Intensification techniques in the cultivation of seed rootstocks of VNIISPK breeding for the production of pear seedlings

Igor Semin*

Russian Research Institute of Fruit Crop Breeding (VNIISPK), Zhilina, 302530 Orel region, Orel district, Russian Federation

Abstract. The article presents the results of research on optimizing the methods of intensification of growing seed rootstocks based on common quince of VNIISPK breeding in a nursery. In the course of the research, it has been found that the highest yield of seed rootstocks with optimal economic and biological characteristics is provided by sowing germinated seeds in late April. Seeds should be sown in artificial beds according to the scheme of 0.5 cm x 20 cm, which will allow to obtain a high yield of seedlings of good quality and increase the efficiency of growing seed rootstocks. With a dense sowing scheme, annual growth does not form branches. A close linear relationship has also been found between the length of annual growth and the length of skeletal roots of seedlings, from which it follows that the longer the growth of a seedling is, the longer its roots are. There is a decrease in the yield and quality indicators of rootstocks when sowing in the field in the seedling nursery, and the additional rearing of seedlings is necessary in the nursery. The studies in this direction will be continued.

1 Introduction

It is known that the production of fruits of pome crops and especially pear cultivars is based on the use of rootstocks, which play one of the main parts in obtaining large and high-quality yields [1-2]. This is especially relevant for pears in central Russia, where industrial cultivation is limited primarily by the acute shortage of intensive rootstocks [3]. Through breeding, VNIISPK scientists have obtained selected seedlings of common quince, capable of reproduction by soft cuttings, having high seed productivity and able to tolerate the climate of central Russia. They can successfully replace the rootstock based on pear seedlings common in central Russia [4; 5; 6; 7; 8]. One of the main advantages of quince over pear is the ability to restrain the growth of cultivars grafted on it and accelerate their entry into fruiting. Despite the fact that the use of clonal rootstocks allows to lay orchards homogeneous in a number of valuable economic and useful traits, more and more attention has recently been paid to the use of seed rootstocks [5; 9; 10]. Their importance increases every year due to unfavorable socio-economic conditions, when significant financial

* Corresponding author: semin@vniispk.ru

investments are needed for the application of intensive technologies using clone rootstocks. In addition, obtaining seedlings is technologically easier and cheaper than vegetative reproduction, and during the season allows to grow much more rootstocks with a high-quality root system [5]. As a rule, the cultivation of seed stocks, including common quince, is carried out by sowing seeds after their preliminary stratification in the seedling nursery with open ground. Often unfavorable climatic conditions of the growing season and especially the lack of moisture do not allow to get rootstocks of the right quality for a year. It is possible to optimize the technology of growing seed rootstocks with a simultaneous increase in their yield per unit area and an increase in the quality of seedlings by using artificial ridges, i.e. greenhouses without shelter.

Based on this, the purpose of our research is to develop and evaluate methods for intensifying the cultivation of quince seed rootstocks of VNIISPK breeding in nursery conditions in the direction of improving their quality for further production of pear seedlings.

2 Methods and materials

The studies were carried out in 2019-2021 at the Russian Research Institute of Fruit Crop Breeding (VNIISPK) using artificial ridges (greenhouses without shelter) and seedling nursery. Seedlings of common quince were used In the experiment. These seedlings are the offspring of selected winter-hardy genotypes of the Institute's breeding, which over 20 years of observations have shown the ability to tolerate the winters of central Russia without significant damage. Seed stratification was carried out with the laying of seeds in three periods (every 10 days) in 3-fold repetition and keeping them at low positive temperatures for 3 months in the humid environment. As the seeds came out of the dormant period , they were sown in the open ground. The generally accepted agricultural techniques of the experiment were used. The research methodology was based on observations and records in accordance with the “Program and methods of fruit, berry and nut cultivar study” [11]. Mathematical processing of the research results was carried out using Microsoft Excel.

3 Results and discussion

3.1. Stratification of quince seeds and determination of the phase of their physiological condition optimal for sowing

Quince seeds, after being extracted from the fruit, are in a state of deep dormancy and cannot germinate immediately. To activate the germination processes, stratification is necessary, i.e. exposure to low positive temperatures for a certain time with constant moisture and good aeration. The long-term experience of VNIISPK shows that the use of sphagnum moss, which has excellent moisture-retaining ability, good aeration and disinfecting properties, ensures the best preservation of quince seeds during the dormancy period. Studies have shown that the stratification of seeds at a temperature of +10 C lasts an average of 96 days. The laboratory germination of seeds after three months of stratification was 95-97%. It is noteworthy that the yield of healthy and full-fledged quince seeds is significantly higher than that of pears, and amounts to 82-89% of the amount laid down for stratification.

