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THE INFLUENCE OF DIFFERENT NUTRIENT SOLUTIONS ON THE PRODUCTIVITY OF *CALLISIA FRAGRANS* IN OPEN-AIR HYDROPONIC CONDITIONS

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The cultivation results of valuable medicinal plant *Callisia fragrans* in open-air hydroponic conditions have shown that the tested nutrient solutions didn't have a significant influence on the productivity of the raw medicinal material. In case of using different nutrient solutions (Davtyan's, Steiner's, Chesnokov-Bazirina's and Knop's) the raw medicinal material exceeded the soil control with fresh (2.3-3.1 times) and dry weight (2.2-3.2 times), as well as with output of sum flavonoids (2.3-3.3 times), extractives (2.6-4.0 times) and tannins (1.2-2.5 times) obtained from one plant.

Callisia fragrans – hydroponics – nutrient solution – productivity – secondary origin substances

Բացօթյա հիդրոպոնիկայի պայմաններում արժեքավոր դեղաբույս *Callisia fragrans*-ի աճեցման արդյունքները ցույց են տվել, որ փորձարկված սննդալուծույթները էական ազդեցություն չեն ունեցել դեղահումքի արդյունավետության վրա: Տարբեր սննդալուծույթների (Դավթյան, Ստեյներ, Չեսնոկով-Բազիրինա, Կնոպ) կիրառման դեպքում դեղահումքը թարմ (2,3-3,1 անգամ) և չոր (2,2-3,2 անգամ) քաշով, մեկ բույսից ստացված գումարային ֆլավոնոիդների (2,3-3,3 անգամ), էքստրակտիվ նյութերի (2,6-4,0 անգամ) և դաբաղանյութերի (1,2-2,5 անգամ) ելքով գերազանցել է հողային ստուգիչին:

Callisia fragrans – հիդրոպոնիկա – սննդալուծույթ – արդյունավետություն – երկրորդային ծագման նյութեր

Результаты культивирования ценного лекарственного растения *Callisia fragrans* в условиях открытой гидропоники показали, что испытанные питательные растворы не оказали существенного влияния на продуктивность лекарственного сырья. При использовании различных питательных растворов (Давтян, Стейнер, Чесноков-Базырина, Кноп) лекарственное сырье по свежей (2,3-3,1 раза) и сухой (2,2-3,2 раза) массе, по выходу суммарных флавоноидов (2,3-3,3 раза), экстрактивных (2,6-4,0 раза) и дубильных веществ (1,2-2,5 раза), полученных от одного растения, превышали почвенный контроль.

Callisia fragrans – гидропоника – питательный раствор – продуктивность – вещества вторичного происхождения

Plant productivity increase and intensification of biosynthesis of valuable substances is particularly due to the optimization of mineral nutrition, which being one of the main and decisive factors in the environment, somewhat directs the biosynthes processes in plants [1, 11]. The composition of the nutrient solution is very important for normal plant growth and development. Among nutrient solutions used in industrial hydroponics Davtyan's, Knop's,

Helrigel's, Pryanishnikov's, Chesnokov and Bazirina's, Steiner's, Bentley's and other nutrient solutions are most famous [7, 9, 17, 15].

The aim of the work is to study the influence of different nutrient solutions on the productivity and biosynthesis of secondary origin substances of valuable medicinal plant *Callisia fragrans*, first introduced into the open-air hydroponic conditions of the Ararat Valley.

Callisia fragrans (Lindl.) Woodson is a perennial, succulent plant of the Commelinaceae family (fig.1). It is common in Central and South America and Mexico. It is quite a big plant with two types sprouts: vertical and horizontal, which are made up of joints. It mostly propagates with cuttings. The flowers are small, gathered in the glow inflorescences with hyacinth odor [12, 2].

Figure 1. *Callisia fragrans* in open-air hydroponic conditions

As a result of study, the chemical composition of the plant juice, it has been found out that it contains carbohydrates, ascorbic acids, amino acids, phenol acids, flavonoids, coumarins, anthraquinones, triterpene compounds, alkaloids and choline [13]. The plant is also rich in mineral elements. Ca, Mg, Si, P, Ba, Fe, Na, Mn, Cu, Zn and Al are found in the juice obtained from the plant sprouts [18].

