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Effect of adding fish emulsion and vermicompost on the growth of Tarragon (*Artemisia dracunculus* L.)

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Abstract

The experiment was carried out in the canopy of the Horticulture and Landscape Department - College of Agriculture - University of Kerbala during the spring semester of 2023. The study was implemented as a factorial experiment with a randomized complete block design (R.C.B.D.) with three replications. The experiment included two factors: fish emulsion (F), which was added at four concentrations: 0, 1, 2, 3% and added five times every two weeks, while the second factor was vermicompost (V), which was added before transferring the seedlings to the planting pots, at four levels: 0, 25, 50. 100 g pot^{-1}. The results showed that adding fish emulsion had a significant effect on most vegetative growth traits, except for plant height and dry matter percentage, while adding Vermicompost had no significant effect on plant height and chlorophyll content of leaves, while it had a significant effect on the rest of the vegetative growth traits. The results of the intervention treatments between the study factors varied in their influence on the studied traits. The F4V4 intervention treatment gave the highest rate of plant height and number of branches, as it gave 85.16 cm and 32.50 branch plant^{-1}, respectively, while the F2V3 treatment gave the highest rate of stem diameter of 3.127 mm, and F1V3 gave the highest rate of dry matter perce32wesaz2ntage, which gave 20.57%, and F3V3 the highest rate of leaf chlorophyll content, which gave 46.91 mg g^{-1} fresh weight .It can be concluded from this study that fertilizers resulting from organic waste can be used as fertilization sources for plants and combined with them to reduce the use of chemical fertilizers, reduce environmental damage, follow a sustainable agriculture system, and increase the efficiency of fertilizer use.

Keywords: organic fertilizers, fish waste, earthworm, vermicompost, Asteraceae family.

Introduction

The tarragon plant, *Artemisia dracunculus* L., is one of important medicinal plants belonging to the Asteraceae family, which is a perennial herb and is considered suitable for human consumption, whether fresh or dry, as a food flavoring and oil can be extracted from it [1]. Tarragon is one of the uncommon herbs cultivated in Iraq and the spread of tarragon cultivation has begun from western North America and eastern and Central Europe. It is one of the widespread plants in Southern Europe, Russia and the USA [2]. All parts of the tarragon plant and its extracted oil have medicinal therapeutic benefit, as it is a good remedy for indigestion, diuretic, soothing pain, improving sleep, treating nausea, and it is useful for snake bites and its oil is used in lotions and as a hair lotion and a strong antifungal and antibacterial [1].

Use of organic fertilizers has become widespread around the world and organic fertilizers are one of the important sources to provide plants with their nutritional needs and reduce the problems of chemical residues which is harmful to humans and other living organisms [3]. Fish emulsion or fish manure resulting from the anaerobic fermentation of fish waste, is one of the organic fertilizers commonly used in agricultural production, as these fertilizers are an excellent source of nutrition for soil and plants because fish contains the full chain of nutrients [4]. Fish waste contains a high percentage of protein as a source of nitrogen, as well as balanced amounts of (18) nutrients necessary for the growth of plants, as the percentage of N.P.K is 10, 6, 2 [5]. Fertilizers produced from fish waste, like other organic fertilizers, promise to be environmentally friendly to inspect and not washed out of the soil easily, causing pollution of the aquatic environment, in addition to their great role in improving the growth of quantity and quality and their suitability for various crops, they can be added spraying on the plant and using as ground additives [6]. Previous studies have shown different responses by agricultural crops to fertilizing with liquid organic fertilizer resulting from the decomposition of fish waste, while most of the results obtained confirmed the improvement of the qualitative and quantitative qualities of the crop [7, 8, 9].

Vermicompost also is an organic fertilizer as a by-product of earthworm feeding on organic waste [10, 11]. Some studies have shown that this fertilizer contains a number of enzymes such as peroxidase, protease, amylase which are necessary to increase the effectiveness of Microbiology in the soil [12]. Many long-term studies have proven that the addition of worm fertilizer improves the physical qualities of the soil, as it reduces soil density and increases the water holding capacity of the soil and increases the size of soil particles [13].

Tarragon is one of the rare plants cultivated and spread in Iraq and for its medical importance and its many uses in food, this study aims to test the cultivation of this plant under Iraqi conditions and treat it with some manufactured locally organic fertilizers, namely fish emulsion and worm manure to determine the best organic fertilizers and their combinations in terms of growth indicators for tarragon plants.

