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# Growing Arum korolkowii Regel in laboratory conditions

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## ABSTRACT
*Arum korolkowii* Regel is a red book plant growing on the territory of the South Kazakhstan region. It is a medicinal plant. The article describes the methods of growing *A. korolkowii* both by the traditional and modern methods such as hydroponics. Vegetative stages of *A. korolkowii*, the first leaves appear 15-20 cm long in early April. After the inflorescence of the cob appears, light yellow in colour, with a leaf covering at this stage, already large leaves wither. Afterward, only the cob remains on which green berries appear, and in mid-June these berries acquire a bright red hue. Hydroponics is a hydroponic culture of different types of herbs using a certain multicomponent substrate. Hydroponic cultivation can be performed by various techniques, such as deep-sea culture, passive (wick) system, hydrogorshock (periodic flooding system) and aeroponic. In our work, we used a system of deep-sea cultures. In parallel, experiments were conducted on the traditional method of growing plants, and a comparative analysis of all indicators was conducted. The difference between the hydroponic method of cultivation and the traditional one is that the plant needs trace elements, the harvest is high-quality and abundant, and also eliminates the appearance of diseases and pests, thereby excluding the use of pesticides. The product turns out to be environmentally friendly, nutritious and affordable at any time of the year.

**Key words:** Korolkov's Aronnik, hydroponics, Red Book of Kazakhstan, Vermiculite, Plant cultivation, Nutrient fertilizers.
**Article type:** Research Article.

## INTRODUCTION
**Relevance of the research topic.** Perennial plants of *Arum korolkowii* are one of the main types of herbaceous plants of the Aroid families of the genus Aronnik. They grow and bloom in spring and summer, die off every autumn and winter, and return in spring from their rootstock or other wintering structure. They have a flattened spherical tuber. The petiole is a modified flattened-spherical shortened shoot of the plant (Korzhenevskij 2016b). The leaves of this plant are numerous, vaginal, expanded from the base to one-third and twice as long as the lamina, spirally arranged. Vaginas are from long to short. The flowering stem has a height of 50-60 cm, and it is equal to or exceeds the petiole (Aripova 2022). The inflorescence is one in a sympoidal unit, has its own characteristics, is twice as long as the cob. The cover is green, rolled into a narrow tube, or hidden among the foliage. It grows simultaneously with the leaves. compressed between the plate and the tube. The tube can be from ellipsoid to cylindrical (Babichev *et al.* 2021). Within the framework of the article, an experimental cultivation of *A.*

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*korolkowii* was carried out at home. To do this, the author made notes of the entire course of the study, outlined the results obtained and presented them in the form of a table. Prior to the practical experiment, a theoretical study of the properties of such plants, as well as *A. korolkowii*, was carried out. According to the literature, it has been revealed that hydroponic culture is an artificial automated means using certain schemes of techniques for the purpose of growing plants and providing plant products of high quality with the help of synthetic nutrients (without soil). The present study analysed the current data of the scientific literature on this topic. To compare the traditional method of cultivation and the method of hydroponics, seeds of *A. korolkowii* were used. The hydroponics method was based on the study of the root nutrition of plants. In bi-distilled water, a nutrient universal solution of the Buisk fertilizers company was dissolved. Seeds of *A. korolkowii* obtained from the collection of the South Kazakhstan Medical Academy, South clinical and genetic laboratory were grown in this solution (Narimonov *et al.* 2023). A comparative analysis of substrates for hydroponic cultivation of *A. korolkowii* in laboratory conditions was carried out. The differences are due to several factors that meet the requirements for substrates. Methods of cultivation of *A. korolkowii* in laboratory conditions were investigated. The traditional method of growing on the ground showed the lowest results, despite the fact that all the necessary rules were observed, such as light, watering, room temperature, pH of the environment, etc. This plant grows in rocky terrain, in the shade of trees, in the Central Asian highlands, as well as in the North, in the West China and on the territory of Iran (Fadeeva *et al.* 2022). The name of this plant is in honor of N.I. Korolkov, who first brought his tubers to Russia. In 1877, the description of this plant was given in the St. Petersburg Botanical Garden (Tian *et al.* 2023). The tuber is spherical, somewhat flattened. The leaf petiole is at the bottom with an expanded vagina, slightly or 2 times longer than the plate. The leaf blade is heart-shaped-lance-shaped or triangular. The flowering stem is longer than the petiole, 50-60 cm, in reddish stripes. The bedspread is green, rolled into a narrow tube, almost 2 times longer than the cob; its plate is elongated-lanceolate, pointed, green outside and whitish inside. The appendage of the cob is cylindrical, reddish, 1.5-2 times longer than the cob. The fruits are red in colour (Jabborova *et al.* 2023).

