Response of Eggplant (*Solanum melongena* L) Seedlings to Organic and Bio Fertilization

Hussein Ali Salim[1], Noora Bandar Maizar[2], Idrees Ghalib Idrees[3]

[1]Directorate of Diyala Agriculture, Ministry of Agriculture, Iraq
[2]Ministry of Higher education, Diyala University , Iraq
[3]Ministry of Agriculture, Agricultural Extension and Training Department, Iraq
E-mail: h_salim11111@yahoo.com

Abstract

The pot assay was conducted in the plastic greenhouse at the Baqubah nursery, Directorate of Diyala, Iraq, during 2024–2025 to evaluate the effects of PGPR, mycorrhizae, vermicompost, and biochar on the growth of eggplant seedlings. The various treatments included PGPR bacteria, mycorrhizae, vermicompost, biochar, PGPR + mycorrhizae, PGPR + vermicompost, PGPR + biochar, mycorrhizae + vermicompost, mycorrhizae + biochar, vermicompost + biochar, PGPR + mycorrhizae + vermicompost + biochar, and control. The findings indicated that PGPR and vermicompost recorded the highest shoot lengths (24.66 and 24.33 cm, respectively). PGPR achieved the highest root weight (2.20 g) and chlorophyll content (42.20 spad). The combination of PGPR, mycorrhizae, vermicompost and biochar produced the highest dry shoot weight (0.80 g).

Keywords. PGPR, mycorrhizae, vermicompost, biochar

Introduction

The Solanaceae family includes the herbaceous vegetable eggplant (*Solanum melongena*), which is mostly cultivated worldwide; it ranks as the fifth most significant solanaceous crop [13]**.** Seedlings at the early stages of growth require proper care to withstand biotic and abiotic stresses and develop into strong, healthy plants. Farmers frequently use fertilizers because the main goal of increasing yields requires high levels of chemical fertilizer use; however, this is costly, leads to environmental issues and produces ecological pollutants [11]. To improve seedling growth in nurseries and enhance overall yield, there is a growing need to use environmentally friendly fertilizers instead of chemical ones. Many researchers are currently exploring sustainable alternatives such as plant growth-promoting rhizobacteria (PGPR), mycorrhizae, vermicompost, biochar, etc. Living microorganisms known as bio-fertilizers inhabit the rhizosphere zone and are crucial in helping plants absorb the vital nutrients they need [10]**.** Some soil fungi and plant roots form symbiotic connections known as mycorrhizae, which enhance a plant's capacity to absorb nutrients, while the fungi receive sugars from the plant. Earthworms naturally decompose organic waste to produce vermicompost, an organic fertilizer rich in nutrient. Recently, it has been noted that using agricultural wastes can be a sustainable and advantageous practice, especially when their bio-processed products, including biochar and vermicompost are used [3,14]**.** Therefore, this study aimed to evaluate the effects of PGPR, Mycorrhizae, vermicompost, and biochar on the growth of eggplant seedlings.

Materials and Methods

A pot experiment was conducted during the seasons 2024–2025 at the Baqubah nursery, Directorate of Diyala Agriculture, Diyala Province, Iraq, to evaluate the impact of PGPR represented by *Bacillus megaterium*, *Azospirillum brasilense*, and *Pseudomonas fluorescens* as a commercial formulation, mycorrhizae loaded on a nutritional medium, vermicompost, and biochar on the growth characteristics of eggplant seedlings. The physical and chemical characteristics of the pot's soil were analyzed in the soil lab belonging to the Directorate of Diyala Agriculture (Table 1). The eggplant seeds cultivar (Barcelona) was planted in cork plates on 29/8/2024 and then transformed to pots on 29/10/2024. The pots are 27 cm in length, 25 cm in width, and 9 kg in weight with soil; the assay is divided into twelve treatments and three replicates according to the complete randomized design (CRD). The treatments were added to the pots at 5 g/pot on 17/11/2024. The traits of chlorophyll and leaf area were taken on 24/12/2024, and other traits such as shoot and root length, shoot and root weight, dry shoot and root weight on 19/1/2025. The statistical analysis was implemented by using the SPSS program.

