UDC 633.854.78. 631.811.98

Effect of mineral fertilizer doses and crop care on the productivity of sunflower hybrids

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Goal. To determine the features of sunflower yield formation and seed quality in the conditions of Western Polissia, depending on the biological potential of the studied hybrids, different doses of mineral fertilizers and foliar fertilization with growth stimulants.

Methods. The research is based on field experiments using the following methods: field and laboratory - to observe the growth and development of plants; counting and weighing - to determine the parameters of the crop structure and seed yield; mathematical and statistical - to assess the reliability of research results; calculation and comparative - to determine the economic efficiency of the elements of cultivation technologies. **The results.** Data on the results of research on the cultivation of sunflower hybrids Hodavnyk, Huslyar, Integral under the influence of different doses of fertilizer and foliar feeding with growth stimulants, which had a positive effect on plant growth and development, structural indicators and crop productivity, are presented. When applying mineral fertilizers and feeding plants, the productivity changed and manifested itself to a different extent, but the positive effect of this agromeasure compared to the control plots (without fertilizers and without processing) fluctuated within wide limits: 1,98-3,22 t/ha, in the hybrid Hodavnyk, Guslyar – 1,57-2,42 t/ha, Integral from 1,31 to 2,23 t/ha. The yield increase in hybrids was: 0,41–1,42 t/ha, 0,26–0,99 t/ha, 0,22–0,99 t/ha, according to the control (without fertilizers and water treatment).

Conclusions. It was found that applying a dose of $N_{90}P_{60}K_{120}$ fertilizers in combination with foliar application of the growth stimulator Vympel 2 (0,5 l/ha) in the phase of 3-4 and 5-6 leaves of sunflower ensured the highest yield in the studied hybrids Feeder – 3,22 t/ha, Guslyar – 2,24 t/ha, Integral – 2,23 t/ha, and oil yield 1,63 t/ha, 1,20 t/ha, 1,19 t/ha, respectively.

Keywords - *sunflower, hybrids, mineral fertilizers, growth stimulants, weight of 1000 seeds, oiliness.*

Sunflower is one of the important and economically attractive crops of modern agricultural production in Ukraine. It occupies one of the key positions in the world market for production and export. The increase in cultivated areas and the improvement of agricultural culture led to an increase in the gross collection of sunflower seeds [1, 2, 3].

High yield, resistance to weather conditions, demand for sunflower products in Europe motivate farmers to develop this business, in particular, to sow new high-yielding hybrids, carefully approach their selection, so that the result is maximum [4, 5].

Sunflower, throughout the entire growing season, is quite demanding regarding the conditions of mineral nutrition: it needs phosphorus, nitrogen, potassium fertilizers, as well as trace elements such as boron, zinc and manganese. The yield of this crop largely depends on the availability of nutrients in the soil. The maximum profit can be obtained only under the conditions of correct application of agrotechnical measures, in which a balanced fertilization system plays not the least role [6, 7].

Sunflower has a long period of assimilation of nutrients, so it needs much more of them (especially potassium) than grain crops. To obtain 1 t of seeds, sunflower assimilates approximately 5–7 kg of nitrogen, 2,5–2,8 kg of phosphorus and 12–16 kg of potassium. Thus, with a yield of 2,1 t/ha of seeds, sunflower takes 120 kg of nitrogen, 45 kg of phosphorus and 235 kg of potassium from the soil [8, 9].

Nitrogen is evenly absorbed by sunflower plants during the growing season. Starting from the phase of 3–4 pairs of leaves and up to the flowering phase, 70–80% of nitrogen is used. The lack of nitrogen during the formation of the basket has a particularly negative effect. An excess of nitrogen reduces the oil content, leads to excessive vegetative growth [10].

Phosphorus is absorbed by the plant from germination to flowering, accumulates before flowering in the stem and leaves, later moves to the baskets and, as a final result, to the seeds, 60–70 % of the total phosphorus requirement is absorbed by plants during the period of basket formation - the end of flowering. Lack of phosphorus negatively affects the formation and filling of seeds and limits the productivity of sunflower. A sufficient amount of phosphorus increases the drought resistance of plants and the oil content of seeds [11].

Potassium increases the drought resistance of plants, ensures moisture retention and reduces its evaporation. It plays an important role in regulating the moisture balance in the plant. Most potassium is absorbed in the period from basket formation to ripening [12, 13].

The high level of profitability and profitability, the growth of demand for seeds and sunflower oil on the domestic and world markets makes it necessary to increase the sown area and increase the yield of this crop [14].

