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Nutritional Value of Soybean under Outdoor Hydroponics and Soil Conditions of the Ararat Valley

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ABSTRACT

Background: Population growth increases the demand for food all over the world. According to the Food and Agriculture Organization of the United Nations, by 2050 the world population will reach 9.1 billion people, for whom food production is expected to increase by 25-70 %. That will lead to an increase in the demand for alternative farming technologies allowing us to ensure higher yields in less time. One such alternative and highly profitable plant growing technology is soilless culture or hydroponics. Climate change, improved technological capabilities, and need to increase self-sufficiency are good reasons for the introduction of soybean in Armenia.

Soy, as one of the richest and cheapest sources of protein, plays an important role in the diet of people in many countries. The seed of soybeans contains 17 % oil and about 50 % protein. Because soybeans contain no starch, they are a good source of protein for diabetics.

Objective: To establish the possibility and efficiency of soybean cultivation in Ararat Valley by traditional agricultural method and by the regulated hydroponic system and to investigate the nutritional value of soybean seeds.

Results: The cultivation method had some influence on soybean yield and on the biosynthesis of several nutritional components. Thus, soilless culture conditions contributed to the increase in soybean yield: the weight of seeds obtained from one plant was 38.7 g while in the soil it was only 19.9 g. Soil plants were distinguished by the maximum accumulation of fat (28.9 %), while hydroponic ones by the maximum content of protein (31.5 %) and sugar (6.3 %).

Conclusion: The obtained results established the effectiveness of soybean cultivation in Armenia. The regulated hydroponic method ensures obtaining about 11.6 tons ha^{-1} of soybean seeds, 3.7 tons ha^{-1} of protein and 2.6 tons ha^{-1} of fat.
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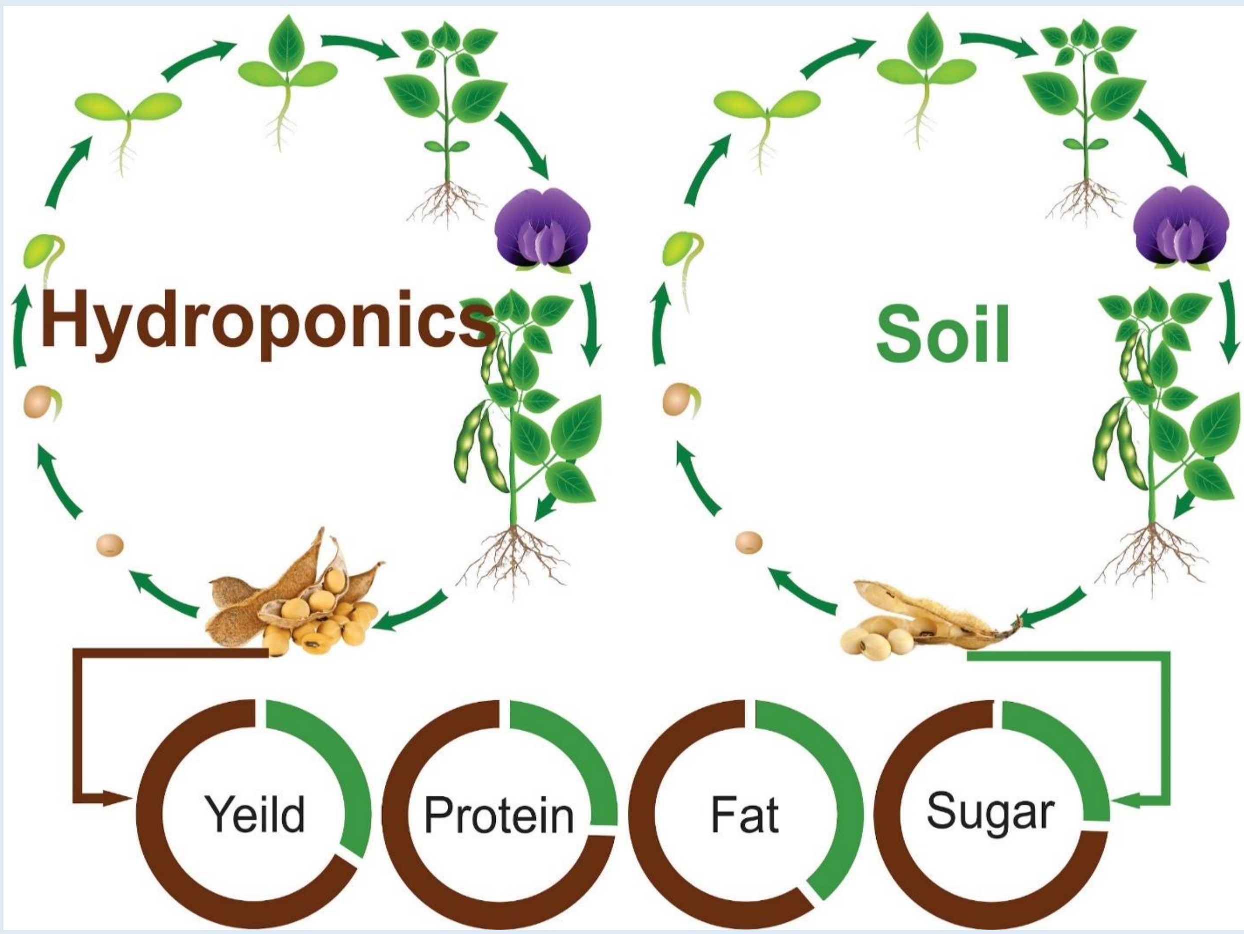
Keywords: *Glycine max* (L.) Merr., soilless culture, proteins, fats, sugars



