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The impact of predecessors on yield and sunflower hybrids' seed in the steppe of Ukraine

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Abstract. Predecessors have a significant impact on the growth and development of the following crop. Depending on the predecessor crop there is different amount of nutrients, moisture left in the arable soil layer as well as phytosanitary conditions of fields differ. The research programme included the study of peculiarities of growth, development and yield formation of the new sunflower hybrids (LG59580, LG50609SX, PR64LE25, Suzuka), which belong to various ripeness groups, depending on predecessors in the north Steppe of Ukraine in order to improve major zonal energy-efficiency technology of sunflower cultivation. In terms of phytosanitary, cultivation of sunflower after sunflower had negative effect. During the cultivation the number of affected plants was twice fewer after other better predecessors. The Suzuka hybrid showed higher resistance. All of the hybrids formed higher productivity in case of their cultivation after winter wheat as a predecessor with 3.45–3.72 t ha^{-1} and after corn as their predecessor with 3.34–3.61 t ha^{-1}. Sunflower re-seeding caused yield reduction by almost 1 t ha^{-1}. The thousand-kernel weight in all hybrids under research was higher in case of their cultivation after winter wheat as a predecessor. After winter wheat and grain corn this parameter fluctuated within the range of 71.5–74.5 and 69.3–72.5 g respectively, depending on the hybrid, while the parameter was much lower after sunflower and only reached 60 g in LG50609SX hybrids. The highest oil content in all the hybrids was measured after winter wheat and grain corn as predecessors. The highest oil content indications of 50.8–51.0% were defined in LG59580 and Suzuka hybrids. Thus, the cultivation of the hybrids under research after winter wheat and grain corn as predecessors contributed to the formation of healthy and productive plants, while growing sunflower in re-seeding conditions led to impaired phytosanitary conditions, reduced yield and decreased quality of seeds.

Key words: thousand-kernel weight, diseases, moisture content, oil content, sunflower productivity.

INTRODUCTION

Sunflower is known as the major oil crop of Ukraine. The seeds of its regional and hybrid varieties contain 50–52% of oil, while some of the selection samples contain up

to 60%. In comparison with other oil crops sunflower has the highest oil yield per unit of area (Andriienko et al., 2020).

The main cultivation regions for sunflower are russia, Ukraine, Argentina, Romania and China. Except for Argentina and China, the prominent role in the market of high oleinic oil belongs to European producers. Ukraine has the second place for its sunflower cultivation area in the world, which constituted 7.1 million ha in the pre-war year of 2021 (Vasylkovska et al., 2022; Vasylkovska et al., 2024).

The worldwide tendency in the farms specialized in plant products is only growing a limited number of crops. These crops make up the major part of sewing areas. As a rule, these are short-term crop rotations. The crop can cover one or two fields in such crop rotations and its proportion increases to 33.3 and 66.6% in tree-field crop rotation or up to 25.0–50.0% in the four-field one. As a result, the term of the crop re-entry to its previous place of cultivation decreases significantly and its sowing becomes more complicated in place of the better predecessors (Brazhenko et al., 2008; Andriienko et al., 2020¸ Kandel et al., 2020).

The need for the following scientifically proved crop rotation in agriculture is justified by biological, physiological, chemical and physical reasons. In case of rational crop rotation, agricultural land and fertilizers are used more productively, the potential of the hybrids is realized to a greater extent, the weediness of agrocenoses is reduced as well as the effect of pests and diseases with the minimal usage of chemicals (Smith et al., 2014; Recanati & Guariso, 2018). The scientifically proved crop rotation is easier to implement in multi-field crop rotations with the rotation period of over 7 years (Smith et al., 2017; Mashchenko et al., 2022; Moldavan et al., 2024).

Havryluik & Kononuik (2009) stated that the use of newer sunflower hybrids which are also more resistant to diseases, next to more intensive technological schemes for their cultivation, the timely pest, disease, and weed treatment enables the re-entry of this popular crop to its previous place of growing in shorter terms than it's usually considered acceptable, namely, in 4 to 6 years, without significant yield reduction.

