Aim. Evaluate in the northern steppe of Ukraine varieties of lentils grown in Canada and Turkey.

Results and Discussion. The features of growth and development of lentil varieties originating from Canada and Turkey have been determined. According to research, varieties of Canadian origin are more adapted to the conditions of the northern steppe of Ukraine, they are almost not inferior in yield to the standard, and some exceeded it in this trait. On average, for three years of research, the most productive variety was CDC Maxim 2.32 t/ha it is 0.16 t/ha more than the standard. Relatively high average productivity at the level of the standard was characterized by cultivars CDC Impress, CDC Imperial, CDC Greenland, CDC Viceroy 2.17-2.09 t/ha. The best yields in 2018 were the variety CDC Greenland – 2.32 t/ha – large seed variety with yellow cotyledons and the variety CDC Maxim – 2.30 t/ha – which belongs to small seeded with red cotyledons, but the excess of yield over the variety Lensa, which was used as a standard, was within the statistical error. In 2019, the variety CDC Maxim was also characterized by the highest yield of 2.02 t/ha, a high yield was also given by the variety CDC Impress 2.02 t/ha. This year, the advantage of these varieties over the standard was statistically significant + 0.36 t/ha. In 2020, the maximum yield was in the varieties CDC Viceroy 2.67 t/ha, and CDC Maxim 2.63 t/ha, but this excess yield compared to the standard was within the statistical error. Varieties from Turkey in given climatic conditions proved to be worse. In all years they yielded less to the yield of the standard and varieties from Canada. The average yield of the most productive variety Altıntoprak was 1.55 t/ha 0.51 t/ha less than the standard, and the maximum of the same variety 2.07 t/ha in 2020 is also less than the standard.

Conclusions. In the conditions of the northern steppe of Ukraine, some of the Canadian varieties are not inferior to the local ones in terms of yield, and in some years they exceed them. When sown in the spring, lentils from Turkey are significantly inferior in yield to local and Canadian varieties.

Keywords: *legumes, lentils, variety, productivity.*

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MAKLIAK K.M., LEONOVA N.M., SUPRUN O.H.
Plant Production Institute named after V.Ya. Yuriev of NAAS
142 Moskovskyi Ave., Kharkiv, 61060, Ukraine
E-mail: yuriev1908sunflower@gmail.com

USE OF SUNFLOWER GENE POOL ACCESSIONS IN BREEDING FOR HIGH CONTENT OF OLEIC ACID IN OIL

The results of using sunflower gene pool accessions (variety-population Kruiz, lines - sterility fixers Kh 1012 B, Mkh 215 B and Kh 52 B) in sunflower breeding for high content of oleic acid in oil are presented. During the period of 2007-2018, 52 self-pollinated lines were created, including 39 lines - sterility fixers and 13 lines - pollen fertility restorers, with high, medium and low content of oleic acid in oil. In 2019-2021, various expression levels of valuable economic and morphological features were determined in 15 lines - sterility fixers. The oleic acid content in oil from seeds of the lines was found to exceed 85%; the "seedlings-flowering" period lasted 53-59 days; the lines were highly resistant to rust, downy mildew and broomrape (parasitic plant). The lines are valuable sources for creating oleic sunflower hybrids.

Keywords: *sunflower, gene pool, accessions, oil, fatty acid composition, oleic acid, breeding, crossing, self-pollination, line*.

INTRODUCTION

Sunflower oil with a high content of oleic acid (monounsaturated) is considered to be good for human health. Sunflower breeding for improved fatty acid composition of oil began in 1976, when the V.S. Pustovoit All-Russian Research Institute of Oil Crops created the first high-oleic sunflower variety, Pervenets, using chemical mutagenesis [1]. This trend was further developed by researchers in many countries, who focused their efforts on elucidating the patterns of genetic control of high content of oleic acid [2]. Studies resulted in the conclusion about monogenic dominant inheritance of high content of oleic acid in oil [3, 4]. However, the trait expression is influenced by other genetic factors, such as complementary genes [5], genes modifiers [6], incomplete penetrance of the main gene in heterozygotes [7]. The complexity of inheritance of and the effect of genetic background on high content of oleic acid in heterozygotes requires testing of expected donors of this trait in different crosses and under various growing conditions [8].

Breeders of the Plant Production Institute named after VYa Yuriev of NAAS have been implementing programs to improve the sunflower oil quality for 30 years [9, 10, 11]. They have proven a possibility of creating self-pollinated sunflower lines with monounsaturated oil, which combine a high content of oleic acid with valuable economic characteristics, and have demonstrated the prospects for their use in heterosis breeding [12]. They have established that there is heterogeneity in the oleic acid content in generations from crosses between high- and low-oleic genotypes, due to which selection driven by this trait is highly effective. A working collection of lines - pollen fertility restorers with a high content of oleic acid in oil [13] has been built up. In addition, a number of commercial oleic hybrids have been produced [14].

