Productivity of oil crops in the conditions of forest-steppe zone of the Republic of Ingushetia

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Abstract. The paper presents the study conducted in the forest-steppe zone of the Republic of Ingushetia on the productivity of new oilseeds in order to recommend their production as an alternative to traditionally grown crops. The morphobiological characteristics, features of growth and development of spring canola, sunflower, mustard, soybeans and camelina, and their yields are distinguished and described.

1. Introduction
The agro-industrial complex is a very heterogeneous system with the concentration of a variety of different complexes. Among them, the oil complex occupies an important place.

Production efficiency is improved by cultivating several crops that use edaphoclimatic resources differently and increase the overall productivity. At present, it is relevant to search for new sources of obtaining physiologically and biologically valuable products from alternative raw materials.

Here, oilseeds play a major role. The production of oilseeds in Russia cannot fully provide the population with vegetable oil (60–70 % only) [7]. Therefore, in order to reduce the dependence of oily raw material production volumes on edaphoclimatic conditions of a particular year agricultural producers need to expand the range of cultivated oil crops.

As an alternative it is possible to consider such promising cultures as soybean, canola, mustard, sunflower, camelina and others. The introduction of new oilseeds into agricultural production is quite promising.

The Ingush Research Institute of Agriculture conducted studies on the productivity of various oilseeds in the forest-steppe zone.

The purpose of this work is to study the possibility of growing various oilseeds in the forest-steppe zone of the Republic of Ingushetia with their subsequent recommendation to agricultural producers.

The main objective was to study the peculiarities of growth and development of spring canola, sunflower, mustard, soybean and camelina, as well as their yield.

2. Methods and materials
Modern scientific methods of field experiments were used during field tests. Accounting, analyses and experimental observations were conducted according to standard experimental techniques. A comprehensive comparative analysis of different oilseeds in relation to forest-steppe conditions for each new seed production variety was carried out. The validity of results of plant growth and development is confirmed by the use of modern techniques.

Frequency of the experiment – triple analysis. Arrangement of variants in experiments – random. Seeding timing – optimal for each culture. The environmental test has been conducted for 3 years.
The experimental site is located near the Nesterovskoe village of the Republic of Ingushetia. Soils of the test site – medium, middle loamy, weakly leached chernozem on the pebble bed with pH 6.9 and humus content of up to 4.9 % (according to Turin) and sufficient amount of NPK labile forms. In terms of its agrophysical and agrochemical properties, the soil of the test site is quite favorable for the cultivation of oilseeds.

Weather conditions (mean air temperature and mean rainfall) of the growing period were characterized as long-term annual average. The agricultural machinery satisfied the production conditions developed on the basis of local agronomic recommendations for the zone.

Research objects – different varieties of oilseeds:
- sunflower: Master, Flagman, Lakomka, Rodnik, Buzuluk;
- canola: Yubileyny, Radical, Start;
- soybean: Arleta, Sparta, Selekt 101, Korana;
- spring camelina: Crystal, Debut;
- mustard: Rapsody, Talisman, Etalon.

3. Results
Oilseeds include a large group of plants with high-fat seeds. They can be defined by several key figures:
- widespread use in various industries;
- positive effect on phytosanitary condition of crops;
- excellent precursors for different cultures.

The production of oilseeds in the Republic of Ingushetia faces the same problems as the whole of Russia. These include non-compliance with crop rotation, use of poor quality seed, reduction of soil fertility, development of cultivation technology, lack of necessary equipment and specialists, spread of diseases and harmful substances [7]. If all these conditions are satisfied, the production of oilseeds will be highly profitable and cost-effective.

Priority should be given to the selection of ecologically plastic, highly productive fast-growing oilseeds adapted to local conditions and most fully realizing the soil and climate potential of the region.

The introduction of these crops into production should be based on long-term study conducted to identify the possibility of growing them in the region.

**Sunflower.** For a long time, sunflower has been one of the frequently grown oilseeds. Sunflower oil is used for food and technical purposes, has high nutritional value for human body, contains vitamins, phosphatides, linoleic and oleic acids.

