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COMPARISON OF CLEARFIELD® AND CLEARFIELD® PLUS PRODUCTION SYSTEMS FOR SUNFLOWER

S. M. Cholovskyi
State Enterprise Institute of Grain Crops of NAAS, 14 Volodymyr Vernadskyi St., Dnipro, 49009, Ukraine

Topicality. *Today, sunflower (Helianthus annuus L.) is one of the leading agricultural crops in Ukraine with sowing area of 5–5.5 million hectares. Among numerous sunflower production systems, the Clearfield® and Clearfield® Plus Production Systems are the most effective in controlling broomrape and difficult-to-control weeds.* ***Purpose.*** *To identify the advantages of the Clearfield® Plus Production System compared to Clearfield®.* ***Materials and Methods.*** *Field trials were conducted on the facilities of Hovtva LLC in Reshetylivka, Poltava region, and Terezyne ALC in Terezyne, Kyiv region, in accordance with the generally accepted research methodology during 2020–2022. All elements of agricultural technology are generally accepted for the Forest-steppe zone.* ***Results.*** *Over three years of research, it was found that the yield of SY Bacardi CLP sunflower hybrid (Clearfield® Plus) compared to the NK Neoma hybrid (Clearfield®) was 0.33 t/ha higher (13.2%) on average in two locations. According to the analysis of a larger sample of Clearfield® and Clearfield® Plus hybrids, the hybrids of the Clearfield® Plus Production System formed a yield of 0.28 t/ha higher (12.8%) compared to hybrids of the Clearfield® ones. Given the average level of weed infestation and the absence of sunflower broomrape and difficult-to-control weeds, there was no significant difference in yields on the background of Euro-Lightning® (1.2 l/ha), Euro-Lightning® Plus (2.5 l/ha) and Pulsar® Flex (2.0 l/ha) herbicides within each Clearfield® and Clearfield® Plus Production Systems. However, the hybrids of the Clearfield® Plus Production System on each herbicide background provided higher statistically significant yield indicators: an increase in yield was 0.29 t/ha (13.3 %) due to application of Euro-Lightning® (1.2 l/ha); 0.21 t/ha (9.8 %) – Euro-Lightning® Plus (2.5 l/ha); 0.34 t/ha (15.3 %) – Pulsar® Flex (2.0 l/ha). The sunflower hybrids of Clearfield® Plus showed higher tolerance to IMI herbicides and stability of the yields.* ***Conclusions.*** *The sunflower hybrids of the Clearfield® Plus Production System have demonstrated an advantage in terms of seed yield and tolerance to IMI herbicides compared to Clearfield® hybrids, so they have the potential to further expand their cultivation areas.*

Key words: *sunflower, hybrid, yield, herbicide, Euro-Lightning® Plus, Pulsar® Flex, phytotoxicity*

Introduction. The Clearfield® production system was introduced in 2003 in the US and subsequently spread to all countries where sunflower is grown, allowing for a wider range of weeds to be controlled and more flexible dates for herbicide application [1–3]. The development of the technology began with the observation of wild sunflower plants that were resistant to the active ingredient imazethapyr in soybean crops in the United States. In such resistant sunflower plants, breeders discovered a gene for resistance to imazethapyr, which was further involved in the breeding process to develop sunflower hybrids. The hybrids developed through this process are also resistant to herbicides of the imidazolinone group. This production technology, which includes an herbicide-tolerant hybrid and a corresponding imidazolinone-based herbicide, is called Clearfield® by BASF.

At the initial stages, the yield potential of the created hybrids was inferior to the sunflower hybrids using traditional cultivation technology, which slowed down the wide spread of the Clearfield® production system. In 2008, this disadvantage was successfully overcome; thus, Clearfield® sunflower hybrids have since reached and exceeded the yields of their analogue hybrids grown using conventional weed control technology.

Herbicides with the active ingredients imazamox and imazapyr inhibit the activity of the acetolactate synthase enzyme and are used to protect sunflower crops in Clearfield® technology. The mechanism of their action is based on interference with the protein metabolism, including inhibition of the biosynthesis of essential amino acids. Imazamox and Imazapyr have a broad spectrum of action and are effective against most annual and perennial (monocotyledonous and dicotyledonous) weeds [4].

Author information:
Serhii M. Cholovskyi, *PhD Candidate,* e-mail: sergii.cholovskyi@gmail.com, https://orcid.org/0009-0007-5523-7645

In 2006, BASF and Nidera joined forces to discover the CLHA-Plus gene through a conventional breeding process. And in 2010, the new Clearfield® Plus production system was introduced to the agricultural industry, which is based on high tolerance to BASF imidazolinone herbicides in sunflower hybrids with this gene. [5]. The new formulation of herbicides, including improved adjuvants, has significantly increased the effectiveness of weed control in sunflower crops without adversely affecting crop tolerance. [6–9].

Even in the case of unintentional overlap of spraying lanes in production conditions, when a double herbicide rate is applied to the plants, Clearfield® Plus sunflower hybrids have virtually no phytotoxic effect. In addition, sunflower hybrids of Clearfield® Plus technology have higher yields [10].

