

Article Type: Research  
J Name: Modern Phytomorphology  
Short name: MP  
ISSN: ISSN 2226-3063/ eISSN 2227-9555  
Year: 2025



Volume: 19 (2)

Page numbers: 178-182

DOI: 10.5281/zenodo.15302209

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#### RESEARCH ARTICLE

# Management of cultivation, market analyses, diversification, and changes in herbicide groups of sunflowers in the northeastern region of Ukraine

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**Received:** 07.03.2025, Manuscript No: mp-25-162107 | **Editor Assigned:** 10.03.2025, Pre-QC No. mp-25-162107 (PQ) | **Reviewed:** 25.03.2025, QC No. mp-25-162107 (Q) | **Revised:** 31.03.2025, Manuscript No. mp-25-162107 (R) | **Accepted:** 06.04.2025 | **Published:** 12.04.2025

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## Abstract

Sunflower cultivation remains a profitable business in Ukraine. Also, a large share of arable land is allocated for sunflowers in the northeastern part of Ukraine, particularly in the Sumy region. The paper is devoted to analysing sunflower seed sales by agro-industrial companies from 2019 to 2024. The pros and cons of three herbicide technologies for growing sunflowers are also analysed. It was found that Syngenta is the leader in sunflower seed sales, although the number of sold seeds decreased by 50% from 2019 to 2024. The 2023-2024 marketing year was marked by the maximum reduction in sunflower seed sales in almost all companies in the Sumy region. It is proven that farmers in the Sumy region choose more herbicide technology Clearfield® (CL)/Clearfield® Plus (CLP) - 31.4% (2023/2024), a slightly smaller share of classical technology - 27.1% and ExpressSun® (SUMO) technology is 19.2% of these three technologies. Due to the prevalence of sunflowers in crop rotations, broomrape (*Orobanche cumana* Wallr.) has a rapid spread in the field, which significantly reduces yield.

**Keywords:** Sunflower, Hybrids, Sowing units, Seeds, Herbicides, Weeds, Yield, Broomrape, Clearfield, Sales organisation structure, Market analysis

## Introduction

Management of sunflower cultivation technology depends on the selection of hybrid, high-quality seeds that are capable of producing uniform, friendly seedlings in the conditions of the northeastern part of the Forest-steppe of Ukraine with a cooler spring (with frosts and excessive precipitation) (Melnyk et al., 2017). Plans for seed procurement include the cost of its acquisition and transportation to the farm (Makarchuk et al., 2022). Representatives of various seed campaigns, scientific institutions and intermediaries actively offer their seed material. Breeding is currently aimed at developing

hybrids with high-stress resistance, namely to drought, frost, certain diseases, productivity, seed quality, oil, speed and uniformity of ripening, etc. (Yeremenko et al., 2018; Kharchenko et al., 2019; Akuaku et al., 2020; Trotsenko et al., 2020).

The structure dynamics of sunflower acreage vary by year (Petrenko et al. 2024; Kostyna et al., 2024). The areas occupied by sunflowers in such regions of northeastern Ukraine as the Chernihiv and Sumy regions have slightly decreased since 2022 (Kysylchuk et al., 2024). In the Chernihiv region, the area under sunflowers in 2024 was 207.3 thousand hectares, and in the Sumy region, it was 173.7 thousand hectares, compared to 2022 indicators of 287.6 thousand hectares and 333.5 thousand hectares. The areas have significantly decreased in the Sumy region due to constant shelling of the border area and the withdrawal of some areas from cultivation (Mustroph, 2018; Bondarets & Vereshchahin, 2024). In general, before the beginning of the war (February 2022), the area under sunflowers was steadily increasing, which caused an outbreak of diseases and pests, particularly sunflower bloomrape (Kurylych & Makliak, 2024). Foreign and domestic scientists are working to create sunflower hybrids resistant to bloomrape and have high-quality seed and yield indicators. At the Institute of Plant Breeding, named after V. Ya. Yuryev, hybrid combinations were identified that combined a low degree of bloomrape damage with early maturity, high oil content and seed yield. Therefore, work continues and aims to create separate lines of parental components that will be competitive in the seed market in Ukraine.

Scientists at the Institute of Food Biotechnology and Genomics of Ukraine are fruitfully studying the racial composition of bloomrape in various sunflower hybrid crops in Ukraine's Forest-Steppe and Polissya zones. However, scientists have stated that no hybrids that are entirely resistant to bloomrape have been developed. Some hybrids are more susceptible to bloomrape, and some are less. Recommendations for implementing measures to contain the spread of bloomrape have been well described. In heavily infected fields, it is recommended to grow hybrids of the Clearfield production system together with herbicides or Euro-Lighting® (Khablak & Spychak, 2024).

