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The Efficiency of Planting Stock of Some Tree-Shrubs in Armenia in Open-Air Hydroponics Conditions

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Abstract

The question of nature conservation became one of the most important in the world. It especially concerns to the countries with dry climate, such as Armenia, where auto recovery possibility of forests is excessively low. Gradual disappearance of forests, green areas is due to human non-competent acting, climate change, which aggravates present ecological crisis. One of the important steps for solution of this problem is the recovery of forests, green areas that requires the existence of huge amount of saplings. The use of open-air hydroponics is one of the best versions to receive healthy, qualify saplings. We studied and developed open-air hydroponic methods and biotechnologies of cultivation of 25 species of tree-shrubs important for the landscaping and forest recovery. There was studied the influence of nutrition solution offered by Davtyan G.S. and used in our Institute many years and its modified variants with the changes of main nutrients elements ratio on the biometric parameters of plants. Received results showed that saplings grown in open-air hydroponics conditions have strong root system, provide high rooting, which is very important in the recovery of forests, green areas, especially today's ecological critical conditions of forest zones.

Keywords: Open-air hydroponics; Thuja orientalis; Pyramidal thuja; Oriental plane; Oak; Saplings.

1. Introduction

In parallel with the growth of Earth's population and scientific and technical progress, the problem of the nature conservation has become one of the most important in many countries. This is especially concerns countries with a dry climate, such as Armenia, where evaporation is 2-4 times higher than precipitation at an altitude of till 1500-1600 m above sea level. Armenia is poor in forests. Only about 11.2% of republic is covered with forests, which is approximately 334.1 thousand ha. The possibility of self-healing of forests is extremely small and their every loss is irreversible [1-3]. The deteriorated ecological state in the republic aggravates the main issue of restoring and expanding the forest zone and green areas, the key solution of which is to organize the production of tree-shrubs saplings [4, 5]. Currently, the main and urgent problem has become the implementation of programs for the creation and restoration of forests and green parks. The mentioned circumstance incomparably increases the demand for saplings of tree-shrubs in our country and further aggravates the main issue of their production in a modern way. Here soilless plant growing, hydroponics, takes its unique place: it allows for a short time to organize accelerated production of planting material [6, 7], which will significantly contribute to the restoration of depleted forests, gardens and green parks of the republic and will prevent the import of seedlings from abroad with high prices.

In order to organize accelerated hydroponic production of tree-shrub saplings, the Institute of Hydroponics Problems of NAS RA has developed cultivation biotechnologies for saplings and seedlings of about 25 valuable tree-shrub (Biota orientalis Endl., Thuja pyramidalis, Platanus orientalis L., Quercus L., Psevdoacacia L., Gleditschia L., Populus L., Morus L., Juglans regia L., Ligus L., Cornus L., Spiraea L., Jasminus L., Forsithia L., Buxus L., etc.).

2. Material and Method

Studies were done in 2000-2018 in the G.S. Davtyan Institute of Hydroponics Problems of NAS RA.

Tree-shrubs were propagated by seeds and vegetative propagation (cuttings). For reproduction by cuttings, annual, well-matured shoots were used. The issue of plants planting density and their correct configuration in the field was important, because the expense done on unit product was conditioned mainly by this. Due to the

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hydroponic method of cultivation some agricultural work (tillage, nourishment, weeding, etc.) were completely absent allowing the increase of the density of tree-shrubs planting (sowing seeds, cuttings) by 8-12 times, while reducing the timing of saplings production (1-3 years) and costs (2-3 times), at the same time providing the light-air and water-nutritional optimal conditions of the above-ground and underground organs [5, 6, 8, 9].

The influence of different factors (filling materials, nutrient solutions, nutrition surface, optimal concentration and ratio of main nutrition elements (N,P,K)) on the cuttings establishment, seeds germination, output and quality of cuttings and seedlings was studied [10].

Planting of cuttings of trees and shrubs was carried out according to schemes 50, 60, 70 and 100, 120, 140 cuttings·m^{-2}, respectively. Tree seedlings were planted according to the scheme 10, 12, 20, 25, 30, 40 seedlings·m^{-2}.

The longitudinal growth and trunk's diameter (on level of base), roots volume and annual average growth of oak were also studied.

Experiments of main nutrition elements were done in little size hydroponic equipments.

