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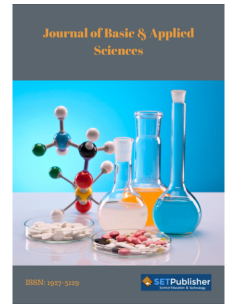

Growing Parental Lines of Sunflower under Group Isolators

Igor Aksyonov*

Department of Plant Growing and Horticulture, Faculty of Agricultural Technology and Ecology, Tavriyskiy State Agrotechnological University, Zaporozhie, Ukraine

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Abstract:

The study has been conducted at the Education-Scientific Institute of Natural and Agrarian Sciences of Lugansk National University named Taras Shevchenko (Ukraine). The research was aimed at establishing the elements of agricultural technology that ensure the maximum yield of pure seeds of sterile analog of the maternal lines GE6A and GE57A when grown under group isolators. This study examined the structure of plant productivity of sterile analog when grown under group isolators with a width of row spacing of 70 and 45 cm, with a plant population of 40, 50, 60, and 70 thousand plants ha^{-1}. The created conditions for growing plants under group isolators had different effects on the development of the vegetative mass of plants and quantitative characteristics of the productivity of plants of lines. A width of row spacing and crop density statistically influenced ($P < 0.05$) the formation of quantitative traits of plant productivity of maternal lines. Growing lines with a width row spacing of 45 cm at a plant density of 40-60 thousand ha^{-1} ensured an increase in the weight of head seeds in the sterile analog of the maternal line GE6A by 3.7-5.8 g, in the sterile analog of the maternal line GE57A - by 4.2-6.2 g. Each maternal line had an individual reaction to changes in growing conditions. A width of row spacing of 45 cm and a sowing density of 50 thousand plants/ha ensured the highest pure yield of seeds from a sieve with a hole size of 2.5 × 20 mm from one isolators of 16.0 kg and a maximum yield of 1.69 t ha^{-1} for the sterile analog of the maternal line GE6A. A width of row spacing of 45 cm and a sowing density of 50-60 thousand plants/ha ensured the highest pure yield of seeds from a sieve with a hole size of 2.5 × 20 mm from one isolators of 14.7-14.8 kg and a maximum yield of 1.55-1.57 t ha^{-1} for the sterile analog of the maternal line GE57A. The sterile analog of the maternal line GE6A, with a maximum yield level at a width of row spacing of 45 cm, produced a higher yield of 0.14-0.12 t ha^{-1} than the sterile analog of the maternal line GE57A. The research results allowed us to recommend the use of agricultural technology elements individually when growing maternal lines under group isolators.

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*Corresponding Author
E-mail: iva281256@gmail.com

1. INTRODUCTION

In Ukraine, as in many countries of the world, sunflower is the main source of oil. The demand for sunflower oil leads to an increase in the area planted with this crop. As a result, the sowing area under sunflowers in the world is about 26 million hectares, and in Ukraine about 6 million hectares [1]. Increasing demand for sunflower seeds and marketable for the products of this crop in the world food market led to an increase in the volume of sunflower cultivation while simultaneously increasing requirements for the quality of products obtained from seeds and the quality of seed material [2, 3]. To satisfy the demand of consumers, the created varieties and hybrids of sunflower have different economic uses and significance - with a high-fat content in the seeds, with a high content of oleic acid, confectionery with a high content of protein in the seeds, are resistant to the hydrolytic decomposition of oil, are resistant to the imidazoline group herbicides and a group of sulfonylurea herbicides, to produce silage. The hybrids sunflower seeds contain 48-52% fat and about 20-22% protein [4, 5, 6].

Breeders are working to create sunflower varieties and hybrids. However, in the world the sunflower sown area is sown mainly with hybrids, with a small number of varieties. The transition in agriculture from the cultivation of sunflower varieties to the cultivation of mainly sunflower hybrids makes the crop more commercially viable and profitable for originators - research institutions and private breeding companies, and also more technologically advanced and more productive for producers of commercial oilseeds of this crop [7, 8]. In this regard, the goal of hybrid sunflower seed programs is to obtain seed material of lines and hybrids with high genetic purity [9, 10]. It is necessary to consider that the efficiency of growing sunflower hybrids in agricultural enterprises, the possibility of stable and economically profitable production of hybrid seeds in breeding research institutions has a significant dependence on the quality and productivity of seeds of the maternal form, the organization of primary seed production of parental lines in the breeding institutions themselves [11]. The widespread introduction of hybrids into production is limited and mainly hampered by complex seed production, which involves maintaining parental lines at a high level of genetic purity [12].

