The response of Okra *Abelmoshus esculentus* L. to mycorrhizae and biological stimulators (biozyme and phosphalas) on yield and quantity indicators

R M Abdul-alhussein¹, M M Alawi¹ and H H Abood²

¹ University of Baghdad / College of Engineering Agriculture Sciences
² University of Al-Qadisiyah / College of Agriculture

Email: dr.ridhaalubaidy@gmail.com

Abstract. The research was carried out in the fields belongs to Horticulture Department / Agriculture Faculty Baghdad University / Al-Jadiriya for the Spring season 2016 -2017 to study the effect of bio-fertilizer and spraying with Biological Stimulators and their interaction effect on yield and quantity characters of (local okra Petra). The experiment was lay out as a factorial experiment in Randomized Complete Block Design (RCBD), the experiment included (12) treatment Distributed to three replicates. The three factors used in this experiment included. The inoculation with control (C), *Mycorrhizae* (M), Biozyme (B) (B1 2cm³.L⁻¹), (B2 4cm³.L⁻¹), Phosphalas (P) (P 2cm³.L⁻¹), (M+B1), (M+B2), (P+M), (P+B1), (P+B2), (M+P+B1), (M+P+B2).The readings were analyzed according to the design followed and the mean was tested by the lowest significant difference at 0.05%. The results showed a significant increase in the studied traits. The results showed that the three factors and their interactions had significant effects on most of the growth characters measured. The inoculation with the *Mycorrhizae*, Biozyme and Phosphalas was superior in giving higher values of yield per plant (2435) g.plant⁻¹ (M₁B₁P₁), total yield 9.34 ton. ha⁻¹ (M₁B₂P₁), carbohydrate in pods 33.61 % (M₁B₂P₁), protein in pods 2.94 % (M₁B₀), fiber in pods % (M₁B₂P₁) respectively.

Key words: Okra, Mycorrhizae, Biozyme, Phosphalas, Yield

1. Introduction

*Abelmoshus esculentus* L. belongs to the Malvaceae family, one of the important summer vegetable crops in Iraq, which is characterized by the other vegetable crops whose seeds are highly desirable in Iraq Okra is grown for the purpose of green corns that are eaten after cooking or dried, frozen, canning. The original habitat of the okra is the region of Abyssinia, Eritrea, Central Africa, Sudan and Egypt, and from there it moved to the Mediterranean basin, India and the Arabian Peninsula. Okra plant is a good source of nutrients, carbohydrates and proteins where each (100) g of fresh pods contains. (88.9%) of water and (36) calories, (2.4%) of protein, (6.7%, 0.051%) of phosphorus, (0.092%) of carbohydrate, and riboflavin and thiamine. and vitamin C [1].

Microorganisms are spread in all types of soils and in a wide range of ecosystems, extending to the desert, tropical, forest, aquatic, and soils (that filled of water) [2] and [3]. Mycorrhizae (interior and external types) is the most important type of fungi ant it is more effect on growth of plants. Mycorrhizae was studied in decades ago, despite of age of Mycorrhizae exceeds (900 million) years and it belongs to ancient historical period. Biological fertilizers are important factors that provide the plant with the need for nutrient elements after changing the image of the element from the image is not...
ready to facilitate the absorption of the plant, which contributes to reduce the need of the plant for chemical fertilizers by (25%) and reduce the costs of agricultural operations [4]. Douds found that the use of the microorganism in the inoculation of potato tubers led to increase yield by (20%) in inoculated plants if it compared to non-inoculated plants [5]. Using of organic compounds as extract contributes to improve growth of plant due to its nutrients such as nitrogen, phosphorus, potassium, iron, copper, boron, zinc, etc. [6]. As well as it contains many vegetarian hormones such as Auxins, Giberellins, and Cytokinins [7] and organizations of growth have a significant role in the physiological processes that relate to growth of plant and its harvest. [8].

The aim of the experiment was to determine the extent of the response of the Okra crop to the microorganism of the Mycorrhizae and spray with Biozyme and Phosphalas in the growth and production characteristics.

