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TARRAGON (*ARTEMISIA DRACUNCULUS* L.) RESPONSE TO FISH EMULSION AND VERMICOMPOST FERTILIZERS

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SUMMARY

The following experiment on tarragon (*Artemisia dracunculus* L.) transpired in the spring of 2023 at the Kerbala University, Kerbala, Iraq. A factorial experiment with a randomized complete block design and three replications comprised the investigations. The first factor was fish emulsion with four different concentrations (0%, 1%, 2%, and 3%), while the second was vermicompost application with four different levels (0, 25, 50, and 100 g pot^{-1}) before moving the seedlings to pots containing them. The results showed adding fish emulsion at 2% concentration significantly affected the percentage of nitrogen and protein in the leaves, with averages of 3.407% and 21.29%, respectively. The outcomes also revealed adding vermicompost fertilizer at a level of 100 g was superior in phosphorus and carbohydrate contents in the leaves with averages of 0.482% and 379 mg 100 g^{-1}. As for the interaction between the factors, it was remarkably significant for all the traits under study. The findings confirmed the effectiveness of fertilizers resulting from organic waste, individually or in combination, to raise the efficiency of the qualitative traits of horticultural crops, as well as reduce the chemical fertilizers' use in maintaining a sustainable and nontoxic ecosystem.

Keywords: Tarragon (*A. dracunculus* L.), fish emulsion, vermicompost fertilizer, biochemical traits

Key findings: In tarragon (*A. dracunculus* L.), the addition of fish emulsion (2%) had a significant effect on most biochemical traits in the leaves. Likewise, adding vermicompost with the highest dose (100 g pot^{-1}) significantly increased the phosphorus content in leaves.

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INTRODUCTION

Medicinal and aromatic plants are vastly applicable in the treatment of many widespread diseases, which play an important role in the national economy. The tarragon (*Artemisia dracunculus* L.) is one of the vital medicinal plants, a perennial herb belonging to the family Asteraceae. It is considerably suitable for human consumption, whether fresh or dry, as a flavoring for foods to enhance the tastes and as an essential oil extracted from the leaves and flowering tops of the tarragon plant (Aglarova *et al.,* 2008).

Tarragon is one of the rare herbs grown in Iraq. It came from Western North America and Eastern and Central Europe. It is also a widely distributed plant in Southern Europe and Russia. For tarragon, the best growing conditions include basal conditions, sandy-clay soils, relative sunshine and humidity, and a temperature range of 15 °C to 40 °C. Essential oil extraction from the whole plant is possible, providing numerous medicinal benefits. It can be beneficial in the treatment of nausea, indigestion, improving sleep, soothing pain, and snake bites. Tarragon oil can also serve to make different types of lotions, including hair lotions, and is a potent antifungal and antibacterial agent (Ekiert *et al.,* 2021).

One of the most crucial ways to provide plants with nourishment, tarragon requires the use of organic fertilizers, which can also lessen the issue of chemical residues that are hazardous to human beings and other living organisms (El-Sayed *et al.,* 2009). Since fish includes the entire chain of nutrients, fish emulsion produced by the anaerobic decomposition of fish waste is one of the organic fertilizers frequently utilized in agricultural production (Ihemanma and Ebutex, 2013). The NPK ratio (10:6:2) of fish waste means that it has a higher percentage of protein as an alternative source of nitrogen, along with balanced levels of other nutrients required for plant growth. Like other organic fertilizers, fish excrement fertilizers have the potential to be ecologically sound and do not wash out of the soil easily, polluting the aquatic environment. Organic fertilizers also significantly contribute to enhancing the quantity and quality of crop growth and are appropriate for various crops. Ultimately, organic fertilizers can be effective as a foliar spray on plants and as a soil additive (Ahuja *et al.,* 2020). In past research, crops clearly responded to the addition of fish waste extracts regarding their quantitative, medicinal, and qualitative properties (Taresh *et al.,* 2021).