When producing hybrid seeds, the fundamental importance is the use of the Syt^S - rfrf system. Exactly, the system of Syt^S – rfrf ensures the effectively controlled pollination of the sterile analogue of the maternal line with sterile cytoplasm Syt^Srfrf by the pollen of the sterility fixer (fertile analogue) Syt^Nrfrf with the normal cytoplasm of the same maternal line [13]. The effectiveness of pollination and obtaining high-quality seed material is determined by the presence and compliance with spatial isolation. However, when growing seeds of parental lines in primary seed production, the problem of maintaining spatial isolation has already arisen [14].

To avoid uncontrolled pollination, the plots propagation of seeds of sunflower parent lines must be located within spatial isolation of five kilometers from other sunflower crops. The saturation of crop rotations with sunflower in the Steppe and Forest-Steppe of Ukraine leads to a violation of spatial isolation and does not allow obtaining biologically pure seed material, since mother plants are inevitably pollinated by pollen from plants of other lines and forms of sunflower [15]. Such disturbances during the propagation of lines lead to the appearance in plots of hybridization of atypical plants in height, atypical plants with other morphological signs, fertile plants (fixers of sterility) of the maternal form and a decrease in the level of genetic purity of sunflower lines and hybrids [16]. Obtaining and maintaining a high level of genetic purity of parental lines and sunflower hybrids is an important task for breeders. For example, in the USA, a breeder simultaneously evaluates the adaptability of a hybrid for cultivation in specific soil and climatic zones and has the responsibility for preserving the genetic purity of self-pollinated parental lines during their propagation in primary and industrial seed production. This approach allows to decide the problem of growing a new hybrid over a large area in several states at once [17, 18].

One of the options for obtaining parental lines and sunflower hybrids with a high level of typicality is to grow parental lines under group isolators. This solution to the problem makes it possible to obtain hybrids with a willow typicality level in the range of 96-97%. Plants of the lines under group insulators are grown in unusual, stressful conditions, in conditions of elevated air temperature and possible conditions of moisture deficiency. Growing plants in unusual conditions causes stress in plants and can lead to changes in plant productivity, reduced yield, and changes in the relationship between the vegetative part of the plant and the root system [19, 20, 21, 22]. This can be explained by the fact that self-pollinated sunflower lines have a narrow genetic basis and a high dependence on unfavorable weather conditions in the first phases of ontogenesis [23].

Therefore, justifiably, the main tasks of propagating lines under group insulators are the development and application of technologies for growing lines in created artificial conditions. The nature of variability of the main economically useful signs when testing breeding material and seed material in nurseries for estimation posterity has not been studied enough; the scope of variation is indicated without taking into account the direction and magnitude of variability in the structure of plants productivity under the influence of selection often. Taking into account the fulfillment of these tasks, the breeder must ensure in hybrid seed production of sunflower an increase in the yield of quality seeds per unit area of propagation of the line, since the efficiency of production of hybrid sunflower is determined by the quality of the seeds, the volume of the harvest of high-quality seeds of the maternal lines in the propagation plots [24, 25]. One of the main directions for increasing the efficiency of technologies for growing the parent lines of sunflower is the development of varietal agricultural techniques. The basis of varietal agricultural technology is the responsiveness of sunflower plants to sowing terms, plant density and the use of fertilizers [26, 27]. Elements of varietal technologies fully reflect the varietal specificity of responsiveness of plants to the created conditions of development and yield formation. Therefore they are necessary for the development of agricultural technology for growing sunflower lines. However, the significant factors of varietal agricultural technology, that determine the formation of high seed yields of sunflower lines in cultivation technology, have been insufficient studied [28, 29, 30].

Therefore, the relevance of the research is to develop the most important elements of varietal agricultural technology in order to fully realize the biological potential of the seed productivity of parental lines. In this regard, we conducted research to study and establish the effectiveness of use the elements of varietal agricultural technology (a width of row spacing, plant density) when growing maternal sunflower lines GE57A and GE6A under group insulators, which would ensure maximum productivity of plant lines and the maximum yield of conditioned seeds from one group isolator.

2. MATERIALS AND METHODS

A field experiment with sugar beet was carried out in 2021-2023 in the Education-Scientific Institute of Natural and Agrarian Sciences of Lugansk National University named Taras Shevchenko. The parent lines of sunflower were sown after green manure fallow. Green manure crop – white mustard.