2. Materials and Methods
This study was carried out in the fields belongs to Horticulture Department / Agriculture Faculty/Baghdad University/ in Al-Jadiryah during Spring (2016 – 2017). The main purpose for this study is knowledge of effect Mycorrhizae inoculation (Concentrations please) and spraying (Mention Biozyme and Phosphalas and its Concentrations please.) with biological Stimulators and their interaction on growth, quantitative and qualitative yield of the (local okra Petra). The seeds of the okra were planted in the field during March on form rows where the distance between plants was (30 cm) and the distance between rows was (75 cm). the length of the experimental units was (3 m) for (10) plants where it included following design of the complete random sections in the experiment. The experiment included (12) treatments and distributed to three replicates [9]. The first spraying process of plants conducted after three weeks of their planting and the second spraying process was after two weeks of the first spraying process.

The treatments are included as following: -
1. The control (C)
2. Mycorrhizae (M) P + M
3. Biozyme (2 cm³, L-1) (B1) P + B1
4. Biozyme (4 cm³, L-1) (B2) P + B2
5. Phosphalas (2 cm³, L-1) (P) M + P + B1
6. M + B112- M + P + B
7. M + B2
8. P+M
9. P+B1
10.P+B2
11.M+P+B1
12.M+P+B2

Studied indictors include as the following:
1. The yield per plant (g. plant-1)
2. Total yield (ton. Ha-1)
3. Carbohydrate in pods (%)
4. Protine in pods (%)
5. Fiber in pods (%)

3. Results
3.1. Yield per Plant (g. plant-1)
According to (Table 1), it is clear that there was a significant increase in yield per plant due to the inoculation with the mycorrhizae. Inoculation (M1) recorded higher values for yield per plant (2150 g) than that for non-inoculated plants (1751 g). Also, treatment with (Biozyme) resulted in significant increase in yield per plant especially at (2 cm). L-1(B1) (2092 g) compare to (1788 g) cm for the
control. Treatment with the Phosphalas(P1) recorded plant height of (2000 g) cm while in control treatment the yield per plant was (1901 g).

For the interaction between the inoculation with the mycorrhizae and spray with the Biozyme (M1B1) combination treatment was superior in its effect yield per plant at this treatment was (2249 g) while in control treatment the yield per plant was (1608 g). In the same way for interaction between the inoculation with the mycorrhizae and the spray with the Phosphalas, M1P1 combination treatment resulted in yield per plant with an average yield per plant of (2151 g) in compare to that for the control M0P0 (1654 g). Also, the B2P1 combination treatment, interaction between Biozyme and the Phosphalas, gave the highest yield per plant (2183 g), while the control treatment gave the lowest yield per plant (1654 g) interaction among the three factors has also significant effect. The M1B1P1 combination treatment resulted in higher plants with an average of (2435 g) compare to (1250 g) for the control treatment (M0B0P0).

Table 1. Effect of Mycorrhizae and spray with Biozyme and Phosphalas in the yield per plant (g. plant⁻¹) of okra cv. Ptera

| P  | B      | M₀    | M₁    | P x B | Average |
|----|--------|-------|-------|-------|---------|
| P₀ | B₀     | 1250  | 1883  | 1654  | 1901    |
|    | B₁     | 1965  | 2052  | 1955  |         |
|    | B₂     | 1781  | 2128  | 2183  |         |
| P₁ | B₀     | 1607  | 2370  | 2009  | 2000    |
|    | B₁     | 1931  | 2435  | 1989  |         |
|    | B₂     | 1974  | 2030  | 2002  |         |
| L.S.D 0.05 | 16.67 | 11.79 | 6.81  |         |

