MANAGEMENT OF THE ELEMENTS OF TECHNOLOGY OF GROWING OF SUNFLOWER IN THE RIGHT-BANK STEPPE OF UKRAINE

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Abstract. The article presents the results of scientific research on the management of technology elements and the influence of factors on the productivity of sunflower in the Right Bank Steppe of Ukraine. The studies were conducted in the fields of the Institute of Agriculture of the Steppe NAAS, which is located in the black earth zone of the Right-Bank Steppe of Ukraine. Studies have beenestablished that the level of productivity of sunflower is determined by the level of provision of plants with factors of life. The water regime is formed by weather conditions, the amount of soil moisture reserves, the amount and intensity of rainfall during the year, incl. and during the vegetative period. To a large extent, the soil's water regime depends on the morphological features of the hybrids, the plant standing density, the sowing time, and the cultivation technology. It was found that the moisture available to plants in the meter layer of soil before sowing, in flowering phase and before harvesting was different during the years of research and varied in terms of sowing and depended on the density of plants. Of particular importance for sunflower plants is the content of available moisture in the 0-100 cm layer of soil after the formation of baskets. Considering the annual variation of the weather conditions of spring period of sowing, it should be differentiated with regard to water and heat regimes. High soil moisture reserves during the vegetative period serve as a prerequisite for high sunflower crop yields. Studies have shown that the amount of nitrogen, phosphorus and potassium has varied significantly over the years and under the influence of different fertilizer backgrounds. Appli-

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cation of nitrogen fertilizers in combination with phosphorus and potassium $N_{40}P_{40}K_{40}$ + PP and $N_{40}P_{40}K_{40}$ improves soil nutrition and creates more favorable conditions for growing and developing sunflower plants and maintaining soil fertility. Under these conditions, plant density of 60 thousand hectares contributes to the formation of the highest yield per hectare. The highest seed yield was provided by the LG55.82 hybrid for the first sowing period – 3.85 t/ha. Considering the economic indicators, it is efficient to grow LG 54.85, LG 55.82 hybrids for the first sowing period. Forward, LG 56.32 Sunflower Hybrids provide the highest economic performance for the third sowing period. Among the hybrids, it is most economically apropriate to grow LG 55.82 when sowing at soil temperatures of 5-6°C and plant density of 60 thousand/ha. The net profit in this variant was 22043 UAH / ha, the level of profitability was 224.1%. The energy efficiency ratio was the highest in the first sowing period of the LG 55.82 hybrid and was 4.44.

1. Introduction

In today's intensive agriculture, there is a growing need for increased production of agricultural products, including sunflower seeds. By scale of distribution, versatility of use and energy value, sunflower is the most important oilseed crop in Ukraine and Europe.

Increasing sunflower productivity is possible through the development of new and improvement of existing elements of technology of cultivation of crop [7, p. 75].

The choice of the optimum sowing time and plant standing density is a prerequisite for the efficient use of environmental resources for the formation of high crop yields [4, p. 23].

The value of the sunflower crop is determined by many factors, among which is the existence in the soil of moisture and nutrients necessary for the growth and development of plants.

Among the reasons that deter the growth of sunflower seeds, a significant role is played by the lack of soil nutrients [9, p. 204], and the moisture content of the soil in conditions of unstable moisture is limiting and one of the most important factors for creating favorable conditions for plant growth and development [6, p. 173].

It is ground water reserves and nutrients that in most cases is the cause of low or high sunflower productivity.

The better the crops are provided with moisture, the higher the crop yield the seeds form. The decisive role is played by the fall-winter period and the first half of vegetation [8, p. 591].

The use of moisture by sunflower crops can to some extent be regulated by the sowing time. Shifting the sowing time to earlier allows changing the conditions of growth and development of sunflower plants, namely – better provided by plants with moisture, and it is possible to bypass critical temperature periods of plant development.

The consumption of plants by elements of nutrients is largely determined by the moisture content of the soil: the better the plants are provided with moisture, the greater the consumption of nitrogen, and on the contrary, the worse the plants are provided with moisture, the lower their doses [3, p. 27].

In the system of fertilizers in the steppe areas, the main fertilizer should be dominated which used for soil tillage. It provides the placement of fertilizers in the soil layer with guaranteed moisture, which increases the availability elements of nutrients for plants [1, p. 376].

The background of nutrition is one of the main elements in the technology of cultivation of crop. Fertilize application increases the content of minerals available to plants in the soil. This changes the chemical composition of soil, its physical and other qualities. Improvement of mineral nutrition has positive effect on the processes of photosynthesis, provides normal growth and development of plants, crop formation and quality of seeds [2, p. 35].