INTRODUCTION

The Second Green Revolution aims to strengthen food security against new global challenges. Pulses have the great potential to address this problem due to their ability to symbiotically fix atmospheric nitrogen and thus provide economically sustainable benefits to agriculture. Additionally, human health benefits are directly connected with a legume-rich diet. However, pulses constitute only a small part of the modern human diet, and legumes are underutilized [1]. Grain legumes including soybeans, occupy about 14 % of the world's arable area. They are extremely important as a source of sustainable quality plant protein and many plant-based foods [2]. Protein deficiency is a major issue to the sustainability of agriculture and the food industry. The ongoing absence of coordinated attention to pulses has threatened human health, food security and sustainable food production.

As stated by the US National Library of Medicine, nearly 65 % of the ability to digest lactose is lost in almost all people after infancy. Because of this, people lose the ability to digest dairy and dairy-based products, which leads to protein deficiency in their body. Every year there are nearly 10 million more cases of lactose intolerance, which causes nausea every time people consume any lactose-containing product [3]. Soy products contain the same nutrients as dairy products while being more environmentally friendly.

According to the analysts at IndustryARC, the soybean market size is estimated to reach $259 billion by 2030 growing at CAGR of 4.4 % during 2023-2030. In 2022, Trading Economics stated that the US, Brazil, Argentina, and Paraguay are the world's largest producers (80 %) and exporters (90 %) of soybeans. China is the largest importer of soybeans (60 % of total imports), followed by the European Union, Japan, Mexico, and Taiwan. This represents the outlook for the soybean industry [4]. The global soybean crop area was 122 million hectares, of which 34 million hectares in Brazil, 32 million hectares in the United States, 18 million hectares in Argentina, 11 million hectares in India and 9 million hectares in China. The largest importer of soybeans was China (92 million tons), and the exporter - Brazil (84 million tons) [5].

The USDA's Foreign Agricultural Service (FAS) projects that Brazilian farmers will plant 2.4 hectares more soybeans in 2022-2023 compared to 2021-2022. It is expected that the soybean harvest will be 153 million tons in 2022-2023 [6]. Soybeans are rich in protein and various valuable nutrients. It is estimated that up to 50 % of a single soybean meal contains enough protein to build muscle in vegetarian athletes who need amino acids.

60 % of the world's vegetable oil and protein consumption is covered by soybeans, which are the fourth largest field crop by volume. Per capita soybean consumption is projected to increase by about 17 % by 2029 [7]. Soybeans rank first among other legumes in protein content, and the quality of soy protein is close to the quality of animal protein. Soybeans are an important source of healthy fats, such as omega 3 and 6 fatty acids. [8].

Still, in 2014, Professor A. Ustyuzhanin, the president of the Russian Soy Union of that time, wrote that a few years ago the international company "Prograin" conducted experiments on growing soybeans in Armenia and concluded that the resources allowed to get a high soybean crop [9]. At the beginning of 2019, "Agricultural Technology" LLC planned to make an initial investment of 300,000 US $ in the Ararat region of Armenia, to cultivate soybeans on about 50 hectares of uncultivated or pasture lands, but the project has not been implemented yet [10]. In 2020 soybeans were sown on 2 hectares in Shirak region, but, unfortunately, due to the damage caused by the hail, no harvest was carried out. It should be noted that in 2021 about 250 tons of soybeans were imported to Armenia [11].

