Biological diversity of non-traditional oil crops

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Abstract. The article presents the results of a study of non-traditional oilseeds of the family Brassicaceae (camelina, crambe) and the Asteraceae family (safflower, ramtil) in the Middle Volga region. The crop productivity was studied, which was high and varied in the range of 1.35–2.77 t/ha. The oil content in the seeds ranged from 28.3 % in safflower to 43.1 % in crambe. The fatty acid composition of these crops is used for various applications. A high content of erucic acid of 59.3 % was noted in the oil seeds of crambe, 2.92 % in the seeds of camelina. A high content of erucic acid (58.9 %) in the oil of crambe allows it to be used for the production of biodiesel. A sufficiently high content of linolenic (35.6 %), oleic (13.7 %) and a low content of erucic (up to 3.1 %) acids allows using camelina oil for food purposes. The content of erucic acid in safflower oil is reduced to trace values 0.03 %, which allows it to be attributed to valuable edible oils. The fatty acid composition of ramtil oil seeds is represented by a high content of linoleic acid (79.3 %). Ramtil oil can be considered as a valuable source of omega-6 essential fatty acids.

1. Introduction
The climatic conditions of the Russian Federation make it possible to grow almost the entire spectrum of oilseed crops, the most common of which are sunflower, soybean and rapeseed, which occupy more than 77 % of the area under oilseeds [1].

Diversification of the crop industry, climate aridization, expanding the range of products and reorienting markets, developing new types of oilseed production for food and industrial vegetable oils, for the production of biodiesel fuel determines the need to expand the range of oilseeds grown, paying attention to non-traditional crops. These include camelina, crambe (Brassicaceae family), safflower, ramtil (Asteraceae family).

Interest in them is due to the special fatty acid composition of the oil and the possibility of their multifaceted use. The vegetable oils obtained from them make up, on the one hand, the basis of rational human nutrition, and on the other hand, they are the necessary raw materials for various industries [2, 3].

Camelina is an unconventional oilseed crop of spring and winter form. Interest in camelina is due to the fact that it successfully combines the high potential seed yield (up to 2.5 t/ha) with a high content of drying oil (39–45 %) for both food and technical use [3, 4].

In relation to the content of α-linolenic acid (up to 36–41 %), camelina oil is close to linseed oil and is characterized by a relatively low content of erucic acid (from 1.5 to 4.2 %). The optimal ratio (2:1) of omega-6 and omega-3 polyunsaturated fatty acids favorably distinguishes this oil from the oils of other plants. This ratio is recommended for the diet of people with high cholesterol in the blood [2, 4].
Camelina oil, due to the relatively high content of long chain fatty acids (eicosenic and erucic, totaling up to 17–24 %) is used to produce renewable fuel–biodiesel [5].

The agronomic value of camelina lies in its flexibility in terms of natural conditions. It can grow in a wide range of hydrothermal conditions. It does not require massive use of pesticides, is a good soil phytosanitary and a precursor for other crops [6].

Crambe is a high-oil (fat content in seeds up to 45-48 %) crop mainly for technical use, associated with the presence of high erucic acid content in oil (up to 60 %). Crambe oil is used in the chemical and paint industry, for the production of plastics, drying oils and lubricating oils, as well as for the production of biodiesel [7].

Numerous trials of crambe in Russia and abroad have shown its high productivity (up to 3.5 t/ha), adaptability, unpretentiousness to soil and drought tolerance [2, 7, 8].

The aerial mass of crambe can be used as a sideral culture along with white mustard and oil radish [7].

Safflower is a fairly new culture for Russian agricultural producers. Its market is only being formed, but is developing rapidly. Until recently, the history of safflower was associated with the use of only its flowers, from which the dye carthamine was extracted [9].

At present, when speaking about the advantages of safflower, firstly, its importance as one of the sources of world production of vegetable oil should be noted.

Safflower seeds contain up to 50–56 %, and fruits up to 25–36 % of oil, which mainly consists of linoleic acid with a very low content of linolenic, as a result of which it is an almost ideal semi-drying oil and is widely used in food and technical industry [10, 11].

