



Performance on nutritive solution utilization by Tarragon (*Artemisia dracunculus* L.) cultivated in hydroponic

Desempenho na utilização de solução nutritiva por estragão (*Artemisia dracunculus* L.)
cultivado em hidroponia

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The interest in species with multiple benefits and many molecules with potential uses in different areas of knowledge has recently grown. The demand generates the search for production to meet the needs in quantity and quality. The advantages of the hydroponic system in the cultivation of leafy and aromatic herbs are known. However, the efficiency information of what would be the most responsive nutrition for aromatic species deserves attention and further studies. Thus, the objective was to evaluate the response of tarragon plants submitted to different rates of nutrient solution. The following proportions of the nutritive solution for leaves were evaluated: I - 50%, II - 75%, III - 100%, and IV 125%. Such a solution was chosen as a standard due to the balance between nutrients and the wide use by hydroponic producers. Hydroponic cultivation is a good alternative to grown Tarragon. The 100% nutrient solution shows good performance for most of the characteristics evaluated. The 15% reduction provides maximum production of the fresh mass of shoots, however, it causes a reduction of 11.3% in the production of dry mass, 6% in the number of stems, and 3.4% in height, which would not be interesting to meet dry mass demand. For fresh consumption, a 25% reduction in nutrient concentration generates a drop of only 1.3% in the maximum fresh mass of tarragon in hydroponic cultivation.

Keywords: nutrients, plant nutrition, medicinal plants.

O interesse por espécies com múltiplos benefícios e muitas moléculas com potencial de uso em diferentes áreas do conhecimento tem crescido recentemente. A demanda gera a busca por produção para atender as necessidades em quantidade e qualidade. As vantagens do sistema hidropônico no cultivo de ervas folhosas e aromáticas são conhecidas. No entanto, a informação de eficiência de qual seria a nutrição mais responsiva para espécies aromáticas merece atenção e estudos mais aprofundados. Assim, objetivou-se avaliar a resposta de plantas de estragão submetidas a diferentes doses de solução nutritiva. As seguintes proporções da solução para folhas foram avaliadas: I - 50%, II - 75%, III - 100%, e IV 125%. Tal solução foi escolhida como padrão devido ao equilíbrio entre os nutrientes e a ampla utilização pelos produtores hidropônicos. O cultivo hidropônico é uma boa alternativa ao estragão cultivado. A solução nutritiva 100% apresenta bom desempenho para a maioria das características avaliadas. A redução de 15% proporciona a máxima produção de massa fresca de brotos, porém provoca redução de 11,3% na produção de massa seca, 6% no número de hastes e 3,4% na altura, o que não seria interessante para atender a demanda de massa seca. Para consumo in natura, uma redução de 25% na concentração de nutrientes gera uma queda de apenas 1,3% na massa fresca máxima de estragão em cultivo hidropônico.

Palavras-chave: nutrientes, nutrição vegetal, plantas medicinais.

1. INTRODUCTION

In recent years, market studies have shown a growing trend in products derived from aromatic and medicinal herbs to use in the perfume industry and basic medicines [1]. In agriculture this use is also growing since the continuous use of pesticides over decades has been generating the contamination in the environment and resistance of pests to the molecules used, which are critical issues to solve.

Natural herbs rise as possible insecticides in controlling diseases and vectors, minimizing the demand for synthetic pesticides [2]. Sofi et al. (2022) [3] found significant larvicidal activity (*Aedes aegypti*), with ethanol extract of *Artemisia*, suppressing the organism's (enzyme activity) without acquiring resistance, being an alternative to use as a pest and vector control.

Tarragon (*Artemisia dracunculus* L.) is a perennial herb of the Asteraceae family. It is widely used as salad, aroma, and flavor in the food industry and dietary supplement since has an anticarcinogenic, antifungal effect and radical-scavenging activities. The species is characterized by great morphological and phytochemical variation, which attribute to qualities such as antibacterial and insecticide [4].

