Pre-Sowing Treatment of Hawthorn Seeds

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Abstract

The genus hawthorn has a huge number of species and due to this diversity, pronounced polymorphism within the species is manifested. One of the most important indicators of the qualitative development of plants is its ability to reproduce - fruiting. For seed germination, various methods of pre-sowing treatment were tested: soaking, treatment with concentrated sulfuric acid, hydrothermal treatment, scarification, seed crushing, radiography. The studies made it possible to establish the most acceptable methods. The results of radiography and crushing were almost identical, the maximum number of the studied species have viable and good-quality seeds, and both crushing and radiography revealed larvae in the seeds of the European and Central Asian species, which had a negative effect on soil germination. Treatment of hawthorn seed covers with sulfuric acid gives good results, and hydrothermal treatment, especially at high exposures, is not always acceptable for hawthorn seeds, especially for species with small seeds. Positive results were obtained from seeds extracted from fruits that had not reached morphological ripeness. The aim of the research is to determine the soil germination of hawthorn seeds.

Keywords: hawthorn, seed quality, seed radiography, soil germination of seeds, pre-sowing seed treatment, scarification.

1. Introduction

The genus *Crataegus L.* belongs to the subfamily Maloideae Focke of the rose family Rosaceae Juss. The Latin name Crataegus comes from the words χραταιγος or χραταιγών: χρατος - strength, strength, firmness; αγειν - to lead, to act. «A tree with viscous, hard wood and strongly developed thorns» (Theophrastus, 1951). C.Linnaeus (1753) used the genus name *Crataegus L.* to designate the hawthorn species known at that time - 3 species of Sorbus and a species of Raphioleris.

There are over 80 wild and 90 introduced species growing in the CIS (Solovieva and Kotelova, 1986; Izembaeva et al., 2024). In the Baltics, R.E. Tsinovskis (1971). was the first to discover and describe 12 species, 1 variation and 4 forms of hawthorn that are new to botanical science. Cultivation continues everywhere and, consequently, the species composition is expanding.

There are 7 wild species growing in Kazakhstan: *C. almatensis A. Pojark., C. pontica A. Koch, C. turkestanica A. Pojark., C. sanguinea Pall., C. altaica* Lge., *C. transkaspica A. Pojark., C. songarica Koch. In the culture 4 species: C. maximowiczii Schneid., C. rotundifolia Moench, C. punctata Jaeg., C. submollis Sarg.* Hawthorn is widespread in the mountains of the Northern Tien Shan: Zailiysky, Dzhungarsky and Kungey Alatau. The peculiarity of the forests of the Northern Tien Shan is the presence of fruit tree plantations in them. They are located in a strip of 3-4 km along the lower parts of the slopes and in the foothills at an altitude of 800 to 1500 m. It is here among the fruit trees that some species of hawthorn grow - *C. almatensis Pojark., C. sanguinea Pall., C. turkestanica Pojark., C. altaica Lge, C. songarica C. Koch.* are also found. On the north-eastern and north-western slopes (5-100), apple-hawthorn, aspen-apple-

hawthorn forests are formed. On the northern slopes, hawthorn is confined to deep and medium-deep leached mountain chernozems or mountain forest dark gray soils. On the southern slopes, *C. songarica C. Koch* is found. In the mountains of the Western Tien Shan, the hawthorn forest is located mainly on the eastern and western slopes with a steepness of up to 15-300, at an altitude of 800 to 1200 m above sea level (Kentbayeva et.al., 2022).

Numerous species of the genus Crataegus L. can be a vital source of raw materials used for medicinal and food purposes. Hawthorn berries contain vitamins, a number of organic acids, sugars, carotene, pectin and tannins, sorbitol, choline, and quercetin. Adenine, adenosine, guanine aminopurine, choline, and other substances have been found in medicinal raw materials (Izembaeva et al., 2024).

The range of arboretums of Kazakhstan includes up to 40-50 species of hawthorn. Due to its decorative properties, hawthorn is found in landscaping; in particular, according to our observations, at least 20 species grow in the city plantings of Almaty (Kentbayeva et.al., 2022).