For nutrition solution following ratios of N: P: K were used:

1. 1N nutrition solution proposed by G. S. Davtyan as a control nutrition solution,
2. Nutrition solution with 50% less amount of nitrogen,
3. Nutrition solution with 50% less amount of phosphorus,
4. Nutrition solution with 50% less amount of potassium,
5. Nutrition solution with 50% more amount of nitrogen,
6. Nutrition solution with 50% more amount of phosphorus,
7. Nutrition solution with 50% more amount of potassium.

The plants were nourished during week 5 days with nutrition solution and 2 days with common water till the end of vegetation. pH of nutrition solution in all versions of experiment were kept within 5.5-6.5.

3. Results and Discussion

Results of many years' experiments given in table 1 show that thuja and pyramidal thuja from the cypress family (Cupressaceae) become ready saplings during 3-4 years, the height of which reaches 120-145 cm and diameter of trunk 20-28 mm, respectively (Fig. 1, 2, tab. 1).

Seedlings planted during the first year have high rooting (about 100%), but growth is slow. Due to the powerful root system, the growth of the thuja is activated in the 3rd, and the pyramidal thuja in the 4th and 5th years [5, 6].

Due to the annual intensive growth and high rooting of saplings of thuja and pyramidal thuja, hydroponics allows to receive from 1 m^2 12 saplings of thuja and 8 saplings of pyramidal thuja, which have a strong root system, good presentation and can be successfully used in the field of gardening and urban planning.

The studies were shown that in soilless cultivation conditions of planting material of trees in the composition nutrition solution quantitative changes of nitrogen, phosphorus, and potassium have significant influence on growth and output of saplings (Table 2).

> *Thus, it was revealed that in nutrition solution normal dose of nitrogen (175 mg/l) has a positive influence on plants growth. In the case of half deficiency of nitrogen quantity (87.5 mg/l) annual general growth is slowing down by 17-19 cm, and more quantity (262.5 mg/l) is strengthening shoots growth by 12-18 cm, because of which their tissues are becoming more fragile, are poorly maturating and poorly stiffening, hence are freezing easily, too Hovsepyan, et al. [11]. Because of this on the end of vegetation from the September it is important to remove nitrogen from the nutrition solution and also gradually decrease watering frequency (twice, once a week and once during ten days, etc.) till the end of vegetation` dependent from the autumn climatic conditions.*

Plants maturation (stiffening) is accelerated in the variant with the giving of normal dose of phosphorus in nutrition solution (65 mg/l). In the case of 50% deficiency of phosphorus (32.5 mg/l) plants growth decreases, which is accompanied with poor development of root system. In the case of content of 300 mg/l potassium drought tolerance and frost resistance of plants is enhanced.

Planes (Platanus orientalis from the family of Platanaceae) are well propagated by seeds. Unlike other tree shrubs, plane seeds are harvested from the seeds of the second year. Plane seeds are sown in spring in March-April. Before sowing, seeds were soaked for 1 day in water to increase germination. From a unit of surface during the first year from plane seeds it is possible to receive 150-200 seedlings with 30-50 cm height and 5-7 mm diameter of trunk. During the next spring, seedlings were planted in hydroponic stages according to the scheme of 20 seedlings/m^2. Rooting was 95% (Table 1).

From our studies it was also revealed that in hydroponic conditions during 2 years from 1m^2 19 saplings appropriate to standards were received from plane seedlings, average height of which was 250 cm and trunk diameter 25 mm (Fig. 3). Under the regulated conditions of soilless culture plane saplings grow most intensively during second year: they have developed root system and may successfully be used in the spheres of gardening, urban planning and forestation.

Oak – *Quercus* L. - belongs to the family Fagaceae. From the five species of oak (Georgian, Caucasian, Aleppo, European and sessile) that are met in natural conditions of Armenia we experienced Caucasian and Georgian species, that are cold resistant and drought tolerant, are not demanding for soil, are well adjusted to specific conditions of cities, especially to smoke, gases and dust.

From the studies done in hydroponics it was confirmed that the highest rooting, growth and efficiency of oak saplings were provided black volcanic slag substrate the use of which allows saplings and seedlings to develop powerful, fibrous root system. During translocation of saplings little fractions of black slag are mainly excreted away with root system. Without shaking, they are being located in plastic bags and transported into planting place.

Privet belongs to the family of oilseeds and is a large, rod-shaped shrub with a high density of leaves. Due to that privet is easily exposed to design, it is successfully used in urban planning in obtaining of borders, fences and alleys [1, 2, 8]. Privet is usually propagated by cuttings. Privet cuttings are collected in early spring and put in trenches. In the spring, cuttings of 12–15 cm in length are made from pre-ditched cuttings for planting. To ensure the physiological moisture of the cuttings, they were kept in water for 12-14 hours before planting.