## Materials and Methods

The article uses empirical methods of cognition aimed at generalising and systematising data. The work also uses comparative analysis and synthesis of data. Materials on sowing units and market share of sales in Ukraine and the Sumy region are taken from companies' representatives, campaign web pages, and agro-websites. Mathematical analysis is used to present analytical material.

## Results and Discussions

### Market evaluation

Tab. 1 shows the amount of sunflower seeds purchased from 2019-2024.

**Table 1.** Sunflower seeds sold in Sumy region, 2019-2024

Agro-industrial company	2019-2020		2020-2021		2021-2022		2022-2023		2023-2024	
	Sowing units' number	%	Sowing units' number	%	Sowing units' number	%	Sowing units' number	%	Sowing units' number	%
<b>Syngenta</b>	39152	45	39158↑	48	36680	43	36310	49	19740	45
<b>LNZ-group</b>	26844	31	20830	25	28840↑	34	14180	19	9490	22
<b>Pioneer</b>	5160	5.9	3738	4.6	5750↑	6.8	4970	6.8	2800	6.3
<b>Limagrain</b>	4810	5.5	3486	4.3	3760↑	4.4	6600↑	8.9	4370	9.9
<b>NuSeed</b>	4733	5.4	1310	1.6	2330↑	2.8	2470↑	3.4	515	1.2
<b>Lidea</b>	2728	3.1	2529	3.1	3160↑	3.7	1620	2.2	1080	2.5
<b>Others</b>	3973	4.6	10830	13	4301	5.1	7484	10	6167	14
<b>Total</b>	87400	100	81881	100	84821	100	73634	100	44162	100

In the table, we have presented the results of sunflower seed sales of five companies in the Sumy region. As for other companies, we will discuss them in the text. It should be noted that in the 2019-2020 marketing year, farmers in Ukraine purchased 2,575,157 sowing units (1 unit = 150,000 seeds) and in the Sumy region 87,400 units (3.39% market share). The

sales leaders are Syngenta (44.8%) and the LNZ group (30.7% market share). In the same year, the seeds of the MAS company amounted to 1.56%, RAGT – 0.83%, KWS – 0.21%, and the Ukrainian Scientific Institute of Plant Breeding (USIPB) – 0.06%.

In the 2020-2021 season, Syngenta remains the leader in sunflower seed sales, with a market share in the Sumy region of 6 sowing units more than last year. LNZ group sales showed a 6014 sowing unit decrease, accounting for 22.4% of the market share. Pioneer recorded a more significant decrease – by 27.6%, NuSeed – by 27.67%, Limagrain – by 27.5%, MAS – by 13.6%, Lidea – by 7.2%, while RAGT showed an increase of 32.9%, KWS – by 2.5 times, USIPB – in 9 times. The share of sunflower seed sales in the Sumy region fell by 6.38%. In total, 2,783,899 sowing units were sold in Ukraine, 81,881 sowing units in the Sumy region ( $\approx 2.94\%$ ).

In the 2021-2022 season, Syngenta is also first in the ranking, but a decrease in sales is noted, while more seeds from the LNZ group, Pioneer, Limagrain, Nuseed, and Lidea are entering the market. Compared to the 2020-2021 season, this season was promising: 2,649,908 sowing units were sold in Ukraine, 84,821 sowing units in the Sumy region ( $\approx 3.20\%$ ). USIPB sold seeds at 1,170 sowing units (1.38%).

In the 2022-2023 season, the situation began to change towards a decrease in sown areas because much arable land was occupied or was in a combat zone at a dangerous distance. Nevertheless, the leading seed-selling companies, Limagrain (6600 s.u.), Nuseed (2470 s.u.), and KWS (877 s.u.) increased their sales. In LNZ and Lidea's case, sales dropped by half. In Ukraine, 2,192,130 sowing units were sold, and in the Sumy region – 73,634 sowing units ( $\approx 3.36\%$ ).

