Study on cultivation of pistachio (Pistacia vera L.) seedlings in containers

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Abstract. This article highlights the results from the effect of changing the volume of containers on the growth and development of pistachio seedlings, as well as the effect of hydrogel, moisture-accumulating substances on the preservation of pistachio seedlings planted on plantations. According to the research, seedlings of pistachio, planted on containers 20x40 cm in size, reached an average height of 18.2 cm, an average diameter at the root collar of 4 mm and an average root length of 30.4 cm. Pistachio seedlings (planted in a permanent place) grown by this method reached safety 95%, which is 122% compared to control group. It is possible to maintain a high field moisture capacity for 2-3 years by adding moisture-accumulating substances - hydrogel to the soil. This allows retaining moisture sufficient for the preservation and growth of pistachios in dry conditions. The preservation of moisture is necessary for pistachio seedlings for good growth and development, branching, budding, to shorten the period of entry into fruiting and increase the yield. Studies, conducted on the effect of hydrogel on transplanted annual shows that the most effective rate is 100 grams/plant. At this application rate, the average plant growth was 20.5 cm, which is 113% compared to control group, the average growth of lateral branches is 6.5 cm, which is 118.0% compared to control group.

1. Introduction
Pistachio trees grow in every soil. Nevertheless, on rich, sandy loam soils, they grow stronger. The number of trees in lower soils should be increased. This will allow maximum production earlier than in planting orchard and about the same time as plantings in good soils, with more space between trees. Pistachio trees can grow up to 20-30 feet tall, long-lives, tap-rooted. Well-drained soils are important to maximize production, like any other fruit or nut tree. Real pistachio is a cost-effective and highly profitable crop in many countries of the world. Every year, 885 thousand tons of pistachio nuts are grown in the world [1]. A large-scale research is being carried out worldwide to increase the productivity of natural forests of Pistacia vera L., as well as to improve the quality of plantations and create pistachio plantations from fruitful varieties. A number of researches have been carried out and results have been obtained on the selection and creation of pistachio varieties capable of growing and bearing a fruit in arid rainfed conditions, providing fruits of high quality, competitive in the world market, and sowing for a permanent place according to the technology of cultivation of this crop. Research on the creation of industrial pistachio plantations is...
being carried out in several countries around the world [2, 3, 4]. In particular, in Iran, Jirandehi and others [5] conducted a study on the effect of hydrogel on the growth and development of *Pistacia atlantica* and obtained positive results. In China, Lu and others [6] studied the effect of the relative humidity of the soil on photosynthesis of pistachio leaves. With increasing moisture deficit, the intensity of photosynthesis and transpiration decreased [7, 8, 9, 10, 11]. The critical relative humidity, that is, the humidity at which watering is required, is 40%. The main reason for the decrease in the intensity of transpiration at a relative humidity of 40-60% is an increase in the resistance of the plant stomata.

In Uzbekistan, a study on the creation of industrial plantations of this pistachio was carried out by Chernova [12], Nikolai [13], Eshankulov [14], and Kholmurotov [15]. According to the research results, the seedlings grown in containers from seeds of local forms and varieties have shown good survival and safety. Based on this, the study of optimization of container sizes and the use of moisture-accumulating substances are the most important taking into account the arid conditions of Uzbekistan. The aim of this study is to improve the cultivation technology of pistachio seedlings in containers and to achieve high survival and safety rate of seedlings while transplantation process into plantations.

### 2. Methods

When conducting research on growing pistachio seedlings in containers, the technology, developed by Chernova [12] and Nikolai [13], was adopted as a basis, but unlike them, containers of 5x25 cm, 10x25 cm, 15x30 cm, 20x40 cm were used. The recommended (by the Research Institute of Forestry) container of 5x25 cm was taken as control. The substrate for containers is made in the form of a mixture of 3 parts of soil and 1 part of rotted manure.

The use of a hydrogel leads to a change in the soil structure [16, 17]. To ensure the growth and development of seedlings, different concentrations of hydrogel 50 grams, 100 grams, 150 grams, 200 grams were used in the form of experimental options. Control - substrate without hydrogel.

During the research, the indicators of the annual growth of pistachio, branching degree, and change in the size of leaves in the variants were experimentally studied. The study was carried out in 75 plants in 3 replicates. Annual growth rates were measured at the end of the growing season.

### 3. Results and Discussions

A high laboratory seed germination rate is a prerequisite for a high field germination rate and leads to a good germination rate of plants in containers. Therefore, we studied the germination of seeds with different shelf life when sowing in containers.

