Formation of agrocenosis camelina sylvestris in the conditions of Black Sea region

V S Pashtetskiy, E L Turina, E N Turin, A V Cherkashyna and Y N Rostova

Federal State Budget Scientific Institution «Research Institute of Agriculture», 150 Kievskaya str., Simferopol, 295493, Russia

E-mail: priemnaya@niishk.ru

Abstract. Winter Camelina (Camelina sylvestris) is an oilseed crop of the Brassicaceae family, the oil of which is used in various industries. Sowing dates and sowing rates have a significant impact on the productivity of camelina in the arid conditions of Black Sea region. The purpose of this study was to determine the effect of sowing dates and sowing rates on the duration of the growing season, field germination, winter hardiness and yield structure in Black Sea region. The agroclimatic resources of Black Sea region allow the successful introduction of winter camelina, which is distinguished by their broad agroecological resistance to biotic and abiotic stress factors. The Penzyak variety of winter camelina is well adapted in the zone and is able to form a satisfactory yield in a wide calendar range. By correcting certain technology elements taking into account meteorological conditions, it is possible to create prerequisites for a more complete realization of the potential productivity of culture. The length of the growing season of camelina in the Black Sea region is from 179 to 269 days, depending on the sowing period and weather conditions. The winter hardiness of winter camelina in the Black Sea region depends on the sowing period: when sowing on September 15 and 30 and on October 15 it is high and reaches 92-100%. The winter hardiness of the late sowing season depends on the prevailing weather conditions in the winter: in some years it can be high (98–99%), but in the years when bulging and blowing of plants by the wind is manifested, it decreases to 44–49% when sowing on October 30, and to 20% when sowing on November 15.

1. Introduction

The depletion of global reserves of hydrocarbon resources has prompted scientists to search for bioenergy crops that can produce high sustainable crops in various soil and climatic conditions. One of these crops is the cruciferous Camelina sylvestris plant, since camelina oil is used as a raw material for the production of biodiesel and bioaviocerosene [1–4]. In addition, the high content of unsaturated fatty acids, squalene, vitamins and phytosterols allows the use of oil in food [5] and technical industry [6], medicine [7], animal husbandry [8] and aquaculture [9].

Winter camelina is referred to cosmopolitan plants due to its high resistance to drought, low temperatures and damage by pests, and low soil requirements [10–11].

Thanks to these features, the culture is cultivated in many countries of the world: the USA, Ukraine, Latvia, Poland, Canada, France, Austria, Chile and others. Winter camelina has been grown in Russia for the last 2 years (2018–2019) on an area of 78.9 and 75.9 thousand ha, respectively, occupying the largest areas in the Orenburg and Rostov regions, as well as the Republic of...
Bashkortostan [12]. Winter camelina is a new crop for Black Sea region; it has been cultivated on the peninsula on an industrial scale since 2015.

Since the sowing period and the sowing rate are the most important elements of the technology of cultivation of any agricultural crop that significantly affect the yield, the aim of our research was to establish the influence of these elements on the duration of the growing season, field germination, winter hardness, yield and its structure of winter camelina in the Black Sea region.

The research objectives included: to study the biological characteristics of the growth and development of winter camelina and determine the optimal parameters of technological methods (sowing time and seeding rate), allowing to obtain the highest productivity of winter camelina in the Black Sea region.

2. Research methods and conditions

The experimental work on the study of winter camelina was performed during 2015–2019 on the experimental field, which is located in the Krasnogvardeisky district in the Black Sea steppe zone. The soil here is represented by southern weakly humus chernozems.

The climate of the zone is moderately hot and arid with moderately mild winters. Summer is relatively hot, with July temperatures of 23–24 °C. The maximum air temperature in some years in July-August can increase to 35–39 °C.

The hydrothermal regime (HTR according to Selyaninov) of the vegetation periods during the years of research was contrasting: 1.11 in 2015; 0.82 in 2016; 0.61 in 2017, 0.23 in 2018; 0.60 in 2019.

The experiments were laid in a biased systematic method. Sowing mushrooms was carried out on September 15 and 30, on October 15 and 30 and on November 15 in an ordinary way (row spacing 15 cm), with different seeding rates: from 5 to 10 million pcs/ha. In the experiments Penzyak variety was used.

3. Results

It was established that weather conditions and sowing dates influenced the total length of the growing season of winter camelina. With an increase in the HTR index, the vegetation period lengthened (Figure 1). In general, the length of the growing season of the culture in Black Sea region is from 179 to 269 days, depending on the sowing period and weather conditions.