## MATERIALS AND METHODS

The hydroponics method has advantages and can be used in the conditions of *A. korolkowii*. If such substrates as perlite, vermiculite, sand, mineral wool are used during the cultivation of *A. korolkowii*, then this will not bring a positive effect when growing it. If a drip irrigation method is used when growing *A. korolkowii*, then it will have a beneficial effect on the growth of this plant in greenhouse conditions. If you use watering in the laboratory, it will not bring the proper effect and will even be harmful to the growth and development of the plant. The plate is pointed, has a different appearance, sharp or blunt, the heart is prominent, triangular or lance-shaped. When blooming, it is vertical, widely expanded, sometimes twisted into a spiral. Often the plate covers the lower part of the cob (Jabborova *et al.* 2020). The cob is lanceolate, elongated, pointed bend, whitish on the inside. Its appendage is reddish, cylindrical, exaggerating the fruiting part of the cob by 1½—2 times. The gap is occasionally absent, and so short, separates the female and male zones. It consists of pistillodia – barren flowers. The last filamentous appendages, expanded from below, directed upwards. The male zone is conical, cylindrical, hemispherical or ellipsoid. Between the appendage and the male zone, the gap consists of staminodes – infertile flowers directed downward. The infertile apical appendage is often on the pedicle rapidly or gradually expanded into a conical or cylindrical mace (Shhedrin 2022). Blooms occur in spring. The flowers are unisexual. The female flower zone is cylindrical, located in the lower part of the cob. The male flower consists of 2 – 5 stamens, the threads are different and short. The flows are short-obovate, open apical, located opposite each other. The guinea of the female flower is blunt, oblong. The ovary is single-nesting. The funicular is short, the column is short, the placenta is from semi-basal to parietal, the stigma is hemispherical (Korshunov 2022). Pedicel without leaves and of various lengths (shorter than the petiole or much longer). *A. korolkowii* has infertile flowers, 3-row and flattened at the base. The fruits of *A. korolkowii* are 4-6 mm in diameter, 5-9 mm long, red, oblong-pyramidal berries. When studying the ecological features of *A. korolkowii* and its distribution, it is shown that it occurs from Western China to Europe (Great Britain, Austria, the Netherlands, Denmark, Ireland, Germany, Hungary, Poland, Corsica, Portugal, France, Sardinia, Bulgaria, Italy, Ukraine, Morocco, Algeria, Tunisia, Canary Islands, Kazakhstan, Madeira, Turkmenistan, Kyrgyzstan, Uzbekistan, Cyprus, Tajikistan, Iraq, China, Afghanistan, Iran, Pakistan, etc.). It grows at an altitude of up to 4400 m above sea level in subtropical and temperate zones, on stony soil, among forest litter and shrubs, along river banks, and on pastures, wastelands.