#### Table 1. Effect of the shelf life of seeds on germination in containers

| Shelf life of seeds, months | Number of sown seeds, pieces | Laborator germination% | Seed germination time | Number of germinations | Preservation by the end of year % |
|-----------------------------|------------------------------|------------------------|---------------------|-----------------------|----------------------------------|
|                             |                              |                        | start | end | pieces | %     |         |
| 5                           | 100                          | 93                     | 12.03 | 39  | 64     | 64    | 63      |
| 17                          | 100                          | 72                     | 10.03 | 39  | 57     | 57    | 55      |
| 29                          | 100                          | 66                     | 08.03 | 39  | 40     | 40    | 25      |

According to Table 1, seeds that had a shelf life of 5 months had a laboratory germination rate of 93%, a field germination rate of 64%, and a safety of 63% by the end of the year. Seeds that were stored for 17 months had a laboratory germination rate of 72%, a field germination rate of 57%, and a survival rate of 55% by the end of the year. Seeds that were stored for a long time - 29 months had low rates -
laboratory germination rate of 66%, field germination rate of 40%, and preservation by the end of the year was 25%.

To determine the planting depth and preservation, pistachio seeds from the Babatag ridge were used. Seeds with a shelf life of 6 months were sown in 100 pieces, according to options at a depth of 1 cm, 2 cm, 3 cm, and 4 cm. The results of the experiments are shown in Table 2. It can be seen that when sown at a depth of 1 cm, pistachio seeds had the highest field germination rates. But in terms of preservation by the end of the year and in terms of growth, the best results were obtained at a sowing depth of 3 cm. The main reason for this phenomenon is that for deeply planted seeds, drying out of the soil of the upper horizons does not have a negative effect.

Table 2. Effect of sowing depth on field germination and seedlings preservation by the end of the year.

| Sowing depth, cm | Field germination % | Seedlings | Perished % | Seedlings preservation by the end of the year | Average height of seedlings, cm |
|------------------|---------------------|-----------|------------|--------------------------------------------|-------------------------------|
|                  | Date    | Ascended day | Total | Including 1 y | 2 y | 1-2 year | 1-2 year |
| 1                | 78.7    | 10.04       | 41    | 58.7         | 39.6 | 18.6   | 41.8 | 5.1 | 8.3 |
| 2                | 77.9    | 16.04       | 47    | 19.6         | 8.7  | 10.9   | 80.4 | 9.0 | 17  |
| 3                | 69.0    | 19.04       | 50    | 17.3         | 3.9  | 10.4   | 85.7 | 9.4 | 21  |
| 4                | 43.1    | 24.04       | 55.5  | 5.3          | 3.7  | 1.6    | 94.7 | 8.0 | 18  |

Currently, seedlings with a closed root system are widely used when laying pistachio plantations. For this, containers are used in the size of 5x25 cm, 10x25 cm, 10x30 cm, 20x40 cm and more. The containers, which are made from plastic wrap and small drainage holes, are punched closer to the bottom. A mixture is used as a substrate, consisting of 3 parts of non-saline soil and 1 part of rotted manure. After filling the containers with the substrate, one stratified pistachio seed is sown into each container to a depth of 1-2 cm. Seeds are considered suitable for sowing if, after stratification, they have a root with a length of 1-2 mm, that is, "hatched". The procedure for laying in stratification is as follows: before laying in stratification, the seeds are soaked for 1 day in warm (18-20°C) water, then they are etched (for fungal diseases) with a 5% solution of potassium permanganate. The seeds are mixed with clean river sand in a ratio of 1: 5 and placed in a pit. The beginning of stratification in Uzbekistan on January 1-10, a month later the mixture with seeds is brought to room temperature (about + 200C). After 2-3 days, the seeds begin to hatch; such seeds are immediately sown in a container. The seeded containers should be kept in a bright and warm room. The first shoots may appear on the 5th day, the rest gradually emerge within 7-14 days. The containers are kept in greenhouses until the last return frost has passed. After establishing constant positive temperatures, it can be planted in a permanent place. The advantage of this technology: the planting period is extended, the consumption of seeds is reduced, and the survival rate and preservation of the planted plants are significantly increased.

Taking into account the very difficult forest growing conditions (rainfed) when creating pistachio plantations, the correct selection of container sizes, the composition of the substrate, irrigation rates, and other factors are of great importance.

