

Competitiveness and Advantages of *Camelina sativa* on the Market of Oil Crops

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ABSTRACT

The article presents the question of the effect of the effectiveness of various elements of cultivation technologies on the competitiveness of *Camelina sativa* and the profitability of its cultivation on acidic, low-fertility sod-podzolic soils. Fertilizers are one of the fast-acting and effective factors in increasing the yield of *Camelina sativa*. It was established that introduction of mineral fertilizers had a significant impact on competitiveness of *Camelina sativa* seeds. Dependence of productivity elements and yielding capacity on crops has been determined. It was established that spring cruciferous crops had different seed productivity. According to the results of conducted research, it was found that the highest seed yielding capacity among spring cruciferous crops had spring *Brassica napus* L., but the oil content in *Camelina sativa* seeds was 46.53%, which is 4.08% more than in *Brassica napus* L. Therefore, oil outcome from the yield of *Brassica napus* L. and *Camelina sativa* was almost the same.

Keywords: competitiveness, technologies, productivity, world market, biofuel, economic, energy efficiency, yielding capacity.

INTRODUCTION

Today, position of Ukraine on the world market of oil crops is marked by growing production indices, an increase in processing capacities, and a rapid tempo of modernization of technological processes. The market of oil crops is currently one of the most promising for our country and the world in general since cultivation of oil crops in Ukraine is a profitable direction of agricultural activity, as the demand for these products is stable and has positive dynamics. Cultivation of oil crops in Ukraine exceeds 16 million tons on an area of 8 million hectares. Every year, approximately 15 million tons of oil crops are used for

oil production, and 4 million tons of oil crops are exported [Juodka et al., 2022; Riaz et al., 2022].

It is not a secret that oil crops are grown in almost all countries of the world, but each country has its own leading oil crop. In Ukraine, such a crop is sunflower, in USA – soybean, in Canada – linseed, in England and India – rapeseed, in Asia and Africa – peanuts. Soy, peanuts, rapeseed, linseed, sunflower and sesame occupy the largest cultivated areas in the world. The world sown area of oil crops, including soy, is more than 150 million hectares, and the world production of oils is about 185 million tons.

Today, Ukraine has a situation where oil crops such as rapeseed, soybean, and sunflower

can be used as raw materials for biodiesel. But the main raw material in the world for the production of biodiesel is rapeseed oil. Currently, 46% of this oil is processed into biodiesel in the countries of the European Union. The production of this type of fuel in 2020 reached about 18 million tons against 5 million tons in 2010. During the last two years, record crops of rapeseed were obtained in Europe, but, despite this, the demand for oil raw materials was not fully satisfied. While in Northern Europe the main feedstock is rapeseed, in Southern Europe the main feedstock for processing into biodiesel oil is soybean and sunflower [Madhav et al., 2020; Yakupoglu et al., 2021; Hryhoriv et al., 2021; Rieznik et al., 2021].

Currently, the main oil crop for biodiesel production in EU countries and Ukraine is winter and spring *Brassica napus* L. According to the forecasts of experts from Secretariat of Coordination Council of the CMU on Agrarian Policy, to replace annual consumption of 1.9 million tons of diesel fuel, are needed 2.14 million tons of biodiesel, for which it is necessary to use 5.5 million tons of *Brassica napus* L. counting the production of 1 kg of biodiesel from 2.4 kg of *Brassica napus* L.

According to EU Biofuel Directive 2003–30, 10% of biofuels should be used by transport in the countries of European Union already in December 2020. Therefore, upon joining EU, Ukraine is obliged to comply with this directive [Megaloudi, 2006; Hryhoriv et al., 2020; Karbivska et al., 2022a].

One of the most promising cabbage oilseed crops is *Camelina sativa*. *Camelina sativa* seed contains 25–46% of drying oil (iodine number 132–153), 28% of protein. The yielding capacity reaches 2.3 t ha⁻¹. The oil is used as a technical and food oil. Fresh oil has good taste, a wonderful aroma, and can be consumed in its natural form. The cake, after special processing, is fed to cattle in small quantities. 100 kg of cake contains 115 feed units. Today, *Camelina sativa* is grown in Ukraine on small areas in Polissia zone [Putman et al., 1993; Tanchyk et al., 2021].