Experimental work to study the influence of elements of varietal agricultural technology for growing parental lines of sunflowers under group insulators involved the use of deep plowing to a depth of 27-30 cm. After the main tillage, in early – mid-November, the soil was cultivated with a KPS-4 cultivator. In the spring, pre-sowing cultivation was carried out to a depth of 6-8 cm. Treflan herbicide (5 l ha^{-1}) was applied for pre-sowing cultivation with immediate mixing with the soil. Seeds of sunflower parent lines were sown in the soil to a depth of 6-8 cm. The sowing term for parent lines was at the temperature 8-10^{0}C at the depth of the soil layer of 6-8 cm. In the experiment, maternal sterile lines GE6A and GE57A were sown. Seeds of parental lines were sown with row spacings of 70 and 45 cm. Plant density – 40 thousand ha^{-1} (control), 50 thousand ha^{-1} and 60 thousand ha^{-1}.

Distance between plant in a row with a width of a row spacing of 70 cm:

- 35 cm (plant density 40 thousand ha^{-1});
- 28 cm (plant density 50 thousand ha^{-1});
- 24 cm (plant density 60 thousand ha^{-1}) (Table **1**).

Table 1: Distance between Plants in a Row with a Different Width of a Row Spacing

Row spacing, cm	plant density, thousand ha^{-1}		
	40	50	60
70	35	28	24
45	55	44	37

Distance between plants in a row with a width of a row spacing of 45 cm:

- 55 cm (plant density 40 thousand ha^{-1});
- 44 cm (plant density 50 thousand ha^{-1});
- 37 cm (plant density 60 thousand ha^{-1}).

During the growing season, two row-spacing cultivations were done. Each parental line was sown separately under group isolators. In the group isolator, only one maternal line was grown. Before of the sunflower plants were flowered, the group isolator was covered with a special agronomic fiber to prevent the

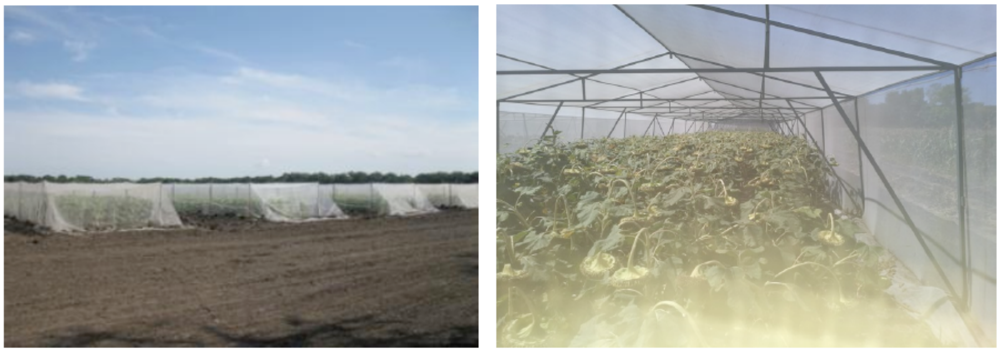

Figure 1: Growing parental lines of sunflower under group isolators.

ingress of pollen from plants of other parent lines of sunflower (Figure **1**).

Under each group isolator, a sterile analogue of the maternal line ($Syt^{S}rfrf$) and a sterility fixer (fertile analogue) of the maternal line ($Syt^{N}rfrf$) were sown. Sowing scheme of the maternal line with a width of a row spacing of 70 cm:

one row $Syt^{N}rfrf$: two rows $Syt^{S}rfrf$: one row $Syt^{N}rfrf$: two rows $Syt^{S}rfrf$ ($Syt^{N}rfrf$: $Syt^{S}rfrf$: $Syt^{S}rfrf$: $Syt^{N}rfrf$: $Syt^{S}rfrf$: $Syt^{S}rfrf$). Four rows of the analog of the sterile maternal line ($Syt^{S}rfrf$) and two rows of the fertile analog (fixer of sterility) of the maternal line ($Syt^{N}rfrf$) were grown under the isolator.

Sowing scheme of the maternal line with a width of a row spacing of 45 cm:

two rows $Syt^{S}rfrf$: one row $Syt^{N}rfrf$: three rows $Syt^{S}rfrf$: one row $Syt^{N}rfrf$: two rows $Syt^{S}rfrf$ (SytSrfrf : $Syt^{S}rfrf$: $Syt^{N}rfrf$: $Syt^{S}rfrf$: $Syt^{S}rfrf$: $Syt^{S}rfrf$: $Syt^{N}rfrf$: $Syt^{S}rfrf$: rfrf). Six rows the analog of sterile maternal line ($Syt^{S}rfrf$) and two rows the fertile analog (fixer of sterility) of maternal line ($Syt^{N}rfrf$) were grown under the isolator.

