Prospects for the use of microwave technologies in the production of oilseeds and their processing

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Abstract. According to the analysis of the distribution of acreage in Krasnoyarsk Region, there has been a noticeable increase in the area of oilseeds, including camelina, recently. This is due not only to the emergence of zoned varieties, but also to an increase in the export of seeds abroad. The rate of production of vegetable oil is increasing with the introduction of various technologies, for example, physical impact on the seeds of these crops. However, oilseeds are susceptible to disease. Agrotechnical and chemical methods of treatment are used to disinfect seeds. At Krasnoyarsk State Agrarian University, rational modes of pre-sowing treatment of camelina seeds in an ultrahigh-frequency electromagnetic field have been established. They are aimed at disinfecting seeds, enhancing their growth, as well as plant development and, ultimately, obtaining environmentally friendly products. To implement this technology, a plant has been developed with a capacity of about 35 kg/h on camelina. Due to the fact that the sown area allotted for oilseeds in different farms of Krasnoyarsk Region has increased in recent years from several hectares to several thousand hectares, it can be assumed that the productivity of the plant we have developed is insufficient. Consequently, on the basis of the results obtained over many years, it is necessary to develop a plant capable of providing not only operating parameters, but also uniformity of seed treatment, and most importantly, taking into account the growing interest in oilseeds, productivity

As the dynamics of change in the cultivated areas allotted by agricultural enterprises of Krasnoyarsk Region of all types of property for oilseeds shows, in the period from 2015 to 2019 there was an increase from 34.61 to 156.01 thousand hectares, i.e. by 4.5 times, including areas for camelina from 0.24 to 0.5 thousand hectares, i.e. by 2 times. At the same time, the gross harvest of oilseeds for the specified period increased by 7 times, and camelina seeds by 5.6 times (table 1) [1, 2, 3].

Table 1. Acreage and gross yield of oilseeds, including camelina, in Krasnoyarsk Region.

| Year | Acreage, thousand hectares | Of these camelina | Gross yield, Thousand c | Of these camelina |
|------|---------------------------|-------------------|-------------------------|-------------------|
| 2015 | 34.61                     | 0.24              | 319.07                  | 0.93              |
| 2016 | 35.47                     | 0.18              | 413.8                   | 1.48              |
| 2017 | 61.27                     | 0.18              | 765.39                  | 1.98              |
| 2018 | 118.36                    | 0.29              | 1793.5                  | 2.94              |
| 2019 | 156.01                    | 0.50              | 2254.87                 | 5.21              |

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The growing interest of agricultural producers in camelina is associated, first of all, with resistance to unfavorable environmental factors, which allows it to be cultivated in various soil and climatic conditions of Krasnoyarsk Region, almost everywhere. In the region, the spring form of camelina is often cultivated, while there are zoned varieties, such as “Chulymsky” and “Uzhursky”. In the region, camelina is grown by LLC “Zarya” in Minusinsky District, Federal State Unitary Enterprise “Mikhailovskoe” in Uzhursky District and a number of peasant farms in Uyarsky District. Camelina seeds are used to obtain oil that meets the requirements for food quality. The oil content in seeds varies depending on the variety, meteorological conditions, the spring growing season, cultivation conditions and the agricultural technology used. The oil yield during cold pressing is 18...20%, with repeated hot pressing, another 5...7% comes out. As by-products in the production of vegetable oils from camelina seeds, cakes and extraction meals are obtained, which contain a large amount of protein and are used for animal feed. 100 kg of cake contains 115 feed units; 1 kg contains 170 g of digestible protein [4].

In general, oilseed processing in Krasnoyarsk Region is currently underdeveloped, so most of the oilseeds, including camelina, are sold to other constituent entities of the Russian Federation, as well as abroad: Mongolia, China, and Latvia [5]. However, in 2020 LLC “Khozyain” (Achinsk) began the production of rapeseed oil by cold pressing: the seeds are pre-cleaned, pressed, and the resulting oil is filtered. All nutrients are preserved in unrefined oil. This year LLC “Khozyain” is planning to produce more than three thousand tons of products. Considering the high added value of the product, the enterprise is increasing its rapeseed processing capacity. In addition, work is underway here on the creation of a large logistics center for sending seeds for export, a new grain storage is being built, the sump of wagons on the railway tracks is being modernized, business relations have been established with partners from abroad. Today, the main buyer of rapeseed oil is China, but there are supplies to Mongolia, Kazakhstan and Uzbekistan [6].

Krasnoyarsk State Agrarian University has developed a technology for two-stage pressing of small-seeded vegetable raw materials, as well as a universal press, in order to perform technological processes of two-stage pressing of seeds [7]. They can be used to produce oil from oilseeds. The proposed technology with the use of a new universal press makes it possible to produce high-quality products by the cold pressing method, bringing the residual oil content in the cake to 3-5%.