In the case of Armenia, the problem of food security and self-sufficiency is exacerbated due to the tragic war, and the loss of 460,000 hectares of arable land in Artsakh. In the long term, increasing the self-sufficiency rate is a fundamental solution to solving cereal and legume import dependency. Improving the profitability of soybean farming is the key to increasing soybean production. It is for this purpose that this research program is launched.

Soybean production is not a problem given the availability of land resources, but hydroponically growing soybeans can be a sustainable source of grain, protein, and fat in hostile environmental conditions such as tens of thousands of saline soils in the Ararat Valley.

Hydroponic technology allows growing plants on land unsuitable for conventional agriculture while minimizing the use of water, mineral salts, and human resources. It is a more manageable system by which the targeted increase of primary and secondary metabolite content in plant material is manageable and realistic.

The aim of the study was to investigate the peculiarities of the valuable crop soybean *Glycine max* Merr. in outdoor hydroponics and soil culture of the Ararat Valley. The obtained results in the future will become a basis for large-scale production of soybean in the outdoor hydroponic and/or soil as one link in the chain of food security and self-sufficiency. Local soybean production will also boost the domestic food and light industry.

Soybean is an annual, valuable food, fodder and technical crop belonging to the *Fabaceae* family. It is an ancient culture. The homeland of the cultivated soybean is China, where it was cultivated in 5-6 thousand years ago BC. Generally, its grains contain 35-52 % protein, 17-25 % fat and 25-30 % carbohydrates [12-15] (Table 1).

Table 1. Nutritional value of soybean mature seeds

Soybean, mature seeds, raw Nutritional value per 100 g			
Energy	446 kcal (1866kJ)	Dietary fiber	9.3 g
Carbohydrates	30 g	Fat	20 g
Sugar	7.3 g	Protein	36 g
Minerals	**Quantity**	**Other constituents**	**Quantity**
Calcium	277 mg	**Water**	**8.54 g**
Magnesium	280 mg		
Source: [16]			

Soy protein is similar in amino acid composition to animal protein. Grain (seeds), butter, as well as soybean flour, milk, margarine, and cheese are used for food. Glue, varnish, wool, soap, and polyethylene are obtained from the grains. Soy products are used in a wide variety of processed foods. Soybeans can be processed to look and resemble many other foods (meat, cheese, dairy) [17-18]. It has been shown that the chemical and physical properties of beef and lamb are improved if the burger fillers consist of 10 % oats and 10 % soy [19].

Soybean has broad therapeutic value, especially in the fight against various types of cancer [20-21], cardiovascular diseases [22].

There are few research groups that have studied soybean hydroponic culture, but at the same time, all of them have proven that hydroponics is an effective, regulated way of growing soybeans [23-24]. It was found that the use of hydroponic technology improves the nutritional value of soy products [25]. Another group demonstrated the effectiveness of hydroponically growing soybeans in the life support bioregenerative system of space [26-28]. Mackowiak and others have noted the possibility of co-growing soybeans and tomatoes hydroponically [29].

This research is being conducted for the first time in Armenia. The obtained results will be the basis for establishing industrial soybean fields in the future.

MATERIALS AND METHODS

Plant material and composition: For the first time, the possibility and efficiency of growing the soybean "Menua" cultivar were studied under the conditions of outdoor hydroponics and soil culture of the Ararat Valley (Fig. 1).

The average temperature in Ararat Valley is from -26.1 to -32.6 ºC in winter and from 37.5 to 42.6 ºC in summer, and annual rainfall is 200–450 mm. The height of the Ararat Valley is 800-1000 m above sea level [30]. The "Menua" cultivar is intended for cultivation in almost all agricultural zones of the Republic of Armenia. This variety is not a genetically modified organism (GMO). 1000 grains weigh about 180g. Crude protein content is approximately 32 %. Plants were grown hydroponically from seeds on a 1:1 mixture of volcanic slag and gravel. The seeds were sown in the second decade of April. The experiments were carried out in hydroponic equipment with a 2 m^2 feeding surface using the EBB & Flow hydroponic system [31]. The planting density was 30 plants/ m^2. The plants were nourished twice a day with a concentration of 900-1000 mg kg^{-1} of Davtyan's nutrient solution, which has been successfully used for growing various crops in soilless culture for many years [32].