> *Soil cultivation of shrub planting material is very laborious and output of saplings is very low from a unit surface. In the case of a usual, soil cultivation 28-50 thousand cuttings are planted on 1 hectare; sometimes ribbon planting is used that allows plantation of 75-90 thousand cuttings Alexeyevski [8]. As a rule, in the breeding grounds, the planting density of the cuttings depends on their soil and climatic conditions, the biological characteristics of the cultivated plants, the agricultural technology used, etc. Soilless culture allows increasing the number of cuttings to 1.0-1.4 million per hectare. This circumstance allows the full use of hydroponic fields to solve the above problem, repeatedly increasing the efficiency of a unit surface.*

Received results clearly show that cuttings rooting in soilless culture is high - 90%. In the case of 140 cuttings/m^2 planting of privet cuttings, 126 high-quality seedlings are received during first year, the average height of which is 43 cm, the diameter is 7mm (Table 1, Fig. 4) and they have strong root system.

From the long lasted experiments results it was revealed that hydroponic production of treeshrub saplings is a new, progressive way. It provides optimal conditions of air-water-nutrition for growth and development of plants' overground and underground organs and compared with soil culture allows:

1. to enhance germination and rooting (65-95%) of seeds, cuttings and seedlings,
2. to increase planting density 8-10 times,
3. to decrease the time of the saplings production by 1-2 years and cost 2-3 times,
4. to receive 80-120 thousand high quality saplings of evergreens, 190-560 thousand high quality saplings of deciduous trees and 720-1260 thousand high quality saplings of shrubs from 1 ha.

4. Conclusion

The studies showed that the best doses of nitrogen, phosphorus and potassium during vigorous growth of trees are 140-175 mg/l, 55-60 mg/l and 180-190mg/l, respectively and during saplings maturation at the end of August the nitrogen must be fully removed from the nutrition solution and the contents of phosphorus must be reduced till 40-45 mg/l leaving potassium content almost unchanged: 250-300mg/l.

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Figure-1. Three year saplings of thuja orientalis in open-air hydroponics

Figure-2. 1-3 years saplings of pyramidal thuja in open-air hydroponics

Figure-3. Two years old saplings of Oriental plane in open-air hydroponics

Figure-4. One-year-old saplings of privet in open-air hydroponics

Table-1. The growth and output of some three-shrubs saplings under open-air hydroponics conditions

Name of tree-shrub	Amount, piece/m^2	Rooting, %	Tree-measurement indicies of saplings		Age of saplings	Output of saplings, piece/m^2
			Height, cm	Diameter of trunk, mm		
Thuja (seedlings)	12	100	120	20	3	12
Pyramidal thuja (seedlings)	8	100	145	28	4	8
Plane (seedling)	20	95	250	25	2	19
Oak (seedlings)	40	80	171	26	3	32
Gleditsia (seedlings)	30	85	260	30	3	25
Acacia (seedlings)	40	90	250	29	3	36
Poplar (cuttings)	70	80	205	35	2	56
Privet (cuttings)	140	90	43	7	1	126
Gaiter-tree (cuttings)	100	80	67	8	1	80
Spiraea (cuttings)	120	60	32	4	2	72
Jasmine (cuttings)	120	65	80	10	2	78

Table-2. The influence of added or removed from nutrition solution on 50% nitrogen, phosphorus, potassium on three years old saplings of oak in open-air hydroponics conditions

Nutrition solution	Quantity of main nutrition elements in solution			Indices for trees' estimation					
	N	P	K	Height, cm	Trunk's diameter, mm	Annual average growth		Total mass of roots, g	Total volume of roots, cm^3
						2nd year, cm	3th year, cm		
Davtyan (control)	175	65	300	171	26	55	91	282	254
Control minus 1/2 nitrogen	87.5	65	300	152*	23	46	73	158	135
Control minus 1/2 phosphorus	175	32.5	300	150	21	48	75	186	164
Control minus 1/2 potassium	175	65	150	169	25	51	88	215	198
Control plus 1/2 nitrogen	262.5	65	300	187*	27	62	108	348	302
Control plus 1/2 phosphorus	175	97.5	300	182	25	56	93	296	249
Control plus 1/2 potassium	175	65	450	176	26	57	95	304	276

* – $p<0.05$ compared with control