Hydroponics is used successfully by farmers, providing higher crop yield and quality, using efficiency of fertilizers and water, as well as a good dominance of climate and pest factors [5]. The system direct delivery the nutrient solution to the plant root zone, with a closed-circuit, that allows an intermittent laminar flow, keeping the roots nourished, moist, and oxygenated, providing 85–90% greater efficiency than traditional agriculture [6].

Generally, the nutrient solutions, in a hydroponic system, for species with little nutritional information such as tarragon are based on the standard formulation suggested by Furlani et al. (1999) [7] for lettuce cultivation. However, the requirements of the crops do not always coincide, and it is important to bring information about the closest concentration for the crop, as it could bring greater efficiency in economic and agronomic terms.

Luz et al. (2011) [8] observed optimal yields of arugula at a concentration of 50% recommended by Furlani et al. (1999) [7] in a hydroponic system. Santos et al. (2021) [9] found optimal results (development and earlier harvest) for green onion cultivation in a concentration of 68.8%. Nutrition represents one of the biggest cost factors in plant cultivation and the reduction can be considered as an optimization of the use of resources, especially non-renewable fertilizers and finite sources [10].

Artemisia dracunculus, despite being rich in phytochemicals and molecules that have been proven for several pharmacological uses, presents scarce availability of information on cultivation and agronomic aspects. The stimulus for investigations with the species guides how the species responds to environmental and management aspects, providing production in quality and quantity to meet demand. We hypothesized that hydroponic systems are a viable and profitable alternative to cultivating tarragon. Our goal here was to find an optimal combination of nutrients to improve the development and yield of tarragon.

2. MATERIAL AND METHODS

2.1 Characterization of the study site

The experiment was carried out at the Federal University of Uberlândia - Campus Gloria, in a high tunnel-type greenhouse, on 4 m long cultivation benches each, with nine medium polypropylene profiles (100 mm) for hydroponic cultivation, with 18 cm spacing between channels and 25cm between holes.

Every three profiles were supplied by a 100-liter plastic reservoir to which a low-power pump is connected (32 watts). The reservoirs were externally painted with white rubber ink to avoid heating at the nutrient solution temperature.

The hydroponic system adopted was the NFT (laminar flow of nutrients technique). The solution nutrient was composed of 750; 500; 150; 400 g of calcium nitrate, potassium nitrate, monoammonium phosphate, and magnesium sulfate, respectively. Additional micronutrients were added in the solution nutrient using copper sulfate (rate: 0.15 g 1000 L⁻¹), zinc sulfate (rate: 0.5 g 1000 L⁻¹) boric acid (rate: 1.5 g 1000 L⁻¹), sodium molybdate (Na₂MoO₄ 2H₂O; rate: 0.15 g 1000 L⁻¹) and ferrilene® (FeEDDHA- 6% Fe; rate: 0.3 g 1000 L⁻¹) [7].

The seedlings were developed on phenolic foam boards with dimensions of 2.5 x 2.5 x 3.0 cm per cell. The plates were moistened with Furlani et al. (1999) [7] nutrient solution and diluted by 50%. The seedlings were kept in a covered structure with a 50% shading screen for 18 days. Then the seedlings obtained were transferred to two development benches (nursery).

The nursery benches consisted of fifteen small polypropylene profiles (50 mm) spaced 10 cm apart and with 10 cm between holes. The circulation of the nutrient solution in the profiles was controlled by a “timer” set during the day (from 6 am to 6 pm) to remain on for 15 min and off for 15 min, and at 24 h it was turned on for 15 min, with a flow of 1.0-liter solution per min.

The seedlings remained in the nursery for a period of 15 days, being then transferred to the growth bench and subjected to irrigation with the nutrient solution at the concentrations of the treatments.