The possibility and the necessity for seeding concentration of the major field crops in short crop rotations are mentioned in a number of articles of many scientists (Pabat et al., 2005; Vasylkovska & Vasylkovskyi, 2014; Kussul et al., 2022). In the meanwhile, there are a number of publications that demonstrate the opposite conclusions based on the results of the research (Yurkevych, 2005; Debaeke et al., 2017).

The proportion of sunflower in crop rotation is typically limited by fungal disease, especially white rot (*Sclerotinia sclerotiorum*). Except for sunflower the crops that are affected by this causative agent are rapeseed and other Cruciferous plants, leguminous plants, tobacco and other vegetable crops. Thus, the proportion of these crops should not exceed 20%, with the least pauses of 4 years between these crops (Dimitrijevic & Horn, 2018).

In the arid conditions of the Ukrainian Steppe, which is a traditional zone for soil cultivation for sunflower, the liming factor for its proportion in crop rotation is the general contents of moisture in the soil layer between 0 and 200 cm and the spread of a parasite plant called sunflower broomrape (*Orobanche cumana W.*) next to other diseases and pest. In this case it is advisable to reseed sunflower in its previous place of growing on the 8th year only.

The location in crop rotation, i.e. the selection of the predecessor, is one of the crucial conditions for growing high and stable yields of any crop, including sunflower. As it is the predecessor that defines the potential soil fertility, its moisture and nutrients contents, its air and water mode, physical, mechanical and chemical composition, and the amount of weed (Recanati & Guariso, 2018).

During the selection of the predecessor for sunflower there are features that are taken into account, e.g. high contents of nitrogen in soil is a stimulus for the development of diseases, leads to the reduction of yield, oil content and causes its late ripening. Thus, it is important to avoid crops which leave a large amount of nitrogen in soil or those that introduce a lot of nitrogen into it (Montemurro & De Giorgio, 2005; Chantal et al., 2018).

There is an opinion that the best predecessor for sunflower are crops which leave a lot of moisture and nutrients behind them, e.g. grain crops and corn (Kussul et al., 2022).

The previous research showed that the yield of middle-early hybrids after such predecessors as winter wheat, soy and corn, fluctuated within 2.98–3.03 t ha^{-1}. The middle-ripe hybrids had maximal yield after soy (3.55 t ha^{-1}), which is by 0.15 t ha^{-1} more than the reference indications (the previous crop is winter wheat), while the yield was reduced by 0.13 t ha^{-1} after corn and grain. The lowest productivity was demonstrated in case of sunflower re-seeding, with the yield reduction by 0.74 t ha^{-1}. The middle-late hybrids gave the highest yield after grain corn (3.27 t ha^{-1}), which is by 0.36 t ha^{-1} more than after winter wheat, while the indications after soy was close to the reference ones. All the hybrids under consideration showed the presence of poorly-developed seeds and accordingly low yield (Savranchuk et al., 2011; Andriienko et al., 2020).

The predecessors have essential influence on the thousand-kernel weight of various sunflower hybrids and the specific weight of seeds. Thus, sunflower growing after soy and corn provided the increase in structural indications, compared to the winter wheat predecessor, while reseeding of sunflower were less favourable for this indication (Kovalenko & Kovalchuk, 2023; Andriienko et al., 2024). However, the research conducted showed that there is a great influence of genetics of the hybrid on such aspects of yield as the thousand-kernel weight and specific weight of seeds (Miklič & Marinković, 2006; Radic et al., 2013; Andriienko et al., 2024).

So, the question of defining individual reaction of hybrids of various ripeness in order to identify the best predecessor for sunflower is still topical and requires further research.

MATERIALS AND METHODS

The aim of this research was the improvement of the major parameters of zonal energy-efficient technology of growing sunflower and the definition of the reaction of hybrids of various ripeness to the change of the predecessor in the conditions of the Ukrainian North Steppe. Field experiment was conducted in 2019-2021 at the testing ground of “Agro Volodymyr” (farm in Velyka Vyska, Novoukrainka district, Kirovohrad oblast, Ukraine - 48.545011, 31.876756).