Creation of female components of oleic hybrids will increase the stable content of oleic acid in oil from hybrids and expand their diversity for valuable characteristics. Our purpose was to investigate accessions of the national collection of plant genetic resources of Ukraine as starting material for creating self-pollinated sunflower lines-sterility fixers with high content of oleic acid in oil and a set of valuable economic features

MATERIALS, METHODS AND CONDITIONS

Common sunflower (*Helianthus annuus* L. subsp. *annuus*) accessions were studied. Sunflower variety Kruiz (National Catalog number UE0100061) bred at the V.S. Pustovoit All-Russian Research Institute of Oil Crops was used as a source of high content of oleic acid. Linoleic line - sterility fixer Kh 1012 B (National Catalog number UE0101198) was created at the Plant Production Institute named after VYa Yuriev of NAAS by inbreeding hybrid combination Kh 1008 B / Kh 1010 B. Linoleic line - sterility fixer Mkh 215 B is an accession of the working collection of lines of the Plant Production Institute named after V.Ya. Yuriev of NAAS and was created by chemical mutagenesis (treatment of line Kh 908 B seeds with 0.05% diethyl urea). Line - sterility fixer Kh 52 B (National Catalog number UE0100939) was created at the Plant Production Institute named after VYa Yuriev of NAAS by individual selection of large-seeded and high-protein biotypes from variety Kharkivskyi 7.

In 2007, fertility-based variety-line crosses were performed using artificial emasculation of flowers. Flowers were emasculated by removing anthers with medical tweezers before opening (in the morning) followed by isolation of calathidiums [15]. Plants of the variety (pollinated with pollen gathered from individual plants of line Kh 1012 B) and plants of the lines - sterility fixers, Kh 1012 B, Mkh 215 B, and Kh 52 B (pollinated with pollen collected from individual plants of the variety) were used as female component. In 2007-2018, annual self-pollination of plants was conducted, and heads were selected by a set of characteristics.

The morphologically homogenous self-pollinated lines were studied in the scientific crop rotation fields of the Plant Production Institute named after VYa Yuriev of NAAS in 2019-2021. The average air temperature during the sunflower growing period (May-September) (data of the meteorological station *Aeroport*, 49°55′N, 36°17′E) was 20.0°C in 2019, 19.0°C in 2020, and 19.7°C in 2021 (the 1981-2010 average is 18.2°C). The precipitation amount in May-September was 265.3 mm in 2019, 476.3 mm in 2020, and 240.7 mm in 2021 (the 1981-2010 average is 260.0 mm). During the study years, stressful conditions (high temperatures and water deficit, or cool rainy weather) were observed during different phases of sunflower ontogenesis, which allowed us to identify more adapted to growing conditions genotypes. Thus, the weather in 2019 was characterized by hot periods during sunflower flowering and ripening, which promoted to the sunflower rust (*Puccinia helianth*i Schwein) development. The cool rainy weather in the early stages of sunflower plant development in 2021 was favorable for the development of type I downy mildew (*Plasmopara halstedii* (Farl.).

In breeding nurseries, accessions (original genotypes, their hybrids, self-pollinated lines) were sown in plots of 1.9 m^2 to 7.6 m^2 within the first or second 10 days of May. The inter-row spacing was 0.7 m; the distance between plants in the row was 0.25 m. Self-pollination was carried out using individual parchment bags. The accessions were described in compliance with the method [16]. During the growing period, the following phenological observations were made: sowing date, germination date, 50% flowering date. The plant height was measured from the soil surface to the head attachment point. The total number of leaves per plant was counted. The leaf area during anthesis was determined by LS Osipova's method [17].

Downy mildew affection in the field was assessed on a 9-point scale-classifier of resistance by calculating the percentage of plants with type I infection, where 9 points - very high resistance, 7 points - high resistance, 5 points - low susceptibility, 3 points - medium susceptibility, and 1 point - high susceptibility. The degree of rust damage in the field was ranked on a 9-point scale, where 1 point - the plant is not affected even after artificial contamination, and 9 points - the maximum damage [18]. Three points were given to resistant plants. The average score was determined for five plants in the plot. Seeds of a local broomrape population for artificial contamination of sunflower were harvested from collection sunflower accessions grown in the scientific four-field crop rotation field of the Plant Production Institute named after V.Ya. Yuriev of NAAS in 2018. Resistance was assessed in an artificial climate (phytotron) by resistance diagnostics method [19]. The degree of damage was calculated as the number of parasitic peduncles per sunflower plant.

The average performance was determined by weighing seeds from five heads. The 1000-seed weight and huskness were determined in compliance with the current standard [20]. The oil content in seeds was determined by magnetic resonance imaging on an NMR analyzer *MQC-5*. Seeds from freely pollinated plants were taken for oil content analysis.

Seeds for fatty acid composition and oil content analyses were sampled from individual plants and from small plots [21]. To analyze the fatty acid composition of oil, seeds were taken from plants isolated under parchment bags during anthesis. The fatty acid composition was determined by gas chromatography of fatty acid methyl esters on a gas chromatographer *Selmichrom 2* by Peisker's modified method [22]. The contents of seven major fatty acids were determined. Accessions with the oleic acid content over 75% were considered high oleic; with the oleic acid content ranging 35% to 75% - mid-oleic; with the oleic acid content below 35% - linoleic (low oleic) [23].

RESULTS AND DISCUSSION

Selection of high oleic biotypes from the variety began in 2007. Calathidiums of about 50 plants of the variety were isolated and self-pollinated during anthesis. The variety turned out to have low autofertility; hence, sufficient numbers of seeds for further work were only gathered

from 22 heads. Analysis of the fatty acid composition of oil in individual heads showed that the average content of oleic acid in oil from Kruiz seeds was 70.81 ± 2.35%, with minimum and maximum of 53.04% and 88.55%, respectively.