It is important to note that the herbicides included in Clearfield® and Clearfield® Plus sunflower cultivation systems are unique herbicides that can ensure effective chemical control of the parasitic weed broomrape (*Orobanche cumana* Wallr.). A parasitic plant uses nutrients from the host plant for its own growth and development. Sunflower roots secrete specific substances that stimulate the germination of broomrape. Sunflower broomrape causes significant losses in yield, which can range from 30 to 100 %, depending on the degree of weed infestation. The best solution for crops infested with sunflower broomrape is to implement Clearfield® Plus technology [11–13].

Since the launch of the Clearfield® Plus Production System, the number of sunflower hybrids cultivated with this technology has been gradually increasing. However, the extension of the Clearfield® Plus sunflower area has been slow. During 2020–2022, a number of trials were conducted to obtain data on the advantages of growing Clearfield® Plus sunflower hybrids compared to Clearfield® hybrids.

This research was aimed at determining the advantages of the Clearfield® Plus production system compared to Clearfield® in terms of sunflower hybrids productivity and the degree of their tolerance to imidazolinone-based (IMI) herbicides.

Materials and Methods. The experimental part of the study was carried out at the farms of Hovtva LLC in Reshetylivka of Poltava region and Terezyne ALC in Terezyne village of Kyiv region during 2020–2022.

The soil of the experimental plot at Hovtva LLC is a deep low-humus chernozem. The arable layer (0–30 cm) includes: humus – 2.0–2.2 % (according to Tiurin), total nitrogen - 24 mg (according to Kjeldahl), mobile phosphorus – 109 mg (according to Chirikov), and exchangeable potassium – 115 mg (according to Chirikov) per 1 kg of soil. The reaction of the soil solution is slightly acidic (pH of the water extract is 5.3–6.4).

The soil of the experimental plot of Terezyne ALC is a deep low-humus chernozem. The arable layer (0–30 cm) contains: humus - 2.1–2.3 % (according to Tyurin), total nitrogen (according to Kjeldahl) – 32 mg, mobile phosphorus – 220 mg (according to Chirikov), exchangeable potassium – 106 mg (according to Chirikov) per 1 kg of soil. The reaction of the soil solution is slightly acidic (pH of the water extract 5.1–6.3).

In 2020–2022, the weather conditions in the area of activity of Hovtva LLC were typical for the Forest-Steppe zone. However, the average daily and average monthly air temperature during the sunflower growing season (May – September) in the years of research mostly exceeded long-term values by 0.3–3.9 °C (Table 1). Only September in 2021 and 2022 had average daily air temperatures lower than long-term values by 1.2–1.7 °C, which led to an elongation of the seed ripening period in sunflower hybrids.

The total amount of precipitation during the sunflower growing season in 2020 was close to the long-term average, exceeding it by 23 mm in 2021 and 62.4 mm in 2022. A significant precipitation deficit was observed in August 2020 during seed formation and filling, when 9.6 mm fell (the long-term average is 62 mm), and in July 2021 during the formation of sunflower heads and the beginning of flowering when 18.7 mm fell (the norm is 77 mm). The weather conditions in 2022 were favourable for a high sunflower harvest, with rainfall of 74 mm in June, 109.0 mm in July, 75.6 mm in August and 76.5 mm in September, which exceeded the long-term average for this period by 86 mm.

During the research years, the hydrothermal coefficient (HTC) of the sunflower growing season varied from 0.98 (slightly dry condi-

Table 1. Meteorological conditions of the growing season of sunflower hybrids, Hovtva LLC, Poltava region

Year	Months					
	May	June	July	August	September	May – September
Average daily air temperature, °C						
2020	16.9	22.0	22.3	21.4	18.6	20.2
2021	15.5	20.2	24.2	22.7	13.5	19.2
2022	14.7	20.8	20.5	22.8	13.0	18.4
long-term norm	14.4	19.2	21.1	20.3	14.7	17.9
Total precipitation, mm						
2020	159.2	42.0	36.4	9.6	57.0	304.2
2021	58.5	134.9	18.7	71.2	42.7	326.0
2022	30.3	74.0	109.0	75.6	76.5	365.4
long-term norm	54.0	65.0	77.0	62.0	45.0	303.0
Hydrothermal coefficient (HTC)						
2020	3.04	0.64	0.53	0.15	1.02	0.98
2021	1.22	2.23	0.25	1.01	1.05	1.11
2022	0.67	1.19	1.72	1.07	1.96	1.30
long-term norm	1.21	1.13	1.18	0.99	1.02	1.11

tions) to 1.30 (sufficient moisture conditions). At the same time, abnormally dry and unfavourable for the growth, development and formation of high productivity of sunflower in 2020 were June (HTC = 0.64), July (HTC = 0.53) and August (HTC = 0.15), which corresponded to the conditions of medium, severe and very severe drought.

In Terezyne ALC, the temperature regime during the sunflower growing season (May-September) was 1.1–1.7 °C higher than the long-term average over the three years of research (Table 2). However, the average air temperature in May was lower than the long-term average: in 2020 – by 2.7 °C, in 2021 – by 0.9 °C and in 2022 – by 0.6 °C, resulting in a slowdown in the development of sunflower plants at the initial stages of growth.

