**Camelina sp. L in field trials and crop production of Crimea**

E L Turina¹, V S Pashtetskiy¹, T Ya Prakhova², S G Efimenko³ and E N Turin¹

¹ - FSBSI Research Institute of Agriculture of Crimea, 150 Kyievskaia st., Simferopol', 295493, Russia
² - FSBSI Federal Research Center for Bast Fiber Crops, 1b, Michurina st., Penza region, Lunino, 442731, Russia
³ – Pustovoit All-Russian Research Institute of Oil crops (VNIIMK), 17, Filatova str. Krasnodar, 350038, Russia

E-mail: turina_e@niishk.ru

**Abstract.** The objective of the research is to establish the optimal seeding dates and rates of winter Camelina in the Crimea conditions and to determine the yield and quality of different oilseeds in field trials and production conditions. Trials were carried out in 2015-2019 on the field of the field crop department of the FSBI Crimean Agricultural Research Institute located in the central steppe zone of Crimea. The climate is moderately cold, semi-dry, continental, with large annual and daily temperature fluctuations. The average annual temperature is 15.1°C at 350-450 mm of precipitation per year. Meteorological conditions during the years of research differed from long-term average data on the amount of precipitation and temperature conditions: The Selyaninov hydrothermal coefficient (HTC) in 2016 was 0.82, in 2017 - 0.61, in 2018 - 0.23, in 2019 - 0.59. The agroclimatic potential of Crimea is suitable for cultivation of winter camelina on the peninsula, which increases the biodiversity of agrophytocenoses and get high-quality oil for various purposes. The optimal seeding dates for winter camelina in the Crimea is the period from September 30 to October 15, which produces the highest yield of 1.32-1.35 t / ha. However, a fairly wide calendar range gives a satisfactory crop yield. Favourable terms of soil moisture give the most optimal conditions for the winter camelina yield at a seeding rate of 8 million / ha. The fatty acid composition of the oil obtained from camelina grown in the Crimea indicates its suitability for various areas of the national economy.

1. **Introduction**

*Camelina* sp. L - oilseed with a wide range of oil use: in the food industry [1], as a biologically active additive [2], in medicine and pharmacology [3], in aquaculture [4], the technical industry [5-6], including the production of biodiesel [7-8]. The camelina press cake is used for animal feed, as it is a valuable sulfur-containing fodder plant [9-10].

Agronomic value of *Camelina* sp. L lies in the possibility of using it as an insurance crop in winter crops losses, as a phytoremediator, high ability to suppress even the most dangerous perennial root weeds and reduce pesticidal loads on agricultural land [11-12].

*Camelina* sp. L is a cosmopolitan plant and gives a seed crop under rather critical conditions of moisture supply, practically without the use of insecticides as opposed to other plants of the *Brassicaceae family* [13].
The analysis of agrometeorological observations conducted in the Crimean steppe zone shows a tendency to a stable increase in the average annual air temperature. Over the past 30 years, it has grown by 1.4 °C. The amount of precipitation, on average, has not changed for this period, but there is a very uneven distribution both by year and during each particular year. In Crimea, the negative consequences of global warming are also aggravated by the cessation of the Dnieper water supply through the North Crimean Canal. This has already led to an almost complete removing of rice, soybeans, corn, alfalfa, reducing sown areas of rape and late-ripening sunflower varieties and hybrid from the crop rotation of the region.

Crimea is a winter farming zone, and *Camelina sylvestris*, an undemanding crop, can serve as a unique resource for diversification of crop production and fill its niche for stable production of vegetable oil in conditions of water shortage.

*Camelina sylvestris* is a new crop for Crimea; the Crimean Scientific Research Institute of Agricultural Sciences has studied it since 2015. It has not been cultivated on the peninsula before. At the moment, agricultural producers are interested in camelina. In 2019, the crop area in Crimea amounted to more than 1 thousand hectares: 265 ha are located in the Razdolnensky district, 200 ha each in the Krasnoperekopsky and Pervomaisky districts, more than 400 ha in the Krasnogvardeisky district.

The objective of the research is to establish the optimal seeding dates and rates of winter Camelina in the Crimea conditions and to determine the yield and quality of different oilseeds in field trials and production conditions.