At the present time and for the future, an important scientific problem is to increase plant productivity, seed quality, economic and energy efficiency of sunflower cultivation technology due to the selection of hybrid composition, optimization of plant stand density and the use of a scientifically based fertilization system, including through application for foliar fertilization of complex fertilizers with trace elements, growth stimulants [15, 16].

The purpose of research is – to establish the features of sunflower yield formation and seed quality in the conditions of Western Polissia depending on the biological potential of the investigated hybrids, different doses of mineral fertilizers and foliar feeding with growth stimulants.

Research materials and methods. Research was carried out during 2021–2022 in field crop rotation on a typical low-humus light loam chernozem, which has the following agrochemical indicators of the 0–30 cm layer: humus content according to Tyurin – 1,96 %, content of alkaline hydrolyzed nitrogen compounds according to Kornfield – 79,2 mg/kg of soil, mobile phosphorus (P_2O_5) and mobile potassium (K_2O) according to Kirsanov – 251 and 109 mg/kg of soil, pH, respectively – 6,2, hydrolytic acidity according to Kappen – 1,14 m-eq/100 g of soil.

The research was based on hybrids selected by the Institute of Plant Breeding named after V.Ya. Yuryeva of the National Academy of Sciences - Integral, Guslyar and Feeder; fertilization system: 1. Without fertilizers (control), 2. N_{60}, 3. $N_{60}P_{30}$, 4. $N_{60}K_{90}$, 5. $N_{60}P_{30}K_{90}$, 6. $N_{90}P_{60}K_{120}$; foliar feeding: 1. No treatment (control); 2. Pennant 2 (0,5 l/ha) in the phase of 3–4 and 5–6 leaves; 3. Vanguard Grow Amino (1 l/ha) in the phase of 3–4 and 5–6 leaves.

The Huslyar hybrid is a simple interline hybrid of the linoleic type of the oil direction, high-yielding, early-ripening, vegetation period of 105 days; Integral is a simple interline hybrid, early-ripening, 105-day growing season, lodging-resistant and drought-resistant; Feeder - belongs to the medium-early ripeness group, oil direction of use, linoleic type, resistant to shedding.

Mineral fertilizers were applied according to the experimental scheme in the form of ammonium nitrate, ammophos, potassium chloride. Foliar fertilization was carried out with a growth stimulator: Vympel 2 (0,5 l/ha) - which includes humic acids - up to 30 g/l, polyhydric alcohols - 300 g/l, carboxylic acids of natural origin – 3,0 g/l; Avangard Grow Amino is a complex drug, growth stimulator, anti-stressor, which contains amino acids, salts of humic and fulvic acids, succinic acid, carboxylic acids, biohormonal complex and trace elements.

Protection of crops from diseases, pests and weeds was carried out using intensive technology.

Over the years of research during the sunflower growing season, the sum of effective temperatures >10 ºC averaged 1132,4 ºC and was sufficient for optimal plant growth and development.

Research results.

The main indicators of the generative sphere of the sunflower are the flower and the seed. Its flowers are collected in an inflorescence - a basket. The formation of the basket begins at the early stages of growth after the appearance of 3–5 pairs of true leaves (BVSN 16–20) and ends by the phase of 7–8 pairs of leaves (BVSN 26–30), when the basket itself is not yet visible. The size of the diameter of the basket, as the center of attraction of assimilants, affects the main elements of the crop structure, namely the number and mass of seeds [17].

As a result of the research, it was established that the diameter of the sunflower basket depended on the hybrid composition, foliar fertilization, growth

stimulants and fertilization and ranged from 16,8 to 23,9 cm (Table 1). The diameter of the basket depends on the use of different doses of mineral fertilizers in hybrids. increased by 4,0-32 %, two-time application of growth stimulants Vympel 2 (0,5 l/ha) by 7,3-9,0 % and Avangard Grow Amino (1 l/ha) by 4,8-7,7 %.

Regarding the factors and options, the largest diameter of the basket of 23,9 cm and 23,3 cm was in the hybrid Feeder in combination with two-time foliar feeding of the plants Pennant 2 (0,5 l/ha) and Vanguard Grow Amino (1 l/ha) in phase 3 –4 and 5–6 leaves and at the recommended dose of fertilizer $N_{90}P_{60}K_{120}$, while on the variant without fertilizers and without processing (control), these indicators were lower by 3,5–4,7 cm. Similarly, it was found that in the Integral hybrid, the diameter of the basket was 21,8 cm and 21,0 cm for $N_{90}P_{60}K_{120}$ fertilizer in combination with two-time foliar feeding of Vimpel 2 (0,5 l/ha) and Avangard Grow Amino (1 l/ha) plants. while in the control (no fertilizer and water treatment) it was 4,9 and 5,7 cm lower, respectively.