The moisture conditions of the sunflower growing season (May – September) in 2020 were characterised as mild drought with a HTC of 0.89, in 2021 with a HTC of 0.99 – as sufficiently wet, and in 2022 with a HTC of 0.78 – as mild drought. Hydrothermal conditions in June and July 2022 were the most unfavourable for sunflower yield formation and very dry with the HTC of 0.18 and 0.30, respectively. More favourable conditions for sunflower seed harvest were in 2020 and 2021, when periods of excessive moisture alternated with medium or slightly dry conditions.

Popular sunflower hybrids were chosen to compare the production systems: NK Neoma (Clearfield® production system) and SY Bacardi CLP (Clearfield® Plus production system).

For a more in-depth comparative analysis of the Clearfield® and Clearfield® Plus production systems, a study was also conducted with the selection of a greater number of hybrids, namely Clearfield® hybrids: SY Barbati, ES Generalis CL, SY Diamantis, SY Experto, Zurimi CL, ES Coloris CL, Markeza CL, NK Neoma, Puntasol CL, SY Santos, Subella, Talento CL, NC Fortimi CL and Clearfield® Plus hybrids: SY Bacardi CLP, Drakaris CLP, Europa CLP, SY Katana CLP, ES Loris CLP, Lucia CLP, Melita CLP, SY Neostar CLP, Paraiso 1000 CLP, SY Rosetta CLP, Surprise CLP, ES Janis, MAS 92 KP, P64LP130, P64LP140. All elements of agricultural technology are generally accepted for the Forest-Steppe zone and were identical for all hybrids.

The research was conducted on the background of herbicide protection: Euro-Lightning® (Imazamox, 33 g/l + Imazapyr, 15 g/l), 1.2 l/ha, Euro-Lightning® Plus (Imazamox, 16.5 g/l + Imazapyr, 7.5 g/l), 2.5 l/ha, Pulsar® Flex (Imazamox, 25 g/l), 2.0 l/ha, which were applied in the four true leaves stage in sunflower.

Double doses of Euro-Lightning® Plus – 5.0 l/ha, Pulsar® Flex – 4.0 l/ha were also used to study the phytotoxic effects on sunflower

Table 2. Meteorological conditions of the growing season of sunflower hybrids, Terezyne ALC, Kyiv region

Year	Months					
	May	June	July	August	September	May – September
Average daily air temperature, °C						
2020	12.2	21.2	21.2	20.6	17.5	18.5
2021	14.0	19.9	23.1	19.9	12.7	17.9
2022	14.3	21.0	20.7	21.2	12.3	17.9
long-term norm	14.9	17.8	19.0	18.4	13.8	16.8
Total precipitation, mm						
2020	80.8	32.6	68.0	39.4	32.4	253.2
2021	99.3	44.6	46.3	64.4	16.8	271.4
2022	34.0	11.2	19.4	82.0	66.2	212.8
long-term norm	46.0	73.0	85.0	60.0	35.0	299.0
Hydrothermal coefficient (HTC)						
2020	2.14	0.51	1.03	0.62	0.62	0.89
2021	2.29	0.75	0.65	1.04	0.44	0.99
2022	0.77	0.18	0.30	1.25	1.79	0.78
long-term norm	1.00	1.34	144	1.05	0.85	1.16

plants and their tolerance.

The background of mineral nutrition in Hovtva LLC was $N_{47}P_{44}K_{45}$, in Terezyne ALC was $N_{42}P_{46}K_{49}$, where YaraMila $N_{16}P_{16}K_{16}$, YaraMila $N_8P_{24}K_{24}$, YaraMila $N_7P_{20}K_{28}$, YaraMila $N_{12}P_{24}K_{12}$ fertilisers were used.

In 2020, sunflower hybrids were sown in Poltava region at Hovtva LLC on 29 April, and in 2021 and 2022 on 6 and 4 May, respectively, at a seeding rate of 65,000 seeds per hectare. In the Kyiv region, Terezyne ALC sowed on 21, 29 and 28 April 2020, 2021 and 2022, respectively, at a seeding rate of 63,000 seeds per hectare. The sowing area was 75 m^2, the registration area was 50 m^2, and the experiment was repeated three times.

The results of the statistical analysis are presented in the form of box-and-whisker plot diagrams.

Results and Discussion. One part of the study was to compare the yields of the most popular hybrids in Ukraine, NK Neoma (Clearfield® production system) and SY Bacardi CLP (Clearfield® Plus production system). The results of the research at Reshetylivka location show that the yields under Clearfield® Plus production system exceeded the yields of Clearfield® production system by 0.21–0.43 t/ha (11.4–20.7 %) during the years of research, and on average by 0.33 t/ha (14.2 %) over three years (Table 3).

At the Terezyne location, the Clearfield® Plus production system also achieved higher yields compared to the Clearfield® production system: the annual yield increase was 0.07–0.78 t/ha (3.1–20.6 %), and the average yield increase over three years was 0.38 t/ha (11.9 %) (Table 4).