2. Materials and Methods

The object of the study were different species of even-aged hawthorn growing on the same leveled agro- and eco-background in the arboretum of the Issyk State Dendrological Park: Central Asian species: *C. almaatensis* Pojark., *C. altaica* Lge., *C. sanguinea Pall., C. songarica* C. Koch; Far Eastern species: *C. schneideri* Cin., *C. maximowiczii* Schneid., *C. chlorosarca* Maxim., *C. dahurica* Koehne; Baltic species: *C. kupfferi* Cin., *C. curvisepala* Lindm., *C. insularis* Cin.; European species: *C. calicina* Peterm., *C. nigra* W.et.K., *C. volgensis* Pojark.; North American species: *C. douglasii* Lindl., *C. rivularis* Nutt., *C. calpodendron* Medic., *C. flabellate* C. Koch. In the arboretum of the Issyk State Dendrological Park, introduction activities began in 1959, where 50 local and introduced species of hawthorn currently grow (Kentbayeva et.al., 2022).

It is known that hawthorn reproduces vegetatively and by seeds. The objective of our research was to determine the best and most acceptable method of propagating hawthorns for production conditions. Widespread cultivation of hawthorns is unthinkable without data on the sowing qualities of seeds. Despite the fact that hawthorns are being introduced into culture, the quality of seeds of local and introduced species has not been sufficiently studied. Hawthorn seeds have a very hard shell, which prevents their rapid germination. To determine the optimal conditions for germination, various methods of pre-sowing seed treatment were tested. Seeds were sown in open ground on beds up to 1 m wide and up to 3 m long, sowing rows were located across the beds at a distance of 15 cm from each other, 100 seeds were sown in one row, seeds of one species were sown in 5 rows. The experiments were repeated three times.

The state standard was used to determine the mass of 1000 seeds. Experiments were conducted to determine the quality of seeds according to GOST 13056.8-68 (1977).

To determine the quality of hawthorn seeds, we developed a crushing method. Crushing was carried out until cracks appeared on the seed coat, while the embryos should not be damaged. This method involves minimal costs, is distinguished by its efficiency and low labor intensity of the process.

The X-ray method was used to determine the quality of seeds, which provides a complete description of the viability, features of internal development and structure of seeds. The analysis period is reduced to 1 day. For the experiments, 100 seeds of each variant were taken in 3-fold repetition. X-ray of seeds was performed on a REIS-D emitter with a BSI microfocus X-ray tube, which meets the radiation safety requirements: «Basic Sanitary Rules with Radioactive Substances and Other Sources of Ionizing Radiation» (OSP-72/87); «Radiation Safety Standards» (NRB-76/87). When decoding the negatives, the relevant methodological guidelines were used (Naumenko and Deryuzhkin, 1972).

3. Results and Discussion

Hawthorn is propagated by sowing seeds, root shoots, layering, grafting, and cuttings. In culture, the predominant method of propagation is seed. The seed coat of hawthorns is a stony pericarp that delays seed germination. Some species are subject to parthenocarpy (the formation of seeds without an embryo), as a result of which few shoots are formed (Solovieva and Kotelova, 1986).

Seed propagation of plants mainly depends on the quality of seeds. In scientific works of the USSR countries, such data are found for a small number of species. In foreign literature, there are very few reports on the quality of hawthorn seeds and such information is found episodic. Many scientists have studied deep dormancy and determined effective methods of pre-sowing seed preparation. For more successful germination of seeds, there are various methods of pre-sowing treatment: washing the seeds in running water, treatment with concentrated sulfuric acid, air-thermal treatment, scarification, stratification (Solovieva & Kotelova, 1986; Kentbayeva et.al., 2022).

Hawthorn seeds have a long seed dormancy, so seeds from fruits collected before their morphological ripeness germinate faster. Many researchers have conducted experiments on the germination of hawthorn seeds, but the overwhelming majority used seeds from a small number of species. To determine the quality of hawthorn seeds, which have a hard seed coat and a long germination period, the most acceptable methods were crushing and X-ray.

According to our research, the X-ray method basically confirmed the results obtained by crushing the seeds and revealed that the overwhelming majority of species have viable seeds - 44.5%, 22.2% of samples have an average indicator and 33.3% have a low level of good quality. As studies have shown, the highest percentage of good-quality seeds is produced by the species of Baltic origin *C. insularis sp. nov.* (92.0%), the minimum of full-grained seeds is in *C. chlorosarca Maxim.* (16.3%) from the Far East, the amplitude of fluctuation is very high 75.7% (Table 1).