Soil culture served as a control variant (4 x 0.5m^2), for which all accepted agrotechnical rules were observed (soil loosening, weeding, regular watering, fertilization, etc.).

Harvesting was done at the end of August, at the stage of technical maturity of the plants. The cultivation was extended about 120 days. The seeds were dried under room conditions. An average sample was selected for biochemical analysis.

a b

Figure 1. Hydroponic (a) and soil (b) plants of soybean "Menua" cultivar

Chemical analysis: During the research, biometric and morphological observations and biochemical analyses were carried out to qualitatively assess the yield obtained. The content of proteins was determined according to Kjeldahl, crude fibers by Official Methods of Analysis of AOAC International [33], fats according to the Soxhlet [34], sugars according to Bertrand, Ca and Mg by Gasparyan [35].

Determination of proteins: Protein estimation was based on estimating the nitrogen content of the soybean seeds and then multiplying the nitrogen value by nitrogen conversion factor (6.25). The estimation of nitrogen was made by the modified micro-Kjeldahl method.

Soybean seeds were crushed, and 0.5 g of ground sample was accurately measured and poured into a 75-ml Kjeldahl flask, then 5 ml of concentrated H_2SO_4 and 4 g of catalyst mixture (Copper sulfate: Potassium sulfate = 1:7) were added. After that, the mixture was heated at 370 °C for till the sample became colorless (white), which means that the digestion was completed, then the digested sample was cooled and diluted to 60 ml, then a 10 mL sample solution was placed in a distillation apparatus and 25 ml of 40 % NaOH was added to neutralize the pH. The distillate was collected in a conical flask containing 0.25 ml of 2 % boric acid solution and 2 drops of mixed indicator (methyl red and methylene blue) and the total distillate was collected and titrated with standardized HCL solution (0.1 N HCL).

The amount of nitrogen was calculated according to the following formula:

$$\%\,Nitrogen = \frac{(TVS - TVB) \times N\,of\,HCL \times 0.014}{Weight\ of\ the\ sample(g)} \times 100$$

where TVS is the titer value of the sample (mL), TVB is the titer value of the blank (mL), and 0.014 is the conversion factor for the mg-eq. of nitrogen.

The percentage of the nitrogen of the sample was multiplied by 6.25 to obtain the total crude protein (%).

Determination of crude fibers: 1 g of the oven-dried ground sample was collected in a 1-liter beaker, then the beaker was covered with a round bottom flask with cold water to keep the constant volume during boiling. The contents of the beaker were refluxed with 250 mL of 1.25 % sulfuric acid. Then the beaker was covered with cotton and the mixture was boiled on a heater for 30 min. The contents were quickly filtered on a Buchner funnel through a Whatman No. 42 ashless paper filter and washed to remove acid, and then the acid-free residue was refluxed with 200 mL of 1.25 % sodium hydroxide solution for exactly half an hour while maintaining a constant volume. The mixture was then filtered and washed to make the residue alkali-free. The residue was transferred into a crucible and dried in an oven at 100 ± 5 °C until constant weight was reached. The sample was cooled in a desiccator and weighed. After that. The sample was ignited in a muffle furnace at 600 °C for 4 h, cooled again and weighted. The weight loss of the samples indicated the amount of crude fiber.

Determination of fats*:* 30 g sample was lightly grinded with mortar and pestle. 2–3 g of sample was placed in the thimble and then reweighed. After that a small plug of dried glass wool was placed in each thimble and reweighed again. The three samples were placed in a Soxhlet extractor, then 350 mL petroleum ether was put in the flask with several glass boiling beads, and then extracted for 6 h or longer. After that the thimbles were removed from the Soxhlet extractor, air dried overnight in a hood and dried in a vacuum oven at 70 ºC, then samples were dried in desiccator and reweighed. Fat content was measured by weight loss of the sample or weight of fat removed.