Table 3. Seed productivity of sunflower under different production systems, Reshetylivka, Poltava region, 2020–2022

Hybrid name	Seed yield, t/ha				Increase in control, +/–	
	2020	2021	2022	average	t/ha	%
Clearfield® production system						
NK Neoma	1.85	1.64	3.48	2.32	–	–
Clearfield® Plus production system						
SY Bacardi CLP	2.06	1.98	3.91	2.65	+ 0.33	+ 14.2
LSD_{05}, t/ha				0.18	–	–

It should be noted that during all three years of research, easily controlled weed species were present in the experimental plots, and the level of weed infestation was low. Hard-to-

Table 4. Comparative seed productivity of sunflower under different production systems, Terezyne, Kyiv region, 2020–2022.

Sunflower hybrid	Seed yield, t/ha				Increase to control, +/–	
	2020	2021	2022	average	t/ha	%
Clearfield® production system						
NK Neoma	2.32	3.78	2.23	2.78	–	–
Clearfield® Plus production system						
SY Bacardi CLP	2.48	4.56	2.3	3.11	+ 0.38	+ 11.9
LSD_{05}, t/ha				0.35	–	–

control weed species and sunflower broomrape were absent. The efficiency of weed control on all herbicide backgrounds was high and was 93.5–100%, depending on the species, and practically did not differ between the herbicide backgrounds. This made it possible to evaluate the genetic properties of sunflower hybrids, their response to different ingredients of herbicides and application rates. According to our opinion, the genetic characteristics of the Clearfield® Plus sunflower hybrids provide higher tolerance to imidazolinones and allow for more efficient and faster metabolism of herbicide active ingredients. These features had a significant impact on the yield indicators.

The species composition of weeds in sunflower crops at Terezyne ALC was represented by lambsquarters (*Chenopodium album* L.), barnyard grass (*Echinochloa crus-galli* L.), black bindweed (*Poligonum convolvulus* L.), Shepherd's purse (*Capsella bursa-pastoris* L.), and European black nightshade (*Solanum nigrum* L.). Among the weed species in the experiments in 2020, lambsquarters (up to 5 % of the projection leaf cover in the control variants), barnyard grass (up to 5 %), black bindweed (up to 3 %), Shepherd's purse (up to 3 %) dominated; in 2021 – lambsquarters (4–6 %), barnyard grass (3–5 %), Shepherd's purse (up to 2 %), black bindweed (up to 1 %); in 2022, barnyard grass (4–12 %), black bindweed (up to 2–3 %), lambsquarters (up to 1 %), black nightshade (up to 1 %) dominated in the sunflower crops.

In sunflower crops at Hovtva ALC, the species composition of weeds included lambsquarters (*Chenopodium album* L.), black bindweed (*Poliganthum convolvulus* L.), lady's thumb (*Poligonum persicaria* L.), yellow foxtail (*Setaria glauca* L.), prostrate pigweed (*Amaranthus blitoides* S.), redroot pigweed (*Amaranthus retroflexus* L.), and field pennycress (*Thlaspi arvense* L.). Among the weed species in the experiments in 2020, the following weeds dominated: lambsquarters (4–6 % of the projection leaf area in the control variants), black bindweed (up to 5 %), lady's thumb (2–3%), in 2021 – lambsquarters (up to 7 %), black bindweed (up to 6 %), lady's thumb (up to 3 %), in 2022 – lambsquarters (6–8 %), yellow foxtail (2–7 %), lady's thumb (1–5 %), prostrate pigweed (2–3 %), redroot pigweed (1–2 %), field pennycress (up to 1 %).

The analysis of the data sampling in two locations for three years of research confirms the superiority of the Clearfield® Plus production system over the Clearfield® production system in terms of yield at the level of 0.19–0.51 t/ha (9.3–20.4 %), and an average of 0.33 t/ha (13.2 %) over three years (Fig. 1).

Analysis of yields on different herbicide backgrounds under the Clearfield® production system over an average of three years shows that the highest yield (2.22 t/ha) was obtained in crops treated with Pulsar® Flex herbicide (2.0 l/ha). The yield of crops treated with Euro-Lightning® herbicide (1.2 l/ha) was 2.18 t/ha, and 2.15 t/ha with treatment with Euro-Lightning® Plus (2.5 l/ha), which indicates that hybrids of the Clearfield® production system are less tolerant to high rates of herbicide active ingredients (Fig. 2). However, the yields on the background of treatment with three herbicides of the Clearfield® production system were within the statistical error of the experiment. It should be noted that no sunflower broomrape or hard-to-control weed species were present in the study plots. In the presence of the following factors, the difference in weed control efficiency and yields is usually greater.

