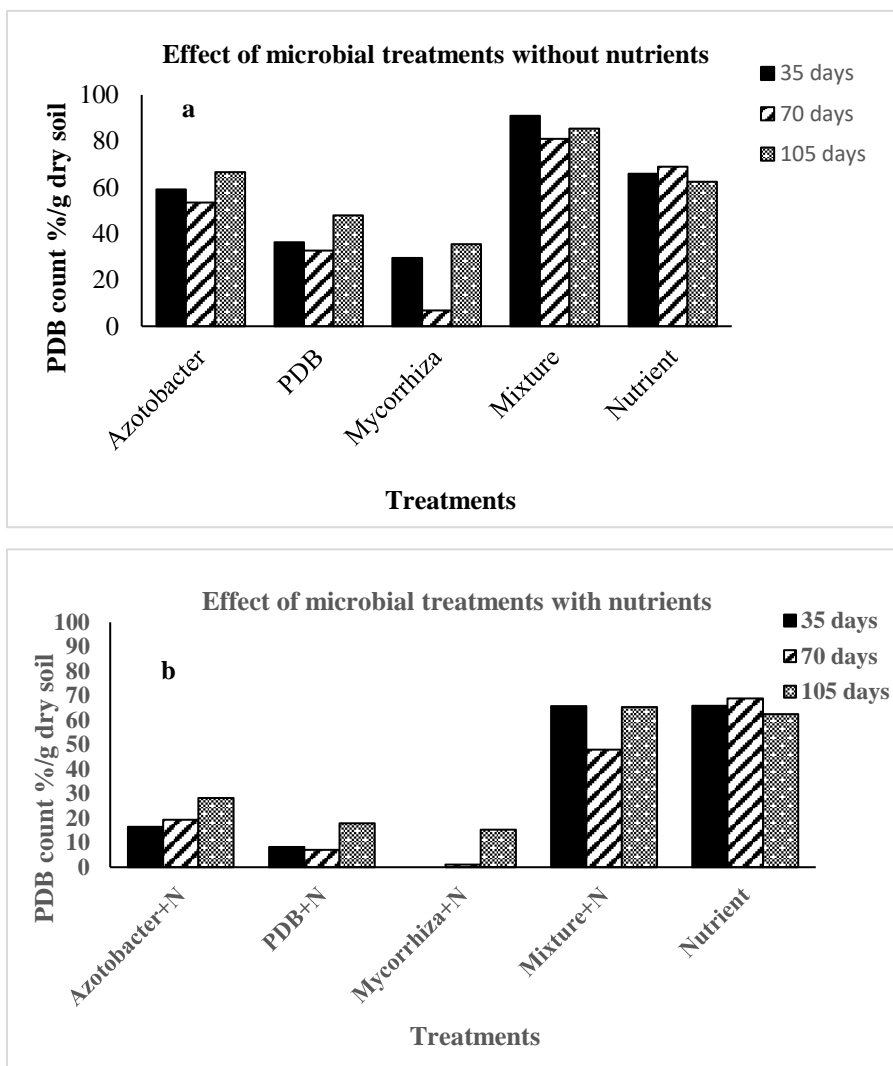


Fig. (3). Effect of microbial treatments **a.** without nutrients and **b.** with nutrients on the PDB count / g dry weight of soil.

3. Bradyrhizobium Counts

All treatments in Fig. (4) show increased *Bradyrhizobium* count compared with the control. Adding nutrient to the treatments had no significant effect on the count, however adding the mixture and the nutrients increased the count significantly ($p < 0.05$) compared with the nutrient alone. Adding *Azotobacter* and PDB treatments increased the number significantly ($p < 0.05$) compared with the control.

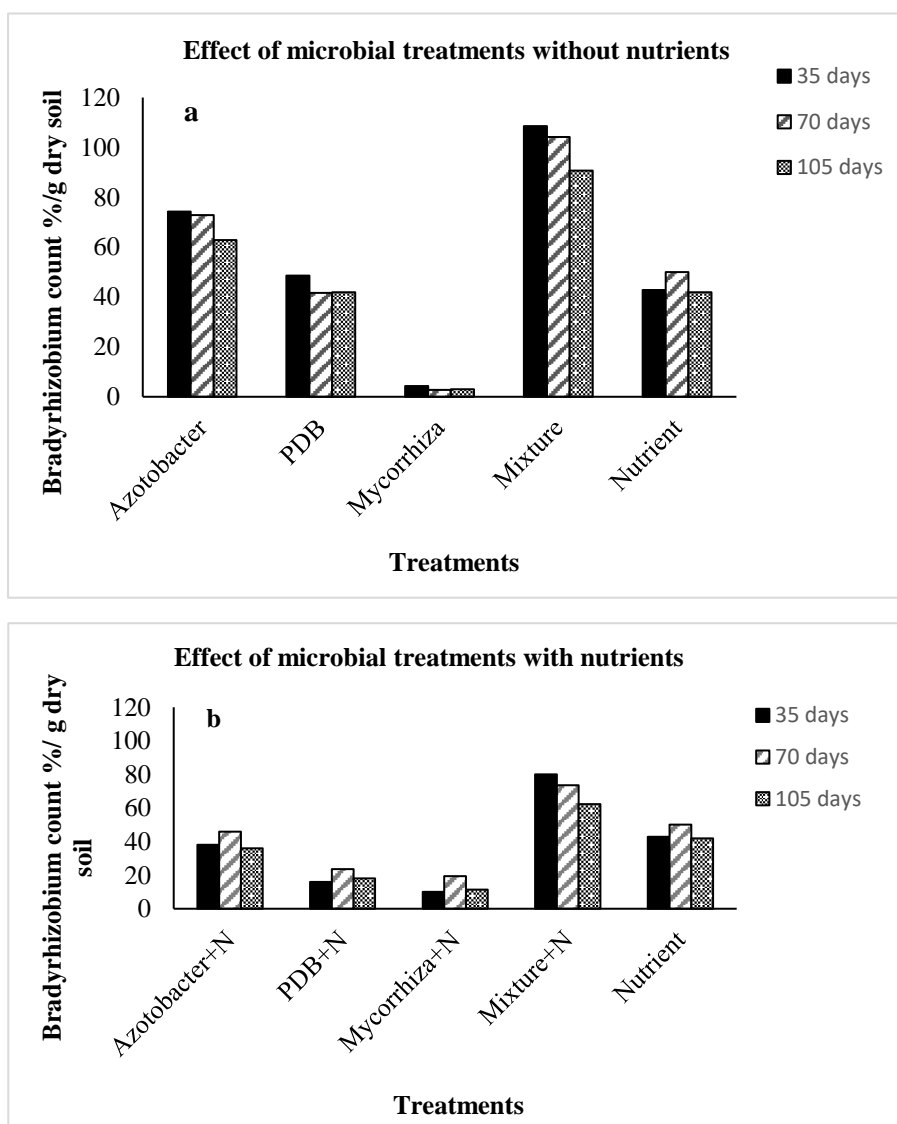


Fig (4). Effect of microbial treatments without nutrient and **a.** with nutrient **b.** on *Bradyrhizobium* count / g dry soil.