Table 1. The soil properties

Measurements	Value	Units
P	4.4	mg. kg^{-1}
K	46	mg. kg^{-1}
Clay	5.12	%
Silt	2.16	%
Sand	92.72	%
Texture of soil	Sandy	-
Organic matter	0.2	%
Ec	2.32	ds Siemens. m^{-1}
pH	7.2	-

Results and discussion

The data in Table 2 demonstrate that individual applications of PGPR and vermicompost significantly enhanced shoot length, with values (24.66 and 24.33 cm, respectively) outperforming all other treatments, followed by mycorrhizae and biochar, with values (23.16 and 22.16 cm, respectively), while the control treatment had the lowest shoot length (18.33 cm). There were no significant differences between treatments in root length. The shoot weight varied significantly among treatments. The control recorded the highest shoot weight (4.56 g), followed by PGPR (3.93 g), vermicompost + biochar (3.90 g), and PGPR + mycorrhizae + vermicompost + biochar (3.16 g), which showed comparable results to the control. In contrast, mycorrhizae + vermicompost produced the lowest shoot weight (2.10 g). Most other treatments showed intermediate values with no significant differences among them. PGPR individual led to the highest root weight (2.20 g), significantly greater than mycorrhizae + vermicompost (1.30 g), which recorded the lowest. All other treatments, including the control (1.96 g), showed intermediate root weights with no significant differences among them.

The data in Table 3 demonstrate that the combination of PGPR + mycorrhizae + vermicompost + biochar produced the highest dry shoot weight (0.80 g), significantly greater than most other treatments. Biochar alone showed the lowest value (0.36 g). All other treatments, including the control (0.50 g), showed intermediate results with no significant differences among them. Vermicompost + biochar resulted in the highest dry root weight (0.75 g), significantly higher than most other treatments. Mycorrhizae (0.27 g), PGPR + vermicompost (0.25 g), and PGPR + biochar (0.28 g) recorded the lowest values. The remaining treatments, including the control (0.40 g), showed intermediate dry root weights without significant differences. There were no significant differences between treatments in leaf area. PGPR alone recorded the highest chlorophyll content (42.20 spad), significantly greater than all other treatments. In contrast, the control showed the lowest value (15.00 spad). Other treatments such as biochar (35.45 spad), mycorrhizae + vermicompost (37.50 spad), and PGPR + biochar (39.35 spad) also showed relatively high values, while combinations like vermicompost + biochar (21.80 spad) and the full combination treatment (22.10 spad) had low chlorophyll levels. This outcome suggests potential antagonism or resource competition among bio-inputs when applied together, and more is not always better, and careful selection of individual bio-inputs may be more effective than their mix together. Inoculating eggplant seedlings with PGPRs supports plant growth and increases yield under saline conditions [12]. The combination of PGPR bacteria (*Azospirillum brasilense, Pseudomonas fluorescens, and Bacillus megaterium*) with the yeast at various concentrations significantly enhanced the vegetative growth traits of cucumber plants [10]. The application of PGPR (*Bacillus megaterium, Azospirillum brasilense, and Pseudomonas fluorescens*) in combination with nitrogen and phosphorus significantly improved morphological traits and yield in cauliflower, compared to the application of nitrogen and phosphorus alone. The treatment resulted in the highest values for leaf length, leaf width, stem height, plant weight, and yield [9]. The findings demonstrated that both vermicompost and biochar enhanced plant growth and yield [6,8]. Adding biochar to the soil can enhance plant development mostly because it improves the soil properties, including reducing bulk density and increasing nutrient availability [2,15]. Biochar increases the cation exchange capacity and soil properties and improves nutrient absorption by plants, which leads to improved plant development [5]. [7] reported that the application of vermicompost and biochar increased the levels of chlorophyll a and b in eggplant leaves. This finding is consistent with the results of [16,2] which showed that biochar application enhanced chlorophyll a and b content by improving the uptake of magnesium and nitrogen essential macronutrients for chlorophyll biosynthesis. [1] reported that soil inoculation with mycorrhizae increased the nitrogen and phosphorus content in leaves, enhanced cutting root formation, and improved plant height, root length, and root dry weight in myrtle**.** [4] indicated that mycorrhizal inoculation enhanced root and shoot fresh and dry weights, plant height, and leaf diameter in pepper plants.