Vermicompost is a natural soil amendment generated by earthworms after consuming the organic leftovers. It may be helpful to produce the organic fertilizer for crop plants (Blouin *et al.,* 2019), as it involves phosphate, nitrogen, and some hormones. Additionally, this fertilizer is highly nutritious with several enzymes, including cellulase, peroxidase, amylase, invertase, phosphatase, dehydrogenase, and urease, which are essential for boosting the soil's microbiological activities (Bottinelli *et al.,* 2010). Humates, micro- and macronutrients, and some beneficial microbes, including bacteria-fixing nitrogen, dissolve phosphate and break down vitamins. Past research demonstrated that adding vermicompost to soil reduces the soil density, increases soil water-holding capacity, and enriches soil grain size. It also functions as a chelating agent, which enhances the chemical characteristics of the soil by decreasing the degree of reaction pH in the root zone, improving the exchange capacity (CEC), and decreasing element deposition (Daood, 2023).

The use of vermicompost can be direct by adding it to the soil, as it dissolves rapidly in water and, therefore, its absorption by plants is faster, given that earthworm manure is rich in certain microorganisms and contains several essential nutrients, macro- and microelements, and hormones. Numerous field crop experiments have demonstrated fertilizers with a crucial role in enhancing both quantitative and qualitative production, as well as bioactive substances in specific plants. As a result, farmers have been benefitting from incorporating earthworm manure into their organic fertilization to produce high-quality crops (Gashaw, 2019). With the aforementioned, the presented study sought to

use locally manufactured fertilizers like fish emulsion and vermicompost to improve the biochemical properties of tarragon in Iraq. The promising study will help in expanding tarragon cultivation and its further development, which is valuable for its medicinal properties and frequent usage in food and folk medicines.

MATERIALS AND METHODS

The following experiment conducted on tarragon (*Artemisia dracunculus* L.) commenced in the spring of 2023 at the Kerbala University, Kerbala, Iraq (latitude: 32' 36' 57.71" North, longitude: 44' 29.57" East). The first factor was the fish emulsion applied with four concentrations (0%, 1%, 2%, and 3%), while the second factor was the vermicompost fertilizer added with four levels (0, 25, 50, and 100 g pot^{-1}) before seedling transplantation into pots. It is an organic fertilizer that contains several nutrients in varying proportions, including organic carbon, nitrogen, phosphorus, potassium, calcium, magnesium, sodium, zinc, and copper.

The seeds' sowing in planting plates preceded the seedlings' subsequent transplanting into pots with a volume of 5 kg of soil. The experiment as laid out in a randomized complete block design (RCBD) had two factors and three replications. The study used a total of 192 plants in the trials, with each treatment comprising four plants for observations. All the seedlings received routine crop service practices up to the experiment's conclusion. The biochemical composition of tarragon leaves reached validation at the end of the experiment by assessing the percentages of nitrogen, phosphorus, and potassium in the leaves (Al-Sahaf, 1989), total carbohydrates (Herbert *et al.,* 1971), and total protein in the leaves according to the method by Joslyn (1970) (N % × 6.25). Using the statistical software Genstat, all the data underwent evaluation and compilation, with the mean averages compared using the $LSD_{0.05}$ test (Al-Rawi and Khalafallah, 2000; Al-Asadi, 2019).

RESULTS AND DISCUSSION

Nitrogen in the leaves

The nitrogen percentage in the tarragon leaves revealed nonsignificant effects from the different levels of vermicompost (Table 1). However, the fish emulsion concentrations significantly affected the said trait. The fish emulsion concentration at 2% showed the highest average of nitrogen (3.407%), while the fish emulsion at 0% recorded the lowest nitrogen average (1.878%). The fertilizer resulting from the decomposition of fish emulsion containing larger amounts of nitrogen increased its readiness and absorption by the plant roots. It could be responsible for the notable increase in the percentage of nitrogen in tarragon leaves as a result of fish emulsion treatments, whether applied alone or in combination with the vermicompost (Ranasinghe *et al.,* 2019).

The interaction effects of vermicompost and fish emulsion levels were significant for nitrogen percentage (Table 1). The interaction of fish emulsion (3%) and vermicompost (0%) outperformed giving the highest nitrogen average (3.407%), while the interaction of fish emulsion (0%) and vermicompost (25 g pot^{-1}) recorded a lower nitrogen average (1.773%). Past studies stated by using fish waste for organic fertilizers can obtain the supreme nitrogen use efficiency, and the fish emulsion plays vital role in increasing the accumulation of mineral elements, including nitrogen in the leaves (Javaid and Mahmood 2010; Ekinci *et al.,* 2019).