Recently, the demand for *Camelina sativa* as oil crop for the production of biodiesel has grown significantly in Europe, USA and other countries. The culture is valued for its high content of long-chain fatty acids (eicosene and erucic, up to 17–25% in total), which are characterized by high heat of combustion. *Camelina sativa* oil and biodiesel are being used as fuel in engine tests with

promising results. *Camelina sativa* oil is rich in tocopherols: their total amount is 785–821 mg/%, including 26–30 mg/% alpha-tocopherol, 728–756 mg/% gamma-tocopherol, 19–21 mg/% delta-tocopherol and 14–16 mg/% plastochromanol. Beta-tocopherols and tocotrienols were not detected in *Camelina sativa* oil. Physico-chemical indicators of *Camelina sativa* oil: iodine number 132–153; acid value – 0.25–13.2; saponification number 181.2–188.1; solidification temperature – 15–19 °C. The oil has an almond-like taste and aroma [Raczyk et al., 2016; Juodka et al., 2022; Tsyuk et al., 2022].

As it turned out, one can make much more oil from *Camelina sativa* than from canola (a Canadian variety of *Brassica napus* L.). And the prime cost of such oil will be half cheaper than *Brassica napus* L. oil. This is due the fact that the plant does not require careful care, it does not need applying of expensive mineral fertilizers, it is resistant to insects. That is, the crops do not have to be treated with chemicals [Jones & Valamoti, 2005; Megaloudi, 2006; Karbivska et al., 2022b].

MATERIAL AND METHODS

Research was conducted on the basis of the Carpathian State Agricultural Research Station of the Institute of Agriculture of the Carpathian Region of the National Academy of Sciences of Ukraine during 2020–2021. The project was implemented on sod-podzolic soils.

The soil of experimental plots is coarsely dusty medium loamy, sod-podzolic, typical for the given agro-soil area, with the following agrochemical parameters: humus – 2.74%, and its content gradually decreases with depth, number of absorbed bases is on average 11–12 mg-eq. per 100 g of soil, provision of bases – 85%, reaction is slightly acidic (pH of saline solution 5.3–5.4, hydrolytic acidity is negligible). The structure of arable layer is sprayed (lumpy-dusty). That is why, after rains, these soils can float and a crust is formed on them. The soils are moderately supplied with available forms of nitrogen and – weakly movable phosphorus and movable potassium: nitrogen – 5.0–5.6 mg per 100 g of soil, phosphorus – 34–49 mg·kg⁻¹ and potassium – 9.3–10.2 mg per 100 g of soil.

For sowing, was used variety Girskyi of the Institute AIP, adapted for the studied region. As scientists have determined that *Camelina sativa*

is not sensitive to potassium fertilizers [Poliakov, 2011; Hryhoriv, 2020], therefore we studied effect of only nitrogen and phosphorus fertilizers. In the experiment, mineral fertilizers were used in the form of nitroammophoska, ammonium nitrate and granulated superphosphate, which were used for the main tillage. Fertilizer was not applied to the control version, it is based on the natural fertility of the soil. Fertilization of spring rye crops was carried out with nitrogen fertilizers, growth stimulants and microfertilizers according to the scheme of the experiment in the phenological stage of plant development 12–14 according to the BBCH scale.

In our work, we used *Camelina sativa* variety Hirskyi selection of Ivano–Frankivsk Institute AIP of National Academy of Sciences, included in the State Register of varieties suitable for cultivation in Ukraine. Yielding capacity of the seeds declared in the patent is on average 2.1 t·ha⁻¹, green mass – 40.5 t·ha⁻¹ [Abramyk et al., 2003; Karpenko et al., 2022; Hryhoriv et al., 2022a].

Soil tillage on experimental plots during cultivation of *Camelina sativa* is traditional for the growing zone: stubble shelling to a depth of 8–10 cm, plowing to a depth of 22–24 cm, pre-sowing soil tillage except for the factors studied [Syvyryn & Reshetnykov, 1988].

The most important factor of natural environment, which plays a decisive role in yield formation of agricultural crops in most cases, is meteorological conditions which developed during the period of their cultivation. Natural and climatic conditions of Ivano–Frankivsk region contribute to the development of agriculture and cultivation of main agricultural crops.

Weather conditions of Precarpathians are formed under the influence of three main factors

of geographical origin, circulation of air masses and litter surface. An important climate-forming factor of this region is the Carpathians, which affect distribution of air currents near the earth's surface. Precarpathians is a moderately warm and humid area.

Weather conditions during the growing season of *Camelina sativa* in the years of research are presented in Table 1.

The analysis of weather conditions during the ontogeny of spring ryegrass showed that they differed significantly from the average long-term data, which were reflected in the productivity of the crop. According to amount of precipitation, the studied territory belongs to the zone of sufficient moisture. Thus, it was established that amount of precipitation during vegetation period of the crop in the study area, according to Ivano–Frankivsk weather station, averages 544 mm. In some years, amount of precipitation, depending on the frequency of moisture-forming processes and their intensity, varies widely from 430.9 mm (60% of the norm) to 514.2 mm (95% of the norm).