4. Plant Growth, Yield Traits and its Chemical Component

4.1. Plant height (cm)

Results in Fig. (5) show that all treatments increased the plant height compared with the control. However, adding nutrient to the mixture increased the plant height significantly ($p < 0.05$) comparing with adding nutrients alone. There was no significant difference between adding nutrients or mixture with nutrients compared with adding the mixture.

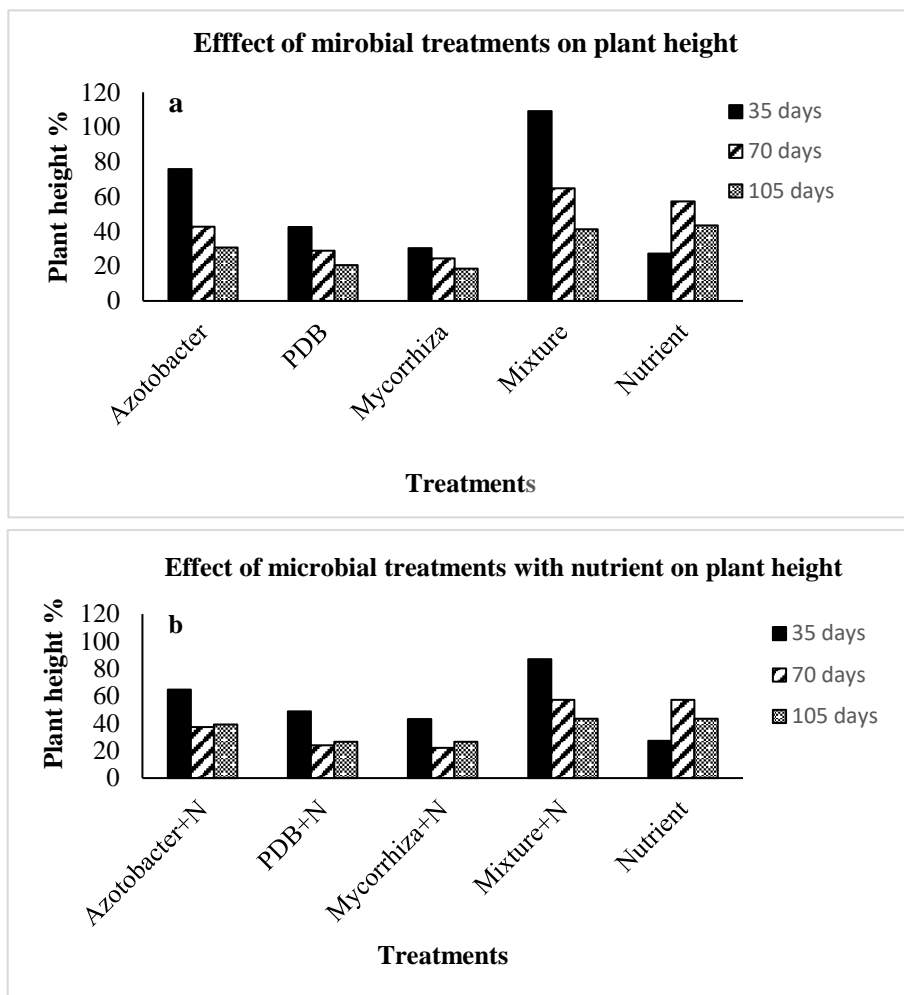


Fig. (5). Effect of microbial treatments **a.** without nutrient and **b.** with nutrient on the plant height.

4.2. Shoot dry weight (g/plant)

All treatments increased shoot dry weight compared with the control. Adding PDB increased the shoot dry weight by 110% after 70 days compared with the control. Adding mixture increased shoot dry weight but there was no significant difference between mixture and mixture with nutrients (Fig. 6).