## MATERIALS AND METHODS

The material of this work is the results of studying a number of theoretical and practical research data with the help of the digital library of the South Kazakhstan Medical Academy, South Kazakhstan University named after M. Auezov (Korzhenevskij 2015). Familiarization with the sources of literature was according to the scheme: general information about hydroponic cultivation, its basic biochemical principles, and substrates (Bashkin 2022). The experiment was conducted in the laboratory at the South Kazakhstan Medical Academy, South clinical and genetic in Shymkent, Kazakhstan. The experience lasted for 1 year. The seeds were planted in the ground on August 20, 2020, and the seeds were also planted on hydroponics. The installation was assembled manually in the laboratory. The installation consists of a container with a nutrient solution, a floating platform, a compressor, as well as a pump for pumping out the solution and a tank that supplies the nutrient solution. The seeds were soaked before the experiment. The following conditions were observed: lighting around the clock, air temperature 23-25 °C, indoor humidity 75-80%, pH 5.8–6.5, EC 3.0–4.0 mSm $cm^{-1}$ (Fadeeva *et al.* 2022). The main mechanism of hydroponics is the involvement of the root system. The authors show that this method can provide different products of plant origin to people who live in different climatic and natural conditions (Milevskaja 2008). The data of many studies have established that hydroponics is a convenient, affordable and effective way to grow plants in extremely simple conditions. One of the main advantages of this method is that the herbs obtained are environmentally friendly for human health, without harmful substances (Korzhenevskij 2016a). The technological features of the hydroponic method facilitate the mechanisms of plant cultivation. The main possibility is the automation of all stages of herb care. Hydroponics also has automated control of light and temperature conditions, as well as mineral fertilizing. Another advantage of this method is the programming of the ionic composition of nutrition, which makes it possible to regulate the mineral parameters of the plant. Many scientific works have demonstrated that the characteristics of herbs obtained by hydroponic cultivation differ in high quality products. The reasons for this are the preserved regime of the underground root system, the stabilization of fertilization processes and the rapid formation of fruits. On the other hand, these plants have a high concentration of essential oils, vitamins, proteins, organic acids, sugars. Moreover, the resulting crop exceeds natural cultivation by several times (Jabborova *et al.* 2023).

### Historical events

The first successful attempt by man to grow plants without using soil was carried out by King Nebuchadnezzar in an engineering structure – the hanging gardens of Semiramis (Seven Wonders of the Ancient World) in the II century BC in Babylon (Iraq). The structure of this system included multi-level gardens, branched artificial water pipelines, numerous tree species, and permanent water supply (Glushko 2022). Another example of growing plants by applying a nutrient solution was floating gardens, which were created by the Indian people in central Mexico (the Aztecs). Nomadic tribes, having moved from fertile lands due to militant movements, came up with an original method of growing plants on the shores of Mexico's Lake Tenochitlan. The indigenous population of America were able to cook champas, i.e., a floating structure created from perennial herbaceous reed plants. The Indian people were able to use this technique to grow herbs of various kinds (vegetable, fruit) to reduce hunger and prevent need (Babichev *et al.* 2021). An important moment in the history of agriculture appeared in 1860 with the birth of various methods of crop production without soil. German professors Wilhelm Knop (1817-1901) and Julius von Sachs (1832-1897) for the first time in the world were able to prepare salt solutions that could be used for cultivating herbs without soil (Zhantasov 2022). The use of hydroponics for a long time was a golden principle and an integral attribute of scientific laboratories. American Professor William F. Gericke was able to carry out a large production of plant products in 1929. His research data showed that the use of an artificial method in the cultivation of various kinds of herbs (fruits and vegetables) was a successful attempt. He proposed the term "hydroponics". During World War II, the American government used the advantages of this technique to supply Military Forces with fruits and vegetables by growing hydroponic pools. The work of William F. Gericke was a moment of motivation for the work of many European scientists in the use of hydroponic culture. In 1937, Professor Pryanishnikova was the author of the installation of a hydroponic station for vegetable expeditions. European scientists, Paul and Piotrovsky built a hydroponic installation in the Carpathians, using the mountainous terrain in the cultivation of ornamental plants. The design of modern hydroponics was created by the German scientist Hernig (Khmurchik *et al.* 2022). Currently, hydroponic cultivation seems to be a successfully growing direction of the agricultural industry. In industrial countries like Germany, China, Brazil, the USA, Switzerland, and our country is no exception, large hydroponic plants have been created to produce more different plants.