As to hybrid combinations created by fertility-based crossings in 2007, the oleic acid content in oil from F_1 seeds gathered from heads of genotypes Mkh215B/Kruiz.6, Mkh215B/Kruiz.7, and Mkh215B/Kruiz.35 ranged from 58.21% to 61.70%. The oleic acid content in oil from F_1 seeds gathered from heads of genotypes Kh1012B/Kruiz.30 and Kh1012B/Kruiz.35 was 66.03% and 58.20%, respectively. The oleic acid content in oil from F_1 seeds gathered from heads of the genotype Kruiz/Kh1012B was 59.41%. Therefore, the oil from seeds of all F_1 hybrid combinations used for further selection of high-oleic biotypes was characterized by medium content of oleic acid - from 58.20% to 66.03%.

In the following years, the best plants were self-pollinated and high-oleic biotypes were selected annually. Non-lodging plants, minimally affected by diseases, with the maximum number of set seeds were selected. A high content of oleic acid was the main selection criterion, but in some of the best plants its content was medium or low.

Morphological and biochemical homogeneity of several traits, in particular in genotypes derived from self-pollinated plants of the variety, was achieved in I_7-I_{10} generations of self-pollination. In 2019, the obtained self-pollinated lines were tested for the ability to fix pollen sterility by applying their pollen on calathidiums of sterile lines - sources of cytoplasmic male sterility. Having tested the created hybrid combinations, specifically having determined the percentages of sterile and fertile plants, we divided the new lines into two groups: lines-sterility fixers and lines-pollen fertility restorers in 2020. In 2021, conversion of the lines-sterility fixers on sterile basis was continued.

Based on the seven original hybrid combinations presented in the article, 33 self-pollinated sunflower lines with valuable economic characteristics have been created. Of them, 28 lines are sterility fixers (18 high-oleic lines and 10 low-oleic lines, which make up 53.8% of the total number of lines) and five lines are pollen fertility restorers (four high-oleic lines and one low-oleic line, which make up 9.6% of the total number of lines).

It should be noted that there were no pollen fertility restorers among the self-pollinated lines originated from variety-line hybrid combinations Mkh215B/Kruiz.6, Mkh215B/Kruiz.7, Mkh215B/Kruiz.35, Kh1012B/Kruiz.30, Kh1012B/Kruiz.35, and Kruiz/Kh1012B. From the hybrid combination Kh52B/Kruiz.35, 10 lines – sterility fixers and five lines – pollen fertility restorers have been created.

Regarding the results of selections from individual plants of the variety, 19 self-pollinated sunflower lines have been created. Of them, 11 lines are sterility fixers (five high-oleic lines, two mid-oleic lines, and four low-oleic lines, making up 21.0% of the total number of lines) and eight lines are pollen fertility restorers (three high-oleic lines, two mid-oleic lines, and three low-oleic lines, making up 15.4% of the total number of lines).

A total of 52 self-pollinated sunflower lines have been created. Of them, 39 lines are sterility fixers (23 high-oleic lines, two mid-oleic lines, and three linoleic lines, which together account for 75.0% of the total number of lines) and 13 lines are pollen fertility restorers (seven high-oleic lines, two mid-oleic lines, and four linoleic lines, accounting for 25.3% of the total number of lines). Such results are in agreement with other researchers' conclusions about broad genetic basis of varieties-populations and possibilities of creating both pollen fertility restorers and sterility fixers on their basis [24, 25].

Of the 28 lines – sterility fixers derived from variety-line hybrid combinations, the percentage of high-oleic ones is 34.6% of the total number of lines (18 lines). Of the nine lines-sterility fixers originated from individual plants of the variety, the percentage of high-oleic ones is 9.6% of the total number of lines (5 lines). Thus, despite the higher content of oleic acid in oil

from seeds of some original plants of the variety, the final number of high-oleic lines selected from variety-line hybrids was higher by 13 lines (25% of the total number of lines).

The oleic acid content in oil from seeds of the original variety-line hybrid combinations ranged from 58.20% to 66.03%. At the same time, the oleic acid content in seeds of the new lines derived from variety-line combinations amounted to 89.07% (Table 2). This is in agreement with data of other researchers who detected high-oleic genotypes in the offspring of mid-oleic ones, explaining this by the presence of three complementary genes responsible for high content of oleic acid [26].

In 2019-2021, we assessed the economic characteristics of the best fifteen lines – sterility fixers with a high content of oleic acid in oil, which were derived from lines Mkh215B, Kh1012B and Kh52B (Table 2). The "seedlings-flowering" period of the lines derived from a variety-line hybrid (line Mkh215B) combination ranged 53 to 56 days in two study years, ie was 1-3 days longer than that of the original line, Mkh215B, but shorter than that of the lines originated from lines Kh1012 B (55-58 days) and Kh52B (54-59 days). The diversity of the new lines in terms of growing period is important for heterosis breeding, as it allows for creation of hybrids belonging to different maturity groups. All the new lines were more early-ripening than the original variety-population, Kruiz (the length of "seedlings-flowering" period is 70 days [27]).