At the end of the stratification period, after 95-97 days, the seeds darken and increase slightly in size due to the accumulation of moisture and activation of the growth processes of the embryo. The acceleration of seed germination at this moment is facilitated by an increase in temperature, while its decrease slows down the growth processes. Studies show that the time of seed release from dormancy can be shifted by 1-2 weeks by changing the storage temperature, but germination in this case may also change. This happens due to the influence of pathogenic microflora on the delicate tissues of young seedlings or the formation of necrosis due to the impact of low temperatures on the tissues of primary roots.

To determine the optimal phase of the physiological state of seeds for the effective development of seedlings at the end of stratification, an experiment was conducted on sowing quince seeds in various degrees of germination. The results presented in Table 1 show that the highest seed germination and seedling yield were obtained by sowing germinated seeds with a primary root length of 3-5 mm. The germination energy in these variants was 2.3 days. Although there was a higher germination rate in the variants with fully germinated seeds than in the previous variant (by 4%), however, the death of seedlings from various diseases increased, which ultimately led to a decrease in the yield of seedlings by an average of 9%. In addition, ramified radicles with large numbers complicate the technical process of sowing seeds in the ground.

Table 1. Determination of the optimal phase of the physiological state of quince seeds at the end of stratification (2019-2021).

Variant	Seed germination, %	Waiting period for sprouts, days	Seedling yield, %
The seeds have not started to germinate. The white skeleton of the primary root is not visible or barely noticeable in single seeds, but the stratification period ends	33,3	6,7	27,3
The seeds began to germinate. The white skeleton of the primary root is visible in 90% of the seeds, but the tubercle is less than 1 mm	65,0	4,7	58,4
The seeds began to germinate. The white backbone of the primary root (3-5 mm long) is clearly visible in 90% of the seeds	78,1	2,3	76,0
The seeds have sprouted. All seeds have a primary root and cotyledon leaves	82,2	1,7	67,1

3.2. Optimization of dates of sowing quince seeds

The observations also showed that the germination and quality of common quince seedlings are influenced by the dates of sowing seeds (Table 2). According to the technology, the seeds are sown in early spring, as soon as the soil warms up. Quince is more thermophilic and photophilic culture than apple and pear, and it needs a well-warmed soil for the development of seedlings. Our research has shown that sowing at a later date than is generally accepted has a negative impact on the germination, yield and quality of quince seedlings. In May and June, the warming of the soil and the evaporation of moisture increases, and therefore, seedlings may experience a lack of moisture. Therefore, when sowing seeds in May and June, the quality indicators of seedlings and the yield of rootstocks decrease. The best results were noted when sowing at the end of April. In addition, a longer growing season contributes to improving the quality of rootstocks.

Table 2. Determination of the optimal sowing period for common quince seeds (2019-2021) (seed sowing scheme - 0.5 x 20 cm).

Indicators of the yield and quality of seedlings	Seed sowing period, decade/month		
	III /April	II /May	I /June
Germination, %	94.7	68.3	13.4
Yield of seedlings, %	87.5	65.4	11.6
Length of increment, cm	26.2	17.1	10.3
Number of roots, pcs..	3.3	3.4	4.8
Root length,cm	18.0	14.1	11.4
Branching order	2.8	2.6	1.4
Root neck thickness, mm	4.7	4.4	2.2
Average thickness of skeletal root, mm	2.8	2.6	1.4

3.3. Assessment of the nutrition area of quince seedlings

For the rational use of the sown area, an important condition is the use of the most effective seed sowing scheme, which ensures a high yield of high-quality seed rootstocks. Studies have shown that, in all variants of the experiment, a much larger number of seedlings with higher quality indicators are obtained in conditions of artificial ridges than in the field (Table 3).

Table 3. Evaluation of seed germination and yield of quince seedlings at different nutrient space (2019-2021).

- in conditions of artificial beds

№ п/п	Seed sowing scheme cm x cm	Number of seeds in repetition, pcs.	Germination, %	Yield of seedlings, %
1.	0.0 x 20	300	79.0	75.0
2	0.5 x 20	300	77.0	74.5
3	1.5 x 20	300	40.0	30.6
4	3.0 x 20	300	8.7	6.0
$LSD_{0,5}$			14.2	

- in the field

№ п/п	Seed sowing scheme cm x cm	Number of seeds in repetition, pcs.	Germination, %	Yield of seedlings,, %
1.	0.0 x 20	300	51.1	41.5
2	0.5 x 20	300	49.0	40.9
3	1.5 x 20	300	23.3	16.7
4	3.0 x 20	300	3.7	0.0
$LSD_{0,5}$			13.7	

On average, according to the variants, the germination of quince seeds was almost 1.5-2 times lower when seedlings were sown in the nursery, which was largely due to the higher density of the soil and its lower moisture supply. It was also found that the thicker the seeds were sown, the higher the germination and yield of seedlings were relative to the number of seeds sown per unit area. The most effective scheme of sowing seeds was 0.5 cm x 20 cm. With a thicker sowing of seeds, germination increased slightly (2-3%), but the quality of rootstocks decreased. This fact was noted both in the conditions of artificial beds and in the field.

