The possibility and prosperity of *Moringa oleifera* Lam. cultivation in Armenia under conditions of outdoor hydroponics and soil

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Abstract. Moringa is one of the most important plants in the fight against malnutrition. Its leaves are largely used in food. This subtropical plant is a non-traditional culture for Armenia. For the first time it was cultivated in outdoor hydroponic and soil conditions in Ararat Valley. The aim of the study was to reveal the plant's cultivation possibility in the outdoor hydroponic conditions and the quantitative and qualitative efficiency of its plant raw material. The results are showing that hydroponic moringa exceeded soil variant 1.7 times in useful biomass of leaves in a count of per plant. Due to high productivity, the hydroponic moringa plants exceeded soil plants with the output of the extractive substances (1.5 times), flavonoids (1.4 times), phenolic acids (1.9 times), tannins (1.2 times), calcium (1.2 times), magnesium (2.9 times), proteins (1.5 times), and carbohydrates (1.3 times). The received results allowed assuming that the hydroponic culture is effective and perspective for moringa cultivation in Armenia.

1 Introduction

Moringa (*Moringa oleifera*) is a drought-resistant tree and belongs to the Moringaceae family. In nature it is spread in tropical and subtropical regions of South Asia. It is named moringa, drum tree (because of long, thin and triangle seed pods), horseradish tree (because of roots taste remembering radish) and benzolive tree (because of oil received from the seeds). Moringa has an exclusively high nutritional value. It is the most important part of the struggle against malnutrition in the global South, while in the West it is gaining popularity as a new "superfood". All parts of the tree are edible [1-3].

The leaves of moringa are excellent sources of vitamin A, B and C and minerals. The leaves are also valuable sources of calcium, potassium, and iron. The content of methionine and cysteine amino acids is also high. The low content of carbohydrates, fats and phosphorus makes it the best plant food ever found [2, 4-7]. As a food and medicinal plant, moringa is a rich source of the bioactive substances, endowed with a lot of medicinal

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properties. Different parts of the plant are endowed with antibacterial, antidiabetic, antilipidemic and antioxidant properties [8-10].

Hydroponic technology allows cultivation of plants on soils unusable for traditional agriculture, minimization of the use of water, mineral salts, and human resources. It is more managed system, the use of which makes controlled and realistic the purposeful increase of the content of secondary metabolites in plant raw material [11].

For the first time the moringa was studied in outdoor hydroponic conditions at the Institute of Hydroponic Problems (IHP) of NAS RA, which is located in the Ararat Valley. According to our data, there is a leak of scientific papers about moringa's cultivation in outdoor hydroponics in other countries [12]. In addition, moringa is considered a new and non-traditional culture for Armenia.

The aim of the study is the evaluation of the cultivation possibilities of the new, non-traditional, valuable plant *Moringa oleifera* Lam., and comparative study of the quantitative and qualitative efficiency of plant raw material in conditions of outdoor hydroponics and soil culture of Ararat Valley.

2 Material and methods

The scientific studies were done in 2019-2021 in the vegetation experimental field, in self-nourishing hydroponic equipment (with the density of 6 plants/m2), using EBB & Flow hydroponic system. Seeds were sown during March-April in pots in greenhouse, where temperature was 23-28 °C. The seedlings were transferred into outdoor self-nourishing hydroponic equipment and soil on the end of April and the start of May. Hydroponic plants were nourished 1-2 times a day with the nutrition solution offered by Davtyan [11]. pH of the Davtyan's solution is 5.5-6.7. At the start of the growing season, 400-500 ppm solution was used, and later nourishment was continued with the 1200-1500 ppm nutrition solution. Optimal pH of the environment for the cultivation of moringa is in a range of 5.0-9.0 [1]. The 1:1 ratio mixture of volcanic slag and gravel particles in 3-15 mm diameter was used as a hydroponic substrate [13]. General soil culture served as a control, where accepted agrotechnical rules were saved [14]. Field (hydroponic and soil) experiments were replicated 4 times. The received results were analyzed using the statistical program GraphPad Prism 5.

5 harvestings of moringa's leaves were done in hydroponics and 4 harvesings in soil. Plants were estimated qualitatively through the biometric and morphological observations (growth rate, development stages and leaves productivity, wet and dry masses of overground organs) in whole vegetation period. As moringa has compound leaves that consist of stems and small leaves, then the biopharmacochemical analyses of leaves (the content of extractive substances according to the State Pharmacopoeia [15], flavonoids according to Grenkevich [16] in the leaves, nutritional value of leaves of hydroponic and soil moringa according to Ofner [17], proteins according to Kjeldahl [18], Ca and Mg in the ash [19], the content of vitamin C according to Yermacov [20] and β-carotene according to Sapozhnikov [21]) were done in the useful biomass (UBM) of the leaves during whole study in different conditions of cultivation. UBM is the mass of little leaves. All biopharmacochemical analyses were replicated 3 times.