Table 1. *Determination of the quality of hawthorn seeds*

№	Species name	X-ray, %	Crushing, %	Weight of 1000 seeds, g	Average values, M ± m, g
1	*C. almaatensis* Pojark.	82.0	82.7	74.7	0.07 ± 0.001
2	*C. altaica* Lge.	29.0	28.3	45.2	0.05 ± 0.001
3	*C. flabellate* C. Koch	27.0	28.0	49,7	0.05 ± 0.002
4	*C. volgensis* Pojark.	44.7	43.7	83.8	0.08 ± 0.003
5	*C. calpodendron* Medic.	30.3	29.3	55.1	0.06 ± 0.002
6	*C. dahurica* Koehne	88.0	86.0	56.2	0.06 ± 0.002
7	*C. Douglasii* Lindl.	35.3	34.0	27.7	0.03 ± 0.001
8	*C. chlorosarca* Maxim	16.3	16.3	23.5	0.02 ± 0.001
9	*C. curvisepala* Lindm.	86.0	87.0	136.0	0.14 ± 0.003
10	*C. sanguinea* Pall.	32.3	33.7	100.4	0.10 ± 0.004
11	*C.Kupfferi* sp. nov.	43.0	40.7	61.3	0.06± 0.002
12	*C. Maximowiczii*	53.0	52.0	34.6	0.03 ± 0.001
13	*C. insularis* sp. nov.	92.0	91.3	97.1	0.10 ± 0.004
14	*C. rivularis* Nutt.	25.7	24.7	40.4	0.04 ± 0.002
15	*C. songarica* C. Koch	57.3	59.3	70.3	0.07 ± 0.003
16	*C. calicina* Peterm.	22.3	23.0	115.4	0.12 ± 0.004
17	*C. nigra* W.et.K.	70.3	68.7	36.4	0.04 ± 0.001
18	*C. Schneideri* nom. nov.	80.7	81.3	18.4	0.02 ± 0.001
					$НСР_{05}$ - 0.01

Depending on the origin, X-ray analysis showed that the best were the hawthorn species from the Baltic States: *C. curvisepala* Lindm., *C. insularis* sp. nov. - 86.0 and 92.0%, respectively, *C. Kupfferi* sp. nov. - 43.0% of high-quality embryos. The seeds of these samples are large, for example, *C. curvi-sepala* Lindm. has the largest seeds and is the leader among the studied species, the weight of 1000 seeds are 136.0 g. European species are in different groups, the percentage of viable seeds varies within the following limits 22.3 - 70.3%. Hawthorn seeds are large, the weight of 1000 pcs is 83.8 g for *C. volgensis* Pojark., 115.4 g - *C. calicina* Peterm., the exception is *C. nigra* W.et.K. with small seeds, but at the same time having a high percentage of good quality ones.

Local species have good seed quality indicators. For example, *C. almaatensis* Pojark. has the highest percentage of quality seeds among local species - 82.0%, with an average weight of 1000 pcs of 74.7 g. It should be especially noted that crushing and X-ray examination revealed larvae in the seeds of *C. songarica* C. Koch and *C. calicina* Peterm., which naturally affected both germination and quality. In accordance with the dispersion analysis conducted on seed weight, one can conclude that the heredity of the trait is genotypically determined.

The predominant method of propagating hawthorn in culture is seed, which is difficult due to the deep dormancy of seeds. As a result, we tested various types of pre-sowing seed treatment: hydrothermal treatment (HT), with sulfuric acid in different exposures, scarification, stratification, soaking in water for 24 hours, dry seeds served as a control.

It is well known that in fruits that have not reached morphological maturity, but already with physiological maturity of seed embryos, seed dormancy may be reduced under certain circumstances. In this case, we tested seeds of 5 hawthorn species that had not reached morphological maturity. The seeds of the studied species were sown in open ground conditions in the first ten days of August, the first shoots appeared in March, mass shoots - in April. The ground germination of seeds with different types of treatment is presented in Table 2.