A group isolator with a width of a row spacing of 70 cm has 4 rows of a sterile analog of the line ($Syt^{S}rfrf$) and 2 rows of a fertile analog ($Syt^{N}rfrf$). A group isolator with a width of a row spacing of 45 cm has 7 rows of a sterile analog of the line ($Syt^{S}rfrf$) and 2 rows of a fertile analog ($Syt^{N}rfrf$). Dimension of the group isolator: width – 4.4 m, length – 30 m.

During the growing season, the assessment and analysis of plants were performed according to the following characteristics: plant height, head diameter, total area of the head, productive area of the head, weight of seeds in the head, weight of 1000 seeds. The productive area of the head was determined by the difference between the total area of the head and the area of the empty part of the head (part of the area of the head with empty seeds). The evaluation and analysis of plants were carried out on 10 plants in 2 replicates for each experimental variant. The each variant had three repetitions.

During harvesting, the heads were cut by hand in the phase of full ripeness. The seeds from the heads were threshed by hand. The accounting of plant productivity was determined by the yield of seeds of sterile analogues of maternal lines. The yield value was recalculated per unit area - t/ha. The quantity of seeds with group isolator and yield was determined by the number of seeds coming out of the sieve after processing. A sieve has the oblong holes. A size of oblong holes is 2.5 × 20 mm. Observations in the experiment were carried out based on methods for conducting research in agronomy. The obtained experimental data of the experiment were assessed based on the methods of mathematical statistics [31-35].

3. RESULTS AND DISCUSSION

The sowing density and a width of a row spacing created different conditions for growing maternal lines under group isolators. The created conditions influenced the growth and productivity of plant of sunflower maternal lines under group isolator. Maternal lines had an individual response to the changing of the growing conditions. In the maternal line GE57A with a width of a row spacing of 70 cm, an increase in sowing density increased the plant height by 9.4-19.2 cm (Table **2**).

An increase in plant height with a width of row spacing of 45 cm in this line by 13.0 cm was observed when the sowing density increased to 60 thousand ha^{-1}. Line GE6 had a different response to changes in a width row spacing and planting density.

Table 2: The Influence of Sowing Density and Width of a Row Spacing on the Height of Plants of a Sterile Analog of Sunflower Maternal Lines, cm (Average for 2021-2023)

Width of a row spacing, cm	Plant density, thousand ha^{-1}	Flowering phase	
		GE6A	GE57A
70 (control)	40 (control)	108.1	149.5
	50	110.2	158.9
	60	116.2	168.7
45	40	109.0	150.1
	50	111.1	152.3
	60	110.3	163.1
$LSD^{*}_{0.05}$ plant density		3.8	
width of a row spacing		4.0	
line		5.2	

[*] Least significant difference.

An increase in the height of plants of the maternal line GE6 by 8.1 cm was noted with width of row spacing of 70 cm and a sowing density of 60 thousand ha^{-1}. The remaining growing conditions did not affect the height of the plants of the line compared to the control variant - a width of a row spacing was 70 cm, and the sowing density was 45 thousand ha^{-1}. Increasing the sowing density at a width of a row spacing of 45 cm did not lead to a change in the height of plants of the maternal line GE6A. Plant height was in the range of 109.0-111.1 cm and did not change with increasing plants density from 40 to 60 thousand ha^{-1}. Different growing conditions (plants density, a width of a row spacing) of maternal lines under group isolators led to changes not only in plant height, but also in plant productivity. Agricultural practices of a width of a row spacing and population of plants changed the diameter of the head and the productive area of the head of sunflower plants. On trait of a head diameter, the parental lines GE6A and GE57A had the same response to changes

Table 3: The Influence of Width of a Row Spacing and Sowing Density on the Formation of Head Diameter and Productive Area of Head in a Sterile Analogue ($Syt^{S}rfrf$) of Sunflower Maternal Lines, (Average for 2021 -2023)

Width of a row spacing, cm	Plant density, thousand ha^{-1}	Head diameter, cm	Total area of the head, cm^{-2}	Productive area of the head, cm^{-2}	Percentage ratio of productive area to total area of head, %
Line GE6A					
70 (control)	40 (control)	16.4	211.1	194.4	92.1
	50	14.2	158.3	142.5	90.0
	60	11.0	95.0	84.7	89.2
45	40	17.5	240.4	226.0	94.0
	50	17.3	234.9	221.0	94.1
	60	15.9	198.5	186.6	94.0
Line GE57A					
70	40	17.2	232.2	211.5	91.1
	50	15.0	177.6	152.7	86.0
	60	12.3	118.8	97.4	82.0
45	40	18.5	268.7	247.2	92.0
	50	18.3	263.9	242.8	92.0
	60	14.0	153.9	141.1	91.7
$LSD_{0.95}$ plant density		1.29			
width of a row spacing		0.96			
line		0.74			

in the growing conditions under group isolators. Growing lines with a width of a row spacing of 45 cm ensured an increase in head diameter by 1.1-4.9 cm for line GE6A, and by 1.3-3.3 cm for line GE57A compared to control (Table **3**).