Due to biologically active substances it also has antioxidant, anti-hypoxic, anti-mutagenic and other healing properties [13, 14, 16]. In the result of phytochemical analysis of the sprouts it has been revealed that the plant also has temperature reducing and anti-inflammatory properties [8].

It is widely used in folk medicine for treating a number of diseases such as cancer, joints and spinal diseases (rheumatism, arthritis, arthrosis, radiculitis, osteochondrosis), liver and pancreas, gastrointestinal tract, skin diseases, bronchial asthma, etc.

Materials and methods. Different nutrient solutions have been tested: Davtyan's, Steiner's, Chesnokov-Bazirina's and Knop's [7, 15, 17, 9]. Plant cuttings obtained by hydroponics method were the planting material. The experiments were carried out in hydroponics vegetation pots with 0.16m2 nutrient surface ($1m^2$/12plant), the mixture of gravel and red volcanic slag (particle diameter 3-15mm) with 1:1 ratio were used as a substrate which was disinfected with $KMnO_4$ 0.05 % solution. Every 8-10 days the plants were rinsed with artesian water. In the experiments soil culture was the control variant where all the accepted agrotechnical rules were observed. The number of replications was 5-6. During the research physiologo-pharmachemical analyses were carried out: water forms in the leaves, osmotic pressure of cellular fluid according to Gusev [6], the content of photosynthetic pigments according to Wettstein [19], and the content of extractives, sum flavonoids, tannins and humidity in dry raw medicinal material according to Grinkevich, Georgievskiy and SP XI [5, 3, 4]. The obtained results were submitted to mathematical elaboration with computer system GraphPad Prism 6.

Results and Discussion. In the result of experiments (tab. 1) it has been revealed that the tested variants of nutrient solutions didn't differ significantly both with fresh and dry weight of all the sprouts (including the ones that were still in the formation stage) and the sprouts which are raw medicinal material. And in case of green mass the difference between Steiner's and Knop's solutions was considerable.

Table 1. The influence of different nutrient solutions on the productivity of *Callisia fragrans*, g/plant

Variant	Leaf		Sprout (raw medicinal material)*		Sprout (total)	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
Davtyan's	890.3^{ab}	57.2^{ab}	487.5^{a}	27.7^{a}	935.8^{a}	48.9^{a}
Steiner's	691.8^{b}	44.7^{b}	490.3^{a}	30.4^{a}	731.3^{a}	42.7^{a}
Chesnokov-Bazirina's	806.7^{ab}	50.4^{ab}	462.9^{a}	29.6^{a}	782.9^{a}	45.3^{a}
Knop's	1047^{a}	67.9^{a}	636.6^{a}	40.9^{a}	994.9^{a}	59.9^{a}
Soil (control)	294.4^{c}	21.1^{c}	205.4^{b}	12.6^{b}	326.4^{b}	19.1^{b}

^{abc} Tukey's Multiple Comparision Test (P<0.05)

* Brownish-purple sprouts of the plant with 9 and more joints are considered to be raw medicinal material [12]

At the same time the same plant grown in hydroponics and soil conditions was compared. In open-air hydroponics the plants nourished with different nutrient solutions exceeded the soil culture with leaf (fresh: 2.3-3.6 times and dry: 2.1-3.2 times) and sprout (fresh: 2.3-3.1 times and dry: 2.2-3.2 times) weight, which are considered raw medicinal material. This can be explained by the fact that in hydroponics the best air-water-mineral nutrition conditions are provided for the root system of the plant, while in soil culture the plants can use the above mentioned factors only for a short period [7, 9].

The same regularity has been maintained in leaf-stem-sprout ratio of all variants; at the same time regardless of cultivation methods a great accumulation of leaves (48-50%) and sprouts (42-46%) has been observed (Figure 2).