Determination of sugars: Bertrand's method is based on the ability of sugar carbonyl groups to oxidize in Fehling's solution and reduce Copper (II) oxide to Copper(I) oxide. By the amount of copper oxide formed, the content of sugars is determined using special tables [35]. 5 g of well-ground plant material was transferred in a volumetric flask with a capacity of 100 mL, 70-200 mL of hot water was poured, and the flask was kept for 1 hour in a water bath at a temperature of 80-90 °C and shaken periodically. Thereafter, the filtrate was cooled. Then 50 mL of cooled filtrate was taken and transferred to a 100 mL volumetric flask, after that 5 mL of hydrochloric acid (reagent grade, relative density 1.19) was added. The flask was immersed in a water bath heated to 80°C. The contents of the flask were heated to 68-70 °C and kept for 8 minutes. After that, the solution in the flask was quickly cooled to room temperature then the content of the flask was neutralized with 20 % sodium hydroxide solution then brought to the mark with distilled water and mixed. 10 mL of the solution was transferred to a 100 mL conical flask, and 10 mL of Fehling's solutions I (4 % solution) and II (an alkaline solution of Rochelle's salt) were added and mixed. The contents of the flask were boiled for 3 minutes. After that, the flask was removed from the heat and the solution was filtered into a Bunsen flask through a quartz filter. After pouring all the liquid onto the filter, the flask and filter were washed several times with hot distilled water until the alkaline reaction of the washing disappeared. After washing the precipitate with water, the filtrate from the Bunsen flask was poured out, and the flask was thoroughly washed first with tap water, and then rinsed with distilled water. In a conical flask, small portions of 20-30 mL of a solution of iron alum or iron sulfate were poured into the sediment of cuprous oxide, each time pouring the solution onto the filter. In the presence of iron sulfate or iron alum, the Copper(I) oxide precipitate reduces an equivalent amount of Iron (II) sulfate to Iron (III) sulfate, the amount of which was determined by titration with a solution of potassium permanganate. According to the amount of permanganate used for titration, the amount of Copper(I) oxide and then the content of sugars in the solution were calculated.

Determination of Ca and Mg*:* The content of calcium and magnesium was calculated in the ash of plant seeds. 0.1-0.2 g of ash was transferred to a porcelain mortar, then 1 mL of distilled water and 2 mL of diluted hydrogen chloride (1:1 ratio with distilled water) was added. The resulting mixture was evaporated in a water bath until a greenish-yellow precipitate was obtained. Then the precipitate was dissolved in 2 mL of HCl (1:1) and 3 mL of hot distilled water. The obtained solution was filtered, then the filter was washed with hot water to a volume of 100 mL.

To analyze the calcium content, 20 mL of the solution was diluted with 30 mL of water, then 1-2 drops of 0.2 % malachite green were added. The resulting turquoise color was decolorized with 5 mL KOH. Then, 2 mL KOH and murexide powder were added to the solution coloring it in a pink color. The titration was carried out with 0.01N of EDTA until a light violet color appeared.

The calcium content was calculated by the following formula:

$$\% \, Ca = \frac{V \times N \times 100 \times 0.02}{n}$$

Where V is the amount of the EDTA solution used for titration (mL), N is the normality of the EDTA solution, and 0.02 is the conversion factor for the mg-eq. of calcium (g) and n is the weight of the ash in the determined volume (g).

To analyze the content of magnesium 20 mL of the solution was diluted with 30 mL water, and then 1 - 2 drop of 0.1 % methyl red was added. The obtained pink color obtained was changed to yellow with the 5 mL KOH. Then 2 mL of ammonium chloride buffer and ET-00 powder were added to the solution, coloring it in a wine-red color. Titration was done with 0.01 N EDTA until a light blue color appeared.

The magnesium content was calculated by the following formula:

$$\% \, Mg = \frac{(V - v) \times N \times 100 \times 0.012}{n}$$

Where V is the amount of the EDTA solution used for titration of the sum of the (Ca + Mg) (mL), v is the amount of the EDTA used for titration of Ca (mL), N is the normality of the EDTA solution, 0.012 is the gram value for the mg-eq. of magnesium (g) and n is the weight of the ash in the determined volume (g).

Statistical analysis: Field experiments were replicated 6 times. All analyses were carried out in triplicates and the data were expressed as means ± standard deviation. The obtained data was processed with GraphPad Prism 6 (t-test) and Excel statistical software.

RESULTS AND DISCUSSION

It has been found that the cultivation method (hydroponics and soil) significantly affects some biometric parameters of soybean plants (Table 2). The average height of plants in soilless conditions was 122 cm, while soil plants were 1.3 times shorter.

In hydroponics, the thickness of the plant stem was 10.4 mm and in soil - 10.5 mm. This means that the cultivation method did not significantly affect the stem thickness of soybean plants. The average number of branches was 2.4 for hydroponic plants and 5.2 for soil plants, indicating that soil plants were 2.2 times more branched than hydroponic ones. The height of the first formed pod in hydroponics plants was 1.9 times higher than in soil ones. The soilless method of growing plants has created the most favorable conditions in terms of pod formation per plant: the average number of pods for the hydroponic plants was 80, while that of the soil ones was 51, which shows that hydroponic soybean plants exceeded soil plants by 1.6 times in this indicator.

