Opportunities for increasing the production of vegetable oils in Black Sea region

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Abstract. Due to changes in the climate both on the planet as a whole and in many regions, in particular in Black Sea region, there is an urgent need to search for the rational use of available environmental resources to form the maximum possible economically useful products. The biopotential of the republic allows cultivating drought-resistant oilseeds, including sunflower. After the commissioning of an oil plant in Black Sea region, with a capacity of up to 35 thousand tons of products per year, the production of the corresponding volume of oil seeds becomes especially relevant. To achieve the required amount of oilseed raw materials and stable provision of the population of the republic with sunflower oil, a mechanism of organizational and economic interaction of producers of raw materials and its processors, the introduction of adaptive hybrids and varieties of sunflower, as well as the development of adaptive technology for their cultivation are necessary. The research held in 2017-2019 at the Research Institute of Agriculture will help to solve the problems posed by introducing scientifically based technology for the cultivation of sunflower domestic selection on the peninsula. It has been established that the maximum harvest of sunflower oil (more than 0.5 t/ha) when cultivating the early ripe Avangard hybrid will be obtained by sowing in the first ten days of April with a plant density of 40K pcs/ha.

1. Introduction
In the Black Sea region, risky farming is aggravated by a stable increase in average annual air temperature and various types of droughts that are possible at every stage of ontogenesis of cultivated crops. Over the past thirty years, it has grown by 1.4 °C, the number and duration of droughts has increased, the hydrothermal coefficient has decreased from 0.77 to 0.58.

In this regard, drought resistance and heat resistance have become priority properties of genotypes adapted for this region. The role of early ripening varieties and hybrids of the steppe ecotype with a high level of drought resistance has increased.
Oil crops are of multilateral importance: they are economically beneficial for producers [1], are able to reduce the pesticidal load on the soil [2], increase its fertility (as siderates) [3], are characterized as good melliferous plants [4] and precursors for grain crops [5], contribute to the biodiversity of agrophytocenoses [6] and are used as feed for farm animals [7], and their oil can be used in food [8], perfumery and cosmetology [9], pharmacological [10], paint and varnish industry and for production of green fuel [11]. In this regard, one of the important economic tasks is to increase the production of oilseeds, vegetable oil and high-quality feed protein [12].

In recent years, in Black Sea region, sown area under oilseeds increased from 57 thousand ha (2010) to 164.2 thousand ha (2019) (Figure 1).

![Figure 1. Dynamics of sown areas of oilseeds in the Black Sea region in 2010-2019, thousand hectares, ha](image)

However, low moisture supply, soil and atmospheric droughts during the growing season of the plants, accompanied by dry winds, increased temperature conditions during the period of crop formation and high air temperature drops during the day are risk factors for their cultivation. This explains the variability of the oilseed yield indicator by years in the region (Figure 2).

![Figure 2. Dynamics of oilseeds productivity in the Black Sea region in 2012–2019, t / ha](image)
Changes in climatic conditions on the peninsula caused a decrease to a minimum of the area of oilseed crops, characterized by a high productivity potential (soybean (up to 0.2 thousand ha) and winter rape (up to 3.2 thousand ha)), as well as late-ripening sunflower hybrids which cultivation without irrigation is very risky [13, 14].

Indirectly, large-scale cultivation of oilseeds in Black Sea region is hindered by the lack of a stable sales market, developed technologies for cultivating traditional and promising crops, etc.

Industrial processing of raw materials in the region became possible with the commissioning of an oil plant with a capacity of up to 35 thousand tons of products per year, which is a serious prerequisite for increasing the production of oilseeds.

In recent years (2016-2018) among oilseeds, Helianthus annuus L. occupies the major part of the sown area in the Black Sea region: almost 120 thousand hectares. In 2019, the area under this crop was reduced by 13 thousand ha, mainly due to the lack of subsidies and amounted to 71 thousand ha (Figure 3).

![Figure 3. Dynamics of cultivated areas of Helianthus annuus L. in the Black Sea region in 2010–2019, thousand ha](image)

To achieve gross harvests of sunflower at the level of available processing capacities and their stabilization, first of all, technologies are needed for cultivating varieties and hybrids adaptive to the climate of the arid zone of the peninsula.