A similar trend was observed for the Clearfield® Plus production system when treating crops with Pulsar® Flex herbicide (2.0 l/ha) with a higher yield of 2.56 t/ha. The yield was 2.47 t/ha on the background of Euro-Light-

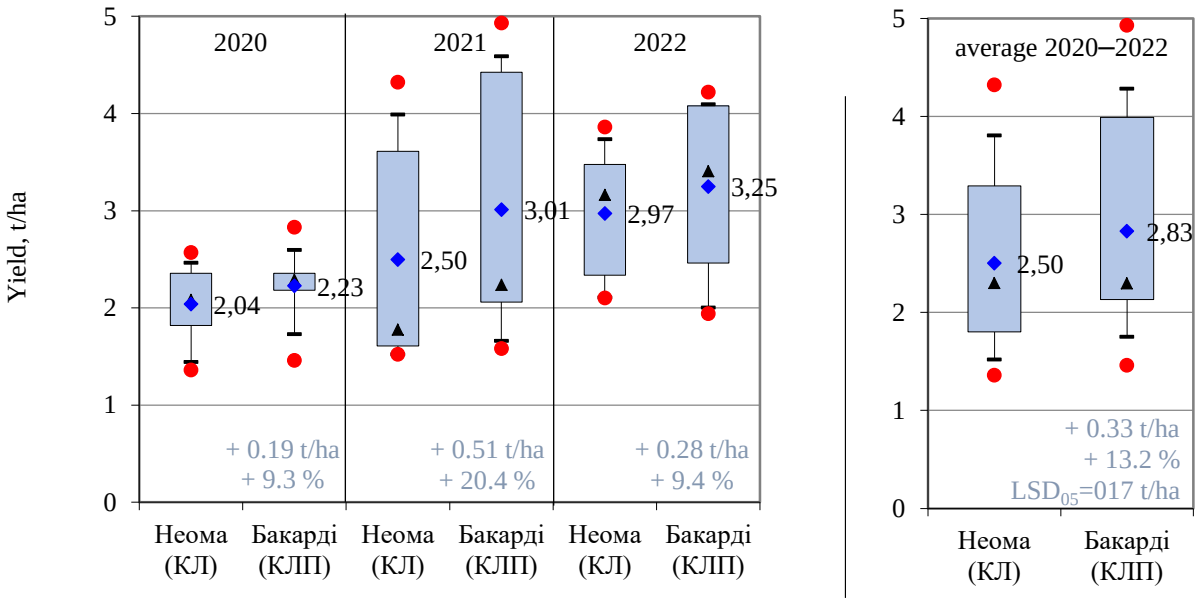

Fig. 1. Seed productivity of sunflower under different production systems, Reshetylivka, Terezyne, 2020–2022.

ning® herbicide (1.2 l/ha) and 2.36 t/ha on the background of Euro-Lightning® Plus (2.5 l/ha).

Comparing the Clearfield® and Clearfield® Plus production systems, depending on the type of herbicide treatment, showed that the yield of Clearfield® Plus sunflower hybrids is 0.21–0.34 t/ha higher (9.8–15.3 %) on average over three years and is statistically significant. The averages for the entire period of research demonstrate the superiority of the Clearfield® Plus production system by 0.28 t/ha (+12.8 %).

Also, studies were conducted to compare the tolerance of sunflower hybrids of the Clearfield® production system (NK Neoma, ES Generalis CL, SY Barbati) and Clearfield® Plus (SY Bacardi CLP, ES Loris CLP, ES Janis) when applying Euro-Lightning® Plus and Pulsar® Flex herbicides to determine their phytotoxicity. Studies to compare the effect of these herbicides on sunflower yield were conducted in Reshetylivka, Poltava region, during 2021 and 2022. The maximum registered rate of Euro-Lightning® Plus and Pulsar® Flex herbicide and their double rates were applied.

The results of studies of the effect of the above herbicides on the yield of Clearfield® and Clearfield® Plus sunflower hybrids show that in the absence of sunflower broomrape and hard-to-control weed species, the highest yields were in variants using Pulsar® Flex herbicide (2.0 l/ha) – 1.76 and 1.92 t/ha in 2021, respectively (Fig. 3).

A high phytotoxic effect of a double rate (5.0 l/ha) of Euro-Lightning® Plus herbicide on hybrids of the Clearfield® production system was found, which was up to 50 % on the 10th day after the herbicide treatment and decreased to 30 % on the 20th day of monitoring.

These results once again confirm the lower tolerance of Clearfield® hybrids to herbicides that are intended for Clearfield® Plus hybrids. In this case, a decrease in yield by 0.38 t/ha (22.1 %) was observed (Fig. 4). It is important to remember that Euro-Lightning® Plus herbicide is not registered for hybrids of the Clearfield® production system due to the risk of phytotoxicity under adverse weather conditions (prolonged period of cool and wet weather).

At the same time, the hybrids of the Clearfield® production system were tolerant to a double rate (4.0 l/ha) of Pulsar® Flex herbicide, where the level of phytotoxic effects reached 10 % on the 10th day of monitoring and decreased to 5 % on the 20th day. The yield decrease of 0.10 t/ha was within the statistical error.