2. **Methodology and research conditions**

Trials were carried out in 2015-2019 on the field of the field crop department of the FSBI Crimean Agricultural Research Institute located in the central steppe zone of Crimea. The trials were laid in four systematic replicates, the sown area of the plot is 27 m², the accounting area is 25 m². The predecessor is spring barley. Sowing was carried out by a seeder SKS-6-10 on September 15, September 30, October 15, October 30, and November 15 with row spacing 15 cm, with different seeding rates from 5 to 10 million units/ha.

The research material was varieties of winter camelina taken in the scientific centres of Russia: Penzyak, Baron, Kozyr from Penza Scientific Research Institute of Agriculture, Carat from V.S. Pustovoit All-Russian Scientific-Research Institute of Oilseeds, Peredovik and Adamas from Russian Research and Design Technological Institute Sorghum and Corn Institute and the Pokrovskoye Experimental and Implementation Institute. The Penzyak variety was the standard, as it is the first winter camelina variety listed in the State Register and recommended for all cultivation regions.

Harvesting was carried out by the Sampo-130 combine in the phase of full ripeness, followed by weighing of the grains. During field trials, there were appropriate observations, counts, measurements and analyzes, according to the methods for oil crops [14].

The fatty acid composition of seed oil was determined according to GOST 31663-2012 [15] and GOST 31665-2012 [16] on a gas chromatograph Khromatek-Crystal 5000. The research was conducted by the biochemistry laboratory of V.S. Pustovoit the All-Russian Research Institute of Oilseeds.

The soils of the Crimean steppe zone are represented by southern chernozems on yellow-brown loess-like light clays. The climate is moderately cold, semi-dry, continental, with large annual and daily temperature fluctuations. The average annual temperature is 15.1°C at 350-450 mm of precipitation per year, the average long-term indicator of Selyaninov hydrothermal coefficient (HTC) is 0.59.

Meteorological conditions during the years of research differed from long-term average data on the amount of precipitation and temperature conditions: The Selyaninov hydrothermal coefficient (HTC) in 2016 was 0.82, in 2017 - 0.61, in 2018 - 0.23, in 2019 - 0.59.
3. Results
It has been established that the growing season of winter camelina in Crimea is from 183 to 269 days, depending on the seeding dates and weather conditions.

Table 1. The productivity of winter camelina Penzyak, depending on the seeding dates and rate. The field trial, FSBI Crimean Agricultural Research Institute, t / ha

| Seeding date (B) | Seeding rate (A), million units / ha | 2015 | 2016 | 2017 | 2018 | 2019 | Average for 5 years |
|------------------|-------------------------------------|------|------|------|------|------|---------------------|
| September 15th   | 5                                   | -    | -    | 0    | 0.53 | 0.58 | 0.37               |
|                  | 6                                   | -    | -    | 0    | 0.59 | 0.56 | 0.38               |
|                  | 7                                   | 0    | 1.14 | 0    | 0.46 | 0.59 | 0.44               |
|                  | 8                                   | 0    | 1.13 | 0    | 0.46 | 0.64 | 0.45               |
|                  | 9                                   | 0    | 1.11 | 0    | 0.39 | 0.61 | 0.51               |
|                  | 10                                  | 0    | 1.02 | 0    | 0.32 | 0.62 | 0.38               |
|                  | 5                                   | -    | -    | 1.60 | 0.57 | 0.69 | 0.95               |
|                  | 6                                   | -    | -    | 1.65 | 0.59 | 0.69 | 0.98               |
| September 30th   | 7                                   | 1.36 | 1.20 | 1.66 | 0.46 | 0.94 | 1.12               |
|                  | 8                                   | 1.61 | 1.21 | 2.24 | 0.46 | 1.10 | 1.32               |
|                  | 9                                   | 1.40 | 1.18 | 1.98 | 0.42 | 0.81 | 1.16               |
|                  | 10                                  | 1.11 | 1.09 | 1.50 | 0.37 | 0.78 | 0.97               |
|                  | 5                                   | -    | -    | 1.38 | 0.29 | 1.50 | 1.06               |
|                  | 6                                   | -    | -    | 1.41 | 0.24 | 1.60 | 1.08               |
| October 15th     | 7                                   | 1.32 | 1.22 | 1.46 | 0.28 | 1.70 | 1.20               |
|                  | 8                                   | 1.45 | 1.27 | 1.95 | 0.19 | 1.89 | 1.35               |
|                  | 9                                   | 1.38 | 1.15 | 1.64 | 0.19 | 1.71 | 1.21               |
|                  | 10                                  | 1.01 | 1.10 | 1.40 | 0.13 | 1.69 | 1.07               |
|                  | 5                                   | -    | -    | 0.69 | 0.27 | 0.80 | 0.59               |
|                  | 6                                   | -    | -    | 0.93 | 0.30 | 0.91 | 0.71               |
| October 30th     | 7                                   | 0.95 | 1.39 | 1.09 | 0.31 | 1.12 | 0.97               |
|                  | 8                                   | 1.29 | 1.40 | 1.18 | 0.26 | 1.02 | 1.03               |
|                  | 9                                   | 1.16 | 1.11 | 1.18 | 0.26 | 0.99 | 0.94               |
|                  | 10                                  | 1.10 | 1.07 | 0.82 | 0.12 | 0.99 | 0.82               |
|                  | 5                                   | -    | -    | 0.49 | 0.39 | 0.66 | 0.51               |
|                  | 6                                   | -    | -    | 0.45 | 0.39 | 0.73 | 0.52               |
| November 15th    | 7                                   | 1.09 | 1.22 | 0.59 | 0.25 | 0.73 | 0.78               |
|                  | 8                                   | 1.19 | 1.22 | 0.47 | 0.26 | 0.73 | 0.77               |
|                  | 9                                   | 1.29 | 1.06 | 0.58 | 0.09 | 0.75 | 0.75               |
|                  | 10                                  | 1.11 | 1.08 | 0.45 | 0.08 | 0.69 | 0.68               |