The purpose of the research is the development of a scientifically based technology for the cultivation of Helianthus annuus L. in the arid conditions of the peninsula, which ensures high productivity of domestic selection hybrids and contributes to an increase in the production of vegetable oils in the Black Sea region.

According to the Order of the President of the Russian Federation No. Pr-1127 dated June 12, 2017, the object of research is a hybrid of domestic selection.

2. Materials and methods

2.1 Field experiment

The studies were carried out in 2017-2019 at the Research Institute of Agriculture in the central steppe part of the peninsula. The soils of the experimental site are represented by southern weakly humus chernozem on yellow-brown loesslike light clays. The arable layer during the years of research was characterized by the following agrochemical indicators: the content of mobile phosphorus (according to B. Machigin) was 5.6 mg/100 g, potassium content (according to B.P. Machigin) was 35 mg/100 g, humus content (according to I.V. Tyurin) was 2.29%.

In the experiment, we studied the productivity of sunflower in three repetitions depending on the density of plants (30, 40, 50, 60 and 70 thousand plants per hectare) for different sowing periods:
1) sowing of sunflower at a time when the soil temperature at a depth of 8-10 cm warms up steadily and within 3–5 days it is 6–9 °C, 2) 10 days after the first sowing time, 3) 20 days after the first sowing time. During the years of research, the first sowing period corresponded to the first decade of April, the second one corresponded to the second decade of April, and the third one to the third decade of April.

The object of study was an early ripe hybrid of sunflower Avanguard variety of VNIIMK Research Center (Krasnodar). It is characterized by high ecological flexibility, adaptability to drought, stable when cultivated on soils with low bonitet, deficit of soil and atmospheric moisture, response to improved agrotechnical conditions of cultivation. It can form seed yield in the main crops up to 3.5 t/ha, in repeated crops up to 3.0 t/ha with an oil content of 47-50%. The period of "seedlings - physiological ripeness" is 75-78 days.

The total area of the plot was 28 m², accounting area was 14 m². The harvest was gathered by a Sampo-130 small-sized combine, with subsequent conversion to 100% purity and 10% moisture of seeds.

The field experiments were performed in accordance with the guidelines of B.A. Dospekhov [15] and methods for conducting field and agrotechnical experiments with oil crops [16].

2.2 Determination of oil content in achenes

The oil content in achenes was determined by an NMR analyzer according to GOST 8.596-2010 elaborated to measure the quality indicators (oil content and moisture) of agricultural materials (oils seeds, their processed products, animal feed and other materials containing vegetable oils), and establish the primary and periodical verification of the analyzers. NMR analyzer is a measuring instrument based on the method of nuclear magnetic resonance (NMR) and one of its directions—the method of nuclear magnetic relaxation (NM-relaxation). NM-relaxation is a process which consists in establishing an equilibrium state of the spin of the nuclei of the system in a constant magnetic field.

Oil collection was determined by the following formula [16]:

\[
OC = \frac{(Y \times O \times (100-10.0))}{100},
\]

where

- OC is oil collection, kg/ha;
- Y is seed yield, kg/ha;
- O is oil content, %;
- (100–10.0) means conversion into absolutely dry biomass.

Weather conditions during the growing season of sunflower in 2017-2019 were contrasting. In 2017, the amount of precipitation in the autumn and winter period exceeded the long-term average norm by 21.7 mm or 9.5%, in 2018 they amounted to 25.7% of the norm (170.2 mm), and in 2019 to 325 mm, which is 96 mm more than the norm (Table 1).