Sunflower forms high-energy biomass, which consumes a large number of mineral nutrients. It uses an average of 5.8–6.2 kg of nitrogen, 2.5–2.7 phosphorus and 18.3–18.9 kg of potassium to form 1 centner of seed. The level of consumption elements of nutrients depends on many factors: terms and methods of fertilizer application, moisture supply weather conditions, as well as the genetic characteristics of the variety or hybrid [5, p. 62].

In the face of climate change and the emergence of new hybrids in the production of research to optimize the sowing time and density of plants of different hybrids is actual and important for science and production.

Goal. The purpose of research is to increase productivity by optimizing the sowing time and density of sunflower plants and their effect on water and nutrient regime of soil in the conditions of the Right-Bank Steppe of Ukraine.

2. Materials and methods of research

The research was conducted in the fields of the Kirovohrad State Agricultural Research Station of the National Academy of Agrarian Sciences of Ukraine (KSASRS NAAS) now the Institute of Agriculture of the Steppe NAAS, which is located in the Black Earth zone of the Right-Bank Steppe of Ukraine.

In the three-factor field experiment investigated: Factor A – medium-early Forward sunflower hybrids, LG 56.32, LG 54.85, LG 5582; Factor B – early sowing time (And – at soil temperature at a depth of 10 cm – 5-6°C, II – 7-8°C, III – 9-10°C); Factor C is the plant density of 50 thousand/ha, 60 thousand/ha, 70 thousand/ha. Replication of the experiment three times, the total area of the sowing area is 50.4 m^2, the accounting area is 25.2 m^2. The precursor-spring barley.

The main difference of the soil cover is the ordinary heavy soil loam. Humus content is 4.72%, easily hydrolyzing nitrogen – 104, mobile phosphorus – 191 and exchangeable potassium – 142 mg per kilogram of soil, mobile forms of manganese, zinc and boron accordingly – 3.1; 0.35 and 1.76 mg per kilogram of soil. Reaction of soil solution pH-5,8.

The climatic conditions of the Institute of IAS NAAS are typical for the Right-bank Steppe of Ukraine with temperate continental climate. This is confirmed by the daily and annual amplitude of air temperature, as well as by significant fluctuations in the annual weather conditions. The average annual rainfall is 499 mm per year.

The weather conditions for research differed, both from each other and from the average long-term indicators in terms of precipitation and temperature.

3. Dynamics of soil moisture content

The researches made it possible to establish that the level of sunflower productivity is determined by the conditions of water and nutritional regime of soil.

Stocks of productive moisture in a meter layer of soil during sowing significantly influenced the dynamics of emergence of seedlings (Figure 1).

So in 2016, the moisture reserves for the first sowing period – 5-6°C (April 6) were 181.9 mm, for the second – 7-8°C (April 10) – 178.8 mm, for the third – 9-10°C (April 13) – 175.0 mm; in 2017, respectively, for the

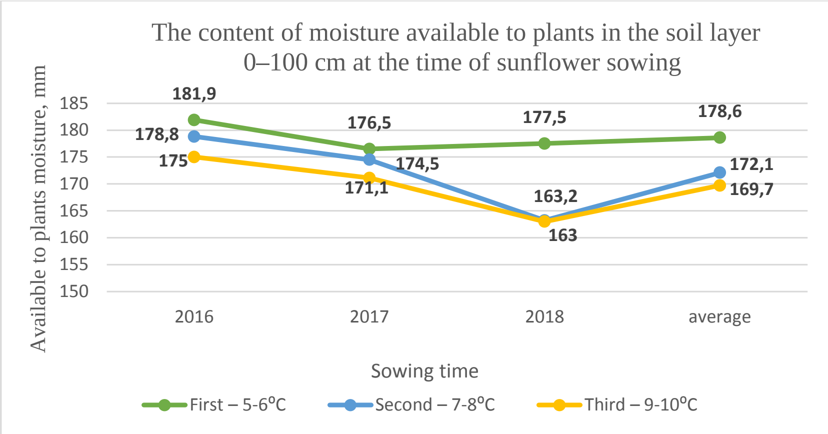

Figure 1. The content of moisture available to plants in the soil layer 0-100 cm at the time of sunflower sowing

first sowing period – 5-6°C (April 7) was 176.5 mm, for the second – 7-8°C (April 12) – 174.5 mm, for the third – 9-10°C (April 28) – 171.1 mm; in 2018, respectively, for the first sowing period – 5-6°C (April 6) were 177.5 mm, for the second – 7-8°C (April 12) – 163.2 mm, for the third – 9-10°C (April 24) – 163.0 mm. On average, during the years of research, the most available moisture in the 0-100 cm soil layer was during the first sowing period – when it was heated to a depth of seed 5–6°C – 178.6 mm for the second sowing period – 172.1 mm for the third sowing period – 169.7mm.