Materials and Methods

The experiment was carried out in the canopy of the Horticulture and Landscape Department/ college of Agriculture/ University of Kerbala during spring season of 2023. Russian tarragon seeds were obtained from the Australian company Mr. Fothergill`s, and the seeds were planted on 20/2/2023 in planting dishes inside a plastic tunnel to provide the appropriate conditions for germination, and the germination process began on 5/3/2023. The seedlings were transferred to pots with a volume of 5 kg soil at 3-4 true leaves appeared on 30/3/2023. The study included two factors, the first factor was the addition of fish emulsion in four concentrations 0, 1, 2 and 3% (F) which was added five times every two weeks, while the second factor was four levels of vermicompost 0, 25, 50, 100 g pot^{-1} (V), which was added before transferring the seedlings to the pots. The study was implemented as a factorial experiment according to a completely randomized block design with three replications. Each replicate contained 16 treatments, with 4 plants in each treatment, so the number of plants included in the study was (16 treatments x 4 observations x 3 replicates = 192 plants). Agricultural service operations were carried out for the plants, including adding neutral chemical fertilizer (NPK) (20, 20, 20) at a rate of 1 g L^{-1}, and adding wooden supports to the plants 15 days after planting to keep the plants from lodging, and irrigation was done regularly until the end of the experiment. At the end of the experiment on 6/20/2023, samples were taken from the experimental units and some vegetative measurements were conducted, such as plant height (cm), stem diameter (mm), number of lateral branches (branch plant^{-1}), percentage of dry matter (%), and total chlorophyll content in leaves (mg g^{-1} fresh weight) [14]. The results were statistically analyzed according to the statistical program Genestat and the averages were compared using the lowest significant difference (L.S.D.) at the probability level of 0.05 [15].

Results and Discussion

plant height (cm)

Results of Table 1 indicate that there are no significant effects for fish emulsion fertilizer and vermicompost fertilizer in the plant height characteristic, while the interactions the two fertilizers had a significant impact on the same trait. The interference treatment F4V4 outperformed in achieving the highest rate of plant height trait and recorded 85.16 cm, while the treatment F3V1 recorded the lowest rate of 70.05cm.

Table (1): Effect of fish emulsion and vermicompost on plant height (cm) of Tarragon plant

Vermicompost g pot^{-1}	Fish Emulsion%				Average of Vermicompost g pot^{-1}
	0% (F1)	1% (F2)	2% (F3)	3% (F4)	
0 (V1)	81.26	78.01	70.05	79.43	77.19
25 (V2)	76.86	78.95	79.77	76.18	77.94
50 (V3)	77.75	83.91	79.05	76.09	79.20
100 (V4)	76.50	72.65	78.70	85.16	78.25
L.S. D	9.236				N. S
Average of Fish Emulsion %	78.09	78.38	76.89	79.21	
L.S. D	N. S				

Stem diameter (mm)

The findings shown in Table 2 demonstrate a noteworthy distinction in the concentrations of fish emulsion and vermicompost on their own, as well as their interaction with stem diameter. Level F2 outperformed in terms of stem diameter rate, scoring 2.902 mm, whilst the comparison treatment recorded the lowest rate, obtaining 2.642 mm. The same table shows that level V1 had the lowest rate of 2.677 mm, whereas vermicompost fertilizer exceeded level V3 in attaining the maximum rate of 2.914 mm. With a score of 3.127 mm, the interaction treatment F2V3 outperformed the F3V1 treatment in terms of stem diameter rate, which was recorded at 2.390 mm the lowest.

Table (2): Effect of fish emulsion and vermicompost on stem diameter (mm) of Tarragon plant

Vermicompost g pot^{-1}	Fish Emulsion%				Average of Vermicompost g pot^{-1}
	0% (F1)	1% (F2)	2% (F3)	3% (F4)	
0 (V1)	2.583	3.073	2.390	2.663	2.677
25 (V2)	2.633	2.780	2.847	2.870	2.782
50 (V3)	2.650	3.127	2.870	3.010	2.914
100 (V4)	2.700	2.627	2.827	2.737	2.722
L.S. D	0.415				0.207
Average of Fish Emulsion %	2.642	2.902	2.733	2.820	
L.S. D	0.207				

Number of lateral branches (branch plant^{-1})

The results of Table 3 indicate that the levels of fish emulsion and vermicompost had a significant effect on the number of lateral branches in the plant, where the level of fish fertilizer F4 gave the highest number of branches 28.85 branch plant^{-1}, compared to the comparison treatment, which gave only 25.83 branch plant^{-1}. As for vermicompost, treatment V3 gave the highest number of branches, amounting to 29.56 branch plant^{-1}, while the comparison treatment had an average number of branches of 24.98 branch plant^{-1}. The overlap treatment F4V4 surpassed in achieving the highest rate for the number of branches in the plant scored 32.50 branch plant^{-1} while F1V1 recorded the lowest average 23.58 branch plant^{-1}.