The temperature regime in 2021 was significantly different from the long-term averages. Yes, the average daily air temperature for the period April–August 2021 was 17.3 °C, which was 1.7 °C higher than the average long-term temperature during the growing season. Whereas 2020 turned out to be similar in terms of indices to long-term average. Thus, average daily temperature for vegetation period (April–August) was 15.6 °C, which is by 0.1 °C less than the long-term average.

In terms of atmospheric precipitation amount, the years 2020–2021 also differed significantly from the indices of average monthly long-term air temperature. It should be noted that precipitation amount

Table 1. Agrometeorological indices of 2020–2021 for vegetation period of *Camelina sativa* (according to data of Ivano–Frankivsk weather station)

Indices	Months					For vegetation period
	April	May	June	July	August	
Precipitations, mm, long-term average	47	67	90	84	75	544.0
2020	12.3	120.9	235.9	122.9	22.2	514.2
2021	52.2	86.1	96.2	147.2	49.2	430.9
Average	32.1	113.5	166.1	135.1	35.7	482.5
Air temperature, °C, long-term average	+8.4	+13.8	+17.0	+19.1	+18.2	15.7
2020	+8.8	+11.7	+18.6	+19.1	+19.9	15.6
2021	+13.8	+16.5	+18.5	+19.7	+18.1	17.3
Average	+11.3	+15.0	+8.5	+19.4	+19.0	14.7
Sum of active temperatures, °C (average)	31.7	258.3	475.3	510.3	608.6	2505
Sum of effective temperatures, °C (average)	5.1	71.7	155.3	260.3	302.0	982.0

in May–July period significantly exceeded average long-term indices, which affected the crop yield.

Thus, hydrothermal conditions during 2020–2021 were specific and had a corresponding effect on the growth, development and formation of *Camelina sativa* plant productivity.

Phenological observations were carried out on all variants of the experiments according to methodology of the State Commission for Varieties Testing of Agricultural Crops. Yield accounting was carried out by the method of a continuous accounting plot with conversion into hectare. Evaluation of cultivation technologies influencing competitiveness was carried out according to methodology of Harkavyi, Petrychenko, and Spirin [Harkavyi, 2003; Woźniak, 2019; Möller et al., 2022].

RESULTS AND DISCUSSION

Under modern market conditions of crop production in Ukraine, its competitiveness is of great importance. Traditional technologies for plant production need to be reconsidered at a qualitatively new creative level and analyzed in terms of energy saturation and resource consumption. By this time, many different models of technologies for growing agricultural crops have been developed, and many complexes of machines are used for their implementation. Introduction of new, more adapted to external environment conditions growing technologies into production can significantly increase competitiveness of plant products. Therefore, determining competitiveness of crop

cultivation technologies is a current and urgent task of modern agricultural science.

Results of the research showed that among oil crops from the *Brassica* family, the highest grain yield was provided by spring *Brassica napus* L. and was 0.07 t ha⁻¹ higher than the one by *Camelina sativa*. Productivity of *Sinapis alba* L. and *Brassica juncea* Gzem significantly lower than the one of *Camelina sativa* – 0.26 t ha⁻¹ and 0.47 t ha⁻¹ respectively. However, oil content of *Camelina sativa* seeds was 46.53%, which is 4.08% more than the one of *Brassica napus* L. Therefore, oil outcome from *Camelina sativa* yield was practically the same (1.01 t ha⁻¹) as the one from *Brassica napus* L. (0.91 t ha⁻¹) (Table 2).

The most promising growing technologies are considered to be those which help to reduce energy costs, and increase energy efficiency ratio. We have to note that competitiveness of crop production depends on a number of different factors, including elements of growing technology. Our research results are consistent with other literature data presented for Romanian, Canadian and Polish genotypes [Ciurescu et al., 2016; Krzyżaniak et al., 2019; Zajac et al., 2020], while they provided higher rates in protein and fat, but slightly lower index in fiber for Italian genotype [Peiretti & Meineri, 2007]. Ciurescu [2016] observed similar protein, fat, and ash content to those found in our studies, but with lower fiber content (about 11%). Zhang [2021] evaluated the quality of two *Camelina sativa* varieties grown under different climatic conditions in different locations of China and reported that protein and fat contents were in

Table 2. Seed yield and oil outcome from spring *Brassica* crops (2020–2021)