Conclusion

The application of plant growth-promoting rhizobacteria (PGPR), mycorrhizae, vermicompost, and biochar applied individually or in

ISSN 2072-3857

combinations enhanced the vegetative growth of eggplant. Among the individual treatments, PGPR and vermicompost were particularly effective, significantly increasing shoot length, shoot and root weight, and chlorophyll content, highlighting their strong potential to improve overall plant vigor.

Table 2. Effects of PGPR, mycorrhizae, vermicompost, and biochar on shoot and root length and shoot and root weight of eggplant seedlings

	Treatments	**Shoot length cm**	**Root length cm**	**Shoot weight g**	**Root weight g**
1	PGPR	24.66 a	9.33 a	3.93 ab	2.20 a
2	Mycorrhizae	23.16 ab	7.83 a	3.00 bc	1.46 ab
3	Vermicompost	24.33 a	9.00 a	3.03 bc	1.80 ab
4	Biochar	22.16 abc	10.33 a	2.63 bc	1.53 ab
5	PGPR + Mycorrhizae	21.50 abc	8.50 a	2.76 bc	1.83 ab
6	PGPR + vermicompost	20.83 abc	8.66 a	2.73 bc	1.93 ab
7	PGPR + biochar	21.33 abc	7.33 a	2.53 bc	1.63 ab
8	Mycorrhizae + vermicompost	19.00 bc	7.50 a	2.10 c	1.30 b
9	Mycorrhizae + biochar	19.00 bc	9.83 a	2.66 bc	1.33 ab
10	Vermicompost+ biochar	21.00 abc	7.16 a	3.90 ab	1.40 ab
11	PGPR + Mycorrhizae + vermicompost+ biochar	20.33 abc	10.66 a	3.16 abc	1.53 ab
12	Control	18.33 c	8.66 a	4.56 a	1.96 ab

Table 3. Effects of PGPR, mycorrhizae, vermicompost, and biochar in leaves content of chlorophyll, Leaf area, dry shoot and root weight of eggplant seedlings

	Treatments	**Dry shoot weight g. plant^{-1}**	**Dry root weight g. plant^{-1}**	**Leaf area cm. plant^{-1}**	**Chlorophyll spad**
1	PGPR	0.60 ab	0.59 ab	178.06 a	42.20 a
2	Mycorrhizae	0.43 b	0.27 c	178.54 a	27.20 cde
3	Vermicompost	0.60 ab	0.43 bc	206.54 a	33.85 bc
4	Biochar	0.36 b	0.37 bc	193.80 a	35.45 ab
5	PGPR + Mycorrhizae	0.41 b	0.36 bc	191.26 a	31.15 bcd
6	PGPR + vermicompost	0.37 b	0.25 c	168.80 a	24.95 de
7	PGPR + biochar	0.40 b	0.28 c	193.21 a	39.35 ab
8	Mycorrhizae + vermicompost	0.47 ab	0.38 bc	179.90 a	37.50 ab
9	Mycorrhizae + biochar	0.43 b	0.36 bc	197.02 a	25.40 de
10	Vermicompost+ biochar	0.71 ab	0.75 a	159.46 a	21.80 ef
11	PGPR + Mycorrhizae + vermicompost+ biochar	0.80 a	0.46 bc	161.18 a	22.10 ef
12	Control	0.50 ab	0.40 bc	186.11 a	15.00 f