Phosphorus in the leaves

The results demonstrated vermicompost levels caused significant variations in the phosphorus percentage in leaves (Table 2). Specifically, the vermicompost level of 100 g pot^{-1} provided the topmost average of phosphorus (0.482%), while the vermicompost control treatment (0 g pot^{-1}) recorded the lowermost average (0.428%). The positive variations in the proportion of phosphorus in tarragon plant

Table 1. Effect of fish emulsion, vermicompost, and their interactions on the proportion of nitrogen in tarragon leaves.

Vermicompost (g pot^{-1})	Fish Emulsion (%)				Means (%)
	0%	1%	2%	3%	
0	1.820	2.100	3.687	4.107	2.928
25	1.773	1.867	3.360	3.640	2.660
50	1.820	3.267	3.173	2.800	2.765
100	2.100	3.313	3.407	2.100	2.730
Means (%)	1.878	2.637	3.407	3.162	
$LSD_{0.05}$ Fish emulsions: 0.9857, Vermicompost: N.S., Interactions: 0.4928					

Table 2. Effect of fish emulsion, vermicompost, and their interactions on the proportion of phosphorus in tarragon leaves.

Vermicompost (g pot^{-1})	Fish Emulsion (%)				Means (%)
	0%	1%	2%	3%	
0	0. 529	0. 470	0. 353	0.358	0. 428
25	0.487	0. 476	0.389	0. 394	0. 436
50	0. 534	0. 507	0. 364	0. 385	0. 448
100	0. 493	0. 459	0. 480	0. 494	0. 482
Means (%)	0. 511	0. 478	0. 396	0. 408	
$LSD_{0.05}$ Fish emulsions: 0.1009, Vermicompost: 0.1009, Interactions: 0.2017					

leaves from adding such types of organic fertilizers may refer to their content of essential macro- and micro-elements. These led to enhancing the readiness of nutrients and their rapid absorption by the roots causing further accumulation in plant leaves (Lazcano *et al.,* 2008). Vermicompost improves the physical, biochemical, and biological properties of the soil and boosts the productivity of crops, as well as raises organic carbon, which helps increase the activity of microorganisms in the soil (Karmegam *et al.,* 2019).

The fish emulsion control treatment (0%) demonstrated superiority and recorded the greatest average of phosphorus (0.511%), whereas fish emulsion at 2% yielded the lowest average of the said macroelement (0.396%) (Table 2). The foliar application of fish extract provides additional amounts of phosphorus found in this extract. This phosphorus attains absorption by plant leaves and becomes vital in processes, such as DNA formation and stimulating plant growth. The interactions of vermicompost and fish emulsion addition revealed notable differences for phosphorus content in the leaves. The interaction of fish emulsion (0%) and vermicompost (50 g pot^{-1}) yielded the highest rate of phosphorus (0.534%), while the interaction of fish emulsion (2%) and vermicompost (0 g pot^{-1}) produced the lowest phosphorus average (0.353%). The foliar application of fish emulsion leads to an increase in the phosphorus percentage in the leaves and plant body, promoting plant growth and development (Drobek *et al.,* 2019).

Potassium in the leaves

The findings exhibited that for the ratio of potassium element in the tarragon leaves, the fish emulsion and vermicompost concentrations had nonsignificant variations (Table 3). However, the interaction of both factors had a major impact on the aforementioned attribute, and the interaction of fish emulsion at 0% and vermicompost at 100 g pot^{-1} proved superior by yielding the maximum potassium average (5.58%). The interaction of fish emulsion (1%) and vermicompost (100 g pot^{-1}) produced the minimum average of potassium (3.33%). Although the individual factors did not significantly affect the said trait, the interaction between the studied factors had an obvious

Table 3. Effect of fish emulsion, vermicompost, and their interactions on the proportion of potassium in tarragon leaves.

Vermicompost (g pot^{-1})	Fish Emulsion (%)				Means (%)
	0%	1%	2%	3%	
0	4.03	4.52	5.22	4.99	4.69
25	4.03	4.69	4.64	4.81	4.54
50	5.30	3.58	5.11	4.41	4.60
100	5.58	3.33	5.18	4.43	4.63
Means (%)	4.74	4.03	5.04	4.66	
$LSD_{0.05}$ Fish emulsions: N.S., Vermicompost: N.S., Interactions: 1.379					

prominent effect, and the interactions with the highest level of vermicompost provided the highest percentage of potassium.