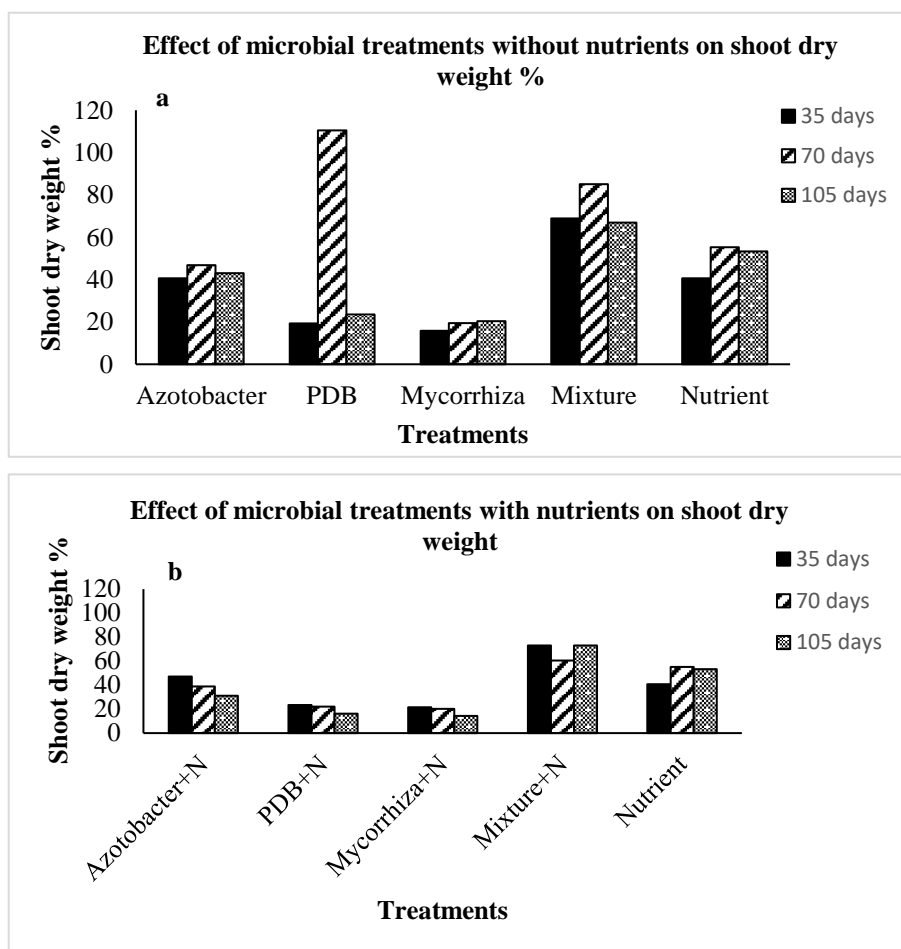


Fig. (6). Effect of microbial treatments **a.** without nutrient and **b.** with nutrient on the shoot dry weight.

4.3. Root dry weight (g/plant)

Data in Fig. (7) show that all treatments increased the root dry weight compared with the control. The mixture highly significantly increased the root dry weight ($p < 0.05$) compared with the control. There was no significant difference between adding the nutrients and the mixture with nutrients compared with adding the mixture on the root dry weight. The highest dry

weight was reached after 35 days in all treatments and there was no positive effect by adding nutrients to the treatments.

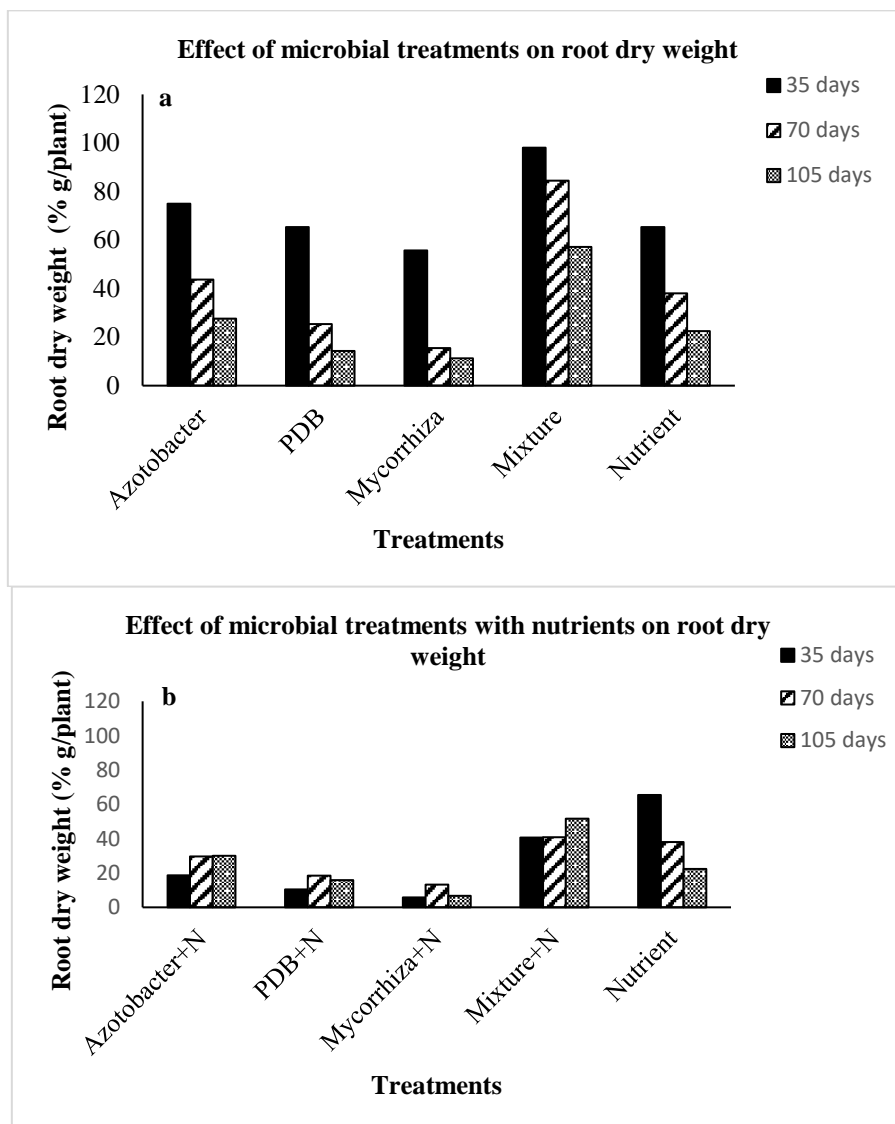


Fig. (7). Effect of microbial treatments **a.** without nutrients and **b.** with nutrients on the root dry weight (g/ plant).

4.4. Number of branches

Fig. (8) clears that all treatments increased the number of branches. Adding nutrient to the microbial treatments significantly increased the number of branches in all treatments ($p < 0.05$). Nutrients alone increased the number

of branches significantly compared with the control. The mixture and the mixture with nutrients increased the number of branches significantly compared with the nutrients alone.