3.2. Total Yield (ton. Ha⁻¹)

According to (Table 2), it demonstrates the significant effect of the inoculation with the mycorrhizae on the total yield. The inoculation treatment (M1) resulted in higher total yield (6.97 ton. ha⁻¹) than that for the control (5.54 ton. ha⁻¹) (M0). Also, for the Biozyme treatments effects, (4 cm). L-1 (B2) treatment recorded the highest of total yield (7.17 ton. ha⁻¹) in compare to (5.66 ton ha⁻¹) for the treatment (B0). Spraying the Phosphalas on plants have also promoting effect on total yield. Higher of total yield was recorded at (P1) treatment (6.59 ton. ha⁻¹) in compare to (5.92 ton. ha⁻¹) for the (P0) treatment. It was obvious from the same table that the interaction between the mycorrhizae and spray with the Biozyme significantly increased of total yield. At the M1B2 combination treatment, the plant was (8.12ton ha⁻¹) while was total yield at the control was much lower (4.99 ton. ha⁻¹). With regard to the effect of the combination between the mycorrhizae and the Phosphalas significant effect was also noticed the M1P1combination treatment recorded the highest total yield (7.38 ton. ha⁻¹) while the control treatment recorded the lower total yield (5.27 ton. ha⁻¹). For the combination between
Biozyme and the Phosphalas treatments increased total yield recorded the highest (7.81 ton. ha\(^{-1}\)) while the control treatment recorded the lower total yield (4.99 ton. ha\(^{-1}\)). As for other parameter measured total yield was affected by the combination among the three factors. The M1B2P1 combination treatment was superior in giving the highest total yield (9.34 ton. ha\(^{-1}\)) the least total yield was (3.98 ton. ha\(^{-1}\)) at the control treatment (M0B0P0).

### Table 2. Effect of Mycorrhizae and spray with Biozyme and Phosphalas in the total yield (ton. H\(^{-1}\)) of okra cv. Ptera

|    | B  | M₀  | M₁  | PxB | Average |
|----|----|-----|-----|-----|---------|
| P₀ | B₀ | 3.98| 6.00| 4.99| 5.92    |
|    | B₁ | 6.00| 6.65| 6.23|         |
| P₀ | B₂ | 5.68| 6.78| 6.53|         |
| P₁ | B₀ | 5.12| 6.17| 6.32| 6.59    |
|    | B₁ | 6.15| 6.91| 5.65|         |
| P₁ | B₂ | 6.29| 9.34| 7.81|         |
|    | L.S.D 0.05 | 0.34 | 0.24 | 0.14 |         |

### 3.3. Carbohydrate in pods (%)

The results of Table 3, it is clearly that the inoculation with the mycorrhizae had significant effect. Carbohydrate in pods increased from (29.68 %) for the non - Inoculated plants to (23.07 %) for the inoculated ones (M1 treatment). Also, with spray with Biozyme the carbohydrate in pods increased from (B2) treatment to (29.99 %) for (B0) treatment (22.57 %). The Phosphalas (P1) treatment had significant effect carbohydrate in pods increased from (27.61 %) for the control treatment (P0) (25.14 %), interaction between the inoculation with the mycorrhizae and Biozyme had significant effect. The highest of carbohydrate in pods combination treatment (32.00 %) while the lowest carbohydrate in pods was recorded at the control (16.03 %) (M0B0). In the same way, interaction between inoculation with mycorrhizae and the spray with the Phosphalas had significant effect. The highest carbohydrate in pods (30.18 %) was obtained at the combination treatment while the lowest carbohydrate in pods was at the control (21.10 %).

Spray with Biozyme along with the Phosphalas resulted in larger the carbohydrate in pods at all combination treatments. The B1P1 combination treatment was superior in its effect which resulted in the prefect carbohydrate in pods (30.63 %) control treatment (B0P0) gave the lowest carbohydrate in pods (20.23 %). For the combination of the three factors studied, the M1B1P0 treatment was more effective in giving the largest carbohydrate in pods (33.61 %) which did not differ significantly from other combination treatments the control treatment (M0B0P0) gave the least of carbohydrate in pods (11.23 %).
Table 3. Effect of Mycorrhizae and spray with Biozyme and Phosphalas in the carbohydrate in pods (%) of okra cv. Ptera

|     |     | M₀   | M₁   | M₀ x M₁ | Average |
|-----|-----|------|------|---------|---------|
| P₀  | B₀  | 11.23| 29.22| 20.23   | 25.14   |
|     | B₁  | 20.82| 29.02| 25.86   |         |
|     | B₂  | 23.78| 27.93| 29.34   |         |
| P₁  | B₀  | 26.64| 27.92| 24.92   | 27.61   |
|     | B₁  | 28.30| 30.39| 27.28   |         |
|     | B₂  | 27.66| 33.61| 30.63   |         |
| L.S.D 0.05 | 1.38 | 0.97 | 0.56 |