In the 2023-2024 season, the structure of sown areas changed dramatically due to changes in logistics, problems with exports, rising energy prices, etc. Accordingly, all companies sold less seed. Syngenta's sales share drop was 1.84 times, LNZ – 1.49, Pioneer – 1.77 times, Limagrain – 1.51, Nuseed – 4.8, Lidea – 1.5, and KWS – 2.66 times. On the contrary, the MAS campaign covered more areas and sold seeds by 25.6% more, Novi Sad – 1.18 times. MAG had a share of the sunflower seed market in the Sumy region of 3.89%, RAGT 1.87%, KWS 0.84%, Novi Sad 2.74%, Dekalb 1.53%, and BASF 1.36%. 2,166,467 sowing units were sold in Ukraine, and 44,162 sowing units in the Sumy region ( $\approx 2.04\%$ ).

## Changes in herbicide groups of sunflowers

There are three sunflower herbicide growing systems: Classic, Express (or SUMO), and Clearfield® (CL)/Clearfield® Plus (CLP). The differences in these systems are based on the different capabilities of sunflower crop protection systems against weeds, depending on specific genetic resistances in the hybrid.

Thus, the classical growing system does not allow the application of any special groups of herbicides during the growing season, except for graminicides or the active halofenmethyl in certain norms. Therefore, the crop protection system for sunflowers of such hybrids is based on the main element – the application of soil herbicides (Datsko et al., 2025). In other words, the possibility of affecting dicotyledonous weeds during the crop-growing season is minimal. Furthermore, this technology does not address the control of sunflower broomrape by applying specific pesticides. The main aspects of controlling this parasite are based on crop rotation and the genetic stability of hybrids.

In turn, Clearfield® (CL)/Clearfield® Plus (CLP) technologies have a wider window of opportunity for weed control in the growing season and chemical control of sunflower broomrape. Thus, when applying Clearfield®/Clearfield® Plus herbicides in the manufacturer's recommended rates and conditions, it is possible to work post-emergence up to 4 pairs of sunflower true leaves and significantly reduce the possibility of sunflower broomrape spreading.

These advantages are significant since the herbicides make it possible to fight even such malicious weeds as *Ambrosia artemisiifolia* L., species of *Amaranthaceae* (for example, *Chenopodium album* L.), *Xanthium strumarium* L., etc. It is important to note that besides Clearfield®/Clearfield® Plus, no other pesticides are as effective against sunflower broomrape. This parasite is already a global problem not only in the southern regions of Ukraine but also in most of the territory of the Sumy region (the northeastern part). Thus, the Clearfield®/Clearfield® Plus system allows farmers to continue working with high-yielding hybrids of the fifth race of resistance in conditions of non-critical spread of broomrape. After all, with its total spread in the fields of commodity producers, to be able to grow sunflower crops in general, it is necessary to use all available opportunities to control this problem – a hybrid with maximum genetic resistance, the Clearfield®/Clearfield® Plus system, crop rotation, and other agrotechnical ways. However, this system, despite all its advantages, has specific nuances. The main one is based on the stability of the active ingredients of Clearfield®/Clearfield® Plus in the soil, which can reach 36 months and imposes certain restrictions on the possibilities of crop rotation depending on soil tillage, weather and climatic conditions of the year. In particular, this concerns the possibility of sowing winter crops

after sunflowers in the year applying Clearfield®/Clearfield® Plus. The rotation of crops is becoming common in the northeastern part of Ukraine, which limits this technology. We can say the same about the official recommendation for the limitation of the application of herbicide of the imidazolinone group on one field no more than 1 time in 3 years. Given that this Clearfield®/Clearfield® Plus is presented not only on sunflowers, farmers often choose another crop for the use of these herbicides, for example, rapeseed.

The Express (SUMO) technology, in turn, is based on the genetic resistance of sunflower hybrids to the active ingredient tribenuron-methyl. Herbicides based on this active ingredient can be applied post-emergence in the phase of 2–8 true leaves of sunflower. Unlike the Clearfield®/Clearfield® Plus technology, this active ingredient has no restrictions on crop rotation for subsequent crops. Therefore, it is much more practical and less risky. It is important to note that the Express (SUMO) technology is ineffective against monocotyledonous weeds, and it cannot be mixed with graminicides in a tank. Therefore, using this technology, it will be necessary to make two separate applications with a time gap for a full spectrum of herbicidal control without applying soil herbicides. Another critical issue is the control of broomrape. The Express (SUMO) technology is ineffective against this parasite.