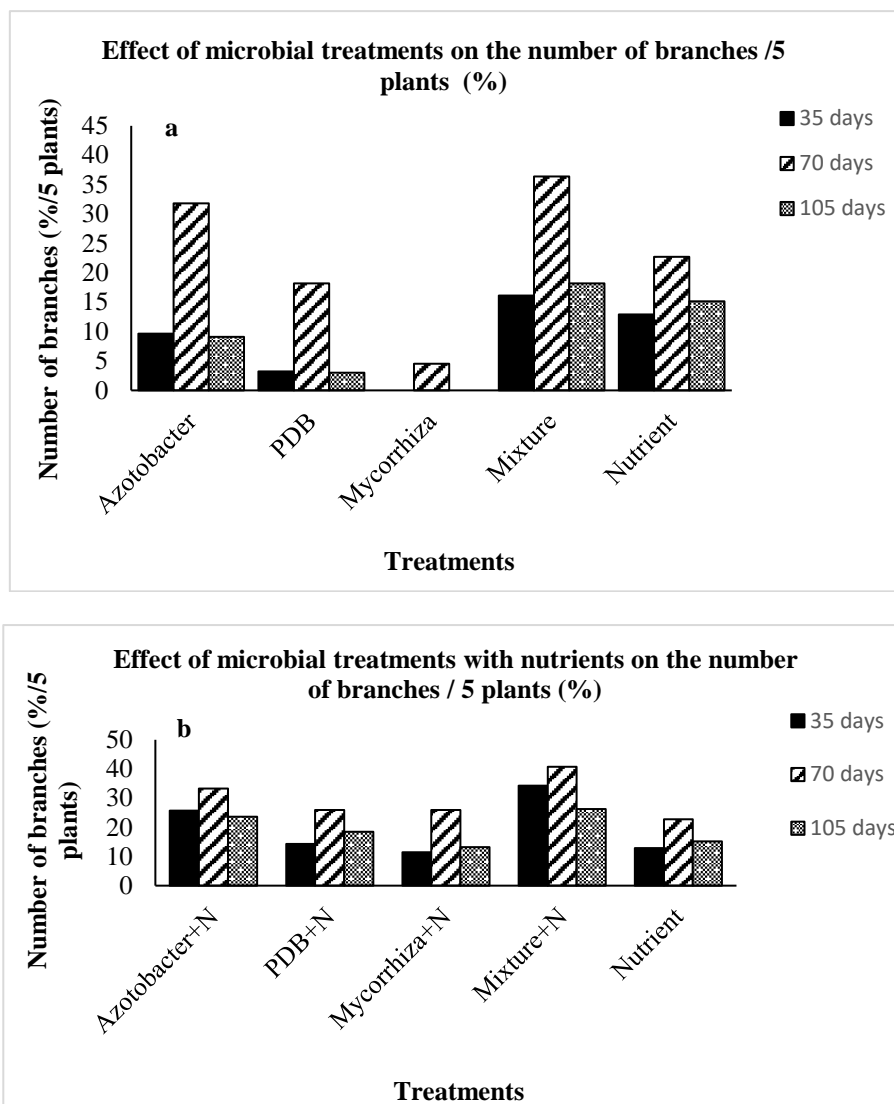


Fig. (8). Effect of microbial treatments **a.** without nutrient and **b.** with nutrient on the number of branches /5 plants.

4.5. Number of nodules

Number of nodules / five plants in Fig. (9) increased with all treatments compared with the control. Increasing was the greatest after 35

days for all treatments. There were no significant differences between all treatments.

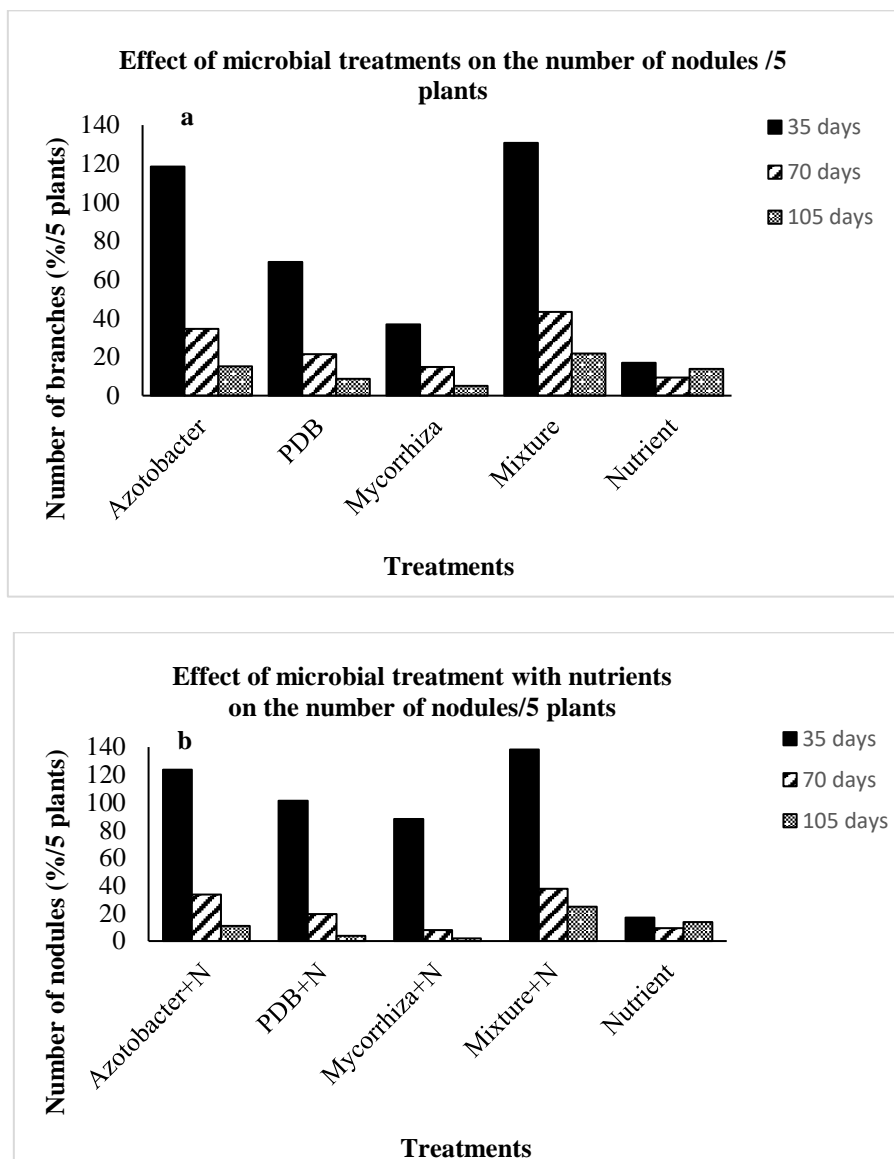


Fig. (9). Effect of microbial treatments **a.** without nutrient and **b.** with nutrients on the number of nodules / 5 plants

4.6. Dry weight of nodules

All treatments increased the dry weight of nodules compared with the control. Increasing was the greatest after 35 days for all treatments. There were no significant differences among treatments (Fig. 10).

