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The Productivity of Some Valuable Medicinal Plants in Conditions of Water Stream Hydroponic

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Abstract

At the IHP NAS RA it was developed and licensed new, modern system water stream hydroponics for the soilless production of different plant species using polymeric film, the benefits of which are low cost, more automated system and beforehand instructed program. Its varieties are continuous, gully and cylindrical hydroponics. The aim of research was to develop of effective biotechnologies for some plants important in medicine and food industry (*Mentha piperita* L., *Ocimum basilicum* L., *Salvia officinalis* L., *Bidens tripartita* L. and *Leonurus quinquelobatus Gilib*.). Cylindrical hydroponic system promoted the 1.3-2.9 times increase of productivity of *Mentha piperita* L., *Ocimum basilicum* L. and *Leonurus quinquelobatus Gilib*. and the 1.3-3.3 times rise of the output of mentioned cultural plants' essential oils (except of *Leonurus quinquelobatus Gilib*.), extractive substances, total flavonoids and tannins. *Salvia officinalis* L.'s productivity was increased 1.2-5.4 times in gully hydroponics. Continuous hydroponic system promoted the high accumulation of extractive substances in the plants of *Mentha piperita* L., *Ocimum basilicum* L., *Salvia officinalis* L. and *Leonurus quinquelobatus Gilib*. High productivity (1.3-1.6 times) of *Bidens tripartita* L. and 1.1-2.5 times output increase of polysaccharides, extractive substances, flavonoids and tannins in it were recorded in classical hydroponics conditions.

Keywords: Water stream hydroponics; Productivity; Medicinal plants; Secondary bioactivity compounds

Introduction

Hydroponics/soilless cultivation of plants as a modern biotechnological method of the plants productivity increase, is more expedient for the land-poor, also water-poor countries, where there are thousands of hectares of unfavorable and unusable in agriculture saline-sodic, stony and sandy soils. But the creation of hydroponicums requires substantial initial investments, thus, the development of novel and cheap systems is one of the main tasks for increasing economic efficiency of plants soilless culture.

For this purpose in 2006-2007 at the IHP NAS RA in a result of the long-term studies it was developed and licensed new, modern system water stream hydroponics for the soilless production of different plant species using polymeric film (instead of hydroponicums with classic ferroconcrete plots) that joins the rank of already existed in the world known hydroponic systems with its low cost, more automated system and beforehand instructed program [1].

Water-stream hydroponics is based on the nutrient solutions automatically controlled periodically and irretrievable push shaped like a jet directly to the root-bearing stratum by providing the optimal air-water-nutrition regime required for the normal growth and development of plant. The usage of nutrient solution irretrievable push principle and closed ecological system excludes the environmental pollution minimizing the danger of diseases' bursts, spread of pests and weeds.

1. The water stream hydroponics includes following varieties:
2. Continuous (Patent of RA, No.1988 A2): smooth surface of land is covered with polyethylene bio-insulating film, which is entire sprinkled with some of substrate (gravel, volcanic slag, etc.) (particles of 3-20 mm) with 20-25 cm thickness. Plants nourishment is being done with the help of the dispencing polyethylene pipes (through holes on them) connected with the main pipe at a necessary distance.
3. Gully (Patent of RA, No.1989 A2): on the land area at a certain distance furrows are digged in 25-30 cm depth and in 35-40 cm width that are isolated from the soil layer with polyethylene film filled with some substrate.
4. Cylindrical (Patent of RA, No.1946 A2): polyethylene cylinders of 30-40 cm in diameter are filled with some substrate (volcanic slag, gravel, etc.) (particles of 3-20 mm).

The aim of the research is to develop the growth biotechnology and to give comparative description of productivity, content and output of bioactive substances of essential oil-bearing and medicinal plants (*Mentha piperita* L., *Ocimum basilicum* L., *Salvia officinalis* L., *Bidens tripartita* L., *Leonurus quinquelobatus Gilib*.) in conditions of new water stream (cylindrical, gully, continuous) hydroponics and classical hydroponics. The choice of above mentioned plants is not occasional. They have wide application in medicine, perfume and food industry.

Mentha piperita L., *Ocimum basilicum* L. and *Salvia officinalis* L. are the essential oil-bearing and medicinal plants belonging to the family Laminaceae. Plants leaves, and essential oils received from them are used for treatment. They are used during treatment of cardiovascular, gastrointestinal tract's, liver, gallbladder's diseases, atherosclerosis, chronic bronchitis, asthma, tonsillitis, gum bleeding and other diseases [2-6]. They have also high antioxidant activity and

are considered as a drug for memory's recovery [7-9].

Bidens tripartita L. is an annual herb belonging to the family Compositae. The plant's overground part contains polysaccharides, tannins, mucous substances, lavonoids, carotene, vitamin C, etc. It is used as external anti-in lammatory, sedative, blood regenerating, antimicrobial medicine. It is applied during treatment of allergy, some skin and gastrointestinal diseases, and it decreases the blood pressure [5].