1. The diameter of the sunflower basket depending on the hybrid composition, foliar fertilization and mineral fertilization, for 2021–2022, cm

Hybrids (factor A)	Foliar nutrition (factor C)	Fertilizer (factor B)					
		No fertilizers (control)	N_{60}	$N_{60}P_{30}$	$N_{60}K_{90}$	$N_{60}P_{30}K_{90}$	$N_{90}P_{60}K_{120}$
Fiddler	No treatment (control)	16,8	17,4	18,4	17,6	18,7	21,2
	Pennant 2 (0,5 l/ha) in the phase of 3-4 and 5-6 leaves	18,1	18,8	19,8	20,3	21,6	23,0
	Vanguard Grow Amino (1 l/ha) in the phase of 3-4 and 5-6 leaves	17,8	18,2	19,4	19,6	21,3	22,8
Integral	No treatment (control)	16,5	16,7	17,7	17,0	18,1	20,2
	Pennant 2 (0,5 l/ha) in the phase of 3-4 and 5-6 leaves	17,7	18,0	18,7	19,1	20,4	21,8
	Vanguard Grow Amino (1 l/ha) in the phase of 3-4 and 5-6 leaves	16,8	17,4	18,5	18,8	20,0	21,0
Breadwinner	No treatment (control)	18,8	19,9	20,1	20,6	21,7	22,1
	Pennant 2 (0,5 l/ha) in the phase of 3-4 and 5-6 leaves	20,3	21,2	21,5	22,7	23,3	24,1
	Vanguard Grow Amino (1 l/ha) in the phase of 3-4 and 5-6 leaves	20,0	20,8	21,1	22,1	23,0	23,3

The morphological parameters of the plants varied to varying degrees depending on the studied elements (Table 2). The smallest number of baskets was noted on the version without fertilizers and water treatment (control) – 4,0 pcs./m^2

(Guslyar), 3,5 pcs./m^2 (Integral), 4,2 pcs./m^2 (Feeder). With the introduction of different doses of mineral fertilizers, this indicator increased by an average of 0,4-1,2 pcs./m^2.

The largest number of baskets – 5,9 and 5,7 pcs./m^2 was found in the hybrid Feeder with mineral fertilizer $N_{90}P_{60}K_{120}$ and with top dressing Vympel 2 (0,5 l/ha) and Avangard Grow Amino (1/ha) in phase 3–4 and 5–6 leaves, while on the control (without fertilizers and water treatment) this indicator was lower – 4,2 pcs./m^2.

2. The number of sunflower baskets depending on the hybrid composition, foliar feeding and mineral fertilizer, for 2021-2022, pieces/m^2

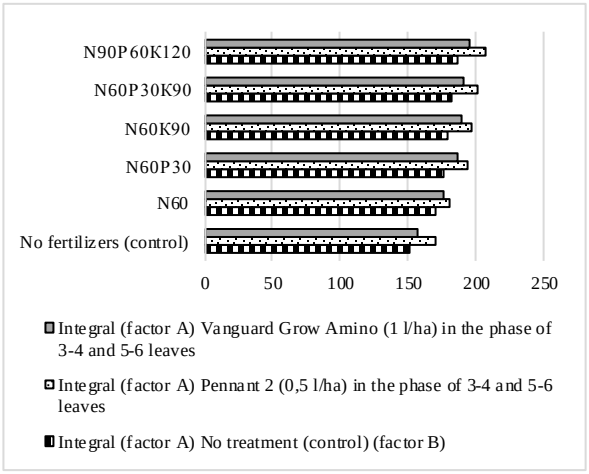
Hybrids (factor A)	Foliar nutrition (factor C)	Fertilizer (factor B)					
		No fertilizers (control)	N_{60}	$N_{60}P_{30}$	$N_{60}K_{90}$	$N_{60}P_{30}K_{90}$	$N_{90}P_{60}K_{120}$
Fiddler	No treatment (control)	4,0	4,4	4,5	4,6	4,7	5,0
	Pennant 2 (0,5 l/ha) in the phase of 3-4 and 5-6 leaves	4,3	4,9	5,0	5,2	5,3	5,4
	Vanguard Grow Amino (1 l/ha) in the phase of 3-4 and 5-6 leaves	4,1	4,7	4,8	4,9	4,9	5,2
Integral	No treatment (control)	3,5	4,0	4,2	4,3	4,4	4,5
	Pennant 2 (0,5 l/ha) in the phase of 3-4 and 5-6 leaves	4,0	4,5	4,6	4,8	4,9	5,1
	Vanguard Grow Amino (1 l/ha) in the phase of 3-4 and 5-6 leaves	3,8	4,4	4,3	4,4	4,5	5,0
Breadwinner	No treatment (control)	4,2	4,7	4,9	5,0	5,2	5,4
	Pennant 2 (0,5 l/ha) in the phase of 3-4 and 5-6 leaves	4,6	5,4	5,7	5,7	5,9	5,9
	Vanguard Grow Amino (1 l/ha) in the phase of 3-4 and 5-6 leaves	4,5	5,1	5,3	5,5	5,6	5,7