3 Results and discussion

It was found that hydroponic moringa plants exceeded soil ones in the growth intensity and height by 1.3-2.5 times in the middle (July-August) of the vegetation period and 1.3 times at the end (September-October). In August, hydroponic plants exceeded soil ones by 2.1

times in a cingulum thickness, and at the end of vegetation period there were not observed essential differences between hydroponic and soil plants (Fig. 1).

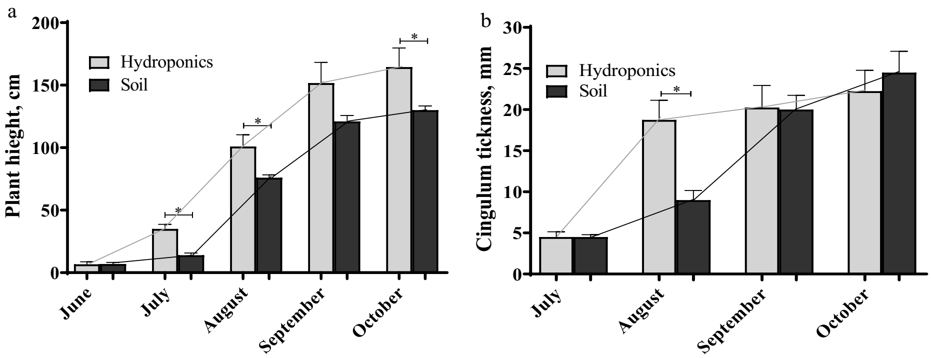

Fig. 1. Growth dynamics of moringa plants height (a) and cingulum thickness (b) during vegetation period depending from the growing conditions (* p<0.05).

At the end of vegetation period the accumulation of moringa's overground organs was studied (Table 1), from which it becomes obvious that hydroponic plants exceeded soil ones with overground dry mass by 1.3 times and with leaves dry mass by 1.6 times.

Table 1. The efficiency of overground organes of moringa in different growing conditions.

Growing media	Stem weight, g/plant		Leaves weight, g/plant		Overground mass, g/plant	
	fresh	dry	fresh	dry	fresh	dry
Hydroponics	240	33[a]	383.0	89.2[b]	623.0	122.2[b]
Soil (control)	212	35[a]	233.2	55.2[a]	445.2	90.2[a]

[ab] t-test (P<0.05)

As the leaves of moringa are compound, then the study of the content of UBM of the leaves of moringa is important. There were not essential differences in a waste content between soil and hydroponic cultures (Fig. 2).

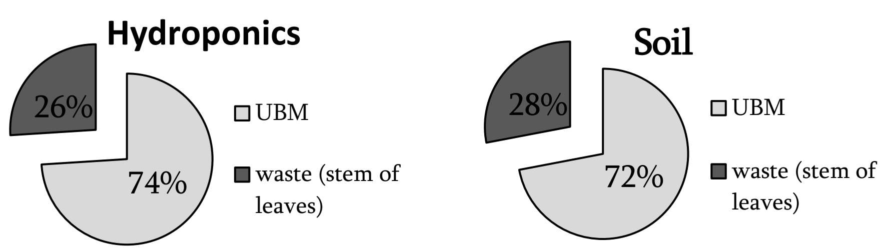

Fig. 2. The content of UBM in leaves of moringa according to the growing media.

In hydroponics, the first harvest of moringa leaves was done in June and in soil in July. During the vegetation period, the relatively large accumulation of leaves of moringa (dry weight) was observed in September-October (Fig. 3). The harvest of these two months has provided more than 60 % of yield in hydroponics and more than 70 % of yield in soil.

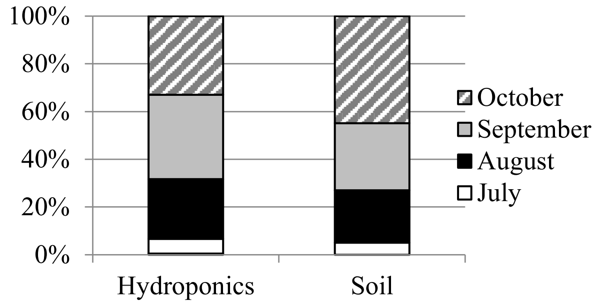

Fig. 3. Accumulation dynamics of moringa leaves yield during vegetation period.

In moringa's growing media optimization experiments it was revealed (Table 2) that hydroponic plants exceeded soil ones respectively 72 % and 65 % in a UBM mass of fresh and dry leaves per plant. The results of the leaves biochemical analyses revealed, that soil plants excelled with the content of extractive substances (1.1 times) and tannins (1.4 times), while about 1.2 times higher content of phenolic acids was observed in plants grown in hydroponic conditions. By the content of flavonoids there were not observed essential differences between hydroponic and soil plants.