When the seedlings were transferred to the definitive 100 mm profiles, the electrical conductivity and pH of the solutions were adjusted. The conditions of temperature, pH, electric conductivity, and nutrient solution volume were measured and corrected daily. The pH was maintained in the range between 5.5 and 6.5 using NaOH or HCl solutions for calibration.

Four concentrations of nutrient solution were evaluated: 50; 75; 100 and 125% of the rates proposed by Furlani et al. (1999) [7], with a rate of 100% being the recommended complete composition. The experimental design was randomized blocks, with five replications.

2.2 Analyzed variables and data processing

The height, number of stems, and fresh and dry mass of shoots and roots were evaluated. After the measurements of fresh mass, the plants were pre-drying inside the greenhouse for 24 hours (withering point) and dried in an oven at 65° C until reaching constant mass for evaluation of the dry mass of root and shoot, which occurred after 72 hours of drying.

The data were submitted to tests of normality (Shapiro-Wilk Test, SPSS Inc., USA), homogeneity of variances (Bartlett Test, SPSS Inc., USA), and analysis of variance (ANOVA) based on the F-test ($p < 0.05$). When the F-test was significant ($p < 0.05$), the nutrient solution concentrations were evaluated by regression test.

3. RESULTS AND DISCUSSION

Plant height and the number of stems showed a positive linear adjustment, with increasing development as the concentration of nutrients increased. At the highest evaluated rate (125%), the plants had 30.77 stems and a height of 46.5 cm. Despite the favorable response of 125%, it was observed that the plants were 5.2% higher than the 100% rate, with a difference of 9.4% in the number of stems (Figure 1).

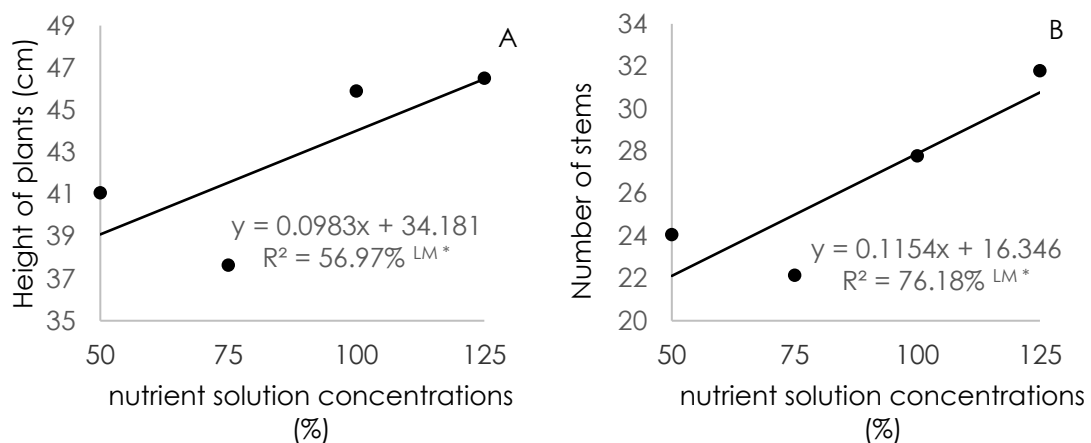


Figure 1. Height (cm) (A) and the number of stems (B) of Tarragon (*Artemisia dracunculus*) with nutritive solution concentrations (50; 75; 100; 125%). LM represents a linear model, * Significant model.

Guardabaxo et al. (2020) [11] evaluating the concentrations of the same solution in the present study in arugula cultivation, observed better productive performance in nutrient concentrations between 67 and 100%. The authors emphasize that rates higher than 100% increase the production cost, without generating significant increases in the accumulation of nutrients, such as nitrogen, phosphorus, and potassium in arugula leaves.

The fresh mass of shoots increased up to the rate of 84.9% (59.75 g plant⁻¹), with a decrease from this rate onwards (Figure 2). Diniz et al. (2019) [12] found higher coriander leaf development at concentrations ranging from 75 to 85% and Oliveira et al. (2016) [13] found a response regarding the height of coriander (87.2%). Luz et al. (2018) [14] observed better performance in height of absinthe at a concentration of 75%.