P x M

|     | M₀ | M₁ | M₀ x M₁ | Average |
|-----|----|----|---------|---------|
| P₀  | 21.10 | 29.18 |         | LSD 0.05 |
|     | 25.04 | 30.18 |         | 0.79    |
| B x M
| B₀  | 16.03 | 29.12 |         | 22.57   |
|     | 25.21 | 27.93 |         | 26.57   |
|     | 27.98 | 32.00 |         | 29.99   |
| L.S.D 0.05 | 0.97 | 0.69 |
| Average | 23.07 | 29.68 |
| L.S.D 0.05 | 0.56 |

3.4. Protine in pods (%)

According to Table 4 that there was a significant increase in the number of Protine in pods inoculation with the mycorrhizae. Inoculation (M₁) recorded higher values for the Protine in pods (2.28 %) than that for non-inoculated plants (2.10 %). Also, treatment with (Biozyme) resulted in significant increase in Protine in pods at 4 cm. L₁(B₂) (2.37 %) compare to (1.91 %) for the control. Treatment with the Phosphalas (P₁) recorded Protine in pods was (2.26 %) while in control treatment Protine in pods was (2.12 %).

For the interaction between the inoculation with the mycorrhizae and the spray with the (Biozyme), M₁B₁ combination treatment was superior in its effect plant height at this treatment was (2.73 %) while in control treatment the plant height was M₀B₀ (1.85 %). In the same way, for interaction between the inoculation with the mycorrhizae and the spray with the Phosphalas, M₁P₁ combination treatment resulted in Protine in pods with an average the Protine in pods (2.52 %) in compare to that for the control M₀P₀ (2.20 %). Also, the B₂P₁ combination treatment, interaction between Biozyme and the Phosphalas, gave in Protine of pods (2.43 %), while the control treatment gave the lowest Protine of pods (1.24 %). Interaction among the three factors has also significant effect. The M₁B₁P₀ combination treatment resulted in the number of legions on the stem with an average of (2.94 %) compare to (1.70 %) for the control treatment (M₀B₀P₀).
Table 4. Effect of Mycorrhizae and spray with Biozyme and Phosphalas in protein in pods (%) of okra cv. Ptera

| P  | B   | M₀   | M₁   | PxB | Average |
|----|-----|------|------|-----|---------|
| P₀ | B₀  | 1.70 | 2.52 | 2.11 | 2.12    |
|    | B₁  | 2.01 | 2.94 | 1.94 |         |
|    | B₂  | 2.11 | 1.78 | 2.32 |         |
| P₁ | B₀  | 1.63 | 2.11 | 2.47 | 2.26    |
|    | B₁  | 2.81 | 1.82 | 1.87 |         |
|    | B₂  | 2.34 | 2.52 | 2.43 |         |
| L.S.D0.05 | 0.22 | 0.16 | 0.09 |       |

P x M

| B   | P₀   | 2.20 | 2.04 | L.S.D 0.05 |
|-----|------|------|------|------------|
| P₁  | 1.99 | 2.52 | 0.13 |           |

B x M

| B   | M₀   | M₁   | P x B | Average |
|-----|------|------|-------|---------|
| B₀  | 1.87 | 1.95 | 1.91  |         |
| B₁  | 1.85 | 2.73 | 2.29  |         |
| B₂  | 2.58 | 2.17 | 2.37  |         |
| L.S.D0.05 | 0.16 | 0.11 |       |         |
| Average | 2.10 | 2.28 |       |         |
| L.S.D 0.05 | 0.09 |       |       |         |

3.5. - Fiber in pods (%)

According to Table 5 it is found that there was a significant increase in fiber in pods due to the inoculation with the mycorrhizae. Inoculation (M₁) recorded higher values for fiber in pods (1.76 %) than that for non-inoculated plants (1.85 %). Also, treatment with (Biozyme) resulted in significant increase in fiber in pods especially at 4 cm. L²(B₂) (1.80 %) compare to (1.79 %) for the control. Treatment with the Phosphalas (P₁) recorded fiber in pods (1.78 %) while in control treatment the fiber in pods was (1.83 %).