The maximum diameter of the head of the line was formed with a width of a row spacing of 45 cm with a plant density of 40 and 50 thousand ha^{-1} – 18.3 cm (line GE57A). Thickening of sowings of maternal lines from 40 to 50 thousand ha^{-1} plants contributed to an increase in the diameter of the basket to the level of 17.5-17.3 cm (line GE6A), 18.5-18.3 cm (line GE57A). However, thickening of sowings of maternal lines from 40 to 60 thousand plants ha^{-1} led to a decrease in the diameter of the head in both lines with a width of a row spacing of 70 cm. The decrease in the diameter of the head in line GE6A was 5.4 cm and in line GE57A – 4.9 cm.

When the lines were grown at with a width of a row spacing of 45, the head diameter of lines decreased up to the level – 15.9 cm (line GE6A) and 14.0 cm (line GE57A) only at a sowing density of 60 thousand plants ha^{-1}. At the same time, a more significant decrease in the head diameter of 4.5 cm was observed in the line GE57A compared to plants with a sowing density of 40 thousand plants ha^{-1} at the same width of a row spacing. Plants of the line GE6A slightly reduced the diameter of the head when plants crops are thickened to 60 thousand ha^{-1} – by 1.6 cm compared to plants with a sowing density of 40 thousand ha^{-1}.

The diameter of the head determined the total area of the head and the productive area of the head. Growing plants with a width of a row spacing of 45 with a plants density of 40 and 50 thousand/ha ensured the formation of the maximum productive area of the head of the lines. In these conditions of growing, line GE6A had a maximum productive area in the range of 226-221 cm^{-2}, and line GE57A had a maximum productive area in the range of 247.2-242.8 cm^{-2}. At the same time, growing lines with a width of a row spacing of 45 cm, independently of sowing density, ensured the same percentage ratio of the productive area of the head to the total area of the head. This ratio was 94.0-94.1% for the line GE6A and 91.7-92.0% for the line GE57A.

Plants of the sterile analog of the maternal line GE6A had higher ratios of the productive area of a head to the total area of a head. This line was characterized by a lower level of decrease in the ratio of the productive area of the head to the total area of the head with an increase in plant density with a width of a row spacing of 70 cm - 2.1-2.9%. In the GE57A line, an increase of the sowing density at a width of a row spacing of 70 cm led to the a more significant decrease in the ratio of productive area of the plant head to total area - 5.1-9.1%. The changes in the indicators of the diameter of the head and the productive area of the head of sunflower plants, in turn, determined the changes in the productive indicators of the lines - the weight of 1000 seeds, the weight of the seeds of the head. Thickening of plants to 50 and 60 thousand/ha led to a decrease in the weight of 1000 seeds and the weight of seeds per plants head of maternal lines with a width of a row spacing of 70 cm. On the sowing plant with a width of a row spacing of 70 cm, the maximum mass of head seeds was obtained at a control plants density of 40

Table 4: Productivity of the Sterile Analog ($Syt^S rfrf$) of Sunflower Maternal Lines in Depending from Growing Conditions under Group Isolators (Average for 2021 -2023)

Width of a row spacing, cm	Plant density, thousand ha^{-1}	Sterile analog ($Syt^S rfrf$) of line GE6A		Sterile analog ($Syt^S rfrf$) line GE57A	
		Weight 1000 seeds, g	Weight of seed of head, g	Weight 1000 seeds, g	Weight of seed of head, g
70 (control)	40 (control)	55.1	48.0	63.7	43.1
	50	50.2	44.2	59.4	41.2
	60	50.0	39.2	55.0	37.0
45	40	60.4	51.7	67.2	47.3
	50	57.2	51.0	67.0	47.2
	60	53.4	45.0	58.2	43.2
$LSD_{0.95}$ plant density		2.1	3.6		
width of a row spacing		2.9	3.2		
line		3.9	2.3		

thousand ha^{-1}. A more significant decrease in the weight of seeds per head with a width of a row spacing of 70 cm and an increase in plants density to 60 thousand ha^{-1} was noted in the sterile analog of the maternal line GE6A. The level of reduction in the weight of 1000 seeds by such conditions of growing in the GE6A line was 18.3% (Table **4**).