![Figure 1. Length of the growing season of camelina in the Black Sea region, depending on the HTR and the sowing period, days](image-url)
The highest field germination was observed in the most favorable year in terms of moisture supply (2015). At the same time, when sowing camelina on September 15th 3 times for 5 years of research (in 2015, 2017 and 2019), field germination was reduced to the minimum values and even to zero, which is associated with rainfall at this time followed by the formation of soil crust (Table 1). At other sowing dates, there was no such adverse event.

In 2019, the calculation of field germination at a late date coincided with negative phenomena: bulging and blowing of plants by the wind.

### Table 1. Field germination of winter camelina seeds, %

| Variant      | 2015 | 2016 | 2017 | 2018 | 2019 |
|--------------|------|------|------|------|------|
| September 15th |      |      |      |      |      |
| 7M pcs/ha    | 0    | 61.1 | 0    | 58.7 | 5.3  |
| 8M pcs/ha    | 0    | 67.2 | 0    | 59.9 | 5.4  |
| 9M pcs/ha    | 0    | 64.5 | 0    | 57.4 | 4.3  |
| 10M pcs/ha   | -    | 61.2 | 0    | 60.4 | 4.4  |
| September 30th |      |      |      |      |      |
| 7M pcs/ha    | 97.7 | 62.7 | 63.7 | 62.2 | 60.3 |
| 8M pcs/ha    | 89.8 | 67.7 | 61.0 | 60.3 | 59.0 |
| 9M pcs/ha    | 81.7 | 66.2 | 62.8 | 59.8 | 59.5 |
| 10M pcs/ha   | -    | 62.1 | 61.2 | 59.9 | 58.8 |
| October 15th |      |      |      |      |      |
| 7M pcs/ha    | 98.4 | 86.7 | 60.4 | 63.8 | 67.0 |
| 8M pcs/ha    | 88.8 | 83.6 | 60.3 | 58.4 | 67.5 |
| 9M pcs/ha    | 87.9 | 81.0 | 60.0 | 60.4 | 65.1 |
| 10M pcs/ha   | -    | 74.9 | 60.1 | 58.1 | 63.9 |
| October 30th |      |      |      |      |      |
| 7M pcs/ha    | 87.7 | 89.1 | 57.8 | 64.4 | 59.8 |
| 8M pcs/ha    | 82.1 | 87.6 | 57.5 | 68.9 | 57.4 |
| 9M pcs/ha    | 75.3 | 88.4 | 54.3 | 64.0 | 55.3 |
| 10M pcs/ha   | -    | 79.9 | 54.8 | 64.8 | 53.2 |
| November 15th |      |      |      |      |      |
| 7M pcs/ha    | 71.0 | 61.2 | 52.7 | 66.2 | 42.6*|
| 8M pcs/ha    | 72.6 | 68.6 | 52.6 | 62.3 | 20.5*|
| 9M pcs/ha    | 66.0 | 63.3 | 53.8 | 67.7 | 39.0*|
| 10M pcs/ha   | -    | 58.4 | 50.6 | 62.4 | 18.9*|

Note: * means at the time of counting field germination, bulging and blowing of plants by the wind was noted.

It was established that the winter hardiness of winter camelina in the Black Sea region depends on the sowing period and does not depend on the seeding rate. When sown on September 30 and October 15, winter hardiness is high and reaches 92–99%. Winter hardiness of plants of late sowing depends on the prevailing weather conditions in winter—in some years it can be high (98–99%); however, in years when adverse events such as bulging and blowing of plants by the wind appear, winter hardiness can decrease to 44–49% when sowing on October 30, and up to 20% when sowing on November 15 (Figure 2).

The number of pods per plant varied in direct proportion to the seeding rate (Table 2). The exceptions were the variants with crops on which any adverse effects (soil crust during the “sowing-seedling” period or bulging) affected the density of plants and leveled the effect of sowing norms (sowing on September 15 in 2015, 2017 and 2019; sowing on November 15 in 2017, 2019; sowing on October 30 in 2019). The largest number of pods, as a rule, was formed on plants in variants with seeding rates of 5–6 million pcs/ha, the smallest number was for 10 million pcs/ha.
Figure 2. Winter hardiness of winter camelina plants depending on the sowing period (seeding rate of 8 million pcs/ha)