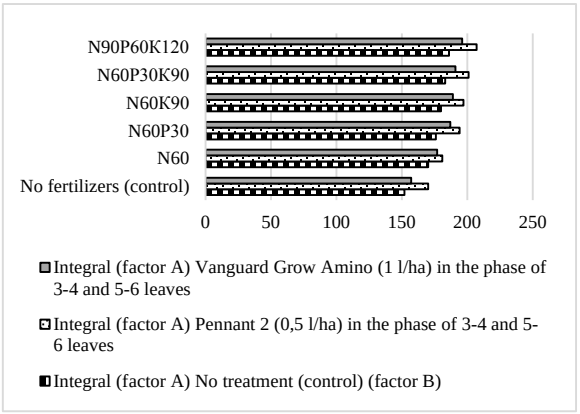
In the Huslyar and Integral hybrids, foliar fertilization with the growth stimulator Vympel (0,5 l/ha) and Avangard Grow (1 l/ha) had a positive effect on the formation of baskets, both in the version without fertilizers and with different

doses of mineral fertilizer, the number of baskets from this of agriculture increased and was the largest for the introduction of $N_{90}P_{60}K_{120}$ in the range of 5,0–5,4 pcs.

Two-time foliar feeding of plants with growth stimulants Vimpel 2 (0,5 l/ha) and Avangard Grow Amino (1 l/ha) ensured an increase in the number of baskets in sunflower hybrids by 8-14 % and 4-11 %, respectively, compared to untreated options.

The seed mass index from one plant is the main component of the sunflower crop structure. Among the research elements, the mass of seeds from the basket has significant fluctuations depending on the studied factors [18]. On the variants without processing (control), when threshing the seeds from the baskets, a decrease in its weight is observed. With the introduction of plant growth stimulants Vimpel 2 (0,5 l/ha) in the phase of 3–4 and 5–6 leaves and Avangard Grow Amino (1 l/ha) in the phase of 3–4 and 5–6 leaves on the background with fertilizer $N_{90}P_{60}K_{120}$ in the hybrid Feeder, these indicators were maximum and increased to 52,3 and 51,6 g, while in the control without processing and without fertilizers (control) – 37,1 g (Fig. 1).





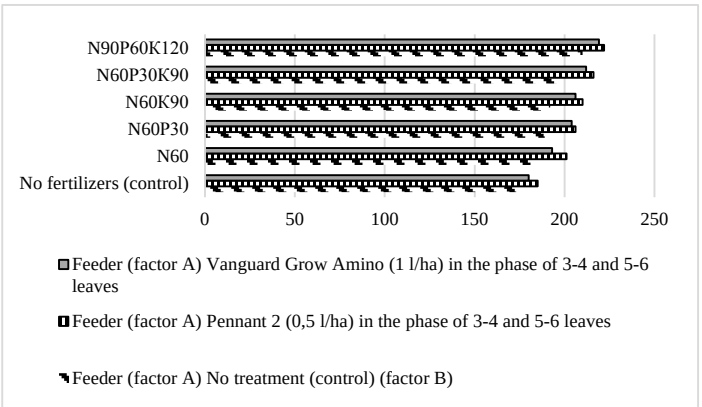


Fig. 1 Weight of seeds from the basket depending on sunflower hybrids, foliar feeding and mineral fertilizer, (average for 2021–2022, grams)

A similar pattern was noted in the hybrid Integral with foliar fertilizing of plants with Vympel 2 (0,5 l/ha) in the phase of 3–4 and 5–6 leaves and fertilizer $N_{90}P_{60}K_{120}$, the weight of seeds from the basket was higher and ranged from 35,0 to 43,1 g in compared to the control without fertilizer (30,2 g).