Sunflower is also widely used as a feed culture. It is a silo with high nutritional value, equal to corn, as well as seed cake and oil seed coarse meal, which are high-protein feed [3].

However, the limiting factor for sunflower cultivation is its low yield. The yield of many farms of the Republic of Ingushetia is less than 10c/ha. Besides, sunflower strongly drains the soil and its return into crop rotation is possible only in 7–8 years.

Therefore, in our research we tried to study and propose new alternative cultures.

Due to the need to develop biodiesel, these studies are becoming more relevant.

The analysis of the sunflower crop structure shows that in experimental crops the studied varieties are characterized by sufficiently high yields compared to production crops (Table 1).

The height of the studied varieties ranges within 170–213 cm. The highest was Master variety, then Flagman. The anthodium diameter varies from 20 to 23 cm.

By the weight of seeds from one anthodium, the Master variety showed the highest result – 72.8 g, while the Buzuluk variety – the lowest – 62.5 g.

The thousand-seed weight is led by the Lakomka variety – 60.5 g and Master – 59.7 g. According this indicator, the Buzuluk variety is the outsider.
Table 1. Morphobiological characteristics and yield of sunflower plants in forest-steppe zone of the Republic of Ingushetia

| Sunflower varieties | Mean height, cm | Average anthodium diameter, cm | Vegetative period, days | Seed weight from one anthodium, g | Thousand-seed weight, g | Actual yield, c/ha |
|---------------------|-----------------|-------------------------------|------------------------|----------------------------------|------------------------|-------------------|
| Master              | 213.2           | 23.3                          | 94                     | 72.8                             | 59.7                   | 16.7              |
| Flagman             | 211.0           | 22.8                          | 92                     | 69.8                             | 54.5                   | 16.2              |
| Lakomka             | 194.2           | 21.5                          | 90                     | 68.5                             | 60.5                   | 17.5              |
| Rodnik              | 175.0           | 20.4                          | 78                     | 64.5                             | 53.2                   | 13.7              |
| Buzuluk             | 170.0           | 20.9                          | 85                     | 62.5                             | 52.2                   | 14.6              |

The Lakomka variety showed the highest yield – 17.5 c/ha, the Master variety lags slightly behind by 0.8 c/ha. The Busuluk variety showed the lowest yield – 14.6 c/ha and the Rodnik variety – 13.7 c/ha, which is 3–4 c/ha less than the leading variety.

**Canola.** Canola is a universal, broad-spectrum culture. Canola oil contains optimal amounts of the necessary acids. In terms of oleic acid content, canola only lags behind olive oil. Canola oil is used in food, confectionery, medical industry.

An important role is assigned to canola meal as a fodder additive, which allows balancing fodder by protein content (use of 1 ton of canola allows balancing 9 tons of mixed fodders by protein content, at the same time the amount of digestible protein in 1 fodder unit increases to 30-40 grams [1].

Besides, canola is a good meliferous plant. Canola plants have a favorable impact on the environment: canola ranks the second in the amount of oxygen released.

Canola is a good precursor to many crops, and its crops contribute to more intense use of farmlands.

The wheat crops on canola are characterized by a 1.5–2 times decrease in the damage with root rot agents, which affects crop growth.

The efficiency of using intermediate canola crops on green fertilizer was also proved, which allows increasing the yield of subsequent cereals by several hundredweight.

In developed countries, canola oil has been used as diesel for more than 20 years. There are also prerequisites for further increase in the volume of canola production for biodiesel in Russia, which should undoubtedly affect the demand for this culture.

Among the three varieties of spring canola, the Start variety has the highest oil content – 47.3 %, and the Radical variety shows lower values – 44.2 % (Table 2).