Crop	Variety	Yielding capacity, t ha ⁻¹	Oil content, %	Oil outcome from the yield, t ha ⁻¹
<i>Brassica napus</i> L.	Mykitynetskyi	2.03	42.47	0.91
<i>Camelina sativa</i>	Hirskyi	1.96	46.53	1.01
<i>Sinapis alba</i> L.	Pidpecheretska	1.77	24.35	0.42
<i>Brassica juncea</i> Gzem	Roksolana	1.56	36.12	0.52

Table 3. Competitiveness of *Camelina sativa* growing technologies

Variant	Coefficient of energy evaluation (K_{E_r})	Coefficient of integral evaluation (J)	Complex coefficient of competitiveness (K_r)
Control (without fertilizers)	1.81	0.91	1.03
$N_{0}P_{45}K_{45}$	1.40	0.90	1.09
$N_{30}P_{45}K_{45}$	0.88	0.82	1.23
$N_{30}P_{45}K_{45} + N_{60}$	0.80	0.82	1.64
$N_{30}P_{45}K_{45} + \text{microfertilizers}$	0.91	0.80	1.40

the range of 21–36% and 26–35% respectively [Zhang et al. 2021; Hryhoriv et al., 2022b].

Obtained results on determining coefficients of energy, integral evaluation and complex coefficient of competitiveness showed that they change depending on the studied factors (Table 3).

As a result of the research, it was established that the highest coefficients of energy evaluation (K_{Er}), integral evaluation (J) and complex competitiveness coefficient (K_k) were observed in the control without fertilizers. Thus, their values were – coefficient of energy assessment (K_{Er}) – 1.81; integral evaluation coefficient (J) – 0.91; and the complex coefficient of competitiveness (K_k) – 1.03.

It was found that application of mineral fertilizers and micro-fertilizers in the studied doses lead to a decrease in coefficients of energy assessment (K_{Er}) and integral assessment (J) of *Camelina sativa* growing technology, and to an increase in a complex coefficient of competitiveness (K_k). Thus, index value for coefficient of energy assessment (K_{Er}) with application of the studied doses of fertilizers decreased to 0.80; coefficient of integral assessment (J) – up to 0.80; and value of complex coefficient of competitiveness (K_k) increased to 1.64.

The lowest indices of coefficients of energy evaluation (K_{Er}), integral evaluation (J) and complex coefficient of competitiveness (K_k) were observed when applying mineral fertilizers in a dose of $N_{30}P_{45}K_{45} + N_{60}$. Thus, their values were – coefficient of energy assessment (K_{Er}) 0.80; coefficient of integral assessment (J) 0.82; and complex coefficient of competitiveness (K_k) – 1,64.

It should be noted that higher indices of coefficient of energy assessment (K_{Er}), coefficient of integral assessment (J) and complex coefficient of competitiveness (K_k) were found in the variant with application of ($N_{30}P_{45}K_{45}$) + Vympel (500 g ha⁻¹) + Oracul multicomplex (1 l ha⁻¹) + Oracul colamine boron (1 l ha⁻¹) + Oracul sulfur active (2 l ha⁻¹) compared to application of mineral fertilizers $N_{30}P_{45}K_{45} + N_{60}$. Thus, their values were – coefficient of energy assessment (K_{Er}) 0.91, which is 0.11 more compared to the variant $N_{30}P_{45}K_{45} + N_{60}$; coefficient of integral evaluation (J) 0.82; and complex coefficient of competitiveness (K_k) 1.40, which is on average 0.24 less compared to the variant $N_{30}P_{45}K_{45} + N_{60}$.

CONCLUSIONS

Camelina sativa is characterized by extraordinary biological plasticity to agro-ecological

conditions due to greater drought resistance, lower demand for soil fertility, and especially for application of chemicals protecting from pests and diseases. Seed productivity of *Camelina sativa* is not inferior to *Brassica napus* L. and, under conditions of Precarpathians, can be about 2.0 t ha⁻¹ with oil outcome for biodiesel production of 1.0 t ha⁻¹.

The highest indices of coefficients of energy assessment (K_{Er}), integral assessment (J) and complex coefficient of competitiveness (K_k) were observed in the control without fertilizers, and the coefficients decreased with application of mineral fertilizers.

We have to note that determination of competitiveness of improved technologies for growing *Camelina sativa*, which are based on different variants of applying doses of mineral fertilizers and micro-fertilizers, indicate the need for further research in order to increase economic, energy efficiency and competitiveness of growing this oilseed crop by optimizing conditions of sowing and mineral nutrition of plants.

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