**Biochemical aspects of hydroponic plant cultivation.** The root system plays a major role in the absorption of nutrients. The zone of absorption of elements is part of the root hairs and stretching (growth). The root system provides the plant and aboveground roots with the necessary substances. It is shown that this system in 1 $mm^2$ of the root surface has about 199-399 root hairs, therefore, increases the root surface hundreds of times. The hairs of the root system are characterized by a high absorption capacity. In the meristematic tissue (according to the literature, the meristem is an educational (undifferentiated) tissue from which other root tissues are formed) there is no vascular system. Plants get oxygen and carbon from the air, and minerals from the soil. In hydroponics, they receive elements (potassium, nitrogen, iron, calcium, phosphorus, and trace elements) from a nutrient solution. Nutrients are necessary for the plant and are replaced by nothing else. The nutrients located in the soil are contained in the following forms: inorganic insoluble salts installed in the soil that are usually inaccessible to grass, dissolved in water – accessible, adsorbed on the surface of colloids and accessible to plants (Babichev *et al.* 2021). The root branching zone is covered with a strong cork layer and is located above the hair zone of the root system. It does not take part in absorption processes (Glushko 2022). The phloem (the conducting system of plants) is formed earlier, while the differentiation of the xylem is higher along the length of the root. According to this system, nutrients (dissolved) and water move upwards. Most of the minerals absorbed by the meristematic tissue are used in the cells of the root system. Some ions, including calcium, from the root system (stretching zones and hairs) enter the aboveground structures, and then are transported to the top. In different areas of the root hairs, different substances are absorbed. Potassium, phosphates, and ammonium come from the entire surface of the root system, while calcium is adsorbed in the apical zones (Khmurchik *et al.* 2022). Substrates are a means of a different nature (organic and inorganic, artificial or natural), used as a natural soil material for growing plants.

According to the data of scientific works, the requirements of the substrates used in the hydroponic installation have been found (Shapkin 2022).

1. Substrates should be water-retaining (retain water) and have good aeration. These characteristics depend on the number of particles and their size. The larger the particles, the higher the porosity and the lower the water retention potential. For example, fine perlite, vermiculite, expanded clay perfectly retain water, but granite crushed stone and gravel are very bad.

2. The substrates must be inert or chemically neutral to the hydroponic solution without toxic substances. Otherwise, the chemical and physical properties of the solution will change, leading to the formation of pathology of the developing plant. In particular, the cultured solution should not contain $CaCO_3$. It is shown that calcium carbonate increases the alkaline reaction of the solution and deposits phosphates.

3. Substrates must have a solid construction: expanded clay, vermiculite, etc. They do not have sufficient strength, and eventually crumble. Thus, the aeration of the root system decreases, requiring frequent replacement at least once every 3-4 years, which is economically unprofitable. Notably, substrates are subjected to prolonged operation; the action of a nutrient solution, leading to a change in their chemical and physical properties, damage to the root system and the plant itself should be taken into account when conducting hydroponic cultivation.

For this reason, in practice, many scientists have developed substrate materials that meet most of the necessary requirements for hydroponic cultivation, e.g., mineral wool (grodan).

Practical substrate can be used in hydroponics: expanded vermiculite, granite crushed stone, coal slag, crushed expanded clay, PVC substrate, etc. Organic substrates such as sawdust, sawdust, peat, etc. are also used. Each of these materials has its own disadvantages and advantages (Korzhenevskij 2016a). Recently, the authors suggest using synthetic high-molecular substrates: polyurethane, synthetic foam resins, polystyrene, etc. Perlite seems to be an ideal medium and therefore has found wide use, especially in agriculture, to improve the structure of the soil, increase its air permeability, mulching, and growing flowers. It is also used for rooting plants with a weak root system. At the same time, it is necessary to pay attention to the fact that the main advantage of perlite is the absence of nutrients and organic compounds.