Plants of the GE57A line suffered from increased sowing density a lesser degree. The level of reduction in the weight of head seeds at this line was 14.2%. Maximum indicators for the traits of the weight of 1000 seeds and the weight of head seeds of the plant lines were achieved with a width of a row spacing of 45 cm. The line GE6A, by decreasing the weight of 1000 seeds on the sowing with the plants density of 50 thousand ha^{-1} to 57.2 g, formed the maximum weight of head seeds of 51.0 g on the sowing with a plant density of 50 thousand ha^{-1}. An increase in the plant density to 50 thousand ha^{-1} did not lead to a decrease in the mass of head seeds of the line GE6A line on the sowing with a width of a row spacing of 45 cm. On the sowing with width of a row spacing of 45, an increase in plant density to 50 thousand ha^{-1} did not lead to a decrease in the weight of 1000 seeds and the weight of head seeds of the line GE57A. Such growing conditions ensured the formation of a maximum weight of 1000 seeds of 67.2-67.0 g and the weight of the head seed of 47.3-47.2 g in this line.

Growing lines with a width of a row spacing of 45 cm with a plants density of 40 and 50 thousand ha^{-1}, increasing the percentage ratio of productive area to the total area of the head provided a higher level of mass of the head seed of the line GE6A in by comparison with the line GE57A. The weight of the head seed of line GE6A was 51.7 g, the weight of head seed of line GE57A was 47.3 g. Growing lines with a width of a row spacing of 45 cm ensured an increase in the quantity of seeds under the group isolator. The percentage ratio of the quantity of seeds after the sieve (pure seeds) on the sowing with a width of a row spacing of 45 cm for the GE6A line was 84.3-76.7%, and for the GE57A line 76.9-70.8 (Table **5**).

With an increase in the plant density, the percentage decrease of the coming of seeds after the sieve (pure seeds) was less significant in sowing with a width of a row spacing of 45 cm than in crops with a row spacing of 70 cm. By thickening of sowings from 40 to 60 thousand ha^{-1}, the line GE6A had a level of reduction of coming of pure seeds on a width a row spacing of 70 cm - 75.9-59.4%, on a width a row spacing of 45 cm - 84.3-76.7%. With thickening of sowings, the line GE57A had a level of reduction of coming of pure seeds after the sieve on a width of a row spacing of 70 cm - 70.6-58.8%, on a width of a row spacing of 45 cm - 76.9-70.8%. The maximum quantity of clean seeds from a sieve with a hole size of 2.5 × 20 mm from one isolator of 16 kg of the line GE6A was obtained when grown with a width of a row spacing of 45 cm and a plants density of 50 thousand ha^{-1}. Increasing the plant density of this line to 50 thousand ha^{-1} increased the quantity of clean seeds from a sieve with openings of 2.5 × 20 mm from one isolator from 13.4 kg to 16.0 kg. A further increase in plants population to 60 thousand

Table 5: The Influence of Growing Conditions under Group Isolators on the Quantity of the Received Seeds of a Sterile Analogue (Syt^{S}rfrf) of Sunflower Maternal Lines (Average for 2021 -2023)

Width of a row spacing, cm	Plant density, thousand ha^{-1}	Sterile analog (Syt^{S}rfrf) of line GE6A			Sterile analog (Syt^{S}rfrf) line GE57A		
		Total weight of seeds with one isolator, kg	Quantity of seeds after coming from a sieve with hole size 2.5 × 20 mm, kg	Percentage ratio of the quantity of seeds after the sieve to the total number of seeds, %	Total weight of seeds with one isolator, kg	Quantity of seeds after coming from a sieve with hole size 2.5 × 20 mm, kg	Percentage ratio of the quantity of seeds after the sieve to the total number of seeds, %
70 (control)	40 (control)	14.5	11.0	75.9	14.3	10.1	70.6
	50	17.4	11.3	64.9	17.3	11.2	64.7
	60	18.0	10.7	59.4	18.2	10.7	58.8
45	40	15.9	13.4	84.3	15.6	12.0	76.9
	50	19.4	16.0	82.5	19.2	14.7	76.6
	60	20.2	15.5	76.7	20.9	14.8	70.8

ha^{-1} reduced the quantity of seeds of the line GE6A to 15.5 kg.