This region is characterized by moderate continental climate. The soil is ordinary chernozem with mid humus content, heavy clay which lumps at the depth of 50–55 cm. The reaction of soil solution is pH 6.5–7.0, which is close to neutral. In the plow layer

humus contents is high of about 4.69%, hydrolysing nitrogen - 137 (low), mobile phosphorus - 100 (moderate), exchangeable pottassium - 151 ppm (high), mobile forms of manganese, zinc, boron and sulfur, respectively, 20.2; 0.41; 1.2 i 9.8 ppm.

Insufficient moisture content is typical of the North Steppe of Ukraine where our research was conducted. The amount of precipitation is irregular throughout the year and constitutes about 500 mm. In spring and summer period there is periodic insufficiency of moisture. It leads to essential yield losses as the lack of moisture coincides with the critical period in water consumption by the majority of agriculture crops and, namely, sunflower. The basic research methods were field and field to laboratory experiments. General scientific methods, such as hypothesis, dialectic method, analysis, induction, deduction and math statistics were also used.

The number of days with the temperature above 0 °C is 265, the number of warm days with the temperature above +5 °C is 212, above +10 °C is 168, above +15 °C is 120 days. The total of active temperatures above +10 °C reaches 2,845 °C, and the sum of effective temperatures above +10 °C comes up to 1,155 °C.

The research programme included the study of growth peculiarities, development and yield formation in new sunflower hybrids of different ripeness depending on the predecessors in the North Steppe of Ukraine. The object of study is new hybrids enlisted to the Register of Plant Varieties of Ukraine and recommended for cultivation in the steppe zone.

The number of variants in each of studies is - 12, with triple recurrence; total number of plots in each study is 36. Crop area of the plot is 560 m^2, accounted area is 420 m^2. The basic research methods were field and field to laboratory experiments. General scientific methods, such as hypothesis, dialectic method, analysis, induction, deduction and maths statistics were also used. The research was conducted using the following sunflower hybrids: middle-early LG59580 and LG50609CX; middle-ripe PR64LE25 and Suzuka. The technique used for growing sunflower during the research was generally accepted for this soil and climate zone (State Register of Plant Varieties Suitable for Distribution in Ukraine. (d. b.), 2025).

The basic tillage conducted included disking at 6–8 cm with further ploughing at 25–27 cm using PON-8-35 plough. In the course of the experiment such complex fertilizers as Nitroammophoska were applied at the rate of 40 kg in active substance of NPK.

The sowing was executed within the most favourable period for the north steppe zone (soil warming temperatures at the enfolding depth is up to 10–12 °C), which was May 2–3 in the year of the research using the Tempo F8 Väderstad seed drill. Standard seeds of high sowing quality were used for sowing with their laboratory germination of 92–94%, purity - 99%, and the thousand-kernel weight 65–70 g. They were treated by Cruiser 350FS. The sowing rate was adjusted to 58,000 seeds ha^{-1} (germinable). The row spacing was 70 cm. Weed control was conducted with the help of herbiside Exspess at the standard of 50 g ha^{-1}. Pest control was conducted, as recommended, in case of exceeding the economic threshold of harm with the help of Coragen 20SC normally at 0.15 L ha^{-1}.

Plant height was determined by measuring fully mature sunflower plants during the flowering period using a ruler, from the soil to the top of the inflorescence. The diameter of the inflorescences during the flowering phase was measured using a ruler. Surveys of

sunflower plant disease incidence (downy mildew (*Plasmopara helianthi*), phoma rot (*Phoma helianthi*), stem blight (*Phomopsis helianthi*), white rot (*Sclerotinia sclerotiorum*), septoriosis (*Septoria helianthin*), rust (*Puccinia helianthin*)) was conducted during the full head formation stage by inspecting 100 plants across all experimental treatments (50 plants in a row in two non-adjacent replicates). Harvesting and yield measurement were conducted by direct threshing in all three replicates, with the average result calculated. Yields were adjusted to a grain moisture content of 7%. During harvesting, 20 sunflower heads were sampled from each plot to determine, under laboratory conditions, the head diameter, The quantity of seeds per one head, the seed weight per head, the thousand-kernel weight, and seed moisture content. Moisture content was determined using the thermal-gravimetric method. The oil content in sunflower seeds was determined using the fat-free residue method (Soxhlet extraction), which involves extracting the oil with ethyl acetate.