**Using a rock of volcanic origin, i.e., perlite.** One of the loosening highly effective additives to the soil is agroperlite, which increases its productivity and improves its structure. It is an inert substance and has great strength (chemically resistant, not crumble, and not stick), slightly mixed with soil components. Agroperlite has thermal insulation properties. It has a large surface and can retain moisture 3 - 4 times its own weight. Therefore, many authors believe that agroperlite is an excellent substrate for soil conditioning. Practically agroperlite is used in various fields for stadium lawns, creation of soil substrates, landscaping of urban lawns, greenhouses, tennis courts, cultivation of indoor plants, turf layer on stationary sites, seedlings, cuttings of flowers and green and vegetable crops on hydroponics, storage of root crops, etc. (Mjazin 2022). When studying the data in Fig.1, it can be revealed that all substances are related to each other, and that the plant cannot assimilate. For instance, vermiculite, which has potassium and magnesium, absorbed by the plant. Accordingly, it is recommended to take their mixture (Paraskun *et al.* 2021).

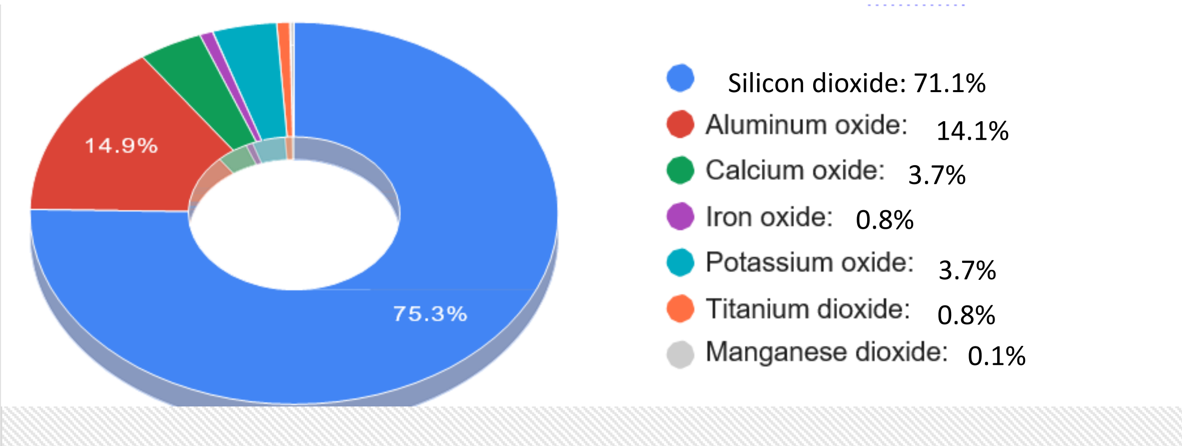


**Fig. 1.** Composition of perlite.

The components of perlite are aluminium oxide, magnesium, silicon dioxide, calcium, iron and calcium, which are 14.1, 0.1, 71.1, 0.4, 0.8 and 3.7% respectively. When analysing the interaction of plants with air, it was noted that they receive the main amount of oxygen through the root system. In many situations, plants will die when planted in tired ground due to changes in the root system, leading to a disruption of oxygen supply. The authors claim that the addition of perlite to the soil is accompanied not only by an improvement in the development of the plant, but also by an elevation in its production.

**The relationship of the plant with water.** Biologically, the nutrition of the plant is various minerals dissolved in water. Therefore, cultured media should contain a large amount of water, have a water-holding capacity. In this case, perlite is the best substrate compared to other means, such as expanded polystyrene, etc. The addition of perlite to engineering irrigation systems causes an elevation in moisture repayment. Perlite particles have the ability to reserve water, and transfer it to each other. Usually, water is obtained from a particle through the root system, while a part of the plant is delivered from a neighbouring one. The thermal conductivity of any material, directly associated with the temperature regime, maintains density. A useful property of perlite is the colour, i.e., white. This gives it the ability to reflect incident energy (heat and light), allowing the preservation of the temperature regime of the substrate. It is noted that the lower the thermal conductivity, the smaller the density. Therefore, the lower density is characterized by slow cooling of the substrate, which protects the root system from overheating and freezing, thereby achieving more comfortable conditions for plant growth (Zebrin, SN 2021). The addition of perlite to the soil preserves it from the dried crust, since its particles are full of moisture, which ensures the supply of the upper layer (Prihod'ko *et al.* 2022).