The yield and content of the main valuable substances of soybean seeds can be influenced by the variety, growing method and environment, planting density, fertilization, location, climatic conditions, etc. The optimal density of soybeans is in the range of 7-100 plants/m^2 depending on variety, season and associated agronomic management options [36-37].

Considering the yield and chemical composition of soybean seeds, Glowaska et al. [38] recommended applying fertilizer at the rate of 60 kg N/ha in two portions - ½ or ¾ before sowing, and the rest during the development of beans and seeds - in combination with the application of sulfur.

Scientists reported that the maximum yield of the plant and the maximum protein content in seeds was observed at 65 % of the irrigation rate [39].

Researchers have found that in hydroponics, inoculating soybean seeds with nodule bacteria was more effective at reducing the nitrogen content of the nutrient solution by 75 % while eliminating nitrogen resulted in a minimal positive effect [23]. At the same time, a review article stated the increasing of the nodules number and dry weight, as well as the oil content in the grains in the case of 60 % less nitrogen fertilization [40].

Table 2. Some biometric parameters of soybean in hydroponics and soil

Cultivation methods	Height, cm	Stem thickness, mm	Number of branches,	First pod height, cm	Number of pods per plant
Hydroponics	122^{b*}	10.4^{a}	2.4^{b**}	8.7^{b***}	80^{a*}
Soil	94^{a}	10.5^{a}	5.2^{a}	16.6^{a}	51^{b}

^{ab} t-test, *P=0.0202, **P=0.0025, ***P=0.0003

One of the main indicators of soybean yield is the weight of 1000 seeds. Under hydroponic conditions, the weight of 1000 seeds were 188 g, and under soil conditions it was 148 g. From the obtained data it can be seen that cultivation method significantly impacted on 1000 seeds weight of soybean plants: with a weight of 1000 seeds hydroponic plants were 1.4 times superior to soil ones, from which it can be assumed that the optimal conditions in hydroponics contributed to the formation of large and full inside seeds (Fig. 2).

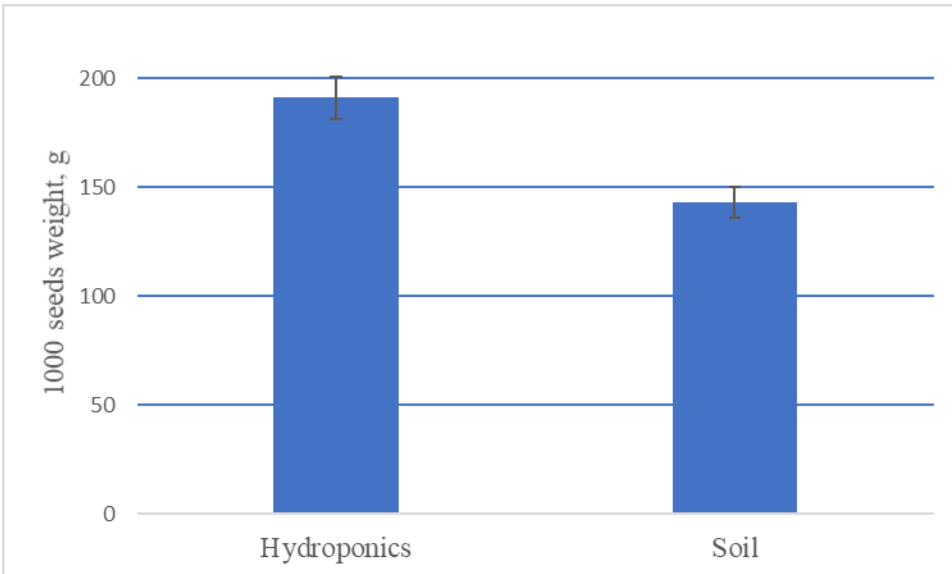


Figure 2. 1000 seeds weight of soybean cultivar “Menua” cultivated in hydroponics and soil (t-test, P<0.001)

The growing conditions significantly affected the yield of soybean. Due to the most efficient air-water-nutrient conditions in hydroponics, the soybean yield from per plant was 38.7 g, while in soil it was10.5 g. So the yield of hydroponic soybean was 3.7 times higher than that of soil plants (Fig. 3).