Table (3): Effect of fish emulsion and vermicompost on number of lateral branches (branch plant-1) in Tarragon plant

Vermicompost g pot^{-1}	Fish Emulsion%				Average of Vermicompost g pot^{-1}
	0% (F1)	1% (F2)	2% (F3)	3% (F4)	
0 (V1)	23.58	26.17	24.00	26.17	24.98
25 (V2)	25.25	30.17	24.33	26.58	26.58
50 (V3)	29.25	30.33	28.50	30.17	29.56
100 (V4)	25.25	25.17	29.33	32.50	28.06
L.S. D	5.490				2.745
Average of Fish Emulsion %	25.83	27.96	26.54	28.85	
L.S. D	2.745				

Dry matter %

The dry matter percentage of leaves was not significantly affected by either fish emulsion level treatment; however, it was significantly affected by vermicompost level treatments (Table 4). The level of vermicompost V1 produced the highest rate of dry matter (19.55%), while the level of vermicompost V4 produced the lowest values (17.13%). In a bilateral interaction between the two fertilizer treatments, the percentage of dry matter generated by treatment F1V3 was highest (20.57%), whereas the percentage produced by treatment F3V4 was lowest (15.95%) (Table 4).

Table (4): Effect of fish emulsion and vermicompost on plant dry matter (%) of Tarragon plant.

Vermicompost g pot^{-1}	Fish Emulsion%				Average of vermicompost g pot^{-1}
	0% (F1)	1% (F2)	2% (F3)	3% (F4)	
0 (V1)	19.99	20.31	18.66	19.24	19.55
25 (V2)	18.80	19.10	19.80	17.84	18.89
50 (V3)	20.57	19.20	20.55	17.21	19.38
100 (V4)	17.78	17.34	15.95	17.46	17.13
L.S. D	2.923				1.461
Average of Fish Emulsion %	.2919	18.99	18.74	17.94	
L.S. D	N.S				

Total chlorophyll content in leaves (mg g^{-1} fresh weight).

The results in Table 5 indicate that there is no significant effect of adding Vermicompost on the total chlorophyll content of the leaves, while the fish emulsion had a significant effect on this characteristic. The results indicate that the treatment of adding fish emulsion at concentration F3 was superior and the highest average was recorded at 44.90 mg g^{-1} fresh weight, while concentration F1 gave the lowest average of

36.95 mg g^{-1} fresh weight. The interaction between the two study factors had a significant effect on the above characteristic, as the intervention treatment F3V3 excelled in recording the highest average of 46.91 mg g^{-1} fresh weight, while the F1V3 treatment gave the lowest average of 32.57 mg g^{-1} fresh weight.

Table (5): Effect of fish emulsion and Vermicompost on the leaf content of total chlorophyll (mg g-1 fresh weight) of Tarragon plant.

Vermicompost g pot-1	Fish Emulsion%				Average of Vermicompost g pot^{-1}
	0% (F1)	1% (F2)	2% (F3)	3% (F4)	
0 (V1)	36.70	42.38	44.81	45.12	42.25
25 (V2)	37.13	42.53	46.13	43.41	42.30
50 (V3)	32.57	44.14	46.91	41.07	41.17
100 (V4)	41.39	37.25	41.73	34.77	41.04
L.S. D	5.451				N.S
Average of Fish Emulsion %	36.95	41.57	44.90	43.35	
L.S. D	2.725				