Table 1. **Output of self-pollinated sunflower lines - sterility fixers and pollen fertility restorers from the hybrids and variety Kruiz**

Original genotype	Total number of lines	Number of new lines											
		Sterility fixers						Pollen fertility restorers					
		Oil type											
		High-oleic		Mid-oleic		Linoleic		High-oleic		Mid-oleic		Linoleic	
		n	%[1)]	n	%[1)]	n	%[1)]	n	%[1)]	n	%[1)]	n	%[1)]
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mkh215B/Kruiz.6	9	4	7.7	0	0.0	5	9.6	0	0.0	0	0.0	0	0.0
Mkh215B/Kruiz.7	1	1	1.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Mkh 215 B/Kruiz.35	1	1	1.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
KH1012B/ Kruiz.30	1	1	1.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
KH1012B/ Kruiz.35	3	3	5.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
KH 52 B/ Kruiz.35	15	7	13.5	0	0.0	3	5.8	4	7.7	0	0.0	1	1.9
Kruiz/ KH 1012 B	3	1	1.9	0	0.0	2	3.8	0	0.0	0	0.0	0	0.0
Total number of lines – descendents of hybrid combin.	33	18	34.6	0	0.0	10	19.2	4	7.7	0	0.0	1	1.9
Kruiz.4	1	0	0.0	0	0.0	1	1.9	0	0.0	0	0.0	0	0.0
Kruiz.16	2	2	3.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Kruiz.18	4	0	0.0	0	0.0	1	1.9	0	0.0	0	0.0	3	5.8
Kruiz.20	10	3	5.8	1	1.9	1	1.9	3	5.8	2	3.8	0	0.0
Kruiz.21	2	0	0.0	1	1.9	1	1.9	0	0.0	0	0.0	0	0.0
Total number of lines – descendents of individual plants of the variety	19	5	9.6	2	3.8	4	7.7	3	5.8	2	3.8	3	5.8
Total	52	23	44.3	2	3.8	14	26.9	7	13.5	2	3.8	4	7.7
Note: [1)] – percentage of the total number of lines													

The average performance of plants − descendants of line Mkh215B varied from 23.7g to 30.5g, which is similar to or exceeds the performance of the original line (21.4g). The performance of the lines derived from line Kh1012B was significantly inferior to that of the original linet (12.2-17.2g in the new lines vs. 22.8g in the original line).

Table 2.1. **Economic characteristics of the new self-pollinated sunflower lines – sterility fixers, their original lines and variety Kruiz, 2019-2021.**

Original/new line	Performance, g of seeds per plant			1000-seed weight, g			Huskness, %		
	2019	2021	Mean	2019	2021	Mean	2019	2021	Mean
Lines – descendents of Mkh 215 B									
Kh 0218 B	22.4	25.0	23.7	34.8	32.4	33.6	30.6	31.0	30.8
Kh 0418 B	25.0	36.0	30.5	49.8	43.0	46.4	32.8	38.0	35.4
Kh 0518 B	34.8	23.6	29.2	31.8	29.3	30.6	28.9	26.0	27.5
Kh 0718 B	20.0	22.8	21.4	36.8	32.8	34.8	32.2	35.5	33.9
Kh 0818 B	32.8	27.2	30.0	49.5	35.7	42.6	35.8	35.6	35.7
Kh 1018 B	21.2	22.6	21.9	33.5	30.3	31.9	33.1	33.0	33.1
Lines – descendents of Kh 1012 B									
Kh 0118 B	15.6	17.2	16.4	32.5	22.2	27.4	35.5	38.0	36.8
Kh 4618 B	10.0	12.2	11.1	25.3	20.2	22.8	27.3	30.8	29.1
Kh 1012 B	33.5	22.8	28.2	29.5	25.1	27.3	24.8	23.9	24.4
Lines – descendents of Kh 52 B									
Kh 4918 B	25.6	18.0	21.8	29.5	24.9	27.2	32.0	35.0	33.5
Kh 5018 B	14.8	19.0	16.9	37.0	30.5	33.8	31.1	25.7	28.4
Kh 5118 B	8.8	12.6	10.7	38.0	24.7	31.4	36.4	37.0	36.7
Kh 5318 B	16.0	12.6	14.3	32.5	37.0	34.8	32.0	33.0	32.5
Kh 5818 B	24.4	14.0	19.2	33.0	20.2	26.6	29.5	30.0	29.8
Kh 6218 B	24.0	18.0	21.0	31.3	34.2	32.8	23.8	29.0	26.4
Kh 6318 B	31.2	27.6	29.4	37.3	36.0	36.7	26.2	27.7	27.0
Kh 52 B	45.3	49.1	47.2	66.1	57.4	61.8	32.0	34.2	33.1

Table 2.2. **Economic characteristics of the new self-pollinated sunflower lines - sterility fixers, their original lines and variety Kruiz, 2019-2021.**

	"Seedlings-flowering" period, days			Oil content in seeds, %			oleic acid content in oil, %		
	2019	2021	Mean	2019	2021	Mean	2019	2021	Mean
1	2	3	4	5	6	7	8	9	10
Lines – descendents of Mkh 215 B									
Kh 0218 B	52	54	53	38.37	38.74	38.56	86.20	86.44	86.32
Kh 0418 B	53	53	53	38.84	36.27	37.56	86.57	85.22	85.90
Kh 0518 B	53	57	55	37.00	39.36	38.18	87.25	88.05	87.65
Kh 0718 B	57	59	58	46.48	45.21	45.85	86.08	82.90	84.49
Kh 0818 B	57	57	57	35.80	32.22	34.01	82.75	81.84	82.30
Kh 1018 B	53	58	56	46.21	37.48	41.85	87.33	82.33	84.83
Mkh 215 B	51	53	52	50.02	48.83	49.42	30.21	28.33	29.27
Lines – descendents of Kh 1012 B									
Kh 0118 B	52	57	55	30.58	31.28	30.93	85.67	86.48	86.08
Kh 4618 B	57	59	58	38.92	42.32	40.62	87.45	87.23	87.34