Table 2. The productivity (g/plant) and the content of the biopharmacochemical indices of moringa under different growth conditions (%).

Growing media	UBM		Extractive substances	Flavonoids	Phenolic acids	Tannins
	Fresh	dry				
Hydroponics	251.9	65.8[b]	32.7± 0.33	1.08 ± 0.09	0.38± 0.023	2.63 ± 0.06
Soil (control)	146.6	39.8[a]	36.9 ± 1.77	1.29 ± 0.12	0.32± 0.020	3.70 ± 0.17

[ab] t-test ($P<0.05$)

From the analyses of the compounds characterizing nutritional value of the moringa leaves, it was revealed (Table 3) that relatively high contents of calcium (1.4 times) and carbohydrates (1.3 times) were observed in the leaves of moringa grown in soil. However, hydroponic plants were distinguished by a high content of magnesium (1.8 times). There were not recorded significant differences in the content of proteins.

Table 3. Indices of the nutrition value of moringa in different growth conditions (%).

Growing media	Ca	Mg	Proteins	Carbohydrates
Hydroponics	15.9±0.95	6.2±0.18	24.6 ± 2.00	9.2 ± 0.86
Soil (control)	22.9±1.29	3.5±0.5	28.0 ± 2.22	12.1 ± 1.01

It was revealed that though hydroponic plants were inferior to soil plants in some biochemical indices, they exceeded soil plants with output of extractive substances (1.5 times), flavonoids (1.4 times), phenolic acids (1.9 times) and tannins (1.2 times) due to high yield. In UBM of moringa high output of calcium (1.2 times) and magnesium (2.9 times), as well as proteins (1.5 times) and carbohydrates (1.3 times) were observed in plants grown in hydroponic conditions (Fig. 4).

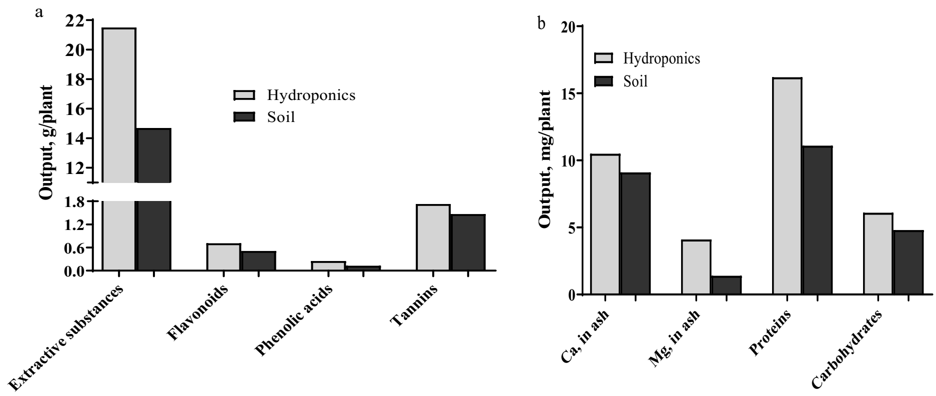

Fig. 4. Output of extractive substances, flavonoids, phenolic acids, tannins (a) and calcium, magnesium, proteins and carbohydrates (b) of hydroponic and soil moringa.

In August, fresh leaves of hydroponic moringa had a 1.5 higher content of C vitamin compared with soil ones, but in the content of β-carotene there was not recorded essential difference (Table 4).

Table 4. The content of biochemical indices in fresh leaves of Moringa under different growing conditions (mg%).

Growing media	Vitamin C	β-carotene
Hydroponics	172.0±2.38	24.0±0.94
Soil (control)	119.0±4.02	22.4±0.75

4 Conclusions

The possibility of cultivation of Moringa in different growing media (hydroponic and soil) in the conditions of the Ararat Valley of Armenia has been confirmed. Moringa in hydroponic conditions exceeded soil plants with the growth intensity, height, and cingulum thickness. Hydroponic culture has provided high yield of moringa leaves, which is an important index for the plant considering as a superfood.

Although soil plants excelled with the high content of extractive substances (1.1 times), tannins (1.4 times), calcium (1.4 times) and carbohydrates (1.3 times), plants grown in hydroponic conditions exceeded them with content of phenolic acids (1.2 times), magnesium (1.8 times) and vitamin C (1.4 times). At the same time, hydroponic moringa has exceeded soil plants in the output of some bio-pharmacochemical indices: the extractive substances - 1.5 times, flavonoids - 1.4 times, phenolic acids - 1.9 times, tannins - 1.2 times, calcium - 1.2 times, magnesium - 2.9 times, proteins - 1.5 times) and carbohydrates - 1.3 times.

Through the improvement of the hydroponic growing technology (the best hydroponic substrate, optimizing of mineral nutrition, etc.) it is possible to stimulate the synthesis of bioactive compounds in moringa leaves.

Acknowledgements

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