The results of the statistical analysis indicated varying effects of the study factors on the traits under study (Table 1-5), as some traits were significantly affected by fish emulsion (stem diameter, number of branches, content of total chlorophyll), while others were significantly affected by vermicompost (dry matter%, number of branches, stem diameter). This discrepancy in results may be due to field conditions and the nature of experimental procedures, such as the quantity and method of addition. The results of the tables above clearly indicated that the two organic fertilizers had a significant combined effect on all the vegetative growth traits studied (Table 1-5). The effect of vermicompost, whether as a single treatment or combined with fish emulsion fertilizer, on vegetative growth characteristics may be attributed to the role of vermicompost in the good and balanced preparation of the nutrients necessary for plant growth (such as nitrogen, phosphorus, potassium, iron, magnesium and copper) and some growth stimulants (hormones), and these nutrients are released slowly as organic matter decomposes, providing a constant supply of nutrients to plants over time [16]. In addition, it contains some effective microorganisms and some necessary enzymes such as Peroxidase, Protase, and Amylase necessary to increase the effectiveness of microorganisms in the soil [12]. Moreover, it contains humates, micro- and macronutrients, and some beneficial microorganisms such as Nitrogen-fixing bacteria, phosphate-degrading bacteria and vitamins [17]. It was found that earthworm waste is an important and effective factor in improving the chemical, physical and microbiological properties of the soil, which is reflected in increasing its fertility and improving its ability to produce optimal crops grown in it ([18, 19]. Numerous studies have shown that the addition of vermicompost boosted the vegetative development of a variety of plants, viz., stevia (*Stevia rebaudiana* Bert.) [18, 20], Coriander (*Coriandrum sativum* L.) [21], tomato (*Solanum lycopersicum*) 2024) [22, 23, 24], *Thymus vulgaris* L. [25], feverfew plant (*Tanacetum parthenium* L.), 2023) [26], and *Pelargonium zonale* L. [27].

The results in Tables 1-5 confirm that the treatments that contained fish emulsion fertilizer, whether alone or combined with vermicompost fertilizer, gave a significant and clear effect in improving the characteristics of vegetative growth and photosynthetic pigments. These results may be due to the fact that adding fish fertilizer increases the readiness of macro- and micro-nutrients, which leads to increased cell division and biological activities, which is reflected in an increase in plant height and other vegetative traits [28]. The increase in the percentage of dry matter as a result of fish fertilizer may be due to the fermented fish waste containing some amino acids and some sources of nitrogen that increase the effectiveness of photosynthesis in addition to increasing the leaf area (unpublished data). This increases light receptors, which is reflected in the increase in carbohydrates proteins and increased dry matter, in addition, the fish fertilizer containing the necessary macro- and micro-nutrients and some growth regulators led to an increase in the chlorophyll content in the leaves [25]. The increase in vegetative growth may also be attributed to the role of fish fertilizer in increasing and developing roots (unpublished data), which is reflected in increased absorption of nutrients, which leads to plant growth and development [9]. While most research and studies have demonstrated that agricultural crops respond differently to fertilization with liquid organic fertilizer made from the breakdown of fish waste, the majority of the findings have indicated that vegetative growth characteristics are improved, viz., Pak Choy (*Brassica rapaL. subsp. Chinensis*) [29], Tomato [30], soybean (*Glycine max* (L.) Merrill) [31], lettuce (*Lactuca sativa* L.) [9, 32], and *Avicennia marina* [33].

Tarragon treated with a combination of fish emulsion and vermicompost had the greatest average of both photosynthetic pigments and vegetative growth overall. It is clear from the results that various plants, like tarragon, may be grown using locally made organic fertilizer mixtures without suffering financial losses or environmental contamination. Because of this, mineral fertilizers are used less frequently and occasionally not at all in the fertilization routine.

References

1)Kordali, S., Kotan, R., Mavi, A., Cakir, A., Ala, A., & Yildirim, A. (2005). Determination of the chemical composition and antioxidant activity of the essential oil of Artemisia dracunculus and of the antifungal and antibacterial activities of Turkish Artemisia absinthium, A. dracunculus, Artemisia santonicum, and Artemisia spicigera essential oils. Journal of Agricultural and Food Chemistry, 53(24), 9452-9458.