Table 2. Number of pods depending on the timing of sowing and seeding rates, pcs/plant

| Sowing norm (B) [mln pcs/ha] | 2015  | 2016  | 2017  | 2018  | 2019  | Average |
|------------------------------|-------|-------|-------|-------|-------|---------|
| 1                            |       |       |       |       |       |         |
| Sowing period (A1) September 15th |
| 5                            | -     | -     | 0     | 194.0 | 158.2 | 176.1*  |
| 6                            | -     | -     | 0     | 161.0 | 144.8 | 152.9*  |
| 7                            | 0     | 136.1 | 0     | 107.8 | 152.0 | 132.0** |
| 8                            | 0     | 125.9 | 0     | 95.5  | 145.2 | 122.2** |
| 9                            | 0     | 110.7 | 0     | 65.8  | 156.5 | 111.0** |
| 10                           | -     | 94.2  | 0     | 63.5  | 144.2 | 100.6** |
| Average in factor A1         | 0     | 116.7 | 0     | 114.6 | 150.2 |         |
| Sowing period (A2) September 30th |
| 5                            | -     | -     | 223.9 | 202.3 | 120.0 | 182.1   |
| 6                            | -     | -     | 230.0 | 190.4 | 98.2  | 172.9   |
| 7                            | 142   | 125.2 | 198.7 | 131.0 | 95.0  | 138.3   |
| 8                            | 134   | 122.2 | 200.4 | 106.5 | 92.6  | 131.1   |
| 9                            | 128   | 104.2 | 189.8 | 108.5 | 57.0  | 117.5   |
| 10                           | -     | 89.5  | 140.9 | 91.0  | 49.2  | 92.7    |
| Average in factor A2         | 134.7 | 110.3 | 197.3 | 138.2 | 85.3  |         |
| Sowing period (A3) October 15th |
| 5                            | -     | -     | 202.8 | 37.3  | 165.7 | 135.3   |
| 6                            | -     | -     | 208.2 | 29.5  | 142.0 | 126.6   |
| 7                            | 140   | 127.0 | 179.8 | 22.8  | 138.3 | 121.6   |
| 8                            | 135   | 124.9 | 159.9 | 24.2  | 136.5 | 116.1   |
| 9                            | 130   | 99.7  | 158.6 | 22.7  | 103.6 | 102.9   |
| 10                           | -     | 89.9  | 133.3 | 17.5  | 97.1  | 84.5    |
| Average in factor A3         | 135.0 | 110.4 | 173.8 | 25.7  | 130.4 |         |
The mass of seeds from one plant is related to the number of pods per plant. When they decrease, the number of seeds from one plant decreases and, consequently, the mass of seeds from a plant.

The yield conditions of winter camelina plants have a great influence on the formation of productivity. For 3 years out of 5, the oilseed crop was not received or was significantly reduced (to 0.16 t/ha) when sowed at the earliest possible date—September 15. It was during this period after sowing that there were heavy rains which led to the formation of a soil crust, which did not make it possible to obtain normal seedlings.

The average yield for years of research on plots with a sowing date of November 15 was 0.51–0.78 t/ha. Low productivity was due to adverse winter phenomena—bulging and blowing by the wind of immature seedlings, which manifested themselves in the winter.

![Figure 3](image-url)  
*Figure 3.* Effect of the seeding rate on the oil content of winter camelina seeds at a sowing date of October 15 (average over 2015–2019)

The highest yields of winter rye oilseeds were formed on plots with sowing dates of September 30 and October 15 with seeding rates of 8 million pcs/ha—1.32–1.35 t/ha. In extremely dry years, the
yield drops sharply, and, in such years, the highest yield (up to 0.59 t/ha) can be obtained by sowing on September 30 with low seeding rates—5–6 million pcs/ha.

When studying the effect of the seeding rate on the oil content of winter camelina (sowing date October 15), a clear tendency was found to decrease the fat content with an increase in the sowing density (Figure 3).

4. Conclusion
The Penzyak variety of winter camelina is well adapted in the zone and is able to form a satisfactory yield in a wide calendar range. By correcting certain technology elements taking into account meteorological conditions, it is possible to create prerequisites for a more complete realization of the potential productivity of culture. The highest yield of winter camelina is formed during sowing on September 30 and October 15 with seeding rates of 8 million pcs/ha, however, in extremely dry years, the seeding season on September 30 with low sowing rates of 5–6 million pcs/ha has an advantage.

The length of the growing season of camelina in the Black Sea region is from 179 to 269 days, depending on the sowing period and weather conditions.

Winter hardiness of winter camelina in the Black Sea region depends on the sowing period—when sowing on September 15 and 30 and October 15, it is high, reaching 92–100%. Winter hardiness of plants of late sowing depends on the prevailing weather conditions in winter—in some years it can be high (98–99%), however, in years when plants bulge and are blown out by the wind, winter hardiness decreases to 44–49% when sowing on October 30, and up to 20% when sowing on November 15.

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