## Vermiculite in hydroponics

The vermiculite deposit is located in two locations in the state of Montana of America. In the Russian Federation, vermiculite is mined in the Murmansk region. Vermiculite is a multilayer lamellar crystal substance of grey colour. The size varies from a pea to dust and sand. Chemically, it is magnesium ammonium–aluminium-iron and silicon hydrate. The structure of vermiculite, which is a secondary mineral, is layered. It is obtained from dark micas of biotite and phlogopite by weathering and hydrolysis. In hydroponic cultivation 2-4 fractional vermiculite, light material and dry type. Vermiculite is used as a light baking powder in providing a high concentration of oxygen in the substrate. The main factors determining the suitability of vermiculite are lightness of quality, chemical inertia, moisture capacity, air capacity, sterility, chemical inertia, durability of application, strength, buffering, etc. (Masnyj 2022). In factories, vermiculite is processed in ore at a high temperature (760 °C). It is selected, sorted and transported for the technical and electrical industries. The fractionated form of vermiculite is used as a heater in construction (German *et al.* 2022). In South Africa, the use of vermiculite has led to a 5- to 15-fold increase in plant yields. British Professor Mullard was the first to use vermiculite in hydroponics with his experiments for growing clove and cucumber plants. The nutrient solution freely passes through the substrate through slit-like pores. At the same time, vermiculite, when compared to expanded clay, does not injure and does not pop up for more than 10 years without replacement. Therefore, it can be used in the cultivation of a number of herbs without transplanting. In hydroponic cultivation, vermiculite is used exclusively in expanded form. The density of this vermiculite during firing decreases to 300 kg $m^{-3}$. It holds water 5-6 times its own weight, easily gives off and absorbs moisture. The root system of vermiculite is characterized by a powerful development due to its high air capacity (Fadeeva *et al.* 2022). Of the other advantages of vermiculite, it preserves its components unchanged, since it is not subject to salinization. Many authors have shown that substrates used in hydroponics often become unusable after 2-3 years due to the accumulation of salts. Drainage on vermiculite is not required when growing plants. Place a thick layer of large vermiculite on the bottom for 4-5 cm. On an elevated layer, pour fine vermiculite for 20-25 cm. It is noted that highly soluble elements are formed in vermiculite, i.e., magnesium chloride and calcium. They are quickly and easily washed out with ordinary water (Berbekov 2015). Many authors consider vermiculitoponics to be an eco-friendly production. The substrate is replenished with a nutrient medium 10 times a day in accordance with the periods of plant growth. The solution is completely consumed and does not go into the drainage. It is important that harmful substances do not accumulate in plant tissues during growing on the substrate. Vermiculitoponics is widely used in the world, because vermiculite is an excellent substrate and reduces the consumption of nutrient solution by 10-15 times. The main advantages are sterility, cleanliness, increased productivity up to 30 times, with the possibility of repeated use, which has served for 10-15 years, pays off economically quickly. It is used for the production of various plants such as cucumbers, tomatoes, beans, onions, lettuce, potatoes, peas. Vermiculite is a biogenic and active stimulant. It is also used as a ripper in the open ground (Korzhenevskij 2015).

## RESULTS

We analysed the current data of the scientific literature on this topic. To compare the traditional method of cultivation and the method of hydroponics, seeds of *Arum korolkowii* Regel were used. The hydroponics method was based on the study of the root nutrition of plants. In bi-distilled water, a nutrient universal solution of the Buisk fertilizers company was dissolved. Seeds of *A. korolkowii* obtained from the collection of the South Kazakhstan Medical Academy, South clinical and genetic laboratory were grown in this solution. Also, the seeds were planted in pots with soil, watered every two days.