The maximum quantity of clean seeds from a sieve with a hole size of 2.5 × 20 mm from one isolator of 14.7 kg and 14.8 kg of the line GE57A was obtained by growing plants with a width of a row spacing of 45 cm and a sowing density of 50 and 60 thousand ha^{-1}. Increasing the sowing density to 50 and 60 thousand ha^{-1} increased the quantity of pure seeds from a sieve with openings of 2.5 × 20 mm from one isolator from 12.0 kg to 14.7 and 14.8 kg. Increasing the plants density of the line GE57A to 60 thousand ha^{-1} did not reduce the quantity of clean seeds obtained from the sieve. Growing maternal lines with width of a row spacing of 70 cm formed in a lower quantity of pure seeds from one isolator. The sunflower maternal lines in sowing with a width of a row spacing of 70 had the same response to an increase in plant density.

The quantity of pure seeds from a sieve with a hole size of 2.5 × 20 mm from one isolator on sowing with a width of a row spacing of 70 cm was 10.7-11.3 kg for the GE6A line, 10.1-11.2 kg for the GE57A line. Line GE6A and line GE57A by a control density of 40 thousand plants ha^{-1} provided the amount of pure seeds from one isolator of 11.0 kg and 10.1 kg, respectively. The quantity of pure seeds from the sieve increased with the thickening of plants from 40 to 50 thousand ha^{-1}. The quantity of the obtained pure seeds decreased with a further thickening of sowing from 50 to 60 thousand ha^{-1}. Sowing sterile analog of maternal lines GE6A and GE57A with a width of a row spacing of 70 cm on sowing with increased plant density ensured the production of almost the same amount of pure seeds from one isolator according to plant density: 11.3-11.2 kg, 10.7-10.7 kg. Regardless of the density of the sowing, growing plants with a width of a row spacing of 45 cm ensured a higher percentage of seeds coming from the sieve of line GE6A than from line GE57A. An increase in the percentage of pure seeds coming from the sieve of line GE6A line ensured that a larger quantity of seeds were obtained from one isolator for this line.

Recalculation of the yield per unit area (taking into account the yield of pure seeds from a sieve with holes of 2.5 × 20 mm from one isolator) shows that the lines form a higher yield by grown under group isolators with a row spacing of 45 cm. Regardless of the sowing density, growing plants of lines with a width of a row spacing of 45 cm, in comparison with the control width of row spacing of 70 cm, ensured an increase in the yield of the sterile analog in line GE6A - 0.11-0.37 t ha^{-1} and line GE57A - 0.07-0.07 t ha^{-1} (Table **6**).

Growing plants with a width of a row spacing of 45 cm provided a higher level of increase of the yield growth of pure conditioned seeds of the sterile analog of line GE6A in comparison with the sterile analog of line GE57A. The maximum level of yield of maternal lines with a width of a row spacing of 70 cm was obtained by a density of plants of 50 thousand ha^{-1}.

By this sowing density, sterile analogues of the lines formed the same yield level of 1.35-1.33 t ha^{-1}. By a sowing density of 60 thousand ha^{-1}, the seed yield was minimal for both lines: 1.27 t ha^{-1}. By a given sowing density, the difference in the yield of the lines is not found. The line GE6A formed a maximum yield level of 1.69 t ha^{-1} with a width of a row spacing of 45 cm and a sowing density of 50 thousand ha^{-1}. The increase of sowing density of plants to 60 thousand ha^{-1} led to a decrease in seed yield to the level of 1.64 t ha^{-1}. The

Table 6: The Yield of Pure Seeds of a Sterile Analog ($Syt^{S}rfrf$) of Sunflower Maternal lines by grown under a group isolator, t ha^{-1} (average for 2021 -2023)

Width of a row spacing, cm	Plant density, thousand ha^{-1}	Sterile analog ($Syt^{S}rfrf$) of line GE6A	Sterile analog ($Syt^{S}rfrf$) line GE57A
70 (control)	40 (control)	1.31	1.20
	50	1.35	1.33
	60	1.27	1.27
45	40	1.42	1.27
	50	1.69	1.55
	60	1.64	1.57
$LSD_{0.05}$ plant density		0.04	
width of a row spacing		0.06	
line		0.08	

line GE57A formed a maximum yield level of 1.55-1.57 t ha^{-1} with a width of a row spacing of 45 cm and the sowing density of 50-60 thousand ha^{-1}. The increase of the sowing density of plants to 60 thousand ha^{-1} did not lead to a decrease in seed yield in line GE57A.