End of Table 1

1	2	3	4	5	6	7	8	9	10
Kh 1012 B	55	57	56	51.06	46.60	48.83	20.15	22.17	21.10
Lines – descendents of Kh 52 B									
Kh 4918 B	53	58	56	42.11	48.01	45.06	87.28	88.40	87.84
Kh 5018 B	53	55	54	38.54	41.41	39.98	88.90	88.48	88.69
Kh 5118 B	53	58	56	38.31	39.05	38.68	88.43	88.30	88.37
Kh 5318 B	57	56	57	39.72	40.28	40.00	85.70	84.99	85.35
Kh 5818 B	57	60	59	48.82	49.09	48.96	82.05	88.83	85.44
Kh 6218 B	53	58	56	47.40	46.40	46.90	89.00	89.13	89.07
Kh 6318 B	57	60	59	47.99	43.60	45.80	87.93	88.32	88.13
Kh 52 B	56	56	56	33.11	44.46	38.79	25.73	21.20	23.46

The performance of the descendents of line Kh 52 B line did not exceed that of the original line (47.2 g) and was much lower than the performance of the variety-population, Kruiz, (83.0 g [27]).Thus, long-term targeted selection of high-oleic biotypes did not mean selection of high-yielding plants. Of the new lines, line Kh 0418 B had the best performance (30.5 g of seeds per plant).

As to the 1000-seed weight of the lines originated from Mkh 215 B (30.6-46.4 g), they exceeded the original line (28.9 g). The lines - descendants of line Kh 1012 B had the 1000-seed weight of 22.8-27.4 g, being inferior (-4.5 g) or similar to (+0.1 g) the original line (27.3 g). Unfortunately, the high 1000-seed weight of the original line, Kh 52 B, (61.8 g) was not inherited by the high-oleic offspring, so the selection of high-oleic genotypes was accompanied by loss of this valuable trait (high 1000-seed weight). The 1000-seed weight of the lines originated from line KhX 52 B was only 26.6-37.0 g, ie 43-60% related to the 1000-seed weight of the original line. The offspring of the variety did not inherit the high 1000-seed weight either (64.6 g [27]). The largest seeds were recorded in line Kh 0418 B (46.4 g).

All the lines under investigation showed a high huskness, which was not lower than 27.0% (line Kh 6318 B) and amounted to 36.7% (line Kh 5118 B). The most productive line, Kh 0418 B, with the highest 1000-seed weight, was also noticeable for a very high huskness of 35.4%. Such high levels of this trait were not observed in any of the parental components (which had a medium huskness), and we believe that this is associated with a wide variability of this trait in the original variety-population, Kruiz, (mean huskness 28.7% [27]).

In parallel with the high huskness, the oil content in seeds was low (not higher than 45.85%) in the lines derived from Mk 215 B; the oil content was 40.62% in the lines derived from Kh 1012 B and 48.96% in the lines derived from K 52 B. Regarding the last group of lines, the oil content in seeds of some lines of this group was increased to 48.96% (up to +8.17% compared to the original line, KhX 52 B). Such expression of this trait was unexpected, because Kh 52 B is referred to high-protein and low-oil lines [28].

The targeted selection has created lines with a high content of oleic acid in oil, which consistently exceeded 85% in most lines.

In 2019-2021, we studied the morphological features of the new self-pollinated lines derived from seven variety-line hybrid combinations. The diversity of the lines in terms of morphological features allows creating hybrids of different morphotypes, suitable for growing under different conditions.

The lines derived from line Mx 215 B were taller than the original line (89-120 cm vs. 74 cm) and had more leaves (25.5-36.1 vs. 22.5) (Table 3). As to the head diameter and leaf area, the new lines were comparable, inferior or superior (10.0-14.0 cm and 8.08-31.00 dm^2, respectively) to the original line (12.9 cm and 26.68 dm^2, respectively). Line Kh 1118 B had the greatest

number of leaves (36.1), though its leaf area was not the maximum (24.94 dm^2). Line Kh 0918 B had the largest leaves (31.00 dm^2).

Table 3. **Morphological features of the new self-pollinated sunflower lines – sterility fixers and their original genotypes, average for 2019-2021**.