In order to analyse the data received, statistic models and a package of Excel Microsoft Office applications were used (Wambua, 2022).

RESULTS AND DISCUSSION

The impact of a predecessor on sunflower crop is already noticeable at the initial stage of its development and maintains throughout the whole vegetation period.

Stem height is considered to be one of the major morpho-biological features which defines plants' reaction to the change of cultivation conditions.

On average from 2019 to 2021, the tallest sunflower plants were formed after winter wheat as a predecessor in hybrid LG50609SX and constituted 165.0 cm. Other hybrids as LG59580, PR64LE25, Suzuka were also taller if grown after winter wheat. Their plants' heights amounted to 155.3, 164.0 and 161.0 cm, respectively. In case of grain corn as a predecessor the hybrid LG50609SX had taller plants of 164.3 cm which is only by 0.7 cm less than in case of winter wheat as a predecessor. Hybrids LG59580 and PR64LE25 had the heights of 154.7 and 163.3 cm, respectively, with the same predecessor, which is again only by 0.6 and 0.7 cm less than the reference indications. Meanwhile, the Suzuka hybrid demonstrated the difference in plants' heights with these predecessors of 1.3 cm (Table 1).

Table 1. The influence of predecessors on the plants' heights and inflorescence diameter in the flowering phase, average for 2019–2021

Variant	Hybrid Factor A	Predecessor Factor B	Plant height, cm	Inflorescence diameter, cm
1	LG59580	winter wheat	155.3	24,3
2		corn	154.7	24.2
3		sunflower	147.7	21.3
4	LG50609SX	winter wheat	165.0	23.9
5		corn	164.3	23.8
6		sunflower	151.7	21.1
7	PR64LE25	winter wheat	164.0	24.1
8		corn	163.3	23.9
9		sunflower	150.0	20.1
10	Suzuka	winter wheat	161.0	23.9
11		corn	159.7	23.8
12		sunflower	148.7	21.0

The lowest indications of the plants' heights could be observed after sunflower as a predecessor and amounted to 147.7–151.7 cm depending on the hybrid. The decrease in growth in these plants, in comparison with other predecessors reaches from 7.7 to 14.0 cm.

On average from 2019 to 2021, the biggest sunflower inflorescences were formed after winter wheat as a predecessor in all hybrids. The difference in diameters of inflorescences after winter wheat and corn did not exceed 0.2 cm. The greatest difference was observed in the hybrid PR64LE25 after using winter wheat and sunflower as a predecessor and equalled to 3.9 cm. The hybrid LG50609SX was most tolerant to predecessor change and the difference between the smallest and the biggest inflorescences accounted to only 2.7 cm.

Among all the hybrids under research the biggest inflorescences were formed by LG59580 hybrid after winter wheat as a predecessor and reached 24.3 cm. The smallest inflorescences were observed in the hybrid PR64LE25 grown after sunflower and constituted 20.1 cm.

Under the Ukrainian Steppe conditions the most widely spread sunflower diseases are downy mildew, phoma rot, stem blight, white rot and rust (Andriienko et al., 2020). Their treatment has become especially topical lately.

The important factors of plants' vulnerability to diseases are the genetic features of a specific hybrid and the choice of a predecessor it is grown after. Thus, the absence of such disease as downy mildew among the plants of LG59580 and LG50609SX hybrids after any predecessor can be attributed to their genetic peculiarities. By contrast, in PR64LE25 and Suzuka hybrids the number of plans affected by downy mildew does not depend on the genetics but the predecessor of choice. If winter wheat and corn were selected as a predecessor, the number of plants affected by downy mildew in these hybrids equalled to 5 and 3%, in case of re-seeding it equaled to 10% in both hybrids.

The results of the research demonstrated that the susceptibility of LG50609SX and Suzuka hybrids to phoma rot in case of winter wheat as a predecessor, constituted 10%, while in LG59580 and PR64LE25 hybrids it was 15%. In case of corn as a predecessor, the highest number of plants affected was defined in LG59580 hybrid of 22%, with the lowest susceptibility to phoma rot in Suzuka hybrid of only 10% of the total number of plants.

