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SELECTING BLACK CURRANT HYBRID SEEDS IN THE BREEDING PROCESS USING X-RAY

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ABSTRACT

The article describes the process of using soft-beam microfocus radiography for processing hybrid seeds of black currant in order to determine their qualitative characteristics. The studies were carried out using the PRDU-02 X-ray unit. For a more thorough analysis of small seeds, an X-ray microscope RM-01 was used. Soft-beam microfocus radiography is a gentle procedure for seeds, since it does not destroy their structure, and they fully retain their viability and are suitable for further use. It was found that even visually completely developed seeds have internal hidden defects, such as seed rotting, detachment of the shell from the cotyledons and underdevelopment. In general, the viability of seeds of different black currant varieties was at a high level and amounted to 85.7-91.8% of the total number of seeds studied. The largest number of completely developed seeds was revealed for the Il'yaMuromets variety - 91.8%, the smallest for the Binar, Peterburzhenka and Yadryonaya varieties - 85.7%. Microfocus radiography of black currant seeds showed that their viability was within the same limits as revealed by germinating them in laboratory conditions. Thus, the method of soft-beam microfocus radiography in determining the quality of hybrid seeds of black currant can be successfully used in the breeding process.

Keywords: seeds; black currant; varieties; soft beam microfocus radiography.

1. INTRODUCTION

Black currant berries contain minerals, proteins, acids, fiber and pectin, carbohydrates, vitamins and are essential in human nutrition. In Russia black currant berries cultivation accounts for almost half of the total amount of collected berries (45-47%). But unfortunately, 72% of berries are picked in private households. If we consider the production of berries on an industrial scale, black currant occupies an honorable third place [1]. Till now scientists have created many black currant varieties adapted to different growing zones, but varieties tend to become obsolete over time. We need new varieties that are resistant to diseases and pests, and also suitable for mechanized care and harvesting. New methods are increasingly being included in the selection process, research methods are being improved, new equipment and devices are being used. Hybrid seeds are known to be used for developing new varieties, and the quality of seeds used for this purpose directly affects the life of plants grown from them. Healthy, completely developed seeds produce high quality plants. It is no secret that the existing methods for determining the quality of seeds and their viability are destructive. The seeds become unsuitable for further selection work. But there is another method that does not destroy the seeds; it is soft-beam microfocus radiography. It is successfully used in the quality analysis of the seeds of field and vegetable crops [2, 3, 4, 5], in horticulture it is used for the quality control of the seeds of fruit crops, such as apple, pear, plum, cherry plum and cherry [6, 7]. The method is widely used in fruit crop nurseries during plant grafting and in viticulture [8, 9, 10]. During the period from 2017 to 2021 we conducted similar studies in breeding berries for the first time [11].

The purpose of the research is to determine the possibility of using soft-beam microfocus radiography on black currant seeds to determine their viability and quality.

2. MATERIALS AND METHODS

The experiments were carried out on the basis of the Electrotechnical University (Federal State Autonomous Educational Institution of Higher Education "St. Petersburg State Electrotechnical University "LETI" named after V.I. Ul'yanov (Lenin)" in 2017-2021. Black currant seeds were obtained at the breeding site of the research base "Krasnaya Slavyanka" of the Institute of Agroengineering and Environmental Problems. The analytical studies were conducted on the basis of the Institute of Agroengineering and Environmental Problems of Agricultural Production (IAEP - a branch of FSBSI Federal Scientific Agricultural Engineering Center VIM). The seeds of seven black currant varieties (Bagheera, Binar, Veloy, Il'yaMuromets, Orlovskiy waltz, Peterburzhenka, Yadryonaya) underwent radiography. The seeds were selected and glued on special cards (50 seeds on each) (Figure-1).

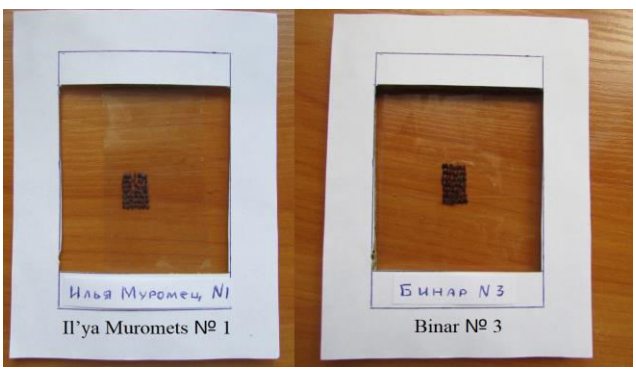


Figure-1. Black currant seeds glued on the cards.

The experiments were laid in threefold repetition 50 seeds in each. The method of the research is soft-beam

microfocus radiography. Soft-beam microfocus radiography was used as radiation. The studies were carried out using the mobile radiography unit PRDU-02 (Figure-2).

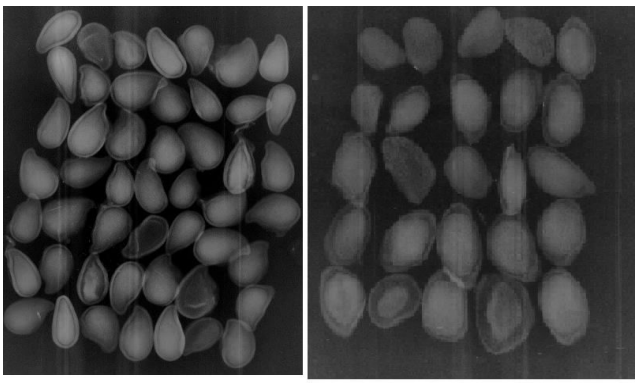
Figure-2. Mobile radiography unit PRDU-02.