Original/ new line	Plant height, cm	Head diameter, cm	Leaf number	Leaf area, dm^2	Head position, points
Lines – descendents of Mkh 215 B					
Kh 0218 B	96	13.4	32.9	11.19	8
Kh 0418 B	105	11.8	25.5	19.14	4
Kh 0518 B	104	14.0	27.9	26.09	6
Kh 0818 B	109	12.4	29.5	23.86	3
Kh 0918 B	89	13.0	25.6	31.00	5
Kh 1018 B	97	11.6	29.3	14.35	4
Kh 1118 B	89	10.0	36.1	24.94	6
Kh 3818 B	120	10.4	29.6	8.08	6
Mkh 215 B	74	12.9	22.5	26.68	4
Lines – descendents of Kh 1012 B					
Kh 0118 B	121	12.0	28.4	11.30	4
Kh 4618 B	89	9.0	25.1	13.92	8
Kh 1012 B	119	13.2	28.4	30.35	4
Lines – descendents of Kh 52 B					
Kh 4218 B	102	12.0	29.7	8.56	4
Kh 4918 B	97	11.0	25.0	23.89	8
Kh 5018 B	107	10.8	28.3	12.10	8
Kh 5118 B	102	11.8	30.4	15.95	5
Kh 5318 B	91	12.0	31.2	12.91	6
Kh 5818 B	95	13.8	36.1	15.20	4
Kh 6118 B	98	10.6	34.0	10.60	3
Kh 6218 B	96	10.4	30.2	13.52	3
Kh 6318 B	103	12.2	34.8	16.06	4
Kh 52 B	126	15.4	23.5	35.77	8

The lines derived from Kh 1012 B were noticeable for plant height (121 and 89 cm vs. 119 cm in the original line), the head diameter (12.0 and 9.0 cm vs. 13.2 cm in the original line), the leaf number (28.4 and 25.1 leaves vs. 28.4 leaves in the original line), and the leaf area (11.30 and 13.92 dm^2 vs. 30.35 dm^2 in the original line).

The lines derived from Kh 52 B were shorter (91-107 cm vs. 126 cm), had smaller heads (10.4-12.2 cm vs. 15.4 cm) and leaves (8.56-23.89 dm^2 vs. 35.77 dm^2) than the original line.

None of these lines was comparable to the original variety-population, Kruiz, in terms of such an important morphological feature as plant height similar (185 cm [27]), which is a positive fact for breeding, since lines with such level of the feature would not be suitable for heterosis sunflower breeding. In general, further studies of expression of the studied morphological features of the lines in the first hybrid generation derived from these lines are needed.

The head position relative to the stem significantly differed in the lines. The expression of this trait was ranked from 3 points (vertical) to 8 points (deflexed with a conspicuously bent stem). Parents with the head positions "semi-deflexed with a straight stem" (4 points) and "deflexed with

a straight stem" (6 points) are of particular value for heterosis hybrid breeding. This head position was intrinsic to lines Kh0418B, Kh0518B, Kh1018B, Kh1118B, Kh3818B, Kh0118B, Kh4218B, Kh5818B, and Kh6318B. It is noteworthy that the head position in the self-pollinated lines was not generally associated with the head position in the original genotypes.

There are a number of features that breeders use to distinguish lines. Sunflower leaves boast a great diversity and, to describe them according to international classifiers, ten main features are used. The new lines differed significantly in the leaf traits (Table 4). The green pigmentation intensity of the leaf varied from weak (3 points) to moderate (5 points). Blistering was ranked from absent or very weak (1 point) to strong (7 points). Serrations ranged from rare or very small (1 point) to moderate (5 points). As to the cross section shape, leaf could be from strongly concave (1 point) to slightly convex (4 points). The leaf top shape varied from lanceolate (1 point) to pointed (8 points).

Table 4. **The leaf traits of the new self-pollinated sunflower lines-sterility fixers and their original lines (points), 2019 and 2021**.

Original/new line	Green pigmentation intensity	Blistering	Serrations	Cross section shape	Top shape	Ligules	Wings	Angle between the lowest and lateral veins	Leaf top position relative to the blade attachment point
1	2	3	4	5	6	7	8	9	10
Lines – descendents of Mkh215B									
Kh 0218 B	3	3	3	2	5	1	2	2	7
Kh 0418 B	3	5	5	2	2	1	2	3	5
Kh 0518 B	3	5	5	1	2	1	2	2	7
Kh 0818 B	5	5	5	3	4	1	2	2	5
Kh 0918 B	3	3	5	3	3	1	2	3	5
Kh 1018 B	3	5	3	2	6	1	2	3	7
Kh 1118 B	3	1	3	2	4	3	2	3	5
Kh 3818 B	5	5	5	2	3	1	2	3	7
Kh 4218 B	5	3	3	3	1	2	2	2	7
Mkh 215 B	5	5	5	4	5	5	2	2	5
Lines – descendents of Kh1012B									
Kh 0118 B	3	3	3	3	3	1	1	2	7
Kh 4618 B	3	1	3	3	4	1	2	2	7
Kh 1012 B	5	3	1	3	8	7	1	3	3
Lines – descendents of Kh52B									
Kh 4918 B	3	7	3	2	2	1	2	1	7
Kh 5018 B	**3**	**7**	**1**	**3**	**2**	**1**	**2**	**1**	**7**
Kh 5118 B	**3**	**3**	**3**	**3**	**4**	**1**	**2**	**1**	**7**
Kh 5318 B	**3**	**3**	**5**	**3**	**3**	**1**	**2**	**1**	**5**
Kh 5818 B	**3**	**3**	**3**	**3**	**3**	**1**	**2**	**1**	**5**
Kh 6118 B	**3**	**3**	**3**	**3**	**3**	**1**	**2**	**1**	**7**
Kh 6218 B	**3**	**3**	**3**	**3**	**3**	**1**	**2**	**1**	**7**
Kh 6318 B	**3**	**1**	**3**	**3**	**3**	**1**	**2**	**1**	**7**
Kh 52 B	3	7	1	2	8	7	1	2	5

Ligules were absent or very small (1 point) to large (7 points). Wings were absent or very weak (1 point) to weak (2 points). The angle between the lowest and lateral veins varied from acute (1 point) to obtuse (3 points). The leaf top position relative to the blade attachment point varied from lowest (3 points) to highest (7 points).