Leonurus quinquelobatus Gilib. is a perennial herb belonging to the family Laminaceae. It contains extractive substances, lavonoids, tannins, saponins, etc. Its overground part is used as a medicinal raw material by way of water extract for treatment of cardiovascular diseases, neurosis and hypertension as a substitute of valerian [5]. Above mentioned medicinal plants, except of *Ocimum basilicum* L., are officially recognized in the State Pharmacopeia [10-12].

Materials and Methods

The seedlings of plants were planted during spring in gully, cylindrical and continuous hydroponic conditions. Classical hydroponics (CH) was the control. During the experiments Davtyan's nutrient solution [13] was used, which was regularly irretrievably pushed to the root-bearing stratum of the plant in the form of jet: in spring and autumn 6-8 times daily and in summer 10-20 times daily with the 10-15 seconds duration. The dosage of the solution given once a day was 20-30 ml/plant in spring and 30-50 ml/plant in summer and autumn. In classical hydroponics the plants were nourished 1-2 times in spring and autumn and 2-3 times in summer.

During vegetation biometric measurements and pharmachemical analyses were done. The content of essential oil, extractive substances, tannins, ash and moisture in dry raw medicinal material was determined according to SPh XI [12]. The obtained data underwent statistical treatment [14]

Results and Discussion

From the Tables 1 and 2 it is obvious that different modules of water stream hydroponics have different in luence on the plants productivity.

The cylindrical hydroponics system promotes the increase of the tested plants' raw medicinal material: *Menta piperita* L., *Ocimum basilicum* L. and *Leonurus quinquelobatus Gilib*. grown in this system exceeded variants grown in gully, continuous hydroponics and control 1.7-2.7; 1.3-2.9 and 2.0-2.2 times, respectively. As the result of the scientific experiments it is revealed that dry raw medicinal material of Salvia officinalis L. grown in cylindrical, gully and continuous hydroponic conditions exceeds classical hydroponics variant 4.6; 5.4 and 4.1 times, respectively. At the same time gully hydroponics is most beneficial for this plant, providing 1.2 and 1.3 times higher dry outputs compared with cylindrical and continuous hydroponics, respectively.

Classical hydroponics provided favorable conditions for normal growth, development of *Bidens tripartita* L. and gaining of its raw medicinal material, exceeding cylindrical, gully and continuous variants 1.3-1.6 times.

The content and output of essential secondary elements were determined during vegetation.

Growth conditions influenced specifically on the qualitative characteristics of *Mentha piperita* L.'s raw medicinal material. According mentioned data, about 3-12% enhancement of essential oils is observed in cylindrical hydroponics. In studied hydroponic systems plants grown in continuous hydroponics are differentiated with high content of extractive substances (6-26% higher from other systems), classical hydroponics is indicated with high content of flavonoids (5-15% higher from other systems), and there are no differences in the content of tannins.

Pharmacochemical studies showed that enhancement of essential oils biosynthesis in *Ocimum basilicum* L.'s raw material approximately 16-26% is observed in continuous hydroponic system compared with other systems, and classical hydroponic system provides high content of extractive substances (7-20% higher from other systems), total flavonoids (6-13% higher from other systems) and tannins (37-47% higher from other systems). The results showed also that in *Mentha piperita* L. and *Ocimum basilicum* L., because of high yield of leafy mass the output of essential oils, extractive substances, total flavonoids and tannins per plant in the conditions of cylindrical hydroponics is increased 1.5-3.3 and 1.3-2.8 times, respectively, compared with other tested variants.

Name of plant	Variety	Dry weight of raw material, g/plant	Essential oil		Extractive substances		Total flavonoids		Tannins	
			content %	output, g/ plant	content %	output, g/ plant	content %	output, g/ plant	content %	output, g/ plant
Mentha piperita L. (according to SPh XI not less than 1%)	Cylindrical	124.8	3.8	4.7	30.0	37.4	2.1	2.6	13.2	16.4
	Gully	56.1	3.7	2.1	28.1	15.8	1.9	1.1	14.4	8.1
	Continuous	74.7	3.5	2.6	31.9	23.8	2.1	1.6	14.4	10.7
	CH (control)	46.5	3.4	1.6	24.3	11.3	2.2	1.0	14.1	6.6
	LED05	20.3								

Ocimum basilicum L.	Cylindrical	129.4	0.82	1.06	30.7	39.7	3.2	4.1	9.4	12,2
	Gully	96.1	0.89	0.85	28.7	27.6	3.1	3.0	9.8	9.4
	Continuous	81.5	1.03	0.84	32.2	26.2	3.3	2.7	10.1	8.2
	CH (control)	45.0	0.85	0.38	34.5	15.5	3.5	1.6	13.8	6.2
	LED05	22.1								
Salvia officinalis L. (according to SPh XI not less than 0.8%)	Cylindrical	59.8	0.72	0.43	26.1	15.6	2.4	1.45	9.4	5.6
	Gully	70.6	0.98	0.69	18.4	13	2.6	1.81	10.6	7.5
	Continuous	53.7	0.91	0.49	37.4	20.1	2.3	1.23	10.4	5.6
	CH (control)	13.1	1.53	0.2	29	3.8	2.3	0.3	13.7	1.8
	LED05	19.8								

Table 1: The productivity of some valuable medicinal plants in conditions of water stream and classical hydroponics.