Table 2. Yield of different canola varieties in forest-steppe zone of the Republic of Ingushetia

| Variety  | Vegetative period, days | Oil content, % | Thousand-seed weight, pcs | Erucidic acid, % | Actual yield, t/ha |
|----------|-------------------------|----------------|---------------------------|-----------------|--------------------|
| Yubileyny| 93                      | 46.4           | 3.5                       | 0.17            | 2.68               |
| Radical  | 95                      | 44.2           | 3.2                       | 0.67            | 2.35               |
| Start    | 97                      | 47.3           | 3.4                       | 0.12            | 2.83               |

By the weight of seeds, the difference is small, this indicator varies within 3.2–3.5 g.

In terms of the yield the Start variety holds the leading position – 2.83 t/ha. The Yubileyny variety gave a yield of 0.15 t/ha, which is less than the Start variety, and the Radical variety is by 0.48t/ha behind the leader.

**Soybean.** Soybean is a high-protein culture. The advantage of such crops is their high carbon content but low protein content. In this context soybean is an ideal culture (up to 50 % of protein and up to 20 % of fat). Soybean protein is identical to animal protein.

The rich chemical composition of soybean makes it possible to use it as food, feed and technical culture. More than 400 types of products are made from soybean, which is considered an almost waste-free culture. Soybean protein ensures perfect balancing of fodders according to nutritional value [4].

Soybean oil is the second most popular after sunflower oil.
Soybean is an optimal precursor for cereals because it is a nitrogen fixer. Its cultivation in crop rotation reduces the need for nitrogen fertilizers.

Soybean is used as a source of healthy nutrition. Soybean protein is more useful than animal protein because it does not contain cholesterol and its use does not reduce vascular elasticity [8].

In Western Europe, soybean consumption as a meat substitute reaches about 4 million tons and this demand is constantly increasing.

The studies of soybean varieties gave the following results:

- by height: the most tall-growing variety was Selekt - 84.2 cm, Sparta (66.8 cm) and Arleta (60.3 cm) are far behind it (Table 3).
- by the number of beans on one plant the difference is not so obvious – 41.3–48.2 beans on one plant, here the Selekt variety has the highest indicators.
- by the height of the lower bean growth, all varieties have almost the same indicators – from 14 to 15 cm.
- Sparta and Arleta varieties – 1.8 and 1.7 t/ha, respectively. The Koran variety has the lowest yield – 1.2 t/ha.
- protein content of the studied varieties is quite high – 39–40 %, except for the Koran, where this value makes 30.2 %. The Koran variety has the highest oil content – 23.4 %, the Arleta and Sparta varieties have the lowest oil content – 21.9 and 21.6 %, respectively.

| Variety   | Plant height, cm | Number of beans on one plant, pcs | Height of lower bean, cm | Thousand-seed weight, g | Actual yield, t/ha | Oil content, % | Protein content, % |
|-----------|------------------|-----------------------------------|--------------------------|-------------------------|-------------------|---------------|-------------------|
| Arleta    | 60.3             | 43.5                              | 15.6                     | 152.3                   | 1.7               | 21.9          | 40.5              |
| Sparta    | 66.8             | 45.8                              | 14.6                     | 156.4                   | 1.8               | 21.6          | 40.1              |
| Selekt 101| 84.2             | 48.2                              | 15.0                     | 156.6                   | 1.5               | 23.3          | 39.4              |
| Korana    | 78.2             | 41.3                              | 15.3                     | 147.2                   | 1.2               | 23.4          | 30.2              |

Camelina. Winter and spring camelina is the new promising culture. Its oil is used in food, paint and coatings, metallurgical industries, as well as in perfumery and medicine, and as fodder in livestock production. For a long time, it has been considered a weed grass, only in the second half of the 19th century it was introduced into agriculture [6].

Camelina is an unpretentious culture with a wide range of applications. There is winter and spring forms of camelina, which in both cases gives good yield, since camelina is resistant to freezing, ice crust, long droughts. This allows it increasing the productivity of mustard, flax, canola.