Experiments were carried out for growing pistachio seedlings in containers of different sizes. For this, containers of 5x25 cm, 10x25 cm, 15x30 cm, 20x40 cm were chosen. Of these, the recommended (by the Research Institute of Forestry) container of 5x25 cm was taken as a control. A mixture consisting of 3 parts of non-saline soil and 1 part of rotted manure was used as a substrate.
Table 3. Effect of the containers size on the growth and development of pistachio seedlings

| Variants | Size of containers, cm | Seedling indicators before planting in a permanent place | | Seedling preservation, % | Ratio to control, % |
|----------|------------------------|--------------------------------------------------------|----------------|--------------------------|------------------|
| 1 (control) | 5x25                   | 8.2±0.14                                               | 10.1±0.14      | 2.1±0.05                 | 78               | 100              |
| 2         | 10x25                  | 12.1±0.13                                              | 12.2±0.13      | 3.1±0.06                 | 85               | 109              |
| 3         | 15x30                  | 18.2±0.22                                              | 15.4±0.18      | 4.1±0.07                 | 88               | 113              |
| 4         | 20x40                  | 32.2±0.21                                              | 17.1±0.19      | 4.1±0.05                 | 95               | 122              |

Stratified pistachio seeds were sown in a container in the first decade of February. In all variants, the first shoots appeared in the third decade of February. In the third decade of March, the seedlings were planted in a permanent place. Changing the size of the containers also influenced the growth and development of pistachio seedlings. As shown in Table 3, seedlings grown in containers 20x40 cm in size reached an average height of 18.2 cm, a root collar diameter of 4 mm, and a root length of 30.4 cm. When planting such plants in a permanent place, the preservation reached 95% or 122% in relation to the control.

Now, polymers are widely produced and used in the agro-industrial complex in many countries of the world. The use of polymers makes it possible to reduce the use of mineral fertilizers and pesticides and to obtain an environmentally friendly product [18, 19, 20, 21]. The moisture-accumulating substance "Hydrogel" is a man-made polymer that can accumulate and retain large amounts of moisture. A hydrogel can absorb and retain moisture 250-400 times its own weight, that is, 10 grams of a hydrogel can absorb and hold 2.5-4 liters of water. By absorbing melt, rain or irrigation water it gradually gives it to plants.

Table 4. Effect of moisture-accumulating substances (hydrogel) on the growth and development of pistachio seedlings

| Variants | Average height before planting, cm | Growth by the end of 1 year, cm | Growth of side branches |
|----------|------------------------------------|--------------------------------|-------------------------|
| 1. Control (without hydrogel) | 18.2±0.02                          | 30.2±0.7                        | Average quantity in one plant, pcs 3 | Average length, cm 5.5±0.02 |
| 2. With hydrogels - 50 g | 18.2±0.02                          | 38.3±0.8                        | 5                       | 6.1±0.02                        |
| 3. With hydrogels - 100 g | 18.2±0.02                          | 38.5±0.8                        | 6                       | 6.5±0.02                        |
| 4. With hydrogels - 150 g | 18.2±0.02                          | 33.3±0.9                        | 6                       | 6.1±0.03                        |
| 5. With hydrogels - 200 g | 18.2±0.02                          | 31.6±1.2                        | 6                       | 6.0±0.04                        |

One of the properties of a hydrogel is that the hydrogel increases the porosity of the soil, thereby improving its aeration. If a hydrogel is added to the sand, then the flowability of the sand fits. Hydrogel in soil does not lose its properties up to 2-3 years. The hydrogel is applied to the soil before planting and is thoroughly mixed with the soil. This substance is a regulator that controls soil moisture. With an excess of moisture, it accumulates moisture, and with a lack of it, it gives it to the plant. Therefore, the use of a hydrogel improves water supply and positively influences the growth and development of pistachio seedlings.
During the experiments on growing pistachios in containers, various concentrations of hydrogel were used. For this, concentrations of 50 grams, 100 grams, 150 grams, and 200 grams were used in experiments and control (without hydrogel). When creating pistachio plantations, pistachio seedlings, grown in containers with an average height of 11.2 cm, were used; when using a hydrogel, these plants gave an annual growth of 13.4-20.3 cm. Considering that in control group, this indicator is 12.0 cm, then when using a hydrogel, this indicator is 1.11-1.69 times higher than the control (Table 4).

Due to the beneficial effect of moisture-accumulating substances (hydrogel), the branching rates and the average length of the branches of pistachio seedlings increase. The studies have shown that the use of the hydrogel promoted branching, on average; the number of side branches was 6 pieces, when the control was 3 pieces, and the control was exceeded 2 times. The average length of lateral branches under control is 5.5 cm, in the variants of experiments this indicator was 6.1-6.5 cm, which exceeds the control by 1.1-1.18 times (Table 4).

4. Conclusions
The study showed that moisture-accumulating substances (hydrogel) did not lose their properties for up to 2-3 years. This allows maintaining moisture and ensures good growth and development of pistachio seedlings in plantations created in rainfed conditions. Stable moisture supply allows shortening the growth period before and after budding, entry into fruiting, and subsequently, to obtain high yields. The results indicated that the application of moisture-accumulating substances (hydrogel) to seedlings of the first year of planting, the highest result was given by a concentration of 100 grams, at which the average growth was 20.5 cm, the ratio to the control was 113%, the growth of side branches was 6.5 cm, and the ratio to the control was 118%.

Conflicts of Interest
The authors declare no conflicts of interest.

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