The high winter hardiness of camelina in Crimea was determined at 92.3-100%. However, planting crops on November 15, 2 times in five years of research (in 2017 and 2019) results in the heaving of...
plants in February due to which the winter hardiness of plants at this seeding date decreased to 20.9-
67.6 %.

The productivity of winter camelina in the Crimea varies by year: the largest - 2.24 t / ha was
obtained in 2017 with a planting date of September 30 with a seeding rate of 8 million / ha, the
smallest - in 2018 - 0.08-0.59 t / ha for all trials, which is connected with drought (Table 1). On
average, over five years of research, planting on September 30 and October 15 with a seeding rate of 8
million / ha - 1.32 and 1.35 t / ha, respectively, produced the highest oilseed yields.

For 5 studied years 3 times (in 2015, 2017 and 2019) when the camelina was sown September 15,
it was noted the low field germination in 2015 and 2017, only individual plants sprouted, which is
associated with heavy rainfall at this time, followed by the formation of soil crust. At other seeding
dates, there was no such adverse event. Thus, the soil crust is very dangerous for shoots of camelina
and can lead to thinning of early crops, up to the need for reseeding.

In the years of favourable moisture conditions, the most optimal seeding rate for camelina was 8
million / ha, however, in 2018, when the drought was noted, small seeding rates of 5-6 million / ha had
an advantage and gave significantly large productivity.

The variety is one of the most important production means ensuring a further increase in the
productivity and quality of cultivated plants. It is well known that different varieties under the same
conditions form different yields. In our experiments, we confirmed this statement: the most effective
for 4 years of research was Penzyak, which formed a seed yield of 1.30 t / ha with an oil content of
39.65%, the Kozyr variety, whose yield and oil content of seeds was 1, was less effective, 15 t / ha and
40.01 %, respectively. For 3 years of research, the yield of the Baron variety was 1.10 t / ha, but the oil
content of the seeds was annually 1.18-2.65 % higher than the Penzyak variety.

In the conditions of 2019, the Adamas variety had a yield increase of 0.11 t / ha relative to control,
so we need to continue working with this variety.

Comparison of the fatty acid composition of winter camelina oilseeds showed the variety stability
of the sum of saturated, palmitic and stearic, acids from 2.49 to 2.55%, oleic from 17.64 to 18.77%,
eruca from 2.72 to 3.05% (Table 2). The variability of linoleic acid content was somewhat broader,
from 18.86 to 20.07%, and linolenic acid - from 29.94 to 32.00%.