It should be noted that the hybrids of the Clearfield® Plus production system had practically no phytotoxic effect, even under double rates of Euro-Lightning® Plus (5.0 l/ha) and Pulsar® Flex (4.0 l/ha) herbicides. Their yield level was within the statistical error for the maximum registered rates of 2.5 and 2.0 l/ha, res-

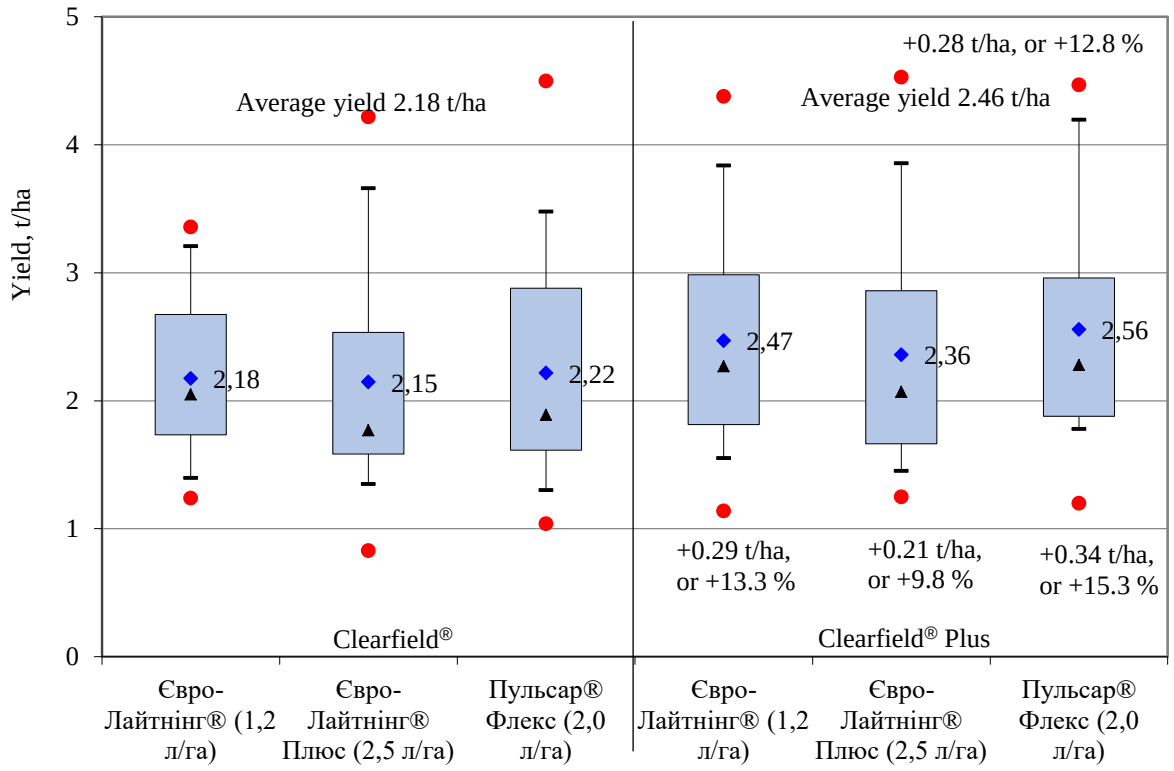

Fig. 2. Sunflower yields of Clearfield®* and Clearfield® Plus** production systems under different herbicide protection variants, Reshetylivka, Poltava region (average for 2020–2022).
LSD_{05}=0.20 t/ha – for herbicide treatment variants;
LSD_{05}=0.12 t/ha – for comparing Clearfield® and Clearfield® Plus production systems.

***Note**. * Clearfield® hybrids: Barbati, Generalis, Diamantis, Experto, Zurimi, Coloris, Marquesa, Neoma, Puntasol, Santos, Subella, Talento, Fortimi*
*** Clearfield® Plus hybrids: Bacardi, Drakaris, Europa, Katana, Loris, Lucia, Melita, Neostar, Paraizo 1000, Rosetta, Surprise, Janis, MAS 92, P64LP130, P64LP140.*