For the interaction between the inoculation with the mycorrhizae and the spray with the (Biozyme) M1B2 combination treatment was superior in its effect the fiber in pods at this treatment was (1.67%) which was not significantly differing from the M0B0 combination treatment, while in control treatment the fiber in pods was (1.76 %). In the same way for interaction between the inoculation with the mycorrhizae and the spray with the Phosphalas, M1P1 combination treatment resulted in with an average the fiber in pods was (1.08 %) in compare to that for the control (1.82 %) M0P0. Also, the B2P1 combination treatment, interaction between Biozyme and the Phosphalas, gave the highest the fiber in pods (1.78 %) while the control treatment gave the lowest the fiber in pods (1.83 %). Interaction among the three factors has also significant effect. The M1B2P1 combination treatment resulted in the fiber in pods with an average of (1.51 %) compare to (1.63 %) for the control treatment (M0B0P0).
Table 5. Effect of Mycorrhizae and spray with Biozyme and Phosphalas in fiber in pods (%)

|   | B   | M₀   | M₁   | PxB   | Average |
|---|-----|------|------|-------|---------|
| P₀ | B₀  | 1.63 | 1.97 | 1.80  | 1.83    |
|    | B₁  | 1.90 | 1.64 | 1.82  |         |
|    | B₂  | 1.90 | 1.73 | 1.88  |         |
| P₁ | B₀  | 1.82 | 1.88 | 1.77  | 1.78    |
|    | B₁  | 1.93 | 1.82 | 1.85  |         |
|    | B₂  | 1.95 | 1.51 | 1.73  |         |

L.S.D 0.05 0.21 0.15 0.09

P x M

|   | P₀  | 1.82 | 1.84 | L.S.D 0.05 |
|---|-----|------|------|-------------|
|   | P₁  | 1.89 | 1.68 | 0.12        |

B x M

|   | B₀  | 1.76 | 1.81 | 1.79        |
|---|-----|------|------|-------------|
|   | B₁  | 1.86 | 1.81 | 1.83        |
|   | B₂  | 1.94 | 1.67 | 1.80        |

L.S.D 0.05 0.15 0.11

Average 1.85 1.76

L.S.D 0.05 0.09

4. Discussions

The increase achieved in the characteristics of the plant and the total product as a result of inoculation with Mycorrhizae fungi and spray Biozyme and Phosphalas and the impact of these factors on vegetative growth and because the plant crop depends on the growth of vegetation significantly as the increase of leaf area of the plant leads to an increase in the photosynthesis process [10]. In addition, inoculation with Mycorrhizae fungi increases the effectiveness of photosynthesis because the symbiotic coexistence between the plant and the fungus and the fungus helps to absorb the element phosphorus, which increases the growth of the plant, which equips the plant with carbonate products [11]. This was led to an increase in the number of pods and plant yield, which is a reflection on the increase of the total yield.

The increase in plant yield and total yield may be due to the role of Mycorrhizae fungi in nutrient readiness and readily absorbed from the soil [12], which is reflected in the increase of food processing and transport to the corneas as the center of the collection of food and water, which leads to the improvement of the qualities of the corneas, quality and weight pods, which leads to an increase in the yield per plant and the total yield [13] and [14].

The improvement of qualitative qualities of the horns can be attributed to the role of Mycorrhizae fungi in increasing the effectiveness of total water root absorption from the soil and encouraging them to produce natural plant hormones that have a basis and are effective in improving plant growth [15], which is reflected in the specific qualities of the horns are carbohydrates, protein and fiber, or it may be due to the role of Mycorrhizae in promoting the growth of roots and the formation of a strong and large root mass in addition to the spread of fungus haifes in areas where cannot reach the root capillaries, which helps the readiness and availability of nutrients hence great costume facilitated of transition to pods being gathered food center and this leads to quality improvement qualities of pods [16].

This may be attributed to the content of Biozyme and Phosphalas on nutrients and plant hormones, which encourage the increase of biological and physiological processes and stimulate cell growth, elongation and division, and thus reflected on the increase of the products of carbon metabolism and
increase the materials manufactured in the center of the manufacture of plant nutrients, the leaves [17], [18] and [19], and then transferred to the corners, which encourages the improvement of qualities of qualitative corners.