According mentioned data *Salvia officinalis* L. grown in classical hydroponic conditions is differentiated with high content of essential oils and tannins in raw medicinal material that are most important secondary origin compounds and are specifying its pharmacochemical in luence (1.6-2.1 and 1.3-1.5 times, respectively), continuous hydroponics is notable for high content of extractive substances (1.3-2.0 times from the others) and gully hydroponics is distinguished by increased level of total lavonoids (about 1.1 times). In the meantime, the output of above mentioned compounds, except of extractive substances, increases 1.2-4.2 times because of high productivity of medicinal herb received in gully hydroponics conditions, compared with the other variants.

From the Table 2 it is obvious also that cultivation conditions in luenced speci ically on the qualitative characteristics of *Bidens tripartite* L.'s medicinal raw material, moreover plants of cylindrical hydroponics are differentiated with higher accumulation of polysaccharides (20-50% higher from the others). In *Bidens tripartite* L. plants grown in classical hydroponic conditions the content of lavonoids, tannins having anti-in lammatory in luence is increased 10-90%, respectively. The content of extractive substances in raw medicinal material does not undergo essential changes in water stream hydroponics conditions. While the output of above mentioned compounds per single plant's calculation is increased 1.1-2.5 times in classical hydroponics conditions because of high productivity of *Bidens tripartite* L., compared with other variants..

Name of plant	**Variety**	**Dry weight of raw material, g/plant**	**Polysaccharides**		**Extractive substances**		**Total flavonoids**		**Tannins**	
			content %	**output, g/ plant**	**content %**	**output, g/ plant**	**content %**	**output, g/ plant**	**content %**	**output, g/ plant**
Bidens tripartita L. (according to SPh XI not less than 3.5%)	Cylindrical	70	12.2	8.6	33	23.1	2.1	1.5	3.4	2.4
	Gully	72	8.3	6	34.3	24.7	3.3	2.4	4.4	3.2
	Continuous	60	8.6	5.1	32.3	19.4	2.7	1.6	4.8	2.9
	CH (control)	95	10	9.5	30.6	29.1	3.5	3.3	6.4	6.1
	LED05	13.1								
Leonurus quinquelobatus Gilib.	Cylindrical	166	-	-	26.3	43.7	2.7	4.4	7.1	11.8
	Gully	74.3	-	-	29.3	21.8	2.8	2.1	8.6	6.4
	Continuous	83.4	-	-	33.9	28.3	3	2.5	8	6.7
	CH (control)	80.6	-	-	22.1	17.8	2.5	2	10.7	8.6
	LED05	28	-							

Table 2: The productivity of some valuable medicinal plants in conditions of water stream and classical hydroponics.

The biosynthesis of extractive substances and total lavonoids in raw medicinal material of *Leonurus quinquelobatus Gilib* . took place by 16-53% more intensively in continuous hydroponics system, while in the case of tannins content the control plants are distinguished (24-50% more compared with others). But in conditions of cylindrical hydroponics the output of above mentioned compounds is increased 1.4-2.5 times, respectively because of high productivity of *Leonurus quinquelobatus Gilib*.

Conclusion

Cylindrical hydroponic system promoted the 1.3-2.9 times increase of productivity of *Mentha piperita* L., *Ocimum basilicum* L. and *Leonurus quinquelobatus Gilib.*, also the 1.3-3.3 times rise of the output of mentioned cultural plants' essential oils (except of *Leonurus quinquelobatus Gilib.*), extractive substances, total flavonoids and tannins. Gully hydroponic system provided the 1.2-5.4 times increase of *Salvia officinalis* L.'s productivity and 1.2-4.2 times enhancement of total flavonoids and tannins in its medicinal raw material. Continuous hydroponic system promoted the high accumulation of extractive substances in the plants of *Mentha piperita* L., *Ocimum basilicum* L., *Salvia officinalis* L. and *Leonurus quinquelobatus Gilib.* Plants of *Bidens tripartita* L. grown in classical hydroponics conditions were differentiated with high productivity (1.3-1.6 times) and with 1.1-2.5 times output increase of most important compounds of secondary origin - polysaccharides, extractive substances, flavonoids and tannins. At the same time higher accumulation of polysaccharides (1.2-1.5 times) was observed in cylindrical hydroponics.

Simultaneously medicinal raw material received from the tested cultural plants, except of *Ocimum basilicum* L., satisfies the adopted requirements of pharmacopoeia.

It is important to mention that till now there is no relevant data about basilic's medicinal raw material in the State Pharmacopoeia (SP), hence our received results with high probability will help to create such scientific – technical document.

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