Moisture reserves in the 0-10 cm soil layer remained high at the time of sowing (Figure 2).

This is due to low temperatures, compensated by the increased relative humidity, low evaporation of soil moisture and precipitations during this period. Thus, during the first sowing period, moisture reserve were – 25.0 mm, in the second – 24.4 mm, and in the third sowing period, 23.6 mm, that is, a gradual decrease in the amount of moisture available to plants in the sowing layer of soil.

Studies show that the moisture available to plants in the meter layer of soil in the flowering phase was different during the years of research and varied in terms of sowing and depended on the density of plants (Figure 3).

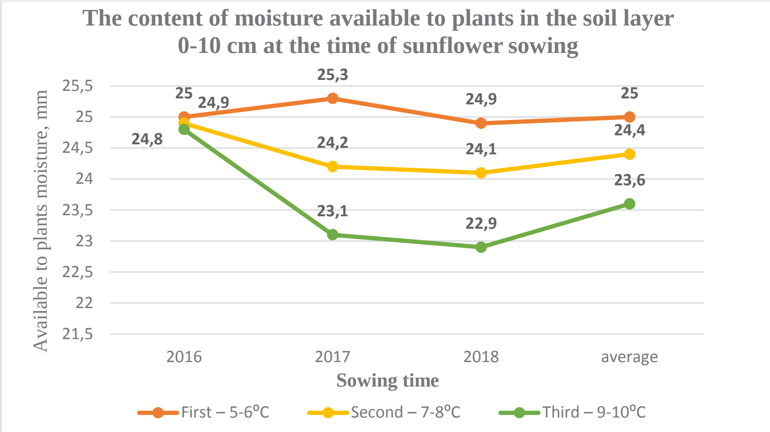

Figure 2. Content of moisture available to plants in the soil layer 0–10 cm at the time of sunflower sowing

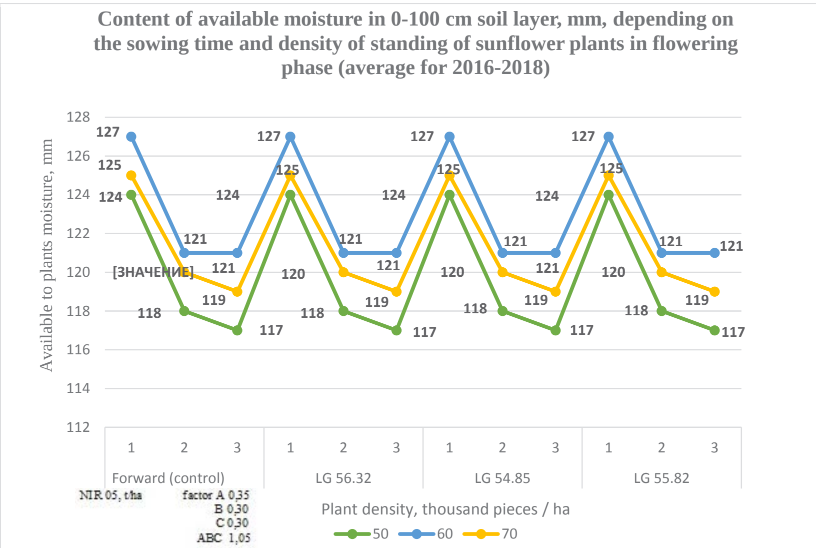

Figure 3. Content of available moisture in 0-100 cm layer of soil, mm, depending on the sowing time and density of standing sunflower plants in flowering phase (average for 2016-2018)

Thus, according to the average data of 2016-2018, the highest reserve of moisture available to plants in the soil layer 0-100 cm., In crops of Forward hybrids, LG 56.32, LG 54.85, LG 55.82 were at the density of standing plants 60 thousand per hectare, for the first sowing period – in the flowering phase was 127 mm, for the second sowing period – 121 mm, for the third sowing period – 121 mm. For plant densities of 50 thousand per hectare for the first sowing period – 5-6°C, in crops of Forward hybrids, LG 56.32, LG 54.85, LG 55.82 the available moisture in the flowering phase was 124 mm, for the second sowing period – 7-8°C – 118 mm, for the third sowing period – 9-10°C – 117 mm. In case of increase of plant standing density up to 70 thousand per hectare, the reserve of moisture available to plants were 125 mm in the first sowing period, 125 mm in the flowering stage, 120 mm in the second sowing period, and 119 mm in the third sowing period.