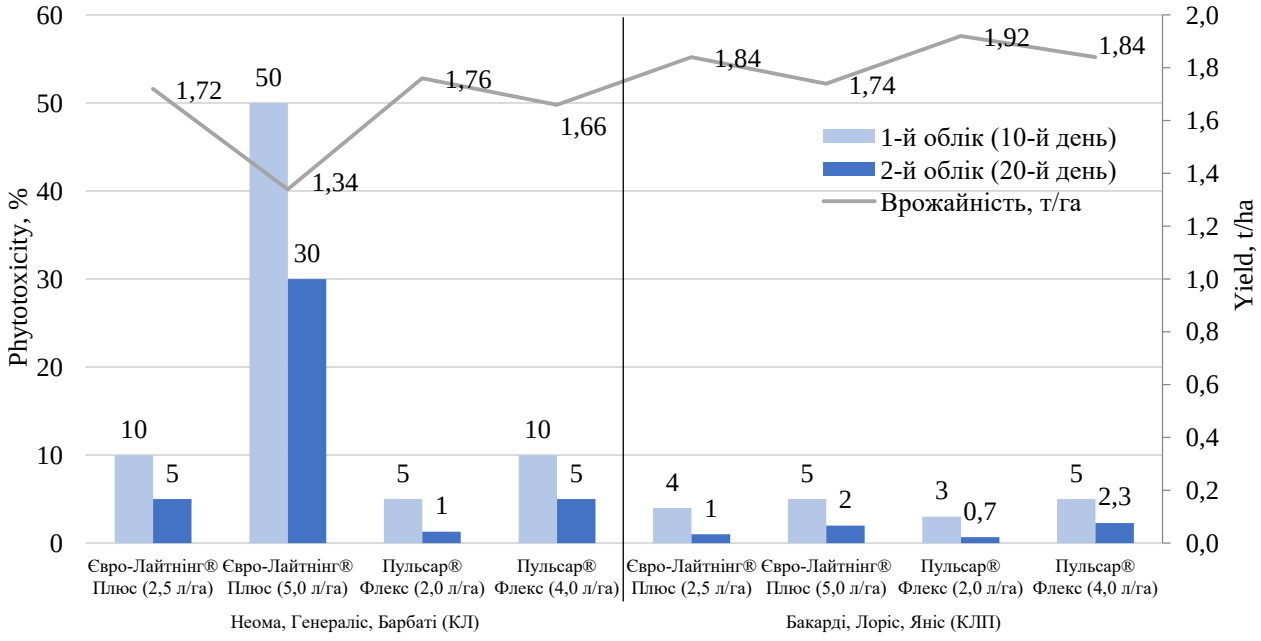

Fig. 3. Comparison of the phytotoxic effects of IMI herbicides on sunflower plants of Clearfield® and Clearfield® Plus production systems, Reshetylivka, Poltava region, 2021.
LSD_{05}=0.37 t/ha – for all variants.

pectively.

In 2022, a fairly high level of phytotoxicity was also recorded for hybrids of the Clearfield® production system when using a double rate of Pulsar® Flex herbicide (4.0 l/ha), which reached 35 % on the 7th day of monitoring and decreased to 13.3 % on the 15th day (Fig. 4). The yield decrease was within the statistical error of the experiment and was at the level of 0.19 t/ha. At the same time, no difference was found in the signs of phytotoxic effects on the hybrids of the Clearfield® Plus production system under both the maximum registered and double rate, which were within 3.3–5 % on the 7th day of monitoring.

The data of our study on the phytotoxic

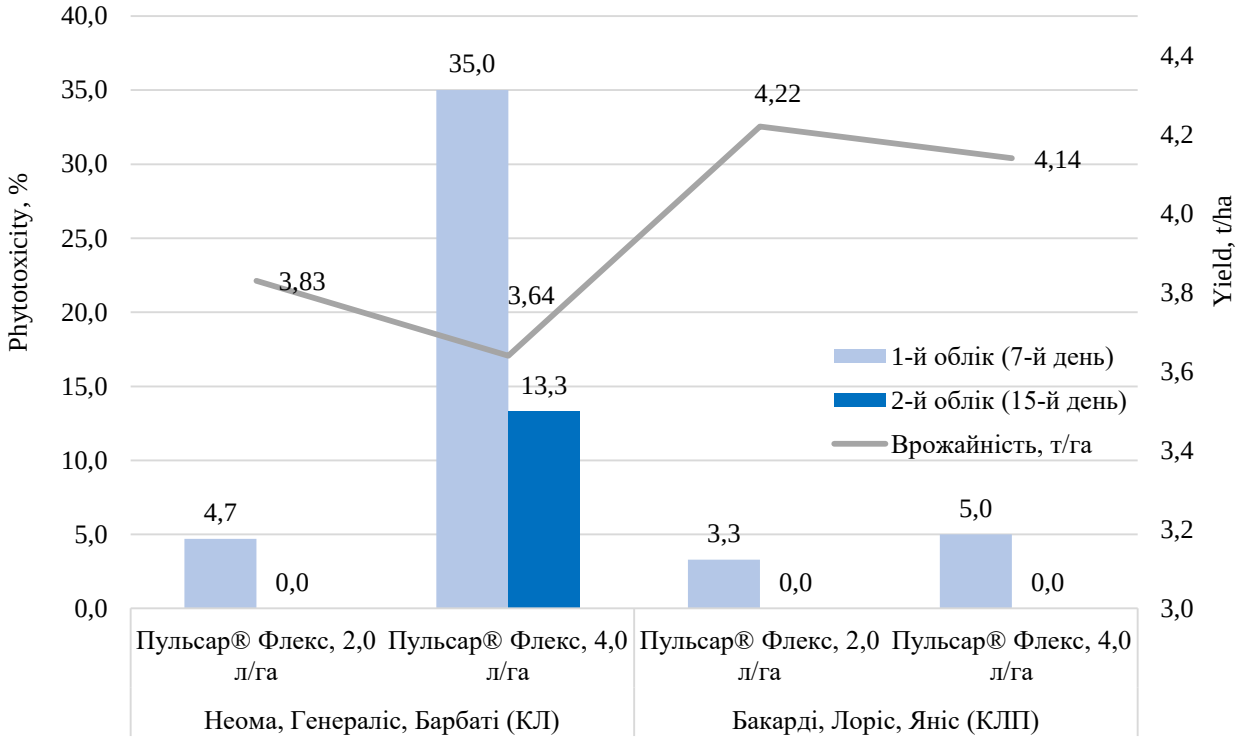

Fig. 4. Comparison of the phytotoxic effects of IMI herbicides on sunflower plants of Clearfield® and Clearfield® Plus production systems (Reshetylivka, 2022).