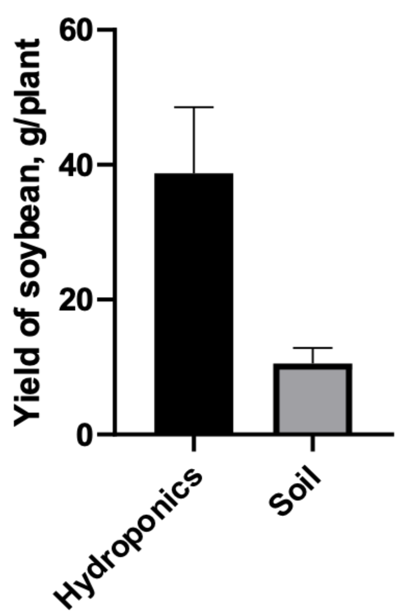


Figure 3. Soybean seeds yield in different growing media (t test, P<0.001)

The hydroponic growing method had a significant positive impact on protein and soluble sugar content in soybean seeds. In our tested soybean cultivar "Menua" protein and sugar accumulation fluctuated in the range of 236-315 and 51-63 mg/g, respectively. The maximum content of protein (31.5 %) and soluble sugar (6.3 %) was observed in hydroponics conditions, while the soil plants distinguished with the minimum content (23.6 and 5.1 %, respectively). Thus, we can state that hydroponic plants exceeded soil plants by 1.3 and 1.2 times in terms of protein and sugar accumulation, accordingly (Table 3). Cultivation methods also had some effect on several important soybean biochemical indicators. As described by Qin et al. [41] its protein has a high-quality protein digestibility adjusted amino acid score (PDCAAS) of 1.00, which is approximately the same as meat and dairy products. Due to its high protein content, soybean is a major source of plant proteins and is widely consumed all around the world. For all soy products (tofu, soybean protein, flakes, flour, hulls, and soybean meal, soybean milk), the averaged PDCAAS was 85.6 ± 18.2 [42].

Soluble sugar is an important quality trait in soybean-based food. The content of soluble sugar in 35 soybean germplasms collected in China's Zhejiang province fluctuated 84.70 - 140.91 mg/g [43]. Hou et al. [44] noted that the content of total sugar of twenty soy genotypes went from 37.21 to 148.76 mg/g.

In our research fats and fiber accumulation in "Menua" cultivar seeds fluctuated in the range of 220-289 and 47-77 mg/g, respectively. The maximum content of fat (28.9 %) and fiber (7.7 %) discovered in soil soybean seeds. Obtained data showed that soil conditions stimulated the biosynthesis of fats and fibers 1.3 and 1.6 times accordingly (Table 3).

It has been shown that soy fiber provided the principal health benefits generally associated with dietary fiber, including improved relaxation and ability to lower cholesterol [45]. Soybean insoluble dietary fiber remarkably reduced the body weight of mice, total cholesterol, fat index, and LDLC while increasing the content of HDLC in high-fat diet mice [46].

Table 3. Several quality indicators of soybeans depend on the growing method, %

Cultivation methods	Fats	Protein	Sugar	Fiber
Hydroponics	22.0±1.4	31.5±2.7	6.3±0.57	4.7±0.39
Soil	28.9±2.1	23.6±2.0	5.1±0.38	7.7±0.72

It was found that growing conditions significantly affected the accumulation of calcium and magnesium in "Menua" soybean seeds. Ca content was increased by 16 % in soilless conditions, and magnesium content by 22 % in soil (Table 4). So, daily consumption of 1 cup (186 g) of soybean row seeds will cover 20 % of the Recommended Dietary Allowance of Calcium (1000 mg) for people 19-50 aged [47].

The Ca accumulation in soybean seeds can be influenced by the cultivars, growing method and media, fertilization, site, climatic conditions, etc. The content of calcium was found to be significantly higher in conventional system grown soybean seeds in opposite to organic ones. However different row spacing didn't affect Ca content in seeds [48]. Moraghan et al. reported that the content of calcium in legumes is low [49]. According to Rymusa et al. [50] and Szostak et al. [51] the average calcium content in "Merlin" soybean was 1.95 g kg^{-1} dw, but Biel et al. [48] reported only 0.83 g kg^{-1} dw.