Table 2. *Soil germination of hawthorn seeds, %*

№	Types of seed treatment	Species names				
		C. almaatensis Pojark.	*C. sanguinea* Pall.	*C. dahurica* Koehne	*C. Douglasii* Lindl.	*C. Maximowiczi i*
1	HT - 5 sec.	3	2	2	1	1
2	HT - 10 sec.	1	1	0	0	0
3	HT - 15 sec.	0	0	0	0	0
4	HT - 30 sec.	0	0	0	0	0
5	H_2SO_4- 5 min.	44	14	64	51	53
6	H_2SO_4- 10 min.	52	5	83	48	64
7	H_2SO_4- 20 min.	76	24	79	38	57
8	H_2SO_4- 30 min.	68	19	57	31	54
9	H_2SO_4- 60 min.	64	10	41	19	32
10	Scarification	29	5	24	12	16
11	Water, (24 h.)	17	3	24	16	14
12	Dry seeds (control)	14	3	21	14	12

When testing hydrothermal treatment at different exposures, the results in the overwhelming majority of cases were zero; only with 5 and 10 second treatment was a small percentage of seedlings noted in some species.

Hydrothermal treatment had a particularly strong effect on hawthorn species with small seeds, the pericarp thickness of which is somewhat thinner. Even short-term exposure to high water temperatures had a detrimental effect on the embryos.

Scarification of immature seeds also showed low soil germination within 3 - 24%. It is possible that seeds with damaged pericarp spoil and are damaged by insects if left in the soil for a sufficient period of time.

Seed treatment with 96% sulfuric acid showed quite good results in all cases. The best conditions are 20- and 30-minute exposures, seed soil germination is within 24-79% and 19-68%, respectively. For example, the Far Eastern species *C. dahurica* Koehne has fairly stable results at all exposures to sulfuric acid, with germination slightly decreasing only after 60 minutes of exposure. *C. Douglasii* Lindl. reduces germination rates with increasing exposure time, which is explained by small seeds and thinner pericarp. Soil germination of local species varies widely. If *C. almaatensis* Pojark. has the most optimal results for all tested treatments, then *C. sanguinea* Pall. has low germination not only against the background of local species, but also against all studied species.

Soaking in water did not have a significant effect on the soil germination of seeds of various hawthorn species. The control variant (dry seeds) is at the level of 8 - 28%. Dry hawthorn seeds germinate mainly after 1.5 - 2 years. In this case, the early emergence of shoots was influenced by sowing seeds extracted from morphologically immature fruits.

4. Conclusion

The conducted studies allowed to establish the most acceptable methods of pre-sowing seed treatment. Thus, with the X-ray method, a complete characteristic of the viability of 18 studied species, features of internal development and structure of seeds was obtained. The results of X-ray and crushing were almost identical, the maximum number of the studied species have viable and good-quality seeds, and both crushing and X-ray revealed larvae in the seeds of *C. songarica C. Koch* and *C. calicina* Peterm., which naturally affected the soil germination. The species of Baltic origin *C. insularis* sp. nov. showed high results of soil germination (92.0%), and the minimum indicators were in hawthorns from the Far East.

Treatment of hawthorn seed coats with 96% sulfuric acid in all cases revealed quite good results, especially at 20- and 30-minute exposures. Hydrothermal treatment at high exposures is not acceptable for hawthorn seeds, especially for species with small seeds. During scarification, seeds with damaged pericarp spoil and are damaged by insects when left in the soil for a sufficient period of time, resulting in low seed germination. Positive results in the form of early and uniform emergence of shoots were obtained from seeds extracted from fruits that had not reached morphological ripeness, which is also confirmed by studies by Belarusian scientists when testing 14 species of hawthorn. Our research results are consistent with the data of foreign authors who studied pre-sowing treatment of hawthorn seeds (Gokturk and Yilmaz, 2015; Gokturk et.al., 2017; Ertekin, M., 2017; Mukhametova and Mukhortov, 2018).

Thus, for determining the quality of hawthorn seeds, which have a hard seed coat and a long germination period, the most acceptable methods were crushing and X-ray. In accordance with the dispersion analysis conducted on the weight of seeds, it is possible to conclude about the genotypically determined heredity of the trait.

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