In terms of phytosanitary, sunflower cultivation after sunflower as a predecessor had a noticeable negative impact. The susceptibility of plants to phoma rot was tremendously higher if compared to other predecessors and fluctuated within 35–45%. The LG59580 hybrid was the most affected one (Table 2).

If to take the incidence of stem blight in hybrids under consideration, we can confidently say that winter wheat is the best predecessor as the number of plants affected after it is the lowest and equals to 8–12% depending on the hybrid. The cultivation of the above-mentioned hybrids after grain corn led to slight but yet an increase in the number of affected plants to 10–15%. The cultivation of sunflower in case of reseeding almost doubled the stem blight incidence and included 20–30% of affected plants.

The genetics of hybrids is also worth mentioning. After all the above-mentioned predecessors it is the LG50609SX hybrid that showed the lowest number of plants affected, compared to other hybrids, which is true not only about incidence of stem blight but also white rot.

Next to LG50609SX, the low level of white rot incidence was registered in LG59580 and Suzuka hybrids which were cultivated after winter wheat and corn as a predecessor and accounted to 2–4%. However, their cultivation after sunflower as a predecessor led to rapid climb in the number of plants affected up to 15%.

Table 2. The incidence of stem and leave diseases in % average for 2019–2021

Variant	Hybrid Factor A	Predecessor Factor B	Downy mildew	Phoma rot	Stem blight	White rot	Septoriosis	Rust
1	LG59580	winter wheat	0	15	12	3	5	10
2		corn	0	22	15	4	3	6
3		sunflower	0	45	30	15	25	40
4	LG50609SX	winter wheat	0	10	8	2	10	35
5		corn	0	12	10	0	9	35
6		sunflower	0	35	20	3	15	50
7	PR64LE25	winter wheat	5	15	12	7	10	8
8		corn	5	20	15	7	8	7
9		sunflower	10	35	25	15	25	35
10	Suzuka	winter wheat	3	10	10	4	3	15
11		corn	3	10	10	2	3	15
12		sunflower	10	35	30	15	15	40

The greatest number of plants affected by stem blight was observed in case of sunflower re-seeding in the hybrids LG50609SX and Suzuka and amounted to 15.0%, while in LG59580 and PR64LE25 hybrids it amounted to 25.0%. The lowest number of plants affected by stem blight was registered while growing sunflower after grain corn and represented 2.0–9.0% depending on the hybrid.

The highest incidence of rust was registered in LG50609SX hybrid of 35.0–50.0% of plants. Similarly, high incidence level could be observed in LG59580 and Suzuka hybrids when sunflower was used as a predecessor and constituted 40.0%. However, the usage of grain corn or winter wheat as a predecessor for these hybrids improved the phytosanitary condition to a great extent and led to the number of plants affected of no more than 6.0–15.0%.

So, in terms of sunflower hybrids' susceptibility to the diseases of stem and leaves, it is worth highlighting the two best predecessors – winter wheat and corn, while growing sunflower in reseeding had negative impact on their sanitary condition. Among all of the hybrids, it is the Suzuka hybrid that distinguished itself with the lowest number of plants affected by diseases. This statement is true for four out of six diseases considered.

The parameters of individual productivity of sunflower hybrid plants is crucial for yield formation and depends on their genetic features, weather conditions throughout their vegetation period and technological influence. Besides, it is important to add that the formation of parameters of sunflower productive organs, like inflorescence size and thousand-kernel weight, defines yield and seed quality.

If the influence of predecessors is considered, the lowest parameters of yield structure elements in all hybrids under research were registered after sunflower. Meanwhile, the highest parameters of individual productivity were observed mainly after winter wheat. However, a part of indications in case of cultivation after corn were not worse and occasionally even superseded.