| Year   | Total precipitation over September-March | Month | Total precipitation over April-September |
|--------|------------------------------------------|-------|------------------------------------------|
|        | Total precipitation over April-May-June-August-September |       |                                          |
| 2017   | 229                                      | 32    | 30                                       |
|        |                                          | 39.9  | 23.6                                     |
|        |                                          | 20.5  | 12.6                                     |
|        |                                          | 53.2  | 1.1                                      |
|        |                                          | 249   | 150.9                                    |
| 2018   | 250.7                                    | 3.1   | 4.3                                      |
|        |                                          | 15.6  | 88.8                                     |
|        |                                          | 46.3  | 294.9                                    |
| 2019   | 170.2                                    | 27.2  | 21.1                                     |
|        |                                          | 23.9  | 266.9                                    |
|        |                                          | 119.6 |                                          |
|        |                                          | 67.5  |                                          |
|        |                                          | 0.6   |                                          |
|        |                                          | 266.9 |                                          |

During the years of research, the uneven distribution of precipitation by months over the growing season was recorded. In May-June of 2017, its deficit was observed, which, at elevated temperature
conditions, had a negative effect on productivity. In 2018, a deficit of precipitation was observed at the beginning of the growing season, which negatively affected the productivity of plants. In addition, in most areas of the Black Sea region, an emergency was declared due to soil and atmospheric drought. Precipitation fell in the amount of 225% of the norm only in the third decade of June, and at the end of July it amounted to 101 mm (360% of the average long-term norm). However, in combination with an air temperature of 30 °C and higher for 9 days (4 days more than the average long-term data), this caused the manifestation of diseases on *Helianthus annuus* L. plants. In 2019, the prevailing weather conditions favored the vegetation of the crop, as it was characterized by the absence of dry winds and lower temperature.

3. Results

3.1. Field experiment

It is known that the production of vegetable oils is directly related to the quality of the supplied raw materials, which, in turn, is determined by the technology of cultivation of the crop. Its elements such as sowing dates and plant density had a direct impact on crop formation (Table 2).

| Plant density [ths. pcs/ha] | Sowing period 1st decade of April | 2nd decade of April | 3rd decade of April |
|-----------------------------|----------------------------------|---------------------|---------------------|
| 30                          | 1.08                             | 1.05                | 1.08                |
| 40                          | 1.37                             | 1.22                | 1.28                |
| 50                          | 1.27                             | 1.18                | 1.09                |
| 60                          | 1.13                             | 1.12                | 1.1                 |
| 70                          | 1.07                             | 1.08                | 1.04                |
| LSD<sub>0.05</sub>          | 0.2                              | 0.13                | 0.15                |

The highest value of seed yield was noted during sowing in the first ten days of April with a plant stand density of 40 thousand pcs/ha and amounted to 1.37 t/ha.

According to the table, the regularity of the indicators of seed productivity of sunflower by the density of plant standing is clearly traced, regardless of the sowing time.

3.2. Determination of oil content in achenes and oil collection in general

In our studies, the dependence of seed quality on factors under agrotechnical control is traced, including on the sowing period and plant density (Table 3). So, there is a tendency to increase the oil content in achenes with thickening of crops at all times. The maximum value of this indicator was recorded during sowing in the first ten days of April with a density of standing of 70 thousand pcs/ha (45.3%).

The highest values of oil collection were recorded at a plant stand density of 40 thousand pcs/ha, regardless of the sowing time. The maximum value of oil collection was obtained during sowing in the first ten days of April with a standing density of 40 thousand plants/ha (0.56 t/ha).

4. Conclusion

As a result of the studies, it was found that in Black Sea region the highest sunflower yield is achieved when sowing in the first ten days of April, when the soil temperature at a depth of 8–10 cm warms up steadily for 3-5 days and is no lower than 6–9 °C, with a plant density of 40 thousand pcs/ha, averaging 1.37 t/ha with an oil content of seeds of 44.6%. Under the same conditions, the best yield will be obtained for sunflower oil (0.56 t/ha).
Table 3. Oil content in achenes (%) and oil collection (t/ha) of sunflower over 2017-2019.