Moraghan et al. [49] determined that the content of magnesium in the seeds of 12 soybean varieties fluctuated 1.67 - 2.23 g kg^{-1}. Percent of Mg in the same cultivars can differ by year even up to 1.7-1.8 times (2.39-4.12 g kg^{-1}).

Table 4. The content of Ca and Mg in soybean seeds depending on the cultivation method, mg $100g^{-1}$ dw

Cultivation methods	Ca	Mg
Hydroponics	111.6±8.6	267.9±22.9
Soil	96.6±6.2	328.4±28.4

The output of yield and some valuable substances per square meter is demonstrated in Figure 4. A comparative analysis of the yield and biochemical parameters of hydroponic and soil soybeans obtained from per square meter showed that under hydroponic conditions it is possible to get 564 g more seeds yield, 225 g more protein and 82 g more fat.

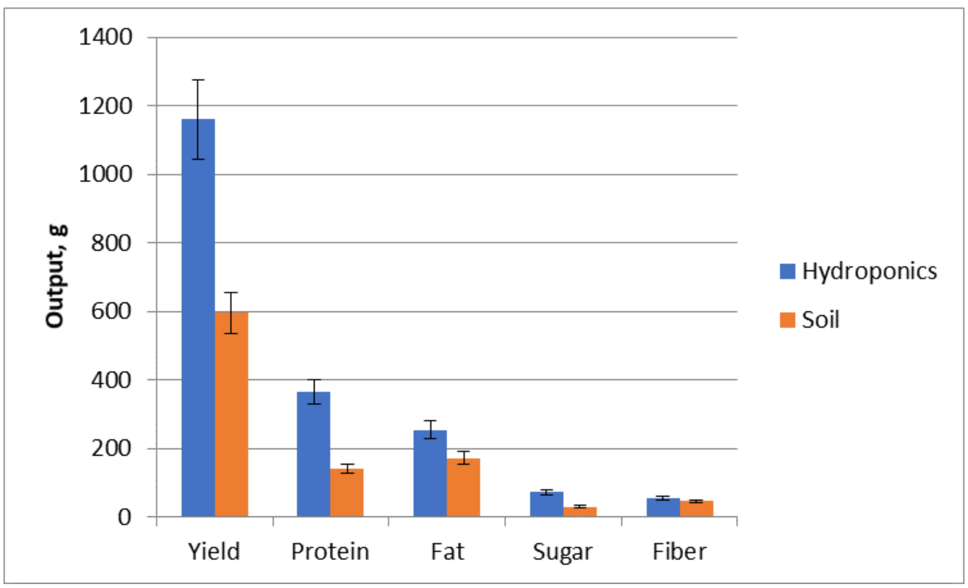


Figure 4. Output of yield and some valuable substances of soybean in different growing media (t-test, P<0.5)

CONCLUSION

Thus, the results of our research have shown that soybean cultivation in the Ararat Valley is possible both by hydroponic and traditional agrotechnical methods, but soilless culture is preferable and more efficient. At the same time, compared with a soil culture, in hydroponics 1.9, 2.6, 1.5, 2.4 and 1.2 times more yield of soybean seeds, output of protein, fat, sugar and fiber can be obtained per square meter.

In the future, using the technology of hydroponic soybean cultivation, it is possible to include tens of thousands of hectares of saline-alkaline, rocky and sandy lands, open pits, unsuitable for traditional farming, in the area of soilless production of this promising plant.

There are almost no domestically produced soy products in Armenia; they are mainly imported from abroad. Thus, local soybean production in Armenia will contribute to the production of various soy-based products (tofu, soymilk, soy meat, etc.), which will meet the needs of certain segments of the population and the food industry.

Based on our research results, we can conclude that hydroponic soybean has the potential for health benefits. Meanwhile according to the definition of functional foods by Functional Food Center (FFC) [52] hydroponic soybean can be adopted as a functional food after clinical and epidemiological studies.

Authors' Contribution: All authors contributed to this research and wrote this paper.

Abbreviations: GMO: genetically modified organism, CAGR: compound annual growth rate, FAS: Foreign Agricultural Service, AOAC: Association of Official Agricultural Chemists, TVS: titer value of the sample, TVB: titer value of the blank, EDTA: ethylenediaminetetraacetic acid, ET-00: eriochrome black t, PDCAAS: protein digestibility-corrected amino acid score, LDLC: low-density lipoprotein cholesterol, HDLC: high-density lipoprotein cholesterol, FFC: Functional Food Center.

Competing Interest: None

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