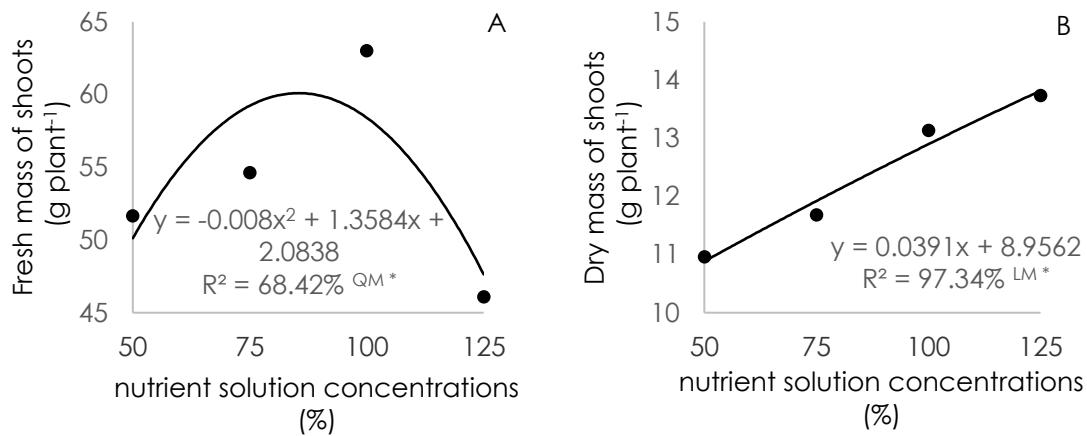


Figure 2. Fresh mass of shoots (g plant⁻¹) (A) and dry mass of shoots (g plant⁻¹) (B) of Tarragon (*Artemisia dracunculus*) with nutritive solution concentrations (50; 75; 100; 125%). ^{LM} and ^{QM} represent a linear and quadratic model, * Significant model.

The rate of 50% and 125% promoted productions 16.3% and 21.5% lower than the estimated maximum rate. Therefore, comparing the concentrations of the solutions, the increase in the concentration of salts in the solution was more harmful to the development than the reduction of the concentration in half of the rate used by the producers (standard concentration - 100%). The composition and salts concentrations in the nutrient solution can affect the absorption of water and nutrients by the roots as observed in the study and described by Lee et al. (2021) [15].

Frescura et al. (2018) [16] studying Rosemary (nutrient solution concentration: 1 a 5 dS m⁻¹ and times harvest), found a decrease in dry weight and yield of essential oil in the larger electrical conductivities due to the water absorption reduction by the roots. According to Sakamoto et al. (2020) [17] the saline effect also can cause ionic toxicity, which generates growth restrictions.

The dry mass of shoots showed a linear increase as the rate increased, with a maximum of 13.8 g plant⁻¹ (125%), corresponding to an increase of 7% about the 100% rate and 15.2% to 50% (Figure 2).

Fernandes et al. (2018) [18] studying lettuce found a reduction in the number of leaves in high concentrated solution. The lower plant performance due to the osmotic effect promoted by the high electrical conductivity of the nutrient solution should be evaluated according to the sensitivity of the crop [19]. According to Nchu et al. (2017) [20] poorly domesticated plants, originating from regions with nutrient deficits or low nutrient requirements, respond well to biomass production with diluted concentrations.

The fresh and dry mass of roots fitted the quadratic model with mass increments up to the rate of 119.3 (25.08 g plant⁻¹) and 100% (1.51 g plant⁻¹), respectively (Figure 3). Using the 100% concentration promotes a reduction of 2.7% in the maximum production of the fresh mass of roots while using the rate of 119% provides a decrease of 0.98% in the dry mass of roots.