In the Huslyar hybrid, the weight of seeds from a basket was the lowest in the control (without processing and without fertilizers) 32,5 g, while with foliar fertilization this indicator increased to 32,9–33,1 g. The highest weight of seeds from a basket was 44,5 g were observed for $N_{90}P_{60}K_{120}$ fertilizer and two-time top dressing Vimpel 2 (0,5 l/ha).

For hybrids Huslyar and Hodvavyky, the mass of 1000 seeds was the largest and ranged from 49,3–52,2 g and 47,8–49,9 g in combination with foliar fertilizing of Vympel 2 plants (0,5 l/ha) in phase 3–4 and 5–6 leaves and Vanguard Grow Amino (1 l/ha) in the phase of 3–4 and 5–6 leaves when applying mineral fertilizer $N_{90}P_{60}K_{120}$, and the lowest value of the studied indicator (43,5 and 42,9 g) was in the variant with the Integral hybrid under similar feeding (Fig. 2).

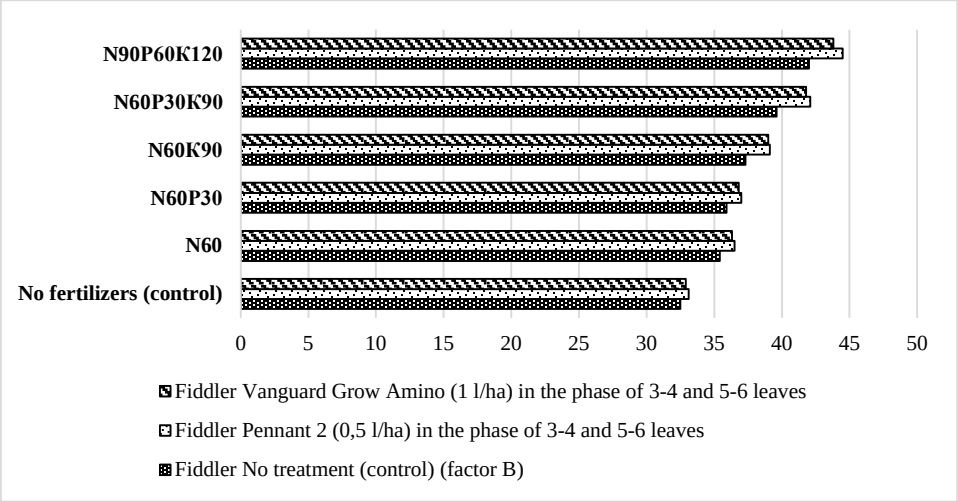


Fig. 2. Weight of 1000 seeds depending on sunflower hybrids, foliar fertilization and fertilization, (2021–2022 average, grams).

Seed yield is the main criterion that characterizes the effectiveness of the studied elements of the technology (Fig. 3).