Safflower is one of the most heat-resistant and drought-tolerant crops, which tolerates air and soil drought well and fully complies with the microzone conditions of the arid Middle and Lower Volga [12].

Ramtil is the oldest oilseed culture in East Africa and Asia. Its seeds contain up to 43 % of oil, which is used for food and technical purposes. The main component of the oil is polyunsaturated linoleic acid and a large amount of vitamin E [13].

In addition, ramtil is a good honey plant and can be used as a sideral and silage culture, capable of forming up to 450 kg/ha of green mass. Culture seeds are used to feed birds (crossbills, parrots and others) [14].

In terms of its biological properties, ramtil is characterized by resistance to drought and elevated temperatures, as well as high responsiveness to additional moisture [15].

The biological characteristics of non-traditional oilseeds allow them to grow in a wide range of soil and climatic conditions. They are well adapted to cultivation both in regions with high relative humidity and sufficient rainfall, and with moderate temperatures during the growing season and in areas with insufficient humidity.

In this regard, the goal of our research was to study the formation of the productivity of these crops in the Middle Volga.

2. Methods and materials
The studies were conducted in 2017–2019 in the fields of the Penza Institute of Agriculture. The climate of the Penza region, where the institute belongs, is temperate continental, where 4 out of 5 years are arid. The amount of annual precipitation varies from 350 to 750 mm.

The vegetation period of crops in 2017 was characterized as insufficiently moistened, the hydrothermal index amounted to 0.8 units at an average daily temperature of 22.3 °C.

The most severe vegetation conditions were noted in 2018, which was characterized as acrid arid. The hydrothermal coefficient here was only 0.4 at average daily temperatures of 19.3 °C.

The growing season in 2019 also proceeded in arid conditions with the hydrothermal coefficient of 0.7 and an average daily temperature of 17.6 °C.

Evaluation of crop productivity was carried out according to the guidelines for oilseeds [16].
Oil content of seeds and their oil and fat composition were determined in the biochemical laboratory of the Penza Institute of Agriculture using the chromatography method according to current GOSTs.

3. Results
A comparative study of crops in the agroecological conditions of the Penza region showed that their productivity reached high values of 1.35–2.77 t/ha, which indicates the full realization of the yield potential, regardless of the conditions of the year (Table 1).

| Crop       | Yield [t/ha] | Average |
|------------|-------------|---------|
|            | 2017        | 2018    | 2019    |        |
| Camelina   | 1.86        | 1.79    | 1.89    | 1.85   |
| Crambe     | 2.89        | 2.64    | 2.79    | 2.77   |
| Safflower  | 1.32        | 1.28    | 1.45    | 1.35   |
| Ramtil     | 1.72        | 1.74    | 1.78    | 1.75   |
| HCP05      |             |         | 0.05    |        |

Crambe formed a high yield, which averaged 2.77 t/ha. Its highest productivity was noted in more favorable vegetation conditions of 2017 (2.89 t/ha). Under stress factors of 2018, namely, insufficient moisture, crop productivity decreased to 2.64 t/ha.

The productivity of camelina was quite high and amounted to 1.85 t/ha. Camelina in different climatic years, on average, realizes its yield potential to 89.1 %, which indicates its high adaptability and stability.

The average yield of safflower seeds for 2017-2019 was 1.35 t/ha. The maximum yield was obtained in 2019 and amounted to 1.45 t/ha. Safflower formed a low yield in 2018 (1.28 t/ha) under arid vegetation conditions with a hydrothermal index of 0.4.

The yields of ramtil for years did not change significantly and ranged from 1.72 to 1.78 t/ha, which indicates its stability and adaptability. On average, over the years of research, crop yields were 1.75 t/ha. The highest value (1.78 t/ha) was reached in the arid conditions of 2018.

The average fat content in seeds over the years of study was high. The highest oil content was possessed by the seeds of ramtil and crambe (41.7–43.1 %). The fat content in camelina seeds was 40.9 % (Table 2).