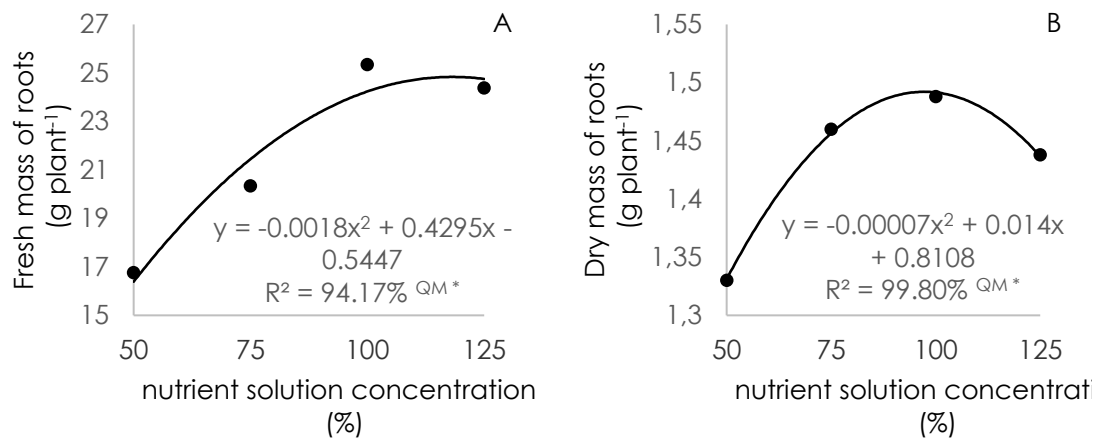


Figure 3. Fresh mass of roots (g plant^{-1}) (A) and dry mass of roots (g plant^{-1}) (B) of Tarragon (*Artemisia dracunculus*) with nutritive solution concentrations (50; 75; 100; 125%). QM represent a quadratic model, * Significant model.

Determination of the optimal nutrient fertilizer dosage for *Artemisia dracunculus* is important to achieve high growth and biomass yield [21]. Considering all evaluations together, tarragon rate response varies according to its use. If the aim is the production of fresh biomass, rates of 85 to 100% promote good performance. However, if the destination is the production of dry mass, the reduction dosage impairs the accumulation of a dry mass of the leaves, and, the increase (125%) generates an increase in dry mass, height, and the number of stems.

The quantity of the nutrient solution administered depends on the type of substrate used (volume and physicochemical properties), the stage of development of the crop, the cultivation and irrigation systems used, and the climatic conditions [22]. But it should be noted this work with tarragon in hydroponics is pioneering in Brazil and further research should provide information, in particular, the impact of management on the accumulation of biocompounds, functional molecules, and essential oils.

According to Lee et al. (2020) [22] cultivation of *Artemisia* in controlled environments has been reported to increase the production of target pharmaceutical raw materials. Efficient nutrient regulation and higher planting density can promote higher yield per hectare and better-quality produce [23]. Nurzynska-Wierdak and Zawislak (2014) [24] reported higher carotenoid concentrations in tarragon plants growing at high density (40×40 cm) than in plants growing less densely (50×50 cm).

This plant can also be used as a remediation tool or for biofortification, since was defined as the accumulator for Selenium, providing a valuable functional food with high biological activity and enhanced essential oil yield [25].

With the increasing use of bio inputs in organic and integrated production systems, the plant extract can be the focus for new products, as studies have already reported efficiency against some field and storage pests, as can be seen in Gospodarek et al. (2022) [26].

Production in a hydroponic system, due to the greater degree of control (compared to field cultivation), is an interesting alternative to Tarragon, especially when the objective of production is the extraction of essential oil or plant extracts, with a concentration of Furlani et al. (1999) [7] solution of 100 to 119% satisfactory. Therefore, *A. dracunculus* due to the wide range of possibilities of use can contribute to countries' economies and contribute to reducing carbon emissions [25].