LSD_{05}=0.54 t/ha – for all variants.

effects of IMI herbicides on sunflower plants confirm the prospects of introducing hybrids of the Clearfield® Plus production system, which are more tolerant to high rates of imidazolinone-based active ingredients and to more active formulations of herbicides with adjuvants. At the same time, the application of such herbicides as Euro-Lightning® Plus and Pulsar® Flex with modern formulations allows to obtain higher herbicidal efficiency compared to Pulsar® 40 and Euro-Lightning® herbicides.

Conclusions. It was found that the sunflower hybrid SY Bacardi CLP (Clearfield® Plus) compared to the hybrid NK Neoma (Clearfield®) on average in two locations provided a yield higher by 0.33 t/ha (13.2 %) over the three years of research.

The analysis of a more extensive sampling of Clearfield® and Clearfield® Plus hybrids showed that the hybrids of the Clearfield® Plus production system had a yield of 0.28 t/ha higher (12.8 %) compared to the Clearfield® hybrids.

The hybrids of the Clearfield® Plus production system provided higher statistically significant yields: with Euro-Lightning® (1.2 l/ha) – by 0.29 t/ha (13.3 %); Euro-Lightning® Plus (2.5 l/ha) – by 0.21 t/ha (9.8 %); Pulsar® Flex (2.0 l/ha) – by 0.34 t/ha (15.3 %).

The sunflower hybrids of Clearfield® Plus showed higher tolerance to IMI-herbicides and stability of yields.

The results of the study demonstrate the advantage and prospects of using sunflower hybrids of the Clearfield® Plus production system with the application of Euro-Lightning® Plus and Pulsar® Flex herbicides.

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Чоловський С. М. Порівняння виробничих систем вирощування соняшнику Clearfield® та Clearfield® Plus. *Grain Crops. 2024. 8 (2). 235–243.*

Державна установа Інститут зернових культур НААН, вул. Володимира Вернадського, 14, м. Дніпро, 49009, Україна

Актуальність. Соняшник (*Helianthus annuus* L.) є однією з провідних сільськогосподарських культур в Україні та останніми роками займає площі на рівні 5–5,5 млн га. Серед низки виробничих систем його вирощування, однією з найефективніших у контролі вовчка соняшникового та складноконтрольованих бур'янів, є системи Clearfield® та Clearfield® Plus. **Мета.** Визначити переваги виробничої системи Clearfield® Plus порівняно з Clearfield®. **Матеріали і методи.** Польові досліди проведені впродовж 2020–2022 рр. відповідно до загальноприйнятої методики дослідної справи на базі господарств СТОВ «Говтва» в м. Решетилівка Полтавської області та ТДВ «Терезине» в смт. Тере-зине Київської області. Всі елементи агротехніки – загальноприйняті для зони Лісостепу. **Результати.** Встановлено, що гібрид соняшнику Бакарді (Clearfield® Plus) у порівнянні з гібридом Неома (Clearfield®), у середньому по двох локаціях, за три роки досліджень, забезпечив рівень врожайності вищий на 0,33 т/га, (13,2 %). Аналіз ширшої вибірки гібридів Clearfield® та Clearfield® Plus показав, що гібриди виробничої системи Clearfield® Plus сформували врожай на 0,28 т/га вище, (12,8 %) у порівнянні з гібридами Clearfield®. За середнього рівня забур'яненості, та відсутності вовчка соняшникового та складноконтрольованих бур'янів достовірної різниці в показниках врожайності між гербіцидами Євро-Лайтнінг® (1,2 л/га), Євро-Лайтнінг® Плюс (2,5 л/га) та Пульсар® Флекс (2,0 л/га) в межах кожної виробничої системи Clearfield® та Clearfield® Plus не виявлено. Проте гібриди виробничої системи Clearfield® Plus на кожному гербіцидному фоні забезпечили вищі статистично достовірні показники врожайності: при використанні Євро-Лайтнінг® (1,2 л/га) – на 0,29 т/га, (13,3 %); Євро-Лайтнінг® Плюс (2,5 л/га) – на 0,21 т/га, (9,8 %); Пульсар® Флекс (2,0 л/га) – на 0,34 т/га, (15,3 %). Гібриди соняшнику Clearfield® Plus проявили вищу толерантність до IMI-гербіцидів та стабільність отриманих врожаїв. **Висновки.** Гібриди соняшнику виробничої системи Clearfield® Plus продемонстрували переваги за врожайністю та стійкістю до IMI-гербіцидів у порівнянні з гібридами Clearfield® і є перспективними для подальшого збільшення їх площ вирощування.

Ключові слова: *соняшник, гібрид, врожайність, гербіцид, Євро-Лайтнінг® Плюс, Пульсар® Флекс, фітотоксичність*