Along with productivity, quality indicators of seeds are of great importance in assessing crops: huskiness and seed size.

| Indicators          | camellina | crambe | safflower | ramtil |
|---------------------|-----------|--------|-----------|--------|
| Oil content [%]     | 40.9      | 43.1   | 28.3      | 41.7   |
| Oil yield [t/ha]    | 0.67      | 1.06   | 0.34      | 0.65   |
| Mass of 1000 seeds [g] | 1.32   | 8.97   | 44.5      | 3.72   |
| Huskiness [%]       |           |        | 39.9      | 24.7   |
| Vegetation period [days] | 295    | 97     | 116       | 119    |

The ramtil seeds were quite large and of high quality, the weight of 1000 seeds was 3.72 g. The huskiness of the seeds was low and averaged 24.7 %.

The mass of 1000 safflower seeds was 42.5 %. The seeds were characterized by rather high huskiness (39.9 %), the value of which affects the oil content of seeds. The fat content in safflower seeds is 28.3 %.

In modern conditions, from the point of view of increasing the efficiency of oilseed production, a new promising direction for the use of oilseeds for biodiesel production is developing, due to the relatively high content of long chain fatty acids (eicosen and eruca ones).
The most suitable crop for this purpose is crambe, the content of erucic acid in the oil which is high and amounts to 58.9 % (Table 3).

The high content of eicosenoic acid (15.5 %) in camelina seeds in total with eruca allows using camelina oilseeds for biodiesel production.

| Fatty acids | Camelina | Crambe | Safflower | Ramtil |
|-------------|----------|--------|-----------|--------|
| myristic    | 0.1      | 0.1    | 0.1       | 0.04   |
| palmitic    | 5.2      | 1.4    | 6.4       | 8.2    |
| stearic     | 2.3      | 0.6    | 2.5       | 5.9    |
| oleic       | 13.7     | 14.1   | 12.3      | 7.7    |
| linolic     | 18.2     | 7.9    | 76.6      | 79.3   |
| linolenic   | 35.6     | 6.1    | 0.13      | 0.4    |
| eicosenoic  | 14.8     | 1.7    | 0.2       | 0.9    |
| erucic      | 3.1      | 58.9   | 0.03      | –      |

A sufficiently high content of linolenic (35.6 %), oleic (13.7 %) and a low content of erucic (up to 3.1 %) acids allows using camelina oil for food purposes.

The concentration of linoleic and linolenic acids in the seeds of camelina is high and is 18.2 and 35.6 %, respectively. The ratio of these acids is 2: 1, which allows using its oil as a diet.

The oleic acid content in the oil seeds of saffron milk and crambe are at the same level of 13.7 and 14.1 %, respectively.

The oleic acid content in the oil seeds of camelina and crambe are at the same levels of 13.7 and 14.1 %, respectively.

Safflower oilseeds were characterized by a very high content of linoleic acid (76.6 %), with a very low amount of linolenic acid (0.13 %).

The amount of saturated acids is 8.9 %, the largest share of which is palmitic acid (6.4 %). The content of erucic acid is reduced to trace values 0.03 %, which allows attributing safflower oil to valuable edible oils.

The fatty acid composition of the ramtil oilseeds is mainly represented by a high content of linoleic acid (79.3 %). The content of unsaturated acids of oleic and linolenic is 7.7 and 0.4 %, respectively. The content of saturated acids, palmitic and stearic, in the composition of ramtil oil is quite high and amounts to 8.2 and 5.9 %.

Due to the fatty acid composition of oilseeds, ramtil oil can be considered as a valuable source of essential omega-6 fatty acids.

The value of ramtil oil for a healthy diet can be enhanced by blending with natural vegetable oils, which are characterized by an increased content of omega-3 fats, such as camelina oil.

4. Conclusion

Thus, the studies showed that all crops in contrasting conditions of the Penza region formed a high and stable oilseed yield (up to 1.35–2.77 t/ha) with a high content of high-quality oil (28.3–43.1 %), which determines the relevance of their cultivation.

The expansion of biological diversity through the introduction of non-traditional crops will significantly increase the cultivation area and production of oilseeds, while reducing agro-ecological tension and expanding the range of products for various uses.

5. References

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