4. CONCLUSION

Hydroponic cultivation is a good alternative to grown Tarragon. The 100% nutrient solution provided better performance for most of the characteristics evaluated. The 15% reduction

provides maximum production of the fresh mass of shoots, however, it causes a reduction of 11.3% in the production of dry mass, 6% in the number of stems, and 3.4% in height, which would not be interesting to meet dry mass demand. For fresh consumption, a 25% reduction in nutrient concentration generates a drop of only 1.3% in the maximum fresh mass of tarragon in hydroponic cultivation.

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6. BIBLIOGRAPHIC REFERENCES

1. Niazian M, Sadat-Noori SA, Tohidfar M, Galuszka P, Mortazavian SMM. Agrobacterium mediated genetic transformation of ajowan (*Trachyspermum ammi* L.) Sprague): An important industrial medicinal plant. *Ind Crops Prod.* 2019;132:29-40. doi:10.1016/j.indcrop.2019.02.005
2. Alois KM, Sangiwa GC, Marciale CM, Sahini MG. Phytochemical constituents and larvicidal efficacy of leaf extracts of *Aristolochia elegans* (Aristolochiaceae). *S Afr J Bot.* 2022;146:383-94. doi:10.1016/j.sajb.2021.11.015
3. Sofi MA, Nanda A, Sofi MA, Maduraiveeran R, Nazir S, Siddiqui N, et al. Larvicidal activity of *Artemisia absinthium* extracts with special reference to inhibition of detoxifying enzymes in larvae of *Aedes aegypti* L. *J King Saud Univ Sci.* 2022;34:1-7. doi: 10.1016/j.jksus.2022.102248
4. Basiri MH, Nadjafi F. Effect of plant density on growth, yield and essential oil characteristics of Iranian Tarragon (*Artemisia dracunculus* L.) landraces. *Sci Hortic.* 2019;257(108655):1-6. doi: 10.1016/j.scienta.2019.108655
5. El-Shal RM, El-Naggar AH, El-Beshbeshy TR, Mahmoud EK, El-Kader NIA, Missai AM, et al. Effect of nano-fertilizers on alfalfa plants grown under different salt stresses in hydroponic System. *Agriculture* 2022;12:1-19. doi: 10.3390/agriculture12081113
6. Azizoglu U, Yilmaz N, Simsek O, Ibal JC, Tägele SB, Shin J-H. The fate of plant growth promoting rhizobacteria in soilless agriculture: future perspectives. *3 Biotech.* 2021;11(382):1-13. doi: 10.1007/s13205-021-02941-2.
7. Furlani PR, Silveira LCP, Bolonhezi D, Faquim V. Cultivo hidropônico de plantas. Campinas (SP): Instituto Agrônomo; 1999. (Boletim Técnico IAC, 180).
8. Luz JMQ, Costa CC, Guerra GMP, Silva MAD, Haber LL. Efeito da variação da solução nutritiva no cultivo hidropônico de rúcula. *Rev Verde.* 2011;6:76-82.
9. Santos JE, Luz JMQ, Oliveira RC, Almeida RF, Silva JR, Lana RMQ. Establishment of hydroponic nutrient solution to the cultivation of green onion. *Comun Sci.* 2021;12:1-7. doi: 10.14295/cs.v12.3775.
10. Wali F, Naveed M, Bashir MA, Asif M, Ahmad Z, Alkhtani J, et al. Formulation of biochar-based phosphorus fertilizer and its impact on both soil properties and chickpea growth performance. *Sustainability* 2020;12:1-20. doi: 10.3390/su12229528
11. Guardabaxo CMS, Assis KCC, Figueiredo FC, Silva LF. Cultivo da rúcula em sistema hidropônico sob diferentes concentrações de sais. *Biosyst Eng Biosystems.* 2020;14(3):274-82. doi:10.18011/bioeng2020v14n3p274-282
12. Diniz AA, Dias NS, Souza FI, Sá FVS, Araújo NO, Fernandes ALM. Produção e qualidade do coentro cultivado com solução nutritiva em fibra de coco. *Rev Bras Agr Irrigada.* 2019;13:3306-13. doi: 10.7127/RBAI.V13N200994
13. Oliveira FA, Souza Neta ML, Oliveira MKT, Silva RT, Martins DC, Costa JPBM. Production of coriander in substrate fertigated with increasing nutrient concentrations. *Rev Ciênc Agr.* 2016;59(3):275-9.
14. Luz JMQ, Oliveira RC, Aguilar AS, Santos TN. Cultivo de *Artemisia absinthium* L. sob concentrações de solução nutritiva em hidroponia. *Rev Agrogeoambiental* 2018;10(1):117-27.
15. Lee JW, Han Z, Kang WH, Son JE. Effects of seasonal light variation and artificial light treatments on growth and flavonoid production of *Artemisia princeps* cultivated in greenhouses. *Hortic Environm Biotechnol.* 2021;62:253-61. doi: 10.1007/s13580-021-00335-0
16. Frescura VD, Boligon AA, Barbosa FM, Souza JM, Lerner MA, Laughinghouse HD, et al. Nutrient solution concentration and collection time in phytomass production, content, yield and chemical