Thus, the created lines were characterized by diversity of the leaf traits, proving their distinctness and simplifying their description for uniformity and stability. The new lines also differed in the characteristics of ray flowers, such as density, arrangement, shape, length, and pigmentation.

Resistance of the self-pollinated lines to pathogens and broomrape is one of the decisive characteristics for parents of heterosis hybrids. Resistance of the new lines to rust varied from slight signs of disease (3 points) to severe damage (9 points) (Table 5). The new lines were highly (7 points) or very high (9 points) resistant to downy mildew in the field.

Table 5. **Rust- and broomrape-induced damage and downy mildew resistance groups of the new self-pollinated sunflower lines-sterility fixers and their original lines**

Line	Rust[1)]	Downy mildew[2)]	Broomrape[3)]	Line	Rust[1)]	Downy mildew[2)]	Broomrape[3)]
Kh 0118 B	3	7	0.8	Kh 4918 B	3	7	2.1
Kh 0218 B	5	9	8.4	Kh 5018 B	3	7	1.3
Kh 0418 B	5	7	0.9	Kh 5118 B	3	7	0.6
Kh 0518 B	5	7	0.7	Kh 5318 B	5	9	1.1
Kh 0818 B	5	7	4.8	Kh 5818 B	5	7	0.7
Kh 0918 B	5	9	0.1	Kh 6118 B	3	9	1.1
Kh 1018 B	3	9	2.3	Kh 6218 B	3	7	0.1
Kh 1118 B	5	7	0.3	Kh 6318 B	3	7	1.4
Kh 3818 B	9	7	22.8	Mx 215 B	5	7	7.9
Kh 4218 B	5	7	0.8	Kh 1012 B	3	7	8.5
Kh 4618 B	7	9	0.7	Kh 52 B	3	7	2.3

Note: [1)] – natural conditions; 2019; damage degree, points
[2)] – natural conditions; 2021; resistance group, points
– artificial conditions (phytotron); 2018-2019 winter; damage degree (number of parasitic peduncles per sunflower plant)

As for the broomrape, the phytotron tests identified lines with the lowest damage by a local population of the parasite. These are lines Kh 0918 B and Kh 6218 B: the degree of broomrape-induced damage was 0.1 peduncle of the parasite per sunflower plant. Of the new lines, we should distinguish lines with group resistance. In particular, lines Kh 1018 B and Kh 6118 B showed very high resistance to rust and downy mildew. Lines Kh 0118 B, Kh 0418 B, Kh 0518 B, Kh 0918 B, Kh 1118 B, Kh 4218 B, Kh 5118 B, Kh 5818 B, and Kh 6218 B were highlighted as highly resistant to downy mildew and broomrape.

After conversion to a sterile basis, the studied lines will be included in a breeding program to create heterosis sunflower hybrids with a high content of oleic acid in oil.

CONCLUSIONS

It was found that the average content of oleic acid in Kruiz oil was 70.81 ± 2.35%, with fluctuations in some heads from 53.04% to 88.55%.

The prospects of using mid-oleic variety-line hybrid combinations in sunflower breeding for high oleic acid content have been proven. Oil from seeds of the initial variety-line hybrid combinations (Mkh 215 B / Kruiz.6, Mkh 215 B / Kruiz.7, Mkh 215 B / Kruiz.35, Kh 1012 B / Kruiz.30, Kh 1012 B / Kruiz.35, and Kruiz / Kh 1012 B) was characterized by a moderate content of oleic acid (58.20 - 66.03%).The content of oleic acid in seeds of the lines derived from these hybrid combinations amounted to 89.07%.

From the variety-line hybrid combinations and individual plants of the variety, a total of 52 self-pollinated lines have been created, of which 39 lines are sterility fixers (including 23 high-oleic lines) and 13 lines are pollen fertility restorers (including seven high-oleic lines).

The "seedlings - flowering" period in the lines originated from the variety-line hybrid combinations lasted (on average for two study years) from 53 days to 59 days, allowing for creation of hybrids of different maturity groups.

The high 1000-seed weight of the original line, Kh 52 B, (61.8 g) was not inherited by the high-oleic offspring. The 1000-seed weight of the lines derived from Kh 52 B was 26.6-37.0 g, ie 43-60% of the 1000-seed weight of the original line.

The "head position relative to the stem" trait in the self-pollinated lines was generally not associated with this trait in the original genotypes. The breeding-valuable positions of the head "semi-deflexed with a straight stem" and "deflexed with a straight stem" were inherent to lines Kh 0418 B, Kh 0518 B, Kh 1018 B, Kh1118 B, Kh 3818 B, Kh 0118 B, Kh 4218 B, Kh 5818 B, and Kh 6318 B. The created lines were diverse in terms of the leaf and ray flower characteristics, proving their distinctness and simplifying their description for uniformity and stability.

Lines with group resistance to diseases and broomrape have been identified. In particular, lines Kh 1018 B and Kh 6118 B were noticeable for very high resistance to rust and downy mildew. Lines Kh 0118 B, Kh 0418 B, Kh 0518 B, Kh 0918 B, Kh 1118 B, Kh 4218 B, Kh 5118 B, Kh5818 B, and Kh 6218 B were classed as highly resistant to downy mildew and broomrape.