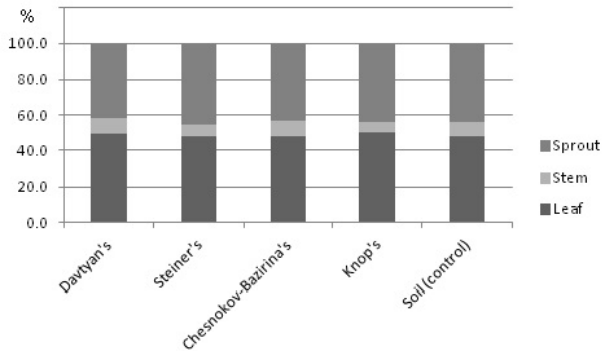

Figure 2. The influence of different nutrient solutions on leaf-stem-sprout ratio of *Callisia fragrans*

The physiological analyses were carried out in the leaves: an average sample was taken from the main plant and from lateral sprouts starting from it. It turned out that the content of total water has undergone very few changes in all variants. It is known that for normal growth and development of plants not only the content of total water is important but also the degree of its mobility, the greater the shares of removable water in the plants, the higer the physiological activity of leaves [9, 10]. A high content of free water (by 5.3-11.1%) was observed in the leaves of the hydroponics plants, compared to the soil ones, as well as small values of bound water (by 7.6-13.1%) and osmotic pressure of cellular fluid (by 3.9-23.7%).

To some extent, cultivation conditions had an influence on biosynthesis of photo-synthetic pigments in leaves. The content of chlorophyll (a+b) in the leaves of the plants obtained with different nutrient solutions exceeded the soil culture by 27.7-60.1% (tab. 2).

Table 2. The influence of different nutrient solutions on physiological indices of *Callisia fragrans*

Indices	Davtyan's	Steiner's	Chesnokov-Bazirina's	Knop's	Soil (control)
Total content of water, %	94.2	93.1	93.7	93.3	93.1
Content of free water, %	61.1	57.9	59.8	58.7	55.0
Content of bound water, %	33.1	35.2	33.9	34.6	38.1
Free water/bound water	1.8	1.6	1.8	1.7	1.4
Osmotic pressure of cellular fluid, atm	1.96	2.47	2.08	2.36	2.57
Chlorophyll (a+b), mg %	34.6	37.2	43.4	36.3	27.1
Carotenoids, mg %	12.4	11.5	12.8	11.3	14.0

Taking into account the fact that the plant has medicinal properties only in case of 9 and more joints on the sprouts, which obtain brownish-purple color, such sprouts were chosen for pharmachemical analysis of secondary origin substances (sum flavonoids, extractives, tannins). Davtyan's solution exceeded other variants with the content of extractives (by 1.1-1.2 times) and the control (by 1.3 times). While the plants nourished with Chesnokov-Bazirina's nutrient solution compared to others had the lowest content of sum flavonoids (by 2.2-2.3 times). Analysis of pharmachemical indices has shown that different nutrient solutions didn't have a significant influence on percentage content of humidity (tab.e 3).

Though a high content of sum flavonoids and tannins has been observed in the plants of the control variant, the output of the mentioned substances per plant reduces by 2.3-3.3 and 1.2-2.5 times, correspondingly, compared to other variants because of raw medicinal material low harvest (tab. 3).

Table 3. The influence of different nutrient solutions on accumulation of secondary origin substances of *Callisia fragrans*

Variant	Extractives		Sum flavonoids		Tannins		Humidity
	%	g/plant	%	g/plant	%	g/plant	%
Davtyan's	39.7	11.0	0.24	0.07	0.7	0.19	9.6
Steiner's	31.8	9.7	0.24	0.07	1.3	0.40	10.3
Chesnokov-Bazirina's	33.3	9.9	0.11	0.03	1.2	0.35	9.1
Knop's	36.9	15.1	0.25	0.10	0.9	0.37	9.5
Soil (control)	30.4	3.8	0.26	0.03	1.3	0.16	9.6

Summarizing the above mentioned we have come to the following conclusions. In open-air hydroponic conditions different nutrient solutions mostly didn't have a significant influence on the productivity of *Callisia fragrans*. Considerable increase of harvest (2.2-3.6 times) has been noticed in soilless culture conditions compared to soil. This can be explained by the fact that the best air-water-nutrition conditions were provided in hydroponics. In soilless conditions activation of important physiological processes has been observed which determines the high productivity of hydroponics plants. Due to raw medicinal material productivity high output of secondary origin substances: flavonoids (2.3-3.3 times), extractives (2.6-4.0 times), tannins (1.2-2.5 times) was also registered in soilless culture conditions.

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