ISSN 2072-3857

References

1. Alsaady M. H. M., Salim H. A, Ali A. F. 2024. Effect of Mycorrhizae and some root stimulators on cuttings of Myrtle (*Myrtus communis* Linn.), Euphrates Journal of Agricultural Science-16 (2):72-78.
2. Chan KY, Zwieten LV, Meszaros I, Downie A, Joseph S. 2008. Using poultry litter biochars as soil amendments. Aust J Agric Res.;46:437–44.
3. D'Hose T, Debode J, De Tender C, Ruysschaert G, Vandecasteele B. 2020. Has compost with biochar applied during the process added value over biochar or compost for increasing soil quality in an arable cropping system. Appl Soil Ecol.. https ://doi.org/10.1016/j.apsoil.2020.10370 6.
4. Efe SOYLU, Mehmet IŞIK and İbrahim ORTAŞ 2023.The Effect of Mycorrhiza Inoculation on Pepper Plant Growth and Mycorrhizal Dependency, International Journal of Agricultural and Applied Sciences, June , 4(1): 127-131, https://doi.org/10.52804/ijaas2023.4121.
5. Keabetswe L, Shao GC, Cui J, Lu J, Stimela TA.2019. Combination of biochar and regulated deficit irrigation improves tomato fruit quality: A comprehensive quality analysis. Folia Hort.;31:181–93.
6. Marschner P. Marschner's mineral nutrition of higher plants. 2011. 3rd ed. London: Elsevier.
7. Mohsen Ebrahimi, Mohammad Kazem Souri, Amir Mousavi and Navazolah Sahebani 2021. Biochar and vermicompost improve growth and physiological traits of eggplant (*Solanum melongena* L.) under deficit irrigation, Ebrahimi et al. Chem. Biol. Technol. Agric. 8:19. https://doi.org/10.1186/s40538-021-00216-9
8. Prasad M, Tzortzakis N, McDaniel N. 2018.Chemical characterization of biochar and assessment of the nutrient dynamics by means of preliminary plant growth tests. J Environ Manag.;216:89–95.
9. Salim H. A., A. F. Ali, M. H. M. Alsaady, U. N. Saleh, N. H. Jassim, A. R. Hamad, J. A. Attia, J. J. Darwish and A. F. Hassan 2020. Effect of plant growth promoting rhizobacteria (PGPR) on growth of cauliflower (*Brassica oleracea* l. Var. *Botrytis*), plant archives, volume 20 no. 1, pp. 782-786.
10. Salim H. A., Kadhum A. A., Ali A. F. , Saleh U. N. , Jassim N. H. , Hamad A.R. , Attia J. A. , Darwish J. J. , Hassan A. F. 2021. Response of Cucumber Plants to PGPR Bacteria (*Azospirillum brasilense* , *Pseudomonas fluorescens* and *Bacillus megaterium*) and Bread Yeast (*Saccharomyces cerevisiae*), Sys Rev Pharm 2021;12 (1): 969-975.
11. Salim, H.A., I.S. Salman and B.N. Jasim 2016. Ipm approach for the management of wilt disease caused by *Fusarium oxysporum f. sp. lycopersici* on tomato (*Lycopersicon esculentum*), *Journal of Experimental Biology and Agricultural Sciences*., 4: 742-747.
12. Samy A. M. Abd El-Azeem, Mohmmed W. M. Elwan, Jwa-Kyung Sung & Yong Sik Ok 2012 . Alleviation of Salt Stress in Eggplant (*Solanum melongena* L.) by Plant-Growth-Promoting Rhizobacteria, Communications in Soil Science and Plant Analysis, 43:9, 1303-1315. http://dx.doi.org/10.1080/00103624.2012.666305
13. Taher D, Solberg S, Prohens J, Chou Y, Rakha M, Wu T. 2017. World vegetable center eggplant collection: origin, composition, seed dissemination and utilization in breeding. Front Plant Sci.;8:1484.
14. Wang X-X, Zhao F, Zhang G, Zhang Y, Yang L. 2017. Vermicompost improves tomato yield and quality and the biochemical properties of soils with different tomato planting history in a greenhouse study. Front Plant Sci.;8:1978.

ISSN 2072-3857

15. Windeatt JH, Ross AB, Williams PT, Forster PM, Nahil MA, Singh S. 2014. Characteristics of biochars from crop residues: potential for carbon sequestration and soil amendment. J Environ Manage.;146:189–97. https :// doi.org/10.3389/fpls.2017.01978.

16. Zargar Shooshtari F, Souri MK, Hasandokht MR, Kalate JS. 2020. Glycine mitigates fertilizer requirements of agricultural crops: case study with cucumber as a high fertilizer demanding crop. Chem Biol Technol Agri.;7(1):1–10.

ISSN 2072-3857