Table 2. The fatty acid composition of oil of various winter camelina varieties in field trials (average
2016-2019)

| Component     | Adamas | Baron | Carat | Kozyr | Penzyak | Peredovik |
|---------------|--------|-------|-------|-------|---------|-----------|
| Myristic      | 0.05   | 0.05  | 0.05  | 0.05  | 0.05    | 0.05      |
| Palmitic      | 5.52   | 5.53  | 5.21  | 5.54  | 5.50    | 5.55      |
| Palmitoleic   | 0.10   | 0.10  | 0.09  | 0.10  | 0.10    | 0.10      |
| Stearic       | 2.42   | 2.45  | 2.40  | 2.44  | 2.43    | 2.42      |
| Oleic         | 18.77  | 18.68 | 17.64 | 18.59 | 18.49   | 18.41     |
| Linoleic      | 20.03  | 20.00 | 18.86 | 19.88 | 19.56   | 20.07     |
| Linolenic     | 29.94  | 30.53 | 32.00 | 30.10 | 30.53   | 30.50     |
| Arachidic     | 1.61   | 1.58  | 1.66  | 1.63  | 1.60    | 1.60      |
| Eicosene      | 15.14  | 14.76 | 15.13 | 15.19 | 15.21   | 15.01     |
| Eicosadiene   | 1.57   | 1.53  | 1.67  | 1.58  | 1.62    | 1.54      |
| Eicosatrienic | 0.94   | 0.94  | 1.10  | 0.93  | 0.97    | 0.95      |
| Behenic       | 0.34   | 0.34  | 0.37  | 0.34  | 0.35    | 0.34      |
| Erucic        | 2.89   | 2.80  | 3.05  | 2.91  | 2.88    | 2.72      |
| Lignoceric    | 0.15   | 0.16  | 0.18  | 0.16  | 0.16    | 0.17      |
| Nervonic      | 0.56   | 0.57  | 0.59  | 0.59  | 0.59    | 0.60      |
The 5-year testing of winter camelina in field trials showed many parameters determining its commercial attractiveness. Firstly, cultivation of camelina does not require herbicides, since it well suppresses weeds. Its resistance to pests and diseases reduces the cost of plant protection products. Secondly, the use of camelina in crop rotation increases biodiversity in crop production of the Crimea. An important advantage of the culture is its low flaking during ripening and the possibility of harvesting by direct combining.

Crimean agricultural producers interested in the listed advantages and in 2019 more than 1 thousand hectares were sown. The yield, oil content and fatty acid composition of the oil are presented in Tables 3 and 4.

Weather conditions in 2019 made it possible to obtain the yield of winter camelina from 0.9 to 1.4 t / ha with the oil content of seeds from 39.81 to 43.60%. The content of erucic acid did not exceed 2.94%, the content of linoleic acid ranged from 17.85 to 19.12%, linolenic acid - 31.49 to 33.47%. The resulting oil is suitable for both food and technical purposes.

Table 3. Productivity and oil content of varieties of winter camelina in production crops of Crimea, 2019

| №   | District of Crimea, company name, field area                          | Variety | Oil content,% | Productivity, t / ha |
|-----|---------------------------------------------------------------------|---------|---------------|----------------------|
| №1  | Krasnogvardeisky, FSBI Crimean Agricultural Research Institute, 78 ha | Baron    | 43.60         | 1.14                 |
| №2  | Krasnogvardeisky, FSBI Crimean Agricultural Research Institute, 10 ha | Carat   | 40.80         | 0.90                 |
| №3  | according to the traditional farming system, 50 ha                  | Penzyak | 40.93         | 1.4                  |
| №4  | Pervomaisky, Agricultural Production Complex Kolos II, 200 ha       | Penzyak | 42.69         | 1.1                  |
| №5  | Krasnoperekopsky, Dniester LLC, Rice field 2, 86 ha                 | Penzyak | 39.81         | 1.2                  |
| №6  | Razdolnensky, Peasant Farm Kundenok, no-till sowing, 50 ha          | Penzyak | 40.02         | 1.0                  |
| №7  | Krasnoperekopsky, LLC Dniester, Rice field 4, 84 ha                 | Penzyak | 40.03         | 1.2                  |