On average, throughout the years of research LG50609SX, PR64LE25 and Suzuka hybrids formed the biggest heads in case of their cultivation after winter wheat as a predecessor with 18.33, 18.53 and 18.33 cm, respectively. Though better results were

achieved in LG59580 hybrid in case grain corn was used as a predecessor with 18.57 cm. It is necessary to mention that the difference in heads diameters in hybrids under research grown after winter wheat and corn as predecessors was within 0.06–0.17 cm. Among all of the hybrids, the biggest heads were 18.57 in diameter and were formed by LG59580. The smallest heads were formed in case of reseeding and fluctuated 15.90–16.53 cm in different hybrids (Table 3).

Table 3. The elements of sunflower yield structure, average for 2019–2021

Variant	Hybrid Factor A	Predecessor Factor B	Inflo-rescence diameter, cm	Seeds per head, pcs.	Seed weight per head, g,	Thousand-kernel weight, g
1	LG59580	winter wheat	18.43	940	69.9	74.0
2		corn	18.57	955	69.6	72.5
3		sunflower	16.53	810	47.9	58.9
4	LG50609SX	winter wheat	18.33	920	66.1	71.5
5		corn	18.27	935	65.2	69.3
6		sunflower	16.43	800	48.2	60.1
7	PR64LE25	winter wheat	18.53	933	67.3	71.6
8		corn	18.30	930	65.2	69.6
9		sunflower	15.90	782	43.8	56.2
10	Suzuka	winter wheat	18.33	927	69.7	74.5
11		corn	18.23	918	66.5	71.9
12		sunflower	16.30	793	47.0	58.6

The quantity of seeds per one head also depended greatly on the predecessor. LG59580 and LG50609SX hybrids had the greatest number of seeds in their heads in case they were cultivated after grain corn with 955 and 935 pieces, respectively. In case of PR64LE25 was grown after winter wheat and grain corn it formed almost the similar number of seeds per inflorescence of 930 and 933 pcs. The greatest number of seeds per head was registered in LG59580 hybrid with 955 pcs. The smallest number of seeds per inflorescence was formed after sunflower as a predecessor with 782–810 pcs.

The seed weight per head was also dependent on the predecessor. None of the hybrids under consideration overcame the parameter of 50 g in case of re-seeding. The seed weight fluctuated within 43.8–48.2 g with the best indications by LG50609SX hybrid. Cultivation of sunflower after grain corn improved these parameters up to 65.2–69.6 g. In case of winter wheat as a predecessor the seed weight varied from 66.1 g in LG50609SX hybrid to 69.9 g in LG59580 hybrid, which means that all the hybrids under research had greater seed weight head if winter wheat was a predecessor.

The thousand-kernel weight was greater in all the considered hybrids in case they were cultivated after winter wheat as a predecessor. This parameter fluctuated within 71.5–74.5 and 69.3–72.5 g if grown after winter wheat or grain corn respectively, depending on the hybrid, while this parameter was much lower after sunflower except for LG50609SX hybrid with 60 g.

Among all the above-mentioned hybrids Suzuka (74.5 g) demonstrated the highest thousand-kernel weight in case their predecessor was winter wheat. In case of cultivation after grain corn LG59580 showed the best results with the thousand-kernel weight of 72.5 g.

The moisture level in the hybrids under consideration reached 6.1–7.6% after winter wheat, 5.6–7.2% after grain corn, and 5.5–6.7% if sunflower was used as a predecessor. Thus, the hybrids had a positive reaction to better predecessors, namely, winter wheat and grain corn. In case of these predecessors, prolonged vegetation and filling were observed which had positive effect on yield and seed quality (Table 4).

Table 4. Sunflower hybrids productivity by predecessors, average for 2019–2021

Variant	Hybrid Factor A	Predecessor Factor B	Moisture content, %	Yield, t ha^{-1}	Oil content, %
1	LG59580	winter wheat	6.10	3.72	50.9
2		corn	5.60	3.61	50.8
3		sunflower	5.50	2.33	45.5
4	LG50609SX	winter wheat	6.20	3.52	50.2
5		corn	6.05	3.38	50.2
6		sunflower	5.90	2.33	46.3
7	PR64LE25	winter wheat	6.75	3.45	50.3
8		corn	6.35	3.34	50.2
9		sunflower	5.95	2.04	45.9
10	Suzuka	winter wheat	7.60	3.66	51.0
11		corn	7.17	3.43	50.9
12		sunflower	6.73	2.24	45.8
	LSD	Factor A		0.12–0.14	
		Factor B		0.13–0.16	
		Factor AB		0.23–0.28	
		Accuracy of the experiment 2.39%	t_{05}=2.07	A: $F_{0.05}$ = 3.12 B: $F_{0.05}$ = 3.53 AB: $F_{0.05}$ = 2.60	