After conversion to a sterile basis, the created lines - sterility fixers and their sterile analogues will be included in breeding programs to create heterosis sunflower hybrids with a high content of oleic acid in oil.

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Макляк К.М., Леонова Н.М., Супрун О.Г.
Інститут рослинництва імені В. Я. Юр'єва НААН
Московський просп., 142, Харків, 61060, Україна
E-mail: yuriev1908sunflower@gmail.com

ВИКОРИСТАННЯ ЗРАЗКІВ ГЕНОФОНДУ СОНЯШНИКУ В СЕЛЕКЦІЇ НА ВИСОКИЙ ВМІСТ ОЛЕЇНОВОЇ КИСЛОТИ В ОЛІЇ

Мета полягає у вивченні зразків національної колекції генетичних ресурсів рослин України як вихідного матеріалу для створення самозапилених ліній соняшнику, з високим вмістом олеїнової кислоти в олії та комплексом цінних господарських ознак.

Результати та обговорення. В результаті доборів з високоолеїнового сорту-популяції Круїз і з його сортолінійних гібридних комбінацій з трьома лініями-закріплювачами стерильності соняшнику Х1012Б, Мх215Б і Х52Б створено 52 самозапилені лінії, з яких 39 ліній-закріплювачів стерильності (з них 23 — високоолеїнові, з вмістом олеїнової кислоти вище 82 %, максимальний вміст 89,13%), та 13 ліній-відновників

фертильності пилку (з них сім – високоолеїнові). Тим самим доведено перспективність використання середньоолеїнових сортолінійних гібридних комбінацій у селекції соняшнику на високий вміст олеїнової кислоти. Тривалість періоду «сходи-цвітіння» нових ліній варіює від 53 до 59 діб, що дозволяє створювати на їх основі гібриди різних груп стиглості. Використання як вихідного генотипу крупнонасінної лінії Х 52 Б не призвело до отримання крупнонасінних високоолеїнових самозапилених ліній. Лінії різняться за ознаками листка та язичкових квіток. Виділено лінії з селекційно привабливим розташуванням кошика по відношенню до стебла: положення «напівобернене донизу разом із прямим стеблом», «обернене донизу з прямим стеблом». Виділено лінії з груповою стійкістю до іржі та несправжньої борошнистої роси, до несправжньої борошнистої роси та вовчка.

Висновки. Після переведення на стерильну основу, створені лінії-закріплювачі стерильності та їх стерильні аналоги будуть включені до програми створення гетерозисних гібридів соняшника, з високим вмістом олеїнової кислоти в олії.

Ключові слова: *соняшник, генофонд, зразки, олія, жирнокислотний склад, олеїнова кислота, селекція, схрещування, самозапилення, лінія.*

Макляк Е.Н., Леонова Н.Н., Супрун О.Г.
Институт растениеводства им. В.Я. Юрьева НААН
Московский просп., 142, Харков, 61060, Украина
E-mail: yuriev1908sunflower@gmail.com

ИСПОЛЬЗОВАНИЕ ОБРАЗЦОВ ГЕНОФОНДА ПОДСОЛНЕЧНИКА В СЕЛЕКЦИИ НА ВЫСОКОЕ СОДЕРЖАНИЕ ОЛЕИНОВОЙ КИСЛОТЫ В МАСЛЕ

Цель заключается в изучении образцов национальной коллекции генетических ресурсов растений Украины, как исходного материала для создания самоопыленных линий подсолнечника, с высоким содержанием олеиновой кислоты в масле и комплексом ценных хозяйственных признаков.

Результаты и обсуждение. В результате отборов из высокоолеинового сорта-популяции Круиз и из его сортолинейных гибридных комбинаций с тремя линиями-закрепителями стерильности подсолнечника Х 1012 Б, Мх 215 Б и Х 52 Б созданы 52 самоопыленные линии, из которых 39 линий-закрепителей стерильности (из них 23 – высокоолеиновые, с содержанием олеиновой кислоты выше 82 %, максимальное содержание 89,13 %), и 13 линий-восстановителей фертильности пыльцы (из них семь – высокоолеиновые). Тем самым доказана перспективность использования среднеолеиновых сортолинейных гибридных комбинаций в селекции подсолнечника на высокое содержание олеиновой кислоты. Продолжительность периода «всходы-цветение» новых линий варьирует от 53 до 59 суток, что позволяет создавать на их основе гибриды разных групп спелости. Использование в качестве исходного генотипа крупносемянной линии Х52Б не привело к получению крупносемянных высокоолеиновых самоопыленных линий. Линии различаются по признакам листка и язычковых цветков. Выделены линии с селекционно привлекательным положением корзинки относительно стебля: положение «полуобернутое вниз вместе с прямым стеблем» и «обернутое вниз вместе с прямым стеблем». Выделены линии с групповой устойчивостью к ржавчине и ложной мучнистой росе, к ложной мучнистой росе и заразихе.

Выводы. После перевода на стерильную основу, созданные линии-закрепители стерильности и их стерильные аналоги будут включены в программу создания гетерозисных гибридов подсолнечника, с высоким содержание олеиновой кислоты в масле.

Ключевые слова: *подсолнечник, генофонд, образцы, масло, жирнокислотный состав, олеиновая кислота, селекция, скрещивания, самоопыление, линия*.