2)Kauschka, M., Burkard, N., Pischel, I., Obolskiy, D., Heinrich, M., Butterweck, V., & Feistel, B. (2012). Russian tarragon – A spice plant and its health potentials. Published by B5SRL Via Mario Donati, Milano – Italy.
3)El-Sayed, A., Sidky, M., Mansour, H., & Mohsen, M. (2009). Effect of organic fertilizer and Egyptian rock phosphate on the growth, chemical composition, and oil production of tarragon (Artemisia dracunculus L.). Journal of Productivity and Development, 14(1), 87-110.
4)Ihemanma, A., & Ebutex, C. (2013). A contrast between fish offal's fertilizer, chemical fertilizer, and manure applied to tomato and onion. Advances in Aquaculture and Fisheries Management, 1(9), 90-93.
5)Gaskell, M. (1999). Efficient use of organic fertilizer sources. Organic Farming Research Foundations. University of California Cooperative Extension.
6)Ahuja, I., Dauksas, E., Remme, J. F., Richardsen, R., & Løes, A. K. (2020). Fish and fish waste-based fertilizers in organic farming – With status in Norway: A review. Waste Management, 115, 95-112.
7)Lindsey, L., Shange, R., Ankumah, R. O., Mortley, D. G., & Karki, S. (2019). Hydrolyzed organic fish fertilizer and poultry litter influence yield and rhizosphere ecology of sweet potato. HortScience, 54(5), 941-947.
8)Karo, B. B., & Marpaung, A. E. (2020). Effectivity of potassium and fish fertilizer on leek growth (Allium fistulosum L.). Journal of Tropical Horticulture, 3(1), 23-28.
9)Shaik, A., Singh, H., Singh, S., Montague, T., & Sanchez, J. (2022). Liquid organic fertilizer effects on growth and biomass of lettuce grown in a soilless production system. HortScience, 57(3), 447-452.
10)Dominguez, J. (2004). State-of-the-art and new perspectives on vermicomposting research. In: Earthworm Ecology. CRC Press Boca Raton, FL, USA, pp. 401–424.
11)Blouin, M., Barrere, J., Meyer, N., Lartigue, S., Barot, S., & Mathieu, J. (2019). Vermicompost significantly affects plant growth: A meta-analysis. Agronomy for Sustainable Development, 39, 1-15.
12)Bottinelli, N., Henry-des-Tureaux, T., Hallaire, V., Mathieu, J., Benard, Y., Tran, T. D., & Jouquet, P. (2010). Earthworms accelerate soil porosity turnover under watering conditions. Geoderma, 156(1-2), 43-47.
13)Moradi, H., Fahramand, M., Sobhkhizi, A., Adibian, M., Noori, M., Abdollahi, S., & Rigi, K. (2014). Effect of vermicompost on plant growth and its relationship with soil properties. International Journal of Farming and Allied Sciences, 3(3), 333-338.
14)Chappelle, E. W., Kim, M. S., & McMurtrey III, J. E. (1992). Ratio analysis of reflectance spectra (RARS): An algorithm for the remote estimation of the concentrations of chlorophyll a, chlorophyll b, and carotenoids in soybean leaves. Remote Sensing of Environment, 39(3), 239-247.
15)Al-Asadi, Maher Hamid Salman. (2019). Genstat for Analyzing Agricultural Experiments. Al Qasim Green University, Faculty of Agriculture. Dar Al-Warith for Printing and Publishing, p. 304.