By understanding the advantages and disadvantages of different technologies, agricultural producers select specific hybrids based on productivity, conditions they need to address, and the tasks they aim to accomplish. Thus, classic hybrids are still popular as the first and oldest on the market. Their market share is based not only on historicity but also on the ease of control of these hybrids in subsequent stages of crop rotation and sometimes higher productivity. Due to this, the market share of these hybrids remains at the level of  $\pm 20\%$ .

Hybrids of the Express technology (SUMO) are gaining popularity year after year. This trend is relevant not only for the Sumy region but also for Ukraine in general. The reason for this phenomenon can be considered the technology's more remarkable plasticity, fewer restrictions on crop rotation (primarily the ability to sow winter wheat without risks in any year), and the affordability of preparations for this technology.

Genetics of Clearfield®/Clearfield® Plus hybrids have the largest market share in the Sumy region ( $\approx 30\%$ ), even though they demonstrate a decrease in popularity among agricultural producers from 45 to 30%. This is due to the replacement of hybrid composition in breeding companies (some of the hybrids were very popular and were grown using classical technology with the ability to work with Clearfield®/Clearfield® Plus) and the technological limitations on crop rotation mentioned earlier.

However, despite all this, it is unlikely that this technology will be forgotten or its share will decrease to a critically low level. After all, the issue of spreading the broomrape is very acute, even in the Sumy Oblast. Furthermore, this problem spreads in seven-mile steps from the south to the north. Thus, agricultural producers will come to this technology sooner or later if they want to continue growing sunflowers. This situation is a very, very likely scenario.

It is worth noting separately why so much attention is paid to the broomrape. By itself, it is a parasitic plant that can multiply on sunflowers, causing a significant decrease in the quantitative and qualitative indicators of crop yield. Losses can reach 90%\*. This plant is a highly harmful parasitic plant with an incredible ability to reproduce and spread throughout the territory. Over the past 4 years, mass infestations of the sunflower broomrape have spread from the border areas with the Kharkiv region to the Konotop-Buryn-Putivl territory.

In general, ignoring this problem and such a rapid spread of broomrape is facilitated by the extraordinary prevalence of sunflowers (up to 20%-30% of the cultivated areas of the Sumy region are sown with sunflowers every year, and in the section of individual farms these indicators can be at the level of 30-50% of the land bank), short crop rotations with the return of sunflower for 3 years-4 years, the cultivation of genetically unstable hybrids or hybrids with low levels of genetic resistance to specific breeds of these parasites. It should be emphasised that there is no panacea for broomrape. After all, even the genetic resistance of a hybrid to the seventh race of the broomrape does not guarantee the complete absence of this parasite in the field. This indicates that the parasite has surpassed the hybrid's resistance, producing offspring that can reproduce even on the most resilient hybrids. These situations are not isolated in the Sumy region, and we can expect to hear about this issue more frequently each year.

Tab. 2 shows the structure of sales of sunflower seeds in 2019-2024, grown using herbicide technologies such as ExpressSun® (SUMO), CL/CLP and Classic.

**Table 2.** Market share of hybrids grown using herbicide technologies SUMO, CL/CLP and Classic in Sumy region, %

Herbicide technology	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
ExpressSun® (SUMO)	7.7	12	12.7	20.2	19.2
CL/CLP	44.8	42.8	36.2	37	31.4
Classic	16.8	19.8	16.4	23.5	27.1
Total	74.8	74.6	65.3	80.7	77.7

As we can see, of the three technologies presented, hybrids grown using Clearfield® (CL)/Clearfield® Plus (CLP) are more prevalent on the market. The largest share of these hybrids was presented in 2019-2021 and then decreased slightly. SUMO technology shows sales growth until the 2023-2024 marketing year. In contrast, the share of sales of hybrids grown using classical technology increased over the last two years, 2022-2024.

## Conclusions

The number of sunflower sowing units sold by seed campaigns decreased in Ukraine from 2,575,157 units to 2,166,467 units. In the Sumy region, since 2019, sunflower seed sales have accounted for 3.39% of sales in Ukraine, and in the 2023-2024 marketing year, they have already accounted for 2.04%. The crisis that arose due to military operations has significantly affected the agricultural sector's work. The selection of hybrids grown using a particular technology depends on the type and degree of weed infestation, particularly damage by sunflower scab. This parasite remains a big problem when growing this crop in Ukraine and the Sumy region. Currently, breeders have not yet developed hybrids that are resistant to scab. In the Sumy region, the share of hybrids grown using classical herbicide technology has increased on the market, while the share of hybrids using Clearfield® (CL)/Clearfield® Plus (CLP) has decreased.

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