### Cultivation of *A. korolkowii* on expanded clay by the hydroponic method

**Fig. 2.** Cultivation of *A. korolkowii* by the hydroponic method on expanded clay (left). Cultivation of the *A. korolkowii* by the traditional method (right).


**Fig. 3.** Cultivation of *A. korolkowii* on expanded clay by the hydroponic method.

Against the background of the use of hydroponic cultivation, rapid plant growth, the absence of harmful substances and pathologies, improvement of the biochemical composition of fruits, regulation of the quality and quantity of products are observed. At the moment, it is possible to fully regulate the concentration of organic acids, sugars, vitamins, iodine, manganese, copper, and other elements in *A. korolkowii*. Therefore, many scientists hope that with the use of hydroponic culture, it is possible to create therapeutic crop production (Korshunov DM 2022). Prognostic control ensured that the duration of the main phenological phases of *A. korolkowii* growth was taken into account. During the observation of the main stages of ontogenesis, it was found that the influencing factors are the method of growing the crop and its conditions (Fig. 4). Therefore, against the background of low-volume hydroponic cultivation, primary seedlings were recorded after 3-4 days of sowing seeds, but with a ground form it was 20-25 days. This dynamic is also noted at the next stages of the vegetation period of plant growth (Korshunov 2022).

## DISCUSSION

A comparative analysis of substrates for hydroponic cultivation of *Arum korolkowii* in laboratory conditions and on the ground was carried out. Table 1 shows the results of the cultivation of Arum by these methods.

**Table 1.** Results of the study.

| Indicators | Growing on the ground | Hydroponics |
|---|---|---|
| The studied indicator/breed | (*Arum korolkowii*) | |
| Average root length (cm) | 8.5 cm | 17.3 cm |
| The total number of formed roots (pcs.) | 5 | 3 |
| The day of the appearance of the first roots | 3rd | 3rd |
| Percentage of rooted bushes (%) | 30% | 80% |
| Note: TM – myrtle–leaved tradescantia, TB – white-flowered tradescantia, common ivy. | | |

The obtained results of the experiment allowed us to draw the following conclusions:

- the best indicators of plant growth (rooting) were obtained when growing by hydroponics, in which the average increase over the period of the experiment was: myrtle–leaved tradescantia - 17.3 cm.
- the most effective method of cultivation is also hydroponics.

Thus, we see that the methods of growing *A. korolkowii* in laboratory conditions have been investigated. The traditional method of growing on the ground showed the lowest results, despite the fact that all the necessary rules were observed, such as light, watering, room temperature, pH of the environment, etc. Drip irrigation is very convenient and effective when growing plants in greenhouses. In the laboratory, it is also not effective, and even harmful. The most promising method of growing a plant is hydroponics. Substrates such as: perlite, vermiculite, sand, mineral wool did not bring a positive effect when growing the *A. korolkowii* Research Institute. In the process of research, we found that the *A. korolkowii* is a very capricious plant that requires special attention.

**CONCLUSION**

According to the results of the study, the most effective way to grow plants is to grow plants on hydroponics using a clay substrate. The soil method of growing aronica is the most inefficient, since the seeds germinate for a long time and it took a year to get a 9.5 cm sprout. Cultivation on hydroponics using vermiculite also did not yield a good harvest, since the aronnik became unviable after the appearance of the leaves. The appearance of yellow spots and the wilting of leaves is the result of the cultivation of aronnik by the drip method. This method also proved its weekly effectiveness and led to the walking of the plant. The hydroponic method of cultivation has many advantages in contrast to growing in the ground: the root system does not dry out and does not lack air exchange. The plant receives the nutrients it needs, and prevents the appearance of hanging pests and diseases. The hydroponic method allows you to get a good.

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