16)Vojevoda, L., Osvalde, A., Čekstere, G., & Karlsons, A. (2017). Assessment of the impact of vermicompost and peat extracts on nutrient accumulation in tubers and potato yield. In International Scientific Conference RURAL DEVELOPMENT 2017 (pp. 178-181).
17) Sinha, R. K., Agarwal, S., Chauhan, K., & Valani, D. (2010). The wonders of earthworms & its vermicompost in farm production: Charles Darwin's 'friends of farmers', with potential to replace destructive chemical fertilizers. *Agricultural Sciences*, *1*(2), 76. https://doi.org/10.4236/as.2010.12011
18) Zaman, M. M., Chowdhury, M. A. H., Islam, M. R., & Uddin, M. R. (2015). Effects of vermicompost on growth and leaf biomass yield of stevia and post-harvest fertility status of soil. *Journal of the Bangladesh Agricultural University*, *13*(2), 169-174.
19) Alkobaisy, J. S., & Mutlag, N. A. (2021). Effect of the use of vermicompost and rhizobial inoculation on some soil characteristics, growth and yield of mung bean (*Vigna radiata* L.). *Iraqi Journal of Agricultural Sciences*, *52*(1), 1-8.
20) Valinezhad, Z., Gholizadeh, A., Naeemi, M., Gholamalalipour Alamdari, E., & Zarei, M. (2019). Effects of vermicompost and mycorrhizal fungus on quantitative and qualitative traits of medicinal plant *Stevia rebaudiana* Bertoni. *Iranian Journal of Medicinal and Aromatic Plants Research*, *35*(3), 484-500.
21) Sakthivel, P., Sujeetha, A. R., Ravi, G., Girish, A. G., & Chander, P. (2020). Effect of vermicompost with microbial bio inoculums on the growth parameter of coriander (*Coriandrum sativum* L.). *International Journal of Current Microbiology and Applied Sciences*, *9*(8), 613-622.
22) Bziouech, S. A., Dhen, N., Helaoui, S., Ammar, I. B., & Dridi, B. A. M. (2022). Effect of vermicompost soil additive on growth performance, physiological and biochemical responses of tomato plants (*Solanum lycopersicum* L. var. Firenze) to salt stress. *Emirates Journal of Food and Agriculture*, *34*(6), 522-531. https://doi.org/10.9755/ejfa.2022.v34.i6.2907
23) Qasim, M., Ju, J., Zhao, H., Bhatti, S. M., Saleem, G., Memon, S. P., ... & Jamali, Z. H. (2023). Morphological and physiological response of tomato to sole and combined application of vermicompost and chemical fertilizers. *Agronomy*, *13*(6), 1508. https://doi.org/10.3390/agronomy13061508
24) El-Sayed, S. S. (2024). Integrated use of vermicompost and biofertilizers to enhance growth, yield and nutrient content of tomato grown under organic conditions. *Egyptian Journal of Horticulture*, *51*(1), 103-116. https://doi.org/10.21608/ejoh.2024.134220
25) Rahimi, A., Gitari, H., Lyons, G., Heydarzadeh, S., Tunçtürk, M., & Tunçtürk, R. (2023). Effects of vermicompost, compost and animal manure on vegetative growth, physiological and antioxidant activity characteristics of *Thymus vulgaris* L. under water stress. *Yuzuncu Yıl University Journal of Agricultural Sciences*, *33*(1), 40-53.
26) Naeemi Golzard, M., Ghanbari Jahromi, M., & Kalateh Jari, S. (2023). Effect of biochar and vermicompost on growth parameters and physiological characteristics of

feverfew (*Tanacetum parthenium* L.) under drought stress. *Journal of Ornamental Plants*, *13*(2), 109-120.
27) El-Sayed, B. A., Noor El-Deen, T. M., Diab, R. I., & Abdelsadek, O. A. (2023). Impact of vermicompost and benzyladenine on geranium plant quality. *Scientific Journal of Flowers and Ornamental Plants, 10*(2), 151-161.
28) Sanjutha, S., Subramanian, S., Rani, C. I., & Maheswari, J. (2008). Integrated nutrient management in *Andrographis paniculata*. *Research Journal of Agriculture and Biological Sciences, 4*(2), 141-145.
29) Karim, N. U., Lee, M. F. M. A., & Arshad, A. M. (2015). The effectiveness of fish silage as an organic fertilizer on post-harvest quality of pak choy (*Brassica rapa* L. subsp. *chinensis*). *European International Journal of Science and Technology, 4*(5), 163-174.
30) Aranganathan, L., & Rajasree, S. R. (2016). Bioconversion of marine trash fish (MTF) to organic liquid fertilizer for effective solid waste management and its efficacy on tomato growth. *Management of Environmental Quality: An International Journal, 27*(1), 93-103. https://doi.org/10.1108/MEQ-11-2014-0071
31) Nagar, G., Abraham, T., & Sharma, D. K. (2016). Effect of different solid and liquid forms of organic manure on growth and yield of soybean (*Glycine max* L. Merrill). *Advances in Research Journal of Crop Improvement, 7*, 56-59. https://doi.org/10.9734/ARJCI/2016/27438
32) Molosag, A., Ion, V. A., Pârvulescu, O. C., Dobrin, A., Bujor, O. C., Moț, A., & Lagunovschi-Luchian, V. (2023). Preliminary results of fish fertilizer effects on lettuce. *Scientific Papers. Series B. Horticulture, 67*(2), 155-162.
33) Al Anoud, A. A., Sheteiwy, M. S., AbuQamar, S. F., & El-Tarabily, K. A. (2024). Enhancement of mangrove growth performance using fish emulsion and halotolerant plant growth-promoting actinobacteria for sustainable management in the UAE. *Marine Pollution Bulletin, 199*, 115916. https://doi.org/10.1016/j.marpolbul.2023.115916