- composition of essential oil of rosemary. J Plant Nutr 2018;41(10):1293-302. doi: 10.1080/01904167.2018.1450420
17. Sakamoto M, Suzuki T. Effect of nutrient solution concentration on the growth of hydroponic sweetpotato. Agronomy. 2020;10(11):1-14. doi: 10.3390/agronomy10111708
 18. Fernandes JMP, Fernandes ALM, Dias NS, Cosme CR, Nascimento LV, Queiroz ISR. Salinidade da solução nutritiva na produção de alface americana em sistema hidropônico NFT. Rev Bras Agr Irrigada. 2018;12:2570-8.
 19. Soares CS, Silva JA, Silva GN, Brito Neto JF. Produção hidropônica de cultivares de alface em duas concentrações da solução nutritiva. BIOFARM. 2020;16:82-93.
 20. Nchu F, Matanzima Y, Laubscher CP. Prospects of N fertilization in medicinal plants cultivation. Intech 2017;11:209-22. doi: 10.5772/intechopen.68165
 21. Widiyastuti Y, Subositi D, Haryanti S. Response of *Artemisia annua* accessions to nitrogen fertilizer on low land. IOP Conf Ser: Earth and Environ Sci. 2021;637(012045):1-8. doi: 10.1088/17551315/637/1/012045
 22. Lee J-Y, Hiyama M, Hikosaka S, Goto E. Effects of concentration and temperature of nutrient solution on growth and camptothecin accumulation of *Ophiorrhiza pumila*. Plants. (Basel). 2020;9(6):793. doi: 10.3390/plants9060793
 23. Fussy A, Papenbrock J. An Overview of soil and soilless cultivation techniques—chances, challenges and the neglected question of sustainability. Plants. 2022;11(9):1153. doi: 10.3390/plants11091153
 24. Nurzynska-Wierdak R, Zawislak G. Herb yield and bioactive compounds of Tarragon (*Artemisia dracunculus* L.) as influenced by plant density. Acta Sci Polonorum, Hortorum Cultus. 2014;13:207-21.
 25. Kocaman A. Assessment of the use of *Artemisia dracunculus* L. and *Erigeron canadensis* in the remediation of heavy metal contaminated soils and their ability to phytoextraction and biomass yield. Turkish J Nature Sci. 2022;11(4):1-10. doi: 10.46810/tdfd.1123517
 26. Gospodarek J, Endalamew A, Worsdale M, Pásmionka IB. Effects of *Artemisia dracunculus* L. water extracts on selected pests and aphid predator *Coccinella septempunctata* L. Agronomy. 2022;12:1-13. doi: 10.3390/agronomy12040788