However, oilseeds are susceptible to diseases such as black stem, downy mildew and powdery mildew, gray mold, Alternaria leaf mold, and in winter crops, in addition, bacteriosis of roots and Fusarium mold.

For disinfection of oilseeds, mainly agricultural techniques are used, the timely and targeted use of which can significantly reduce the harmfulness of diseases, but the problem is that the seeds are infected with several infections at the same time, for disinfection of each of which, most often, it is necessary to use a separate drug for disinfection.

For over 40 years, Krasnoyarsk State Agrarian University has been developing microwave technologies that are aimed at disinfecting seeds, enhancing their growth, as well as developing plants and ultimately obtaining environmentally friendly products [8-16]. Before processing, the seeds are pre-moistened, due to the fact that the time interval between moistening and processing with ET SHF is within 3-5 minutes, the seeds are “wetted” over the surface, which in turn allows heating more moist components of the treated seeds and directly seed infections located on the surface of the seed.

Earlier we have established rational modes of pre-sowing treatment of seeds of camelina with ET SHF [11 - 12], we have proposed original technologies and designs of microwave installations for their implementation. Camelina seeds, pre-moistened to 20.0%, are kept for 3 - 5 minutes and processed in a ET SHF with a processing mode: the specific power of the microwave field is 2548 W/dm², exposure is 30 s, the final seed heating temperature is 46.8-49.9°C. Laboratory seed germination is increased by 14.5% compared to control. At the same time, seeds are disinfected: Alternaria decreases by 16%, peronosporosis - by 33.33%, white rot - by 17.24%, bacteriosis - by 29.63%.

The productivity of the microwave installations developed by us on the basis of one microwave oven [13] is about 35 kg/h on a camelina (figure 1). Assuming the average acreage sown by one agricultural producer under camelina equal to 100 hectares (actually 500 hectares were sown in 2019), at a camelina
seed seeding rate of 8 to 13 kg/ha (we take an average of 10), the required operating time of the microwave installation will be 28.57 hours or about 3.5 shifts. If you make an early pre-sowing microwave treatment of seeds with a continuous sowing cycle, you can avoid a decrease in germination and a disinfecting effect.

Figure 1. Microwave installation for heat treatment of bulk dielectric materials: 1 - storage hopper with a dispenser for feeding seeds into the working chamber; 2 - loading window; 3 - electric drive of the screw conveyor; 4 - reduction gear; 5 - casing of the screw conveyor; 6 - step-down transformer 220/12 V; 7 - screw conveyor of original design; 8 - microwave camera with a control unit; 9 - unloading window; 10 - hopper-storage of the processed seed material; 11 - installation frame [13].

Considering the fact that the acreage allotted for rapeseed in different farms of Krasnoyarsk region in recent years amounted from several hectares to several thousand hectares (ZAO Krutoyarskoye - 808 hectares, PFE Veikhley S.A. - 1376 hectares, ZAO Tagarskoye - 8000 ha), we can conclude that the productive capacity of the microwave installation developed is not enough.

For example, in order to provide the cultivated area of 1000 hectares with treated seeds, at a seeding rate of rapeseed of about 10 kg, the required performance of the microwave installation of about 350 kg/h is obtained.

After reviewing microwave installations of different productive capacity [17], for such productive capacity, the microwave installation “Barkhan” can be used (figure 2) [17].

Frying of seeds and sunflower kernels, pistachio nuts, almond nuts, peanuts, and more, drying of cereals, dry mixture, animal feed, and so forth are carried out on it in addition to pre-sowing seed treatment.

Microwave technologies have also found wide application to increase the quantity and quality of oil in the processing of oil seeds for oil and cake in Kuban [19].

As a result of our research, we found that the “hard” mode: specific power $P=2548$ W/dm$^3$, treatment time in the microwave field 90 s, at a final seed heating temperature of 79.5°C, used for pre-sowing treatment of camelina seeds (option No. 1) [11] may prove to be an effective mode for heating seeds before pressing the oil.
It was established that the acreage allocated by agricultural enterprises of Krasnoyarsk region of all types of ownership for oilseeds from 2015 to 2019 increased from 34.61 to 156.01 thousand hectares, i.e. by 4.5 times, including including areas for camelina from 0.24 to 0.5 thousand hectares, i.e. by 2 times. At the same time, the gross harvest of oilseeds for the specified period increased by 7 times, and camelina seeds by 5.6 times.

Krasnoyarsk State Agrarian University has developed, researched and tested technologies that make it possible to increase the efficiency of the production of oilseeds (rape, camelina, mustard) and their processing: microwave technologies for pre-sowing seed treatment in order to disinfect them and improve sowing qualities; two-stage pressing of seeds and cake by the method of cold pressing, and also scientific work to study the modes of microwave heating of seeds before pressing is carried out, the introduction of which is important in connection with the increasing demand of foreign countries for both oilseeds and their processing products.

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