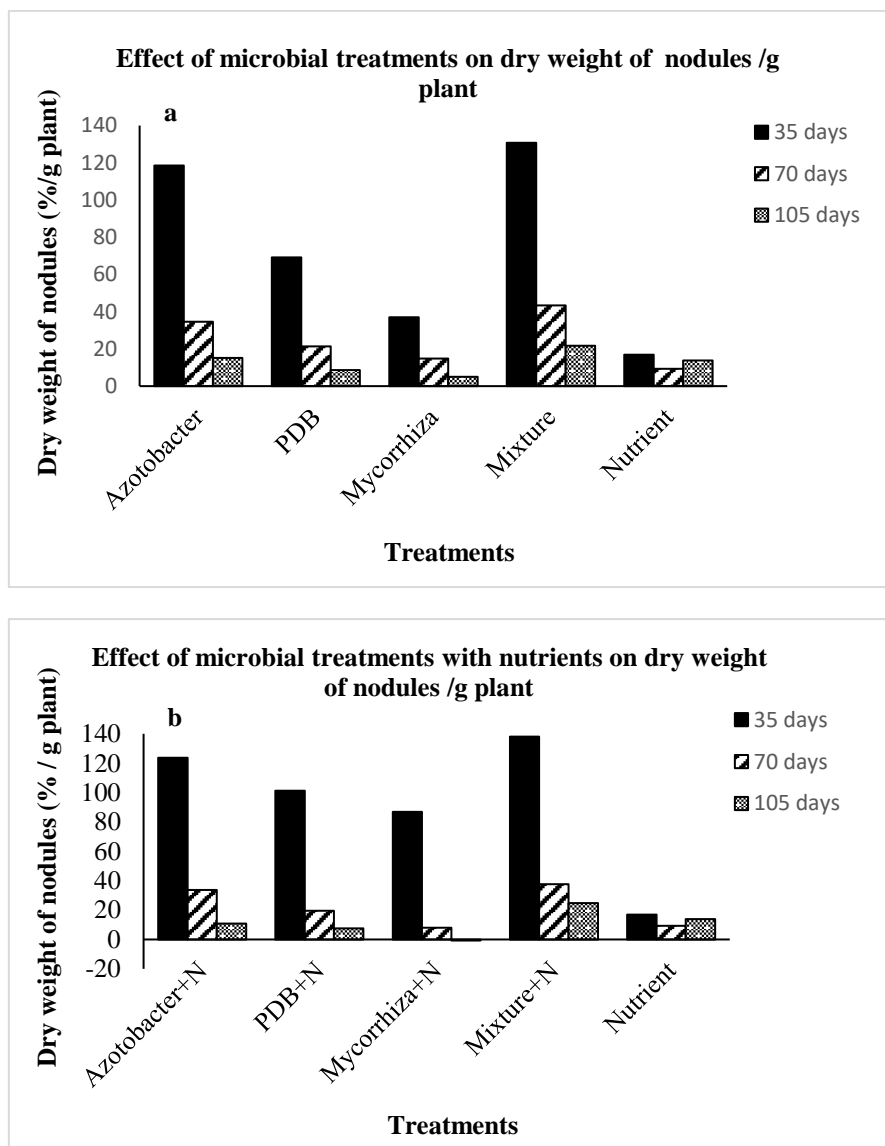


Fig. (10). Effect of microbial treatments **a.** without nutrients and **b.** with nutrients on dry weight of nodules / g plant.

4.7. Nodules nitrogen content

Fig. (11) shows that nitrogen content of nodules increased with all treatments compared with control. The increasing was significant with the mixture and mixture with nutrients treatments compared with control, while there was no significant difference between the mixture and nutrients compared with the mixture alone for all treatments. The highest nitrogen content of nodules was after 70 days by about 67% with the mixture treatment.

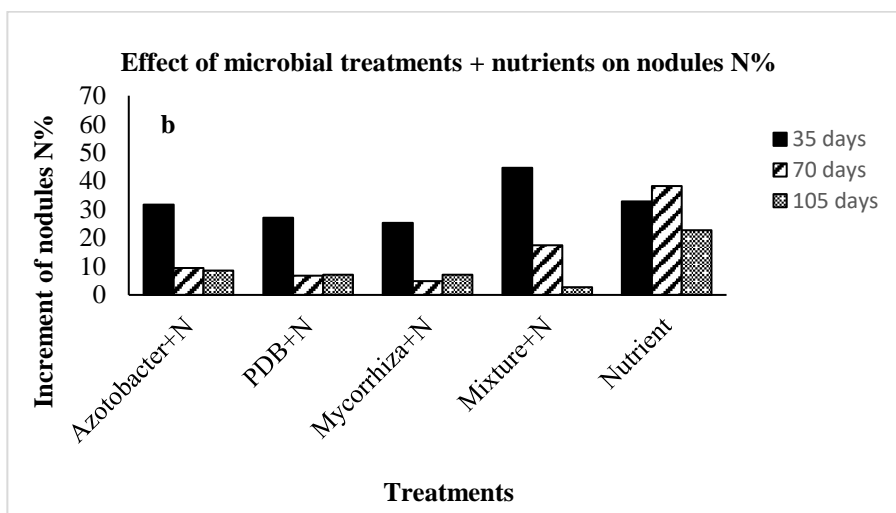
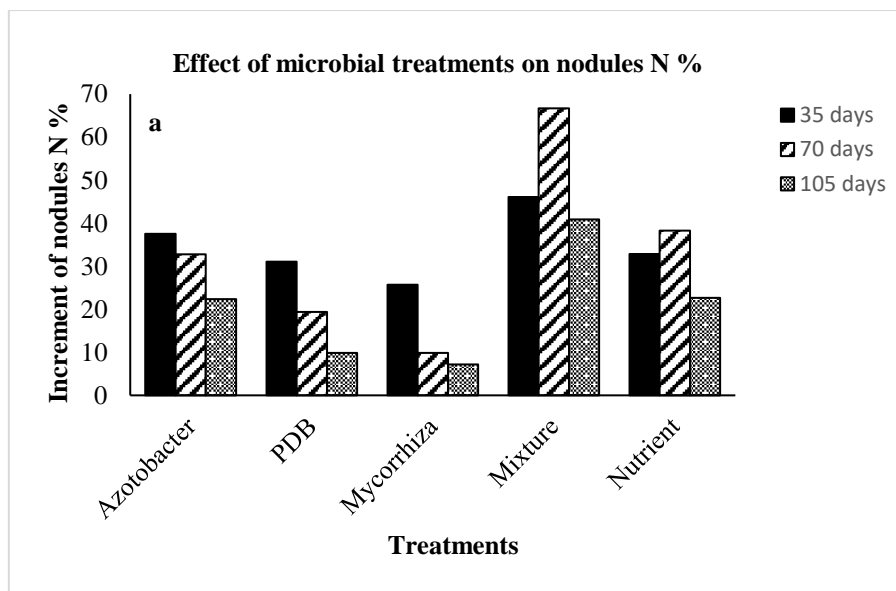


Fig. (11). Effect of microbial treatments **a.** without nutrient and **b.** with nutrient on the N content of nodules.