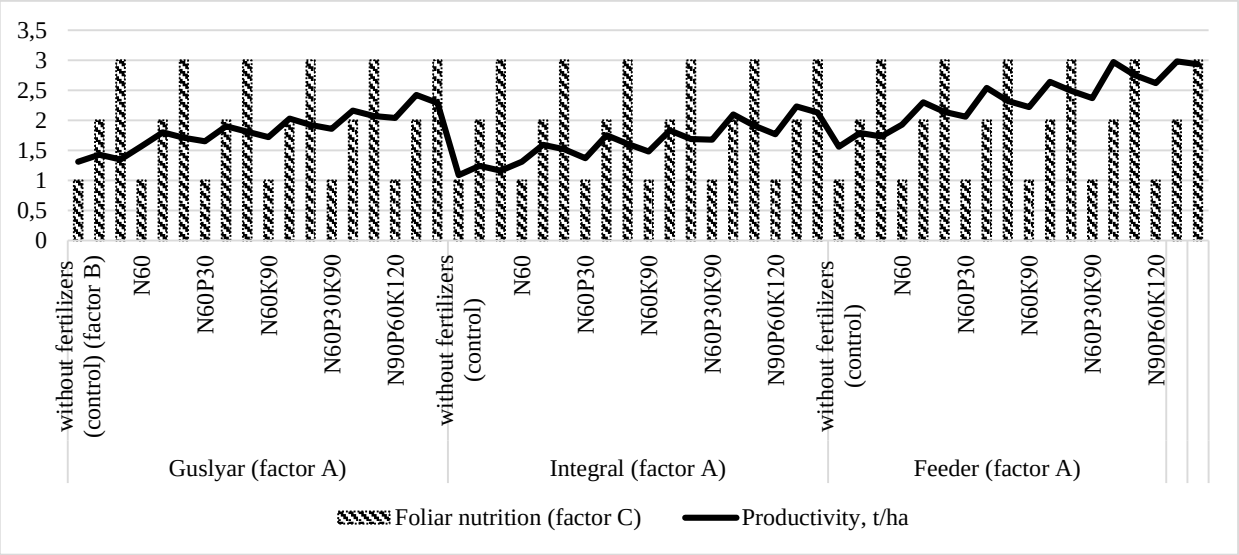


Fig. 3. The yield of sunflower seeds depending on the hybrid composition, foliar feeding and fertilization, (average for 2021–2022, t/ha)

Note: foliar feeding in options 1-3 was carried out according to the experimental scheme.

Depending on the level of mineral nutrition, the yield of hybrids Huslyar, Integral, Feeder was in the range of 1,57-2,42 t/ha, 1,31-2,23 t/ha, 1,98-3,23 t/ha and was higher than the control (without fertilizers and water treatment) by an average of 19,8-79,8%.

According to the results of the research, the highest yield of sunflower seeds was obtained for the cultivation of the Feeder hybrid, 3,22 t/ha ($N_{90}P_{60}K_{120}$). Hybrids Integral and Guslyar were inferior in terms of seed yield to hybrid Feeder by 44-51%. The greatest increase in seed yield from mineral fertilizer of 0,41-1,42 t/ha and 0,23-0,58 t/ha with the application of growth stimulator Vimpel 2 (0,5 l/ha) was found in the hybrid Feeder. Whereas when applying the growth stimulator Avangard Grow Amino (1 l/ha) in the phase of 3–4 and 5–6 leaves, the increase was lower by 15-21%.

It was also established that the yield increase of Huslyar and Integral hybrids with foliar fertilizing of Vimpel 2 plants (0,5 l/ha) in the phase of 3–4 and 5–6 leaves was 0,23–0,38 and 0,15–0,46 t/ha and Vanguard Grow Amino (1 L/ha), which was in the range of 0,14–0,30 and 0,07–0,36 t/ha, compared to the control (water treatment).

The experiment revealed a positive effect of mineral fertilizer levels on the content and yield of oil in sunflower seeds of various hybrids, which varied between 44,2-55,2% on variants with different doses of fertilizers and on the control (without fertilizers and water treatment) 45,0 -45,3 %, oil yield was 0,60-1,63 t/ha and 0,48-0,56 t/ha, respectively. The amount of oil content depended not only on fertilizer, but also on biological characteristics.

The maximum oiliness of sunflower seeds was formed in the hybrids Integral 54,5 %, Feeder 55,2 %, Guslyar 50,2 % at doses of fertilizers $N_{60}P_{30}K_{90}$ compatible

with the introduction of the growth stimulator Vimpel 2 (0,5 l/ha) twice, while the yield of oil 1,19-1,63 t/ha was the highest for $N_{90}P_{60}K_{120}$ fertilizer (Table 3).

3. The influence of the fertilization system on the oil content of sunflower hybrids, for 2021–2022.

Fertilization	Hybrids	Oil content, %	Oil yield, t/ha
$N_{90}P_{60}K_{120}$ + Pennant 2 (0,5 л/га) – twice	Fiddler	49,6	1,20
	Integral	54,1	1,19
	Breadwinner	55,0	1,63

Conclusions

According to the results of research, it was found that in the conditions of the Western Polissia, the improvement of the nutritional regime of the soil with the application of mineral fertilizers and foliar fertilization with the growth stimulator Vimpel 2 (0,5 l/ha) ensured an increase in the yield of sunflower hybrid seeds and the oil content. The highest seed yield of sunflower hybrids, Feeder – 3,22 t/ha, Guslyar – 2,42 t/ha, Integral – 2,23 t/ha, with oil content of 49,6 %, 54,1 %, 54,5 %, respectively received for mineral fertilizer $N_{90}P_{60}K_{120}$ compatible with foliar fertilizing Vimpel 2 (0,5 l/ha) in the phase of 3–4 and 5–6 leaves.

The maximum oiliness of seeds in sunflower hybrids (Feeder 55,2 %, Integral 54,5 %, Guslyar 50,2 %) was formed with $N_{60}P_{30}K_{90}$ fertilizer.