4. Conclusions
Therefore, the agro-climatic potential of Crimea is suitable for cultivation of winter camelina on the peninsula, which increases the biodiversity of agrophytocenoses and get high-quality oil for various purposes. The optimal seeding dates for winter camelina in the Crimea is the period from September 30 to October 15, which produces the highest yield of 1.32-1.35 t / ha. However, a fairly wide calendar range gives a satisfactory crop yield. Favourable terms of soil moisture give the most optimal conditions for the winter camelina yield at a seeding rate of 8 million / ha. The fatty acid composition of the oil obtained from camelina grown in the Crimea indicates its suitability for various areas of the national economy.
Table 4. Fatty-acid oils of different varieties of winter camelina in production crops of Crimea, 2019

| №  | Component         | FSBI Crimean Agricultural Research Institute, Baron variety | FSBI Crimean Agricultural Research Institute, Carat variety | Razdolensky, Peasant Farm Kundenok, Penzyak variety according to the traditional farming system | Agricultural Production Complex Kolos II, Penzyak variety | Dniester LLC, Rice field 2, Penzyak variety | Razdolensky, Peasant Farm Kundenok, Penzyak variety (no-till) | Dniester LLC, Rice field 4, Penzyak variety |
|----|-------------------|-----------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| 1  | Myristic          | 0.05                                                      | 0.05                                                      | 0.05                                                                                           | 0.05                                                   | 0.05                                                   | 0.05                                                                                           | 0.05                                                   |
| 2  | Palmitic          | 5.19                                                      | 5.15                                                      | 5.28                                                                                           | 5.23                                                   | 5.26                                                   | 5.21                                                                                           | 5.21                                                   |
| 3  | Palmitoleic       | 0.08                                                      | 0.10                                                      | 0.09                                                                                           | 0.09                                                   | 0.09                                                   | 0.09                                                                                           | 0.09                                                   |
| 4  | Stearic           | 2.50                                                      | 2.28                                                      | 2.44                                                                                           | 2.45                                                   | 2.34                                                   | 2.40                                                                                           | 2.35                                                   |
| 5  | Oleic             | 18.55                                                     | 17.23                                                     | 17.30                                                                                           | 18.71                                                   | 17.32                                                   | 17.37                                                                                           | 17.43                                                   |
| 6  | Linoleic          | 17.97                                                     | 19.22                                                     | 18.86                                                                                           | 18.79                                                   | 17.85                                                   | 19.12                                                                                           | 17.86                                                   |
| 7  | Linolenic         | 32.90                                                     | 32.95                                                     | 32.86                                                                                           | 31.49                                                   | 33.47                                                   | 32.40                                                                                           | 33.27                                                   |
| 8  | Arachidic         | 1.44                                                      | 1.48                                                      | 1.48                                                                                           | 1.49                                                   | 1.53                                                   | 1.54                                                                                           | 1.52                                                   |
| 9  | Eicosene          | 14.91                                                     | 14.99                                                     | 15.07                                                                                           | 15.29                                                   | 15.18                                                   | 15.12                                                                                           | 15.23                                                   |
| 10 | Eicosadecane      | 1.71                                                      | 1.73                                                      | 1.77                                                                                           | 1.71                                                   | 1.79                                                   | 1.74                                                                                           | 1.77                                                   |
Table 4. Continuation

| №  | Component | FSBI Crimean Agricultural Research Institute, Baron variety | FSBI Crimean Agricultural Research Institute, Carat variety | Razdolnensky, Peasant Farm Kundenok, Penzyak variety according to the traditional farming system | Agricultural Production Complex Kolos II, Penzyak variety | Dniester LLC, Rice field 2, Penzyak variety | Razdolnensky, Peasant Farm Kundenok, Penzyak variety (no-till) | Dniester LLC, Rice field 4, Penzyak variety |
|----|-----------|-----------------------------------------------------------|-----------------------------------------------------------|-------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------------|---------------------------------|
| 11 | Eicosatrienic | 1.16 | 1.09 | 1.10 | 1.07 | 1.22 | 1.07 | 1.21 |
| 12 | Behenic | 0.30 | 0.31 | 0.30 | 0.31 | 0.33 | 0.33 | 0.33 |
| 13 | Erucic | 2.61 | 2.72 | 2.74 | 2.69 | 2.89 | 2.86 | 2.94 |
| 14 | Lignoceric | 0.15 | 0.16 | 0.15 | 0.15 | 0.15 | 0.16 | 0.16 |
| 15 | Nervonic | 0.52 | 0.54 | 0.54 | 0.52 | 0.56 | 0.56 | 0.61 |

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