The proper nutrient supply in the root zone is what gives vermicompost its beneficial effects. It is possible that more nutrient absorption and accumulation appear in other areas of the plant, including the leaves, as a result of the increased availability of these nutrients in the root zone and uptake in cellular metabolism. An escalation in macro- and microelements, including potassium, was visible in plants treated with a greater dose of vermicompost than the lower dose. Nutrient absorption is a function of both nutrient concentration and biomass, which enhanced the nutrients' assimilation (Sharma *et al.,* 2017). Numerous studies supported this belief that organic fertilizers resulting from the decomposition of organic waste, including vermicompost and fish emulsion, enhance the readiness of nutrients in the soil and their absorption and accumulation by the crop plants (Al-Maamori *et al.,* 2023).

Carbohydrates in the leaves

The proportion of carbohydrates in the tarragon leaves had no significant effects from the application of fish emulsion and vermicompost individually (Table 4). However, their interaction has a considerable impact on the ratio of carbohydrates. The interaction between fish emulsion (3%) and vermicompost (50 g pot^{-1}) produced the premier average of carbohydrates (429 mg 100 g^{-1} fresh weight), while the combination of fish emulsion (0%) and vermicompost (50 g pot^{-1}) gave the lowest average (248 mg 100 g^{-1} fresh weight). In the presented study, the use of these organic fertilizers led to an increase in the percentage of carbohydrates in the tarragon leaves, which can refer to an elevation in the readiness and absorption of nutrients required for plant growth. These nutrients manifested with an increase in vital activities, chlorophyll content, photoreceptors, and, consequently, an enhancement in the synthesis and accumulation of carbohydrates in plant leaves (Ramesh *et al.,* 2023).

Protein in the leaves

The results indicated a nonsignificant effect of the vermicompost levels on the protein content in tarragon leaves (Table 5). As for fish emulsion treatments, a significant response appeared on the percentage of protein in the leaves. The fish emulsion (2%) excelled and recorded the highest average of protein percentage (21.29%), while the fish emulsion (0%) gave the lowest average (11.74%). The interaction of fish emulsion and the vermicompost levels also have a substantial impact. The combination of fish emulsion (3%) and vermicompost (0 g pot^{-1}) provided the maximum average of protein (25.67%), while the interaction of fish emulsion (0%) and vermicompost (25 g pot^{-1}) produced the minimum average (11.08%). The increased protein content in the tarragon leaves will certainly reflect a marked rise in the percentage of nitrogen (Table 1) as a result of adding these organic fertilizers, especially those resulting from fish waste due to their high content of amino acids. Several studies supported the latest results, wherein applying these two types of fertilizers emerged on different agricultural crops (Beyk-Khormizi *et al.,* 2023; El-Sayed, 2024).

Table 4. Effect of fish emulsion, vermicompost, and their interactions on the content of carbohydrates in tarragon leaves.

Vermicompost (g pot^{-1})	Fish Emulsion (%)				Means (mg 100 g^{-1})
	0%	1%	2%	3%	
0	365	325	355	272	329
25	277	420	297	265	315
50	248	329	277	429	321
100	372	388	388	367	379
Means (mg 100 g^{-1})	315	365	330	334	
$LSD_{0.05}$ Fish emulsions: N.S., Vermicompost: N.S., Interactions: 135.20					

Table 5. Effect of fish emulsion, vermicompost, and their interactions on the proportion of protein in tarragon leaves.

Vermicompost (g pot^{-1})	Fish Emulsion (%)				Means (%)
	0%	1%	2%	3%	
0	11.37	13.12	23.04	25.67	18.30
25	11.08	11.67	21.00	22.75	16.62
50	11.37	20.42	19.83	17.50	17.28
100	13.12	20.71	21.29	13.13	17.06
Means (%)	11.74	16.48	21.29	19.76	
$LSD_{0.05}$ Fish emulsions: 3.080, Vermicompost: N.S., Interactions: 6.160					

CONCLUSIONS

The results indicated the favorable use of organic fertilizers produced from natural wastes for sustainable agriculture and to increase the efficiency of fertilizer use. The findings showed by using organic fertilizers, the optimal production with high nutritional values can be successful in organic agriculture, as it is evident from the results that the combination of organic fertilizers had better mineral and nutritional values than their individual use.

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