| Plant density [ths. pcs/ha] | Sowing period | 1st decade of April | 2nd decade of April | 3rd decade of April |
|-----------------------------|---------------|---------------------|---------------------|---------------------|
|                             |               | Oil content in achenes [%] | Oil collection [t/ha] |
|                             |               | 44.6                | 42.9                | 43.1                |
| 30                          |               | 44.6                | 43.5                | 43.5                |
| 40                          |               | 45                  | 43.7                | 43.6                |
| 50                          |               | 45.2                | 43.9                | 43.7                |
| 60                          |               | 45.3                | 43.9                | 43.8                |
| 70                          |               | 0.5                 | 0.8                 | 0.6                 |
| LSD₀₅                       |               | 0.5                 | 0.8                 | 0.6                 |
|                             | Oil collection [t/ha] | 0.44                | 0.41                | 0.42                |
| 30                          |               | 0.56                | 0.48                | 0.51                |
| 40                          |               | 0.52                | 0.47                | 0.43                |
| 50                          |               | 0.47                | 0.44                | 0.44                |
| 60                          |               | 0.44                | 0.43                | 0.41                |
| 70                          |               | 0.44                | 0.43                | 0.41                |
| LSD₀₅                       |               | 0.1                 | 0.05                | 0.06                |

Acknowledgments
The study was carried out as part of state assignment No. 0834-2019-0011/AAAA-A16-116022610121-5. “To develop methods to increase the productivity of oilseeds in order to construct highly productive agrophytocenoses with the effective use of the natural resource potential of Krym”.

References
[1] Bushnev A S, Krivoshlykov K M, Mamyroko Yu V, Podlesny S P 2019 Economic efficiency of sunflower cultivation at various seeding rates Oilseeds 3 (179) 97-101
[2] Wang L, Liu Q, Dong X, Liu Y, Lu J. 2019 Herbicide and nitrogen rate effects on weed suppression, N uptake, use efficiency and yield in winter oilseed rape (Brassica napus L.) Glob. Ecol. Conserv 17 e00529
[3] Fageria N K 2007 Green Manuring in Crop Production Journal of Plant Nutrition 30 (5) 691-719
[4] Bartomeus I et al. 2014 Contribution of insect pollinators to crop yield and quality varies with agricultural intensification. Peer J. 2 e328
[5] Lukomets V M 2017 Innovative technologies for the cultivation of oilseeds (Krasnodar: Prosveshcheniye-Yug)
[6] Tkalich I D, Tkalich Yu I and Rychik S G 2011 Flower of the sun (Fundamentals of biology and agricultural technology of sunflower) (Dnepropetrovsk: Novaya Ideologiya)
[7] Bernard J K 2011 Feed Ingredients Feed Concentrates: Oilseed and Oilseed Meals Encyclopedia of Dairy Sciences 349-355
[8] Nasiyev B, Zhanatalapov N and Bushnev A 2018 The influence of seeding time on growth development and productivity of sunflower in the dry steppe area Asian Journal of Microbiology, Biotechnology and Environmental Sciences 20 (4) 1163-1169
[9] Burton J W, Miller J F, Vick B A, Scarth R and Holbrook C C 2004 Altering fatty acid composition in oil seed crops Adv. Agron. 84 273–306
[10] Kostenkova E V, Bushnev A S and Vasilko V P 2019 The study of Helianthus annuus L. of domestic breeding in arid IOP Conference Series: Earth and Environmental Science 341 (1) 012011
[11] Thirumarimurugan M, Sivakumar V M, Merly Xavier A, Prabhakaran D, and Kannadasan T 2012 Preparation of Biodiesel from Sunflower Oil by Transesterification *International Journal of Bioscience, Biochemistry and Bioinformatics* **6** 441-444

[12] Lukomets V M, Gorlov S L and Krivoshlykov K M 2009 Prospects and stimulation of rapeseed production in the Russian Federation *Agriculture* **2** 7-8

[13] Robinson R G 1978 *Sunflower Science and Technology* (Madison:WI) 89–143

[14] Stone L R, Goodrum D E, Schlegel A J, Jaafar M N and Khan A H 2002 Water depletion depth of grain sorghum and sunflower in the central high plains *Agron. J.* **94** 936–943

[15] Dospekhov B A 1985 *Field experiment methodology*

[16] Lukomets V M 2010 *Methodology for conducting field agrotechnical experiments with oilseeds*