4.8. Ethylene production

Fig. (12) reveals that ethylene production per gram dry nodules per hour increased with all treatments. Increasing with the mixture and nutrients treatment was the highest and gave the same increasing with nutrients treatment after 35 and 70 days. There were no significant differences between treatments.

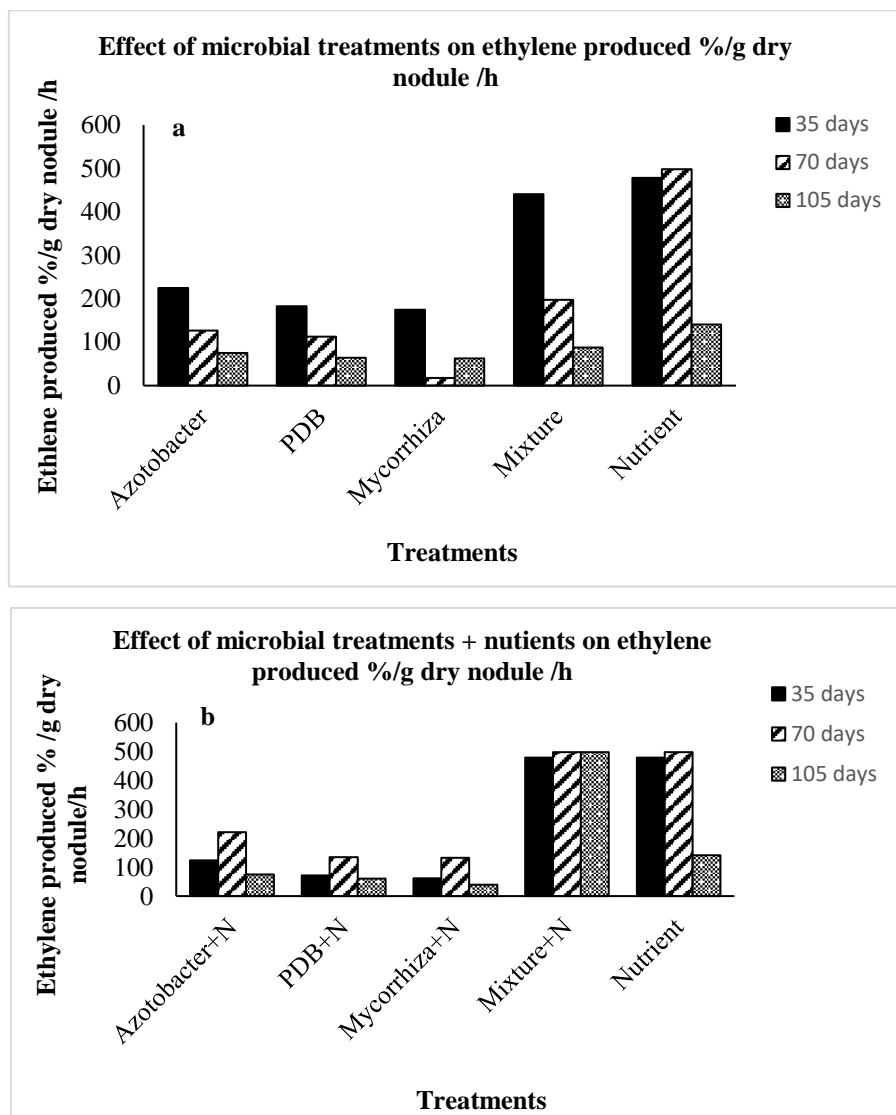


Fig. (12). Effect of microbial treatments **a.** without nutrient and **b.** with nutrient on the ethylene production /g dry nodule/ hour.

4.9. Dry weight of seeds

Data in Fig. (13) show that the highest values were with the mixture and nutrients treatment and *Azotobacter* with nutrient treatment by 204 and 171%, respectively. Despite the nutrients treatment alone gave the lowest value by around 4%. Adding nutrients to all treatments increased the dry weight of seeds, it might be as a result of activation of microbial treatments.

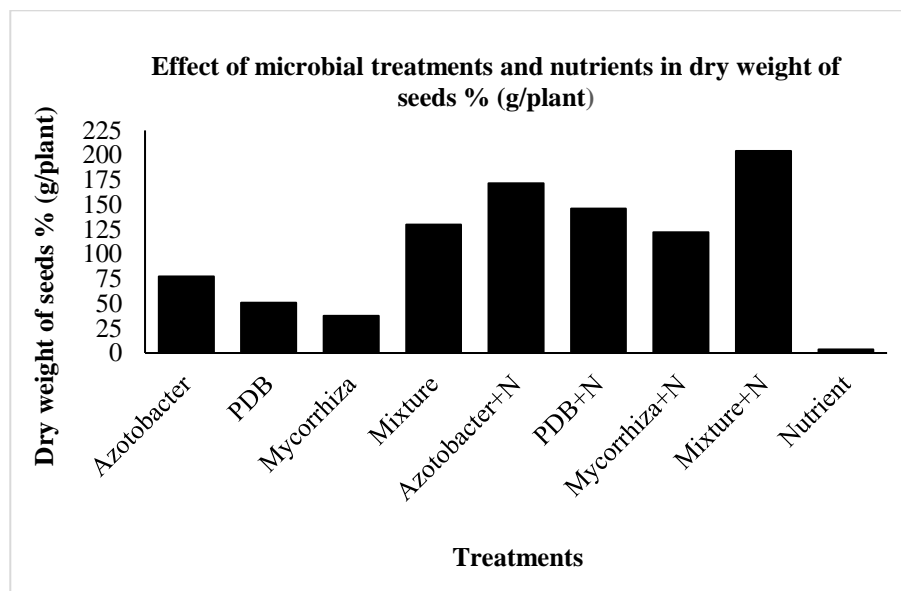


Fig. (13). Effect of microbial treatments with and without nutrient on the dry weight of seeds (g/plant).

4.10. Total lipids

Fig. (14) reveals that all treatments increased the total lipids, and nutrients supply to the microbial treatments increased lipids content percentage. The highest values were with mixture and nutrients and mixture treatments by around 11 and 7%, respectively. The lowest lipids content was with the nutrients treatment.