The analyses and results study shown in this paper are consensus with other experiments of scientists. Our results are supported by other studies. Aguirrezabal *et. al.* [2003] show that changes in growing conditions during seed filling potentially affect sunflower yield components. High-quality seeds of sunflower lines, based on their genetic characteristics, can be formed under the condition of providing a complex of optimal factors for the growth and development of maternal plants [37]. The use of elements of varietal agricultural technology (planting density, row spacing) in our experiments ensured the creation of optimal conditions for the formation of maximum yield of parent lines, taking into account the reaction of the line genotype to growing conditions. Namely, obtaining increased yield and its stability and on main component of yield is ensured by the influence of seeding density and row spacing [38]. The density of sowing and row spacing in interaction with the genotype and growing conditions affect and determine the yield level. Elements of varietal agrotechnics are the main factors in the formation of sunflower yields. Optimal placement of plants in the crop promotes the most complete use of environmental factors and the formation of the highest plant productivity indicators, which determine the level of sunflower yield [39].

Thus, yield and its main components parental lines of sunflower are determine by productivity elements, genotype response to changes in growing conditions and cultural practices.

CONCLUSIONS

A width of a row spacing and sowing density influence the growth of vegetative mass and the formation of plant productivity of maternal lines.

Sterile analogs of sunflower maternal lines GE6A and GE57A, grown under group isolators, have an individual response to the use of agricultural technology elements – width of a row spacing and the sowing density.

The increase in the sowing density leads to a decrease in the productive area of the head of the sterile analog of the maternal line GE6A with a width of a row spacing of 70 cm on 51.9-109.7 cm^2, with a width of a row spacing of 45 cm by 5.0-39.4 cm^{-2}, at the sterile analog of the maternal line GE57A on 58.8-114.1 cm^{-2} and 4.4-106.1 cm^{-2}, respectively.

On the sowing with a width of a row spacing of 45 cm and a plant density of 40-60 thousand/ha, the weight of the head seeds of the sterile analog of the maternal line GE6A increased on 3.7-5.8 g, of the sterile analog of the maternal line GE57A - on 4.2-6.2 g compared to sowing with a width of a row spacing of 70 cm. On the sowing with a width of a row spacing of 70 cm, the increase of sowing density from 40 to 60 thousand ha^{-1} led to a decrease in the weight of head seeds of the sterile analog of the maternal line GE6A on 3.8-8. 8 g. The decrease in the weight of the head seeds of the sterile analog of the maternal line GE57A on 6.1 g was noted in the sowing density of 60 thousand ha^{-1}. The decrease of the mass of head seeds on the swing with a width of a row spacing of 45 cm was noted only at a plant density of 60 thousand ha^{-1}: on 6.7 (line GE6A) and on 4.1 (line GE57A).

The highest coming of pure seeds from a sieve with a hole size of 2.5 × 20 mm from one isolator for sterile analogs of maternal lines GE6A and GE57A was by growing lines with a width of a row spacing of 45 cm.

On sowing with a width of a row spacing of 45 cm, the coming of pure seeds from a sieve with a hole size of 2.5 × 20 mm increased to a level of 16.0 kg by the plant density of 50 thousand ha^{-1} at the line GE6A, to a level of 14.7-14.8 kg by the plants density of 50-60 thousand ha^{-1} at the line GE57A.

The increase in the quantity of pure seeds of lines from under the group isolator with a row spacing of 45 cm is explained by an increase in the quantity of the rows in the group isolator, the change in growing conditions, and the change in the configuration of the feeding area. The maximum yield of 1.69 t ha^{-1} is obtained at the sterile analog of the maternal line GE6A with a width of a row spacing of 45 cm and by the density of the plants sowing of 50 thousand ha^{-1}. The maximum yield of 1.55-1.57 t ha^{-1} is obtained at the sterile analog of the maternal line GE57A with a width of a row spacing of 45 cm and by the density of the plant sowing of 50 and 60 thousand ha^{-1}. By growing under a group isolator, plants of a sterile analog of the line GE57A are able to tolerate an increase of sowing density up to 60 thousand ha^{-1}, forming a high level of seed yield.

To obtain high seed yields (coming of pure seeds from a sieve with a hole size of 2.5 × 20 mm), maternal line

GE6A is recommended to grow with a width of a row spacing of 45 cm and the sowing density of 50 thousand plants ha^{-1}. To obtain high seed yields (coming of pure seeds from a sieve with a hole size of 2.5 × 20 mm), maternal line GE57A is recommended to grow with a width of a row spacing of 45 cm and the sowing density of 50-60 thousand plants ha^{-1}.

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