Yield parameters of sunflower hybrids of various ripeness groups are crucial for evaluating their economic value. The data of the experiment showed on average throughout the years 2019–2021 that LG59580 was the most productive hybrid, with its yield of 3.72 t ha^{-1} in case winter wheat was a predecessor, and 3.61 t ha^{-1} if it was corn. The second result in yield belongs to Suzuka hybrid with its productivity of 3.66 and 3.43 t ha^{-1}, respectively. The lowest yield indications per unit of area after the above-mentioned predecessors was determined in PR64LE25 with 3.45 t ha^{-1} and 3.34 t ha^{-1}, respectively.

As it was mentioned, throughout the years of the experiment all hybrids demonstrated better results in case of seeding after winter wheat. Their productivity fluctuated within the range between 3.45–3.72 t ha^{-1}. At the same time, corn as a predecessor caused yield parameters of 3.34–3.61 t ha^{-1}. In the meanwhile, there was a dramatic difference in Suzuka hybrid only. Though the use of sunflower as a predecessor led to the rapid reduction of hybrid productivity to 2.04–2.33 t ha^{-1}, so the yield shortage exceeded 1 t ha^{-1}.

The results of these studies are significant. At a significance level of $\alpha = 0.05$, the critical value of the Student's *t*-test for this series of experiments is $t_{05} = 2.12$, while the calculated value is 2.07, indicating that there is no statistically significant difference between the treatments. In other words, the deviation falls within the margin of error of

the experiment. In addition, the results of the experiment are reliable. A two-way analysis of variance showed that the effect of hybrids is highly significant ($F_f = 160.6 > F_{0.05} = 3.12$). Predecessors also significantly influence the studied indicator ($F_f = 6.56 > 3.53$). The interaction between the hybrid and predecessor factors is statistically insignificant ($F_f = 0.72 < 2.60$), indicating that their effects are independent.

There was a difference between hybrids under research in their oil content of seeds. On average throughout the years of the experiment, the hybrids demonstrated higher oil contents after winter wheat and grain corn as predecessors. The parameters did not vary much depending on the hybrid and constituted 50.2–51.0% and 50.2–50.9%, respectively. The highest oil content was observed in LG59580 and Suzuka hybrids.

The cultivation of sunflower after sunflower had negative effect. Depending on the hybrid the oil contents in the grown seeds fluctuated within the range of 45.5–46.3%. The only hybrid that exceeded 46.0% was LG50609SX.

As a result of the 3 year experiment we defined the high level of correlation between sunflower hybrids' yield and their oil contents ($r = 0.98$). Such correlation can be considered as a general biological peculiarity as the plants provide higher quality and quantity parameters of yield in better cultivation conditions.

At the moment of harvesting the moisture contents of seeds in hybrids under consideration showed optimal values of 5.5–7.6%. Growing sunflower after winter wheat as a predecessor caused prolonged vegetation and increased moisture content by 0.3–0.9% compared to those grown in reseeding conditions.

CONCLUSIONS

Thus, all the hybrids shower higher productivity in case of their cultivation after winter wheat as a predecessor. The yield level fluctuated within the range of 3.45–3.72 t ha^{-1}, and within 3.34–3.61 t ha^{-1} in case of corn as a predecessor. There is a dramatic difference in yield in Suzuka hybrid only. The usage of sunflower as a predecessor led to yield reduction of 2.04–2.33 t ha^{-1}, which means yield losses equalled to more than 1 t ha^{-1}. The highest oil content level was received in hybrids under consideration when they were cultivated after winter wheat and grain corn as predecessors. The highest oil content level of 50.8-51.0% was measured in LG59580 and Suzuka hybrids.

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