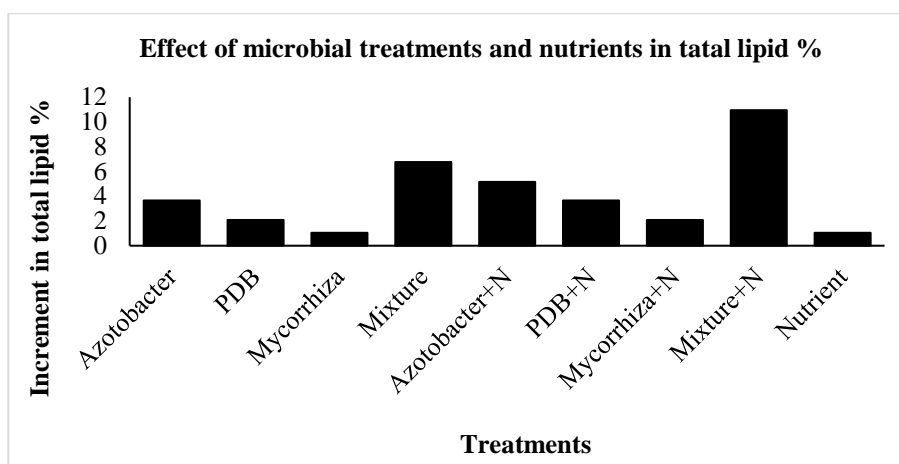


Fig. (14). Effect of microbial treatments with and without nutrients on total lipids.

4.11. Total saturated fatty acids

In Fig. (15), all treatments increased the total saturated fatty acids, but nutrients had no positive effect on total saturated fatty acids percentage. The microbial mixture gave the highest increase of 16% and *Azotobacter* treatment gave 13% increasing.

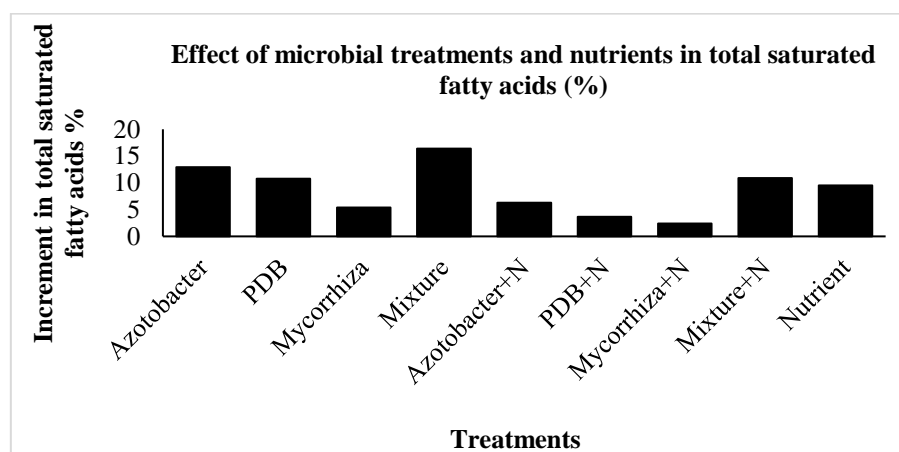


Fig. (15). Effect of microbial treatments with and without nutrient on total saturated fatty acids %.

4.12. Total unsaturated fatty acids

Fig. (16) show that all treatments increased the total unsaturated fatty acids, except mycorrhiza. Adding nutrients to the microbial treatments almost doubled the total unsaturated fatty acids. The microbial mixture with nutrients

gave the highest increase by 3.6% and *Azotobacter* treatment gave 2%, while the treatment with the nutrients alone gave only 0.4 %.

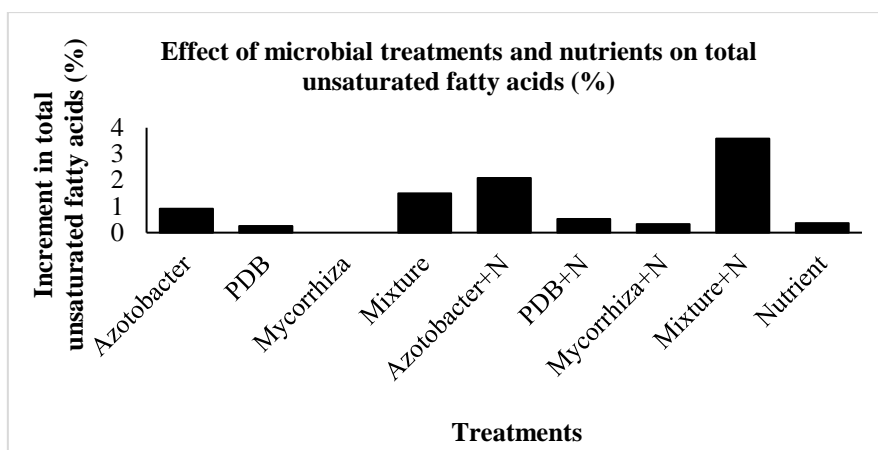


Fig. (16). Effect of microbial treatments with and without nutrients on total unsaturated fatty acids %.

4.13. Total sugars

In Fig. (17), total sugars increased with all treatments compared with control. Adding nutrients to the *Azotobacter* and to the mixture increased the total sugars from 16 to 30% and from 39 to 44%, respectively. The lowest increase was 6% by adding nutrients alone.

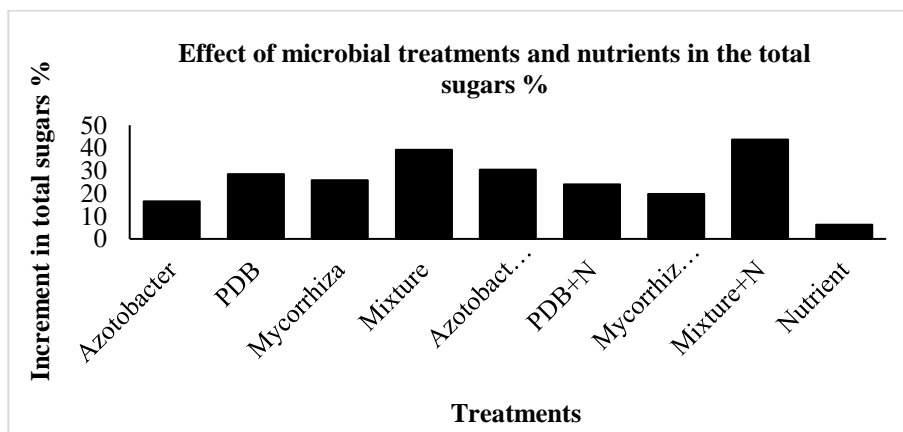


Fig. (17). Effect of microbial treatments with and without nutrients on total sugars.