References
[1] Matlob, A. N., et al. 1989. Production of Vegetables. Part one National Library Printing and publishing Directorate. University of Mosul. Ministry of Higher Education and Scientific Research. Iraq. pp. 68.
[2] Renker, C.; et al. 2005. Diversity of arbuscular mycorrhizas fungi in grassland spontaneously on area polluted by fertilizers plant. Environmental pollution, 135 pp. 255-266.
[3] Brundrett, M.C .1991. mycorrhizas in natural ecosystem in advances in ecological research, VOL.21 Eds. A Macfayden, M Begon, A.H Fitter. pp171=313 Academic press, press UK.
[4] AL-Haddad, Z. A. 2003. Proceedings of the Arab Conference for Organic Agriculture for the Ecosystem and the Promotion of the Economy. Tunisia. pp. 261-770.
[5] Douds, D. D; et al. 2007. Inoculation with am fungi increases the yield of potatoes in high p soil. Biological. Agricultures and Horticulture .25:67-78.
[6] Hegab.M.Y; et al. 2005. Effect of algae extract and mono potassium phosphate on growth fruiting of Balady orange tree (Citrus sinensis) Proc. First science conf., Agriculture. Science of Assuit University.
[7] Ergun.N.; et al. 2002. Auxin, gibberellic acid, abscisic acid and cytokinin production by some species of Mosses and mosses. Turkish. Journal of Botany.
[8] Saleh, S., S. Mohammed. 1991. Physiology of plant growth regulators, First Edition, Ministry of Experiments, Ministry of Higher Education and Scientific Research, Salahuddin. University. pp. 272.
[9] AL-Sahookie, M. M and Wuhaib. K. M.1991. Applications on design and analysis of experiments. Dar AL- Hekma for publishing. Ministry of Higher Education. Iraq.
[10] Allawi, M.M. 2013. Impact of Bio, Organic and chemical fertilization on the roots architectural and growth and yield of pepper plant (Capsicum annuum). The Requirements for degree Doctor of Philosophy in Science. Horticulture & landscape Gardening. University of Baghdad, Iraq.
[11] Paradi, L. Z.; et al. 2003. Influence of arbuscular mycorrhiza and phosphorus supply on polyamine content, growth and photosynthesis of Plantagolanceolata. Biologia Plant. 46: 563-569.
[12] Song, H.2005. Effect of VAM on host plant the condition of drought stress and its Mechanism. Electronic biology 1:44-48.
[13] Al-Umrani, H.H. 2018. Effect of the Inoculation with the Mycorrhizae, ferrous sulfate. Armruxosoluation Application on growth and yield of Okra. thesis degree for Master of Science Agriculture in Horticulture & Landscape Gardening. University of Baghdad. Iraq.
[14] Al-Umrani, H.H. and Abdul al-Hussain R.M. 2019. The Effect of the Inoculation with the Mycorrhizae and Spray with FeSO4 and Anti-Transpiration on Some Growth Characters and Yield of Okra Abelmachus esculentus L. Moench 9(1): pp170 – 178.
[15] Azcon – Aguilar, C. and Barea . J.M. 1996. Effect of soil microorganisms on for mation VA mycorrhizas. trans. Br. Mycol. Soc. 84: 536-537.
[16] Cimen, I.; et al. 2010. Effect of soil solarization and arbuscular mycorrhizal fungus (Glomusintraradices) on yield and blossom end rot of tomato. Internat. J. Agric.Biol. 4: 551-555.
[17] Garmendia, I.; et al. 2004. Effectiveness of three Glomus species in protecting pepper (Capsicum annuumL.) against verticillium. Wilt. Biol. Contr. 31: 296-305.
[18] AL-Ubaidy .R.M. 2006. Effect of Sparing Whey and Mineral Nutrition in Growth and Yield of Tomato. The Requirements for the degree Doctor of Philosophy Science in Horticulture. University of Baghdad, Iraq.
[19] Al-Obady, R.M. 2015. Effect of foliar application with garlic extract and Liquorice root extract and Salicylic acid on vegetative growth and flowering and flower set of tomato and under unheated houses. Journal of Applied Science and Research, 3 (1): 11-22.