An important consequence was that from 1 greenhouse in the conditions of artificial beds, it was possible to obtain much more high-quality seed rootstocks at a lower cost than from the same area in the nursery.

3.4. Qualitative indicators of quince seedlings

The studies showed that the best quality rootstocks were obtained in conditions of artificial beds. Seed germination in this variant was 20% higher than when sowing in the field (Table 4). The indicators of the average length of growth, the number and length of roots were almost 2 times higher than the results obtained in the nursery of seedlings. The skeletal roots of the rootstocks in these variants were thicker and more branched. The decrease in the quality of seedlings in all variants in 2021 was due to adverse weather conditions. The lack of moisture against the background of high air temperature during the growing season negatively affected the development of seedlings in artificial ridges, but slightly affected the rootstocks grown in the field. This was due to the moisture capacity of the soil on which the seedlings were grown – in greenhouses, the soil was loose and breathable, it warmed up and dried faster. Therefore, in conditions of drought, additional watering is necessary. Quince has a superficial root system and a high response to various growing conditions. In the field, the soil, on the contrary, is denser and holds back moisture more strongly. In this regard, quince seedlings develop a root system of lower quality than in greenhouses.

Table 4. Germination of seeds and quality of quince seedlings obtained by sowing in the field and in "artificial beds" (seed sowing scheme - 0.5 x 20 cm).

Parameters	In the field				In artificial beds			
	2019 .	2020.	2021.	**average**	2019	2020 .	2021.	**average**
Germination, %	44.1	31.0	34.0	**36.4**	65.0	92.3	14.7	**57.3**
Average length of growth, cm	12.4	9.2	6.3	**9.3**	17.6	24.4	11.2	**17.7**
Number of skeletal roots, pcs.	2.2	1.4	3.5	**2.4**	3.5	3.1	6.7	**4.4**
Length of skeletal roots, cm	9.0	6.2	7.4	**7.5**	12.0	15.9	9.1	**12.3**
Thickness of skeletal roots, mm	1.3	1.0	1.0	**1.1**	2.7	2.6	1.6	**2.3**
Branching order	2.0	1.4	1.2	**1.5**	3.2	2.8	1.6	**2.5**
Root neck thickness, mm	3.1	2.5	2.1	**2.6**	4.5	4.0	2.4	**3.6**

The analysis of the results of the conducted studies also allowed us to find a close linear relationship between the length of the annual increment of seedlings and the length of skeletal roots (Fig. 1). According to the equation of linear dependence $y = 0.54 x + 2.72$, the longer the increment is, the longer the skeletal roots are. The correlation coefficient was 0.9, which indicates a high correlation of traits. However, based on data from previous studies with quince seedlings, with an annual increment length of 75 cm or more, the growth of skeletal roots in length slows down and their lateral branching increases. Therefore, this equation has a value when the length of the increment is up to 70 cm.

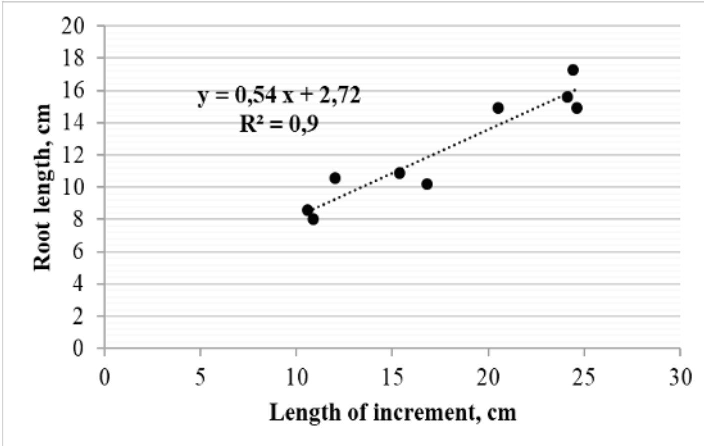

Fig. 1. Linear correlation between the length of annual increment of seed stocks of common quince and the length of skeletal roots of seedlings.

4 Conclusion

The results of the conducted studies have shown that seeds of common quince of VNIISPK breeding must be stratified for 95-97 days in moist moss-sphagnum at a temperature of +1° C. Seeds should be sown during the period when they come out of dormancy in the phase of the beginning of germination, when 90% of the seeds have a skeleton of the primary root 3-5 mm long, which ensures the best germination, germination energy and the yield of seedlings in the nursery. Sowing of seeds should be carried out in artificial ridges in loose soil according to the scheme of 0.5 cm x 20 cm at the end of April, which will allow to obtain a high yield of seed rootstocks of good quality.

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