The shooting modes for the seeds were experimentally determined (17-18 kV, 65-75 μA with an exposure of 2 minutes). For a thorough and detailed examination of small seeds, an X-ray microscope RM-01 was used.

Mathematical processing of experimental data was carried out by the method of dispersion analysis according to V.A. Dospekhov [12].

3. RESULTS AND DISCUSSIONS

Experiments on seeds of different black currant varieties by X-ray exposure have shown that different internally hidden defects have been found in visually healthy completely-developed seeds. All defects found in seeds can be divided into the following categories: small seeds, detachment of the seed shell from the cotyledons, rotted seeds, under-developed seeds. These defects are presented in Figure-3.



a – Veloy b – Bagheera.

Figure-3. Microfocus X-ray images of black currant seeds.

X-ray examination of Bagheera seeds showed that there were 8.2% of uder-developed seeds, 6.1% with a detached shell, and 4.1% of rotted seeds were found. Defective seeds of Bagheera variety were only 18.4%, completely developed seeds amounted to 81.6%. According to the X-ray analysis of the Binar variety seeds, it was revealed that almost 6.1% of the seeds were most susceptible to rotting, slightly less seeds were susceptible to the detachment of the shell from the cotyledons (4.1%) and underdeveloped seeds were 4.1%. Thus, the total amount of defective seeds was 14.3%, and completely developed seeds amounted to 85.7%. X-ray screening of the Veloy variety seeds showed that they also had hidden defects that were not visible to the eye. The main defect of the Veloy variety seeds was underdevelopment, which amounted to 6.1%. The decay of cotyledons came in second place (4.1%). The detachment of the shell from the cotyledons was minimal and amounted to 2.0%. The total number of identified seed defects for the Veloy variety was estimated at 12.2%, and completely developed seeds amounted to 87.8%. Microfocus radiography of Il'yaMuromets seeds has demonstrated that hidden defects are also present in this variety. The largest number of underdeveloped seeds was 4.1%, then followed the seeds with shell detachment (2.0%) and rotting seeds (2.0%). As a result, 8.1% of defective seeds for this variety were identified, and completely developed seeds amounted to 91.9%. According to the results of the X-ray analysis of the Orlovskiy Waltz variety seeds, it was revealed that the detachment of the seed shell from the endosperm was 6.1%, underdeveloped seeds amounted to 4.1%, and no rotten seeds were found. Thus, there were 89.8% of completely developed seeds, and 10.2% of seeds were with defects. Radiography of the Peterburzhenka variety seeds showed that the most noticeable defects were the seeds underdevelopment and the detachment of the seed shell from the endosperm (both amounted to 6.1%, respectively), the most insignificant defect was the rotting of seeds (2.0%). There were 85.8% of completely developed seeds in this option, and 14.2% of seeds were with defects. As for the Yadryonaya variety, it was revealed that both rotting and detachment of the seed shell

from the endosperm were 4.1%, but the underdevelopment of seeds was 6.1%. As a result, there were 14.3% of defective seeds, and 85.7% of completely developed ones.

The results of X-ray exposure of seeds of all the black currant varieties under study are presented in Table-1.

Table-1. Seeds of various black currant varieties with defects detected by soft-beam microfocus radiography, 2021.

Variety	Underdeveloped seeds		Rotten seeds		Seeds with a detached shell		Completely developed seeds		HCP05
	pcs.	%	pcs.	%	pcs.	%	pcs.	%	
Bagheera	2	4.1	2	4.1	1	2.0	44	89.8	0.67
Binar	2	4.1	3	6.1	2	4.1	42	85.7	0.78
Veloy	3	6.1	2	4.1	1	2.0	43	87.8	0.59
Il'yaMuromets	2	4.1	1	2.0	1	2.0	45	91.8	0.62
Orlovskiywaltz	2	4.1	0	0.0	3	6.1	44	89.8	0.71
Peterburzhenka	3	6.1	1	2.0	3	6.1	42	85.7	0.80
Yadryonaya	3	6.1	2	4.1	2	4.1	42	85.7	0.68

The reliability of the X-ray examination of the seeds of different black currant varieties was confirmed by laboratory germination of seeds according to State Standard GOST 12038-84 "Seeds of agricultural crops. Methods for determining germination". Germination of the seeds in laboratory conditions showed that their viability was within the same limits as revealed by microfocus radiography. The results obtained on the viability of seeds of different black currant varieties are shown in Table

Table-2. Viability of black currant seeds, determined by the method of laboratory germination and microfocus radiography, 2021.

Varieties	Laboratory germination		Microfocus radiography		HCP_{05}
	pcs.	%	pcs.	%	
Bagheera	43	87.8	44	89.8	1.87
Binar	42	85.7	42	85.7	1.50
Veloy	44	89.8	43	87.8	1.78
Il'yaMuromets	44	89.8	45	91.8	1.65
Orlovskiy waltz	43	87.8	44	89.8	1.70
Peterburzhenka	42	85.7	42	85.7	1.56
Yadryonaya	43	87.8	42	85.7	1.69

Thus, the method of soft-beam microfocus radiography for detecting hidden defects and determining the quality indicators of black currant seeds works and can be successfully used in the breeding of berry crops.

4. CONCLUSIONS

a) The method of microfocus radiography of seeds can be successfully used in the breeding of different black currant varieties to determine their qualitative characteristics and viability.

b) The X-ray method allows to determine the internal hidden defects of seeds of different black currant varieties that are not visible externally.

c) The radiographic method does not destroy the seeds and allows using them for further work.

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