Camelina seeds contain about 40 % of vegetable fat. Camelina is rich in fatty acids – linoleic, erucal, stearic, etc. High content of vitamin E is its advantage, especially when a human body fights against cancer cells. The use of vitamin A, E, D, K makes its use advisable for children’s food. The growing demand for camelina oil is caused by its demand as raw materials for biofuels, chemical and food industries. Due to the lack of study of this culture, its crops are limited.

Camelina is a rapid and drought-resistant culture, immune to pests (insecticides are not required). They are also weed-clean. The main biological feature of this culture is tolerance to soils, plasticity. The yield of camelina can reach 23–25 c/ha. The potential yield of winter camelina is 23–25 c/ha, spring camelina – 20–22 c/ha. Oil content of winter camelina – 40 %, spring camelina – 45 %. These indicators depend on the weather conditions of the year [6]. Camelina is a good predecessor, returns to crop rotation in 2–2.5 years.

Throughout the environmental test the Crystal variety was more high-yield – 1.53 t/ha. The yield of the Debut variety under the same conditions was by 0.43 t/ha less than the Crystal and made 1.10 t/ha (Table 4).

By the oil content the leader is the Debut variety– 42.3 %, and this indicator for the Crystal variety makes 39.8 %.

The Crystal variety is more high – 66.4 cm, the height of the Debut variety reaches 61.5 cm.
Table 4. Yield of spring camelina varieties in environmental testing

| Variety | Actual yield, t/ha | Oil content, % | Erucic acid, % | Plant height, cm | Thousand-seed weight, g |
|---------|-------------------|----------------|---------------|------------------|------------------------|
| Crystal | 1.53              | 39.8           | 2.8           | 66.4             | 1.5                    |
| Debut   | 1.1               | 42.3           | 2.7           | 61.5             | 1.3                    |

Mustard. Mustard is an oil crop. In terms of its quality the mustard oil is equal to sunflower, and has high food and taste advantages, resistance to oxidation. Mustard seeds contain 34–47 % of oil and white mustard – 25–39 % [2].

Mustard oil has high taste advantages and is also used in perfumery. It has the same low acid index and retains taste properties longer than others. Mustard oil is used as a valuable lubricating oil for motors and equipment, it is possible to process it into biodiesel. Mustard cake contains up to 30 % of protein. The yield of green mass reaches 200 c/ha [5].

Mustard is a spring meliferous plant, it ensures more than 100 kg of honey from 1 hectare. Bees, in turn, contribute to mustard pollination. Therefore, it is necessary to bring apiaries to crops.

Table 5. Yield of mustard varieties in environmental testing

| Variety | Actual yield, t/ha | Oil content, % | Plant height, cm | Thousand-seed weight, g |
|---------|-------------------|----------------|------------------|------------------------|
| Rapsody | 2.1               | 26.2           | 92.5             | 5.0                    |
| Talisman| 1.7               | 28.1           | 88.4             | 4.8                    |
| Etalon  | 1.9               | 25.7           | 101.2            | 4.1                    |

The study covered three varieties of mustard – Rapsody, Talisman and Etalon. The most productive variety was Rapsody – 2.1 t/ha. The Standard variety showed a yield of 1.9 t/ha, which is 0.2 t/ha less than the leader. The smaller yield was shown by the Talisman variety – 1.7 t/ha. However, this variety surpassed the other two and made 28.1 % against 26.2 and 25.7 % in other varieties (Table 5).

Plants of the Etanol variety were higher – 101.2 cm, and the Talisman variety is well behind it – 88.4 cm.

By thousand-seed weight the Rapsody variety showed the biggest weight – 5g, Talisman – 4.8 g and Etanol – 4.1 g.

4. Conclusion

The study showed the relevance of analyzing the oilseeds for the region. Each of them has its own features. Therefore, it is necessary to study them in detail in terms of improving their resistance to drought, frost, diseases and pests, yield, quality of products and other economic and valuable features. The introduction of new types of oilseeds into agricultural production is of great importance and seems quite promising.

The results of the studies show a pronounced degree of their adaptability and ecological plasticity, which under certain natural conditions, in case of droughts or water saturation are able to keep the yield at a stable level.

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