4.14. Total carbohydrates

Microbial mixture and *Azotobacter* treatments in Fig. (17) gave the highest increase in total carbohydrates percentage by 31 and 27%,

respectively. However, all treatments increased the total carbohydrates compared with the control, nutrients had no positive effect on total carbohydrates when added to microbial treatments, and gave almost the same increase in percentage when added to the microbial mixture by around 20%.

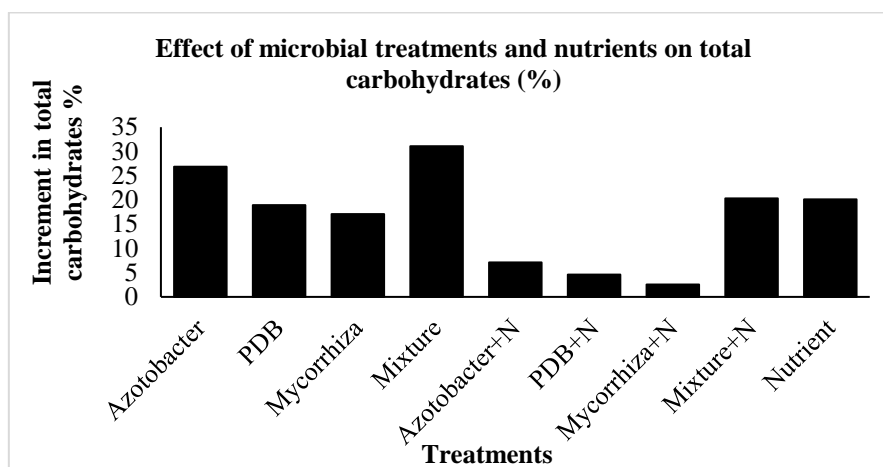


Fig. (18). Effect of microbial treatments with and without nutrients on total carbohydrates.

DISCUSSION

All treatments increased *Azotobacter* count, *Bradyrhizobium* count, plant height, shoot dry weight, root dry weight, number of branches, number and dry weight of nodules, nitrogen content and ethylene production of nodules, dry weight of seeds, total lipids, total saturated fatty acids, total sugars and total carbohydrates over the control. PDB increased significantly with *Azotobacter*, PDB and nutrients treatments. Adding nutrients to the microbial treatments had no positive effect on total microbial count (except the mixture with nutrients treatment), PDB, *Bradyrhizobium*, plant height, shoot dry weight, root dry weight, number and dry weight of nodules, nitrogen content of nodules, nodules ethylene production, total saturated fatty acids and total carbohydrates. However, adding nutrients to the microbial treatment increased number of branches significantly, weight of seeds and total lipids and almost doubled the content of total unsaturated fatty acids over the control. Except mycorrhiza treatment, all treatments increased total microbial count and total unsaturated fatty acids. Mycorrhizal establishment limits root exudation, so microbes which use root exudates might be decline in number in the rhizosphere of mycorrhizal plants. Similar results were reported with Bagyaraj and Menge (1978).

Soil microorganisms' inoculation, increased soil biodiversity, boosted plant growth, and elevated yield (Prabowo, 2017). Biofertilizer contains multi microbes significantly increased plant nutrients assimilation and subsequently

plant yield compared with controls (Bargaz et al., 2018). On the other side, the kind of inoculation in the biofertilizers had no crucial effect on the seeds contents (Bertham et al., 2019).

It was not clear if ethylene plays some role in the nodulation processor (Suganuma et al., 1995). It was reported that ethylene is not immersed in adjustment of nodulation in soybean (Tsyganova and Tsyganova, 2015). On the other hand, some investigations found that ethylene plays a crucial positive role at certain steps of rhizobia-legume mutualism, solo or accompanied with additional hormones, affect the nodules development, orientation, and senescence, besides taking part in host immune responses (Guinel, 2015).

CONCLUSION

A mixture of biofertilizers contains multi microbes significantly increased plant nutrients assimilation and subsequently plant yield compared with controls. *Azotobacter* count, *Bradyrhizobium* count, plant height, shoot dry weight, root dry weight, number of branches, number and dry weight of nodules, nitrogen content and ethylene production of nodules, dry weight of seeds, total lipids, total saturated fatty acids, total sugars and total carbohydrates increased by all treatments over the control.

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تقييم تأثير التسميد الحيوي على تحسين نمو وإنتاجية فول الصويا تحت ظروف القنطرة شرق

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تحتاج زراعة فول الصويا في الأراضي الرملية إلى استخدام أسمدة حيوية صديقة للبيئة يمكنها أن تحل محل الأسمدة المعدنية التي على المدى الطويل والقصير تضر بالبيئة والتربة وكذلك صحة الإنسان. قامت الدراسة على استخدام مجموعة من الأسمدة الحيوية منفردة أو في صورة مخلوط مع إضافة محلول مغذي من الهيوميك ومستخلص الطحالب أو بدونه لدراسة تأثير ذلك على إنتاجية فول الصويا. وقد كان من نتائج الدراسة وجود تأثير إيجابي لكل المعاملات الميكروبية التي اشتملت على بكتريا الأزوتوباكتر كروكوم والباسيلس ميجاثيريم كمذيب للفوسفات وكذلك فطر الميكورهيذا التي تم استخدامها منفردة أو في صورة مخلوط، وتم استخدام بكتريا البرادريزوبيوم جابونيك في جميع المعاملات. وقد حسنت جميع المعاملات من عدد ميكروبات التربة وكذلك الوزن الجاف للسوق والجذور وعدد الأفرع، كذلك طول النبات وعدد والوزن الجاف للعقد الجذرية ومحتواها من النيتروجين والأثيلين. كذلك الوزن الجاف للبذور تحسن ومحتواها من الليبيدات والسكريات والكاربوهيدرات والأحماض الدهنية مقارنة بالكنترول. وتعتبر نتائج الدراسة نواة جيدة لمتابعة دراسات مستقبلية عن أهمية علاقة الميكروبات والنبات وكيفية الاستفادة من ذلك لتحسين الإنتاجية مع تقليل استخدام الأسمدة المعدنية.