4. Influence of elements of nutritios on the fertility of soil and productivity of sunflower

For the formation of high productivity of sunflower, as well as for maintaining the fertility of the soil at the proper level, conditions must be created for the complete providing soil with nutrients.

In general, for three years of studies, the content of nitrate nitrogen in the arable soil was at the level of low NO_3 (0.60-6.60 mg/kg), ammonium nitrogen at the average level of NH_4 (17.5-28.4 mg/kg), phosphorus and potassium at high and high levels of safety (P_2O_5 – 166.9-324.0 mg/kg; K_2O – 96.0-193.0 mg/kg) table 1.

The amount of nitrogen, phosphorus and potassium changed significantly over the years and under the influence of different fertilizer backgrounds.

The application of the fertilizer system for growing sunflower in 2016 contributed to a significant increase in phosphorus on plots when making $N_{40}P_{40}K_{40}$ + PP. and was 232.8 mg/kg of soil, in the non-fertilizer version the phosphorus content was 210.9 mg/kg of soil and in the variant $N_{40}P_{40}K_{40}$ – 195.3 mg/kg of soil, accordingly.

The introduction of $N_{40}P_{40}K_{40}$ contributed to the reduction of phosphorus by 37.5 mg/kg of soil or by 16.2% compared to the variant $N_{40}P_{40}K_{40}$ + PP. and 15.6 mg/kg of soil or 7.4% compared to the fertilizer-free version.

Making $N_{40}P_{40}K_{40}$ + PP contributed to the increase of nitric nitrogen (NO_3) content by 1.35 mg/kg of soil or by 37.5% compared to the version

Table 1

The content of nutrients in the arable soil (0-30 cm), depending on the fertilizer of sunflower for 2016-2018

Years	Fertilizer system	NO_3 mg/kg	NH_4 mg/kg	P_2O_5 mg/kg	K_2O mg/kg
2016	No fertilizer	2,25	17,5	210,9	96,0
	$N_{40}P_{40}K_{40}$	2,83	24,6	195,3	122,5
	$N_{40}P_{40}K_{40}$+ P.P.	3,60	18,8	232,8	137,3
2017	No fertilizer	3,50	18,6	186,0	109,6
	$N_{40}P_{40}K_{40}$	6,60	19,9	266,5	163,0
	$N_{40}P_{40}K_{40}$+ P.P.	6,20	28,4	166,9	169,0
2018	No fertilizer	0,81	17,9	271,9	152,0
	$N_{40}P_{40}K_{40}$	0,76	24,2	166,9	193,0
	$N_{40}P_{40}K_{40}$+ P.P.	0,60	17,6	324,0	145,0

*PP by-products of the predecessor.

without fertilizers. Ammonium nitrogen (NH_4) content in the soil was higher when $N_{40}P_{40}K_{40}$ was applied and amounted to 24.6 mg/kg of soil, which is 28.9% compared to the fertilizer-free version.

In 2017, the phosphorus content was higher in the $N_{40}P_{40}K_{40}$ background and was 266.5 mg/kg of soil, which is higher than in the non-fertilizer version by 80.5 mg/kg of soil or 30.3% and in the variant $N_{40}P_{40}K_{40}$ + PP on 99.6 mg/kg soil or 37.4%.

The introduction of $N_{40}P_{40}K_{40}$ contributed to an increase in nitrate nitrogen (NO_3) content of 3.1 mg/kg soil or 47.0% compared to the non-fertilizer version and 6.1% with the $N_{40}P_{40}K_{40}$ + PP variant. Ammonium nitrogen (NH_4) content in soil was higher when $N_{40}P_{40}K_{40}$ + PP was applied. and amounted to 28.4 mg/kg of soil, up 34.6% compared to the non-fertilizer version.

Making $N_{40}P_{40}K_{40}$ + PP while growing sunflower in 2018 significantly increased the phosphorus content of the fertilizer-free background and the $N_{40}P_{40}K_{40}$ background. The phosphorus content was 324.0; 271,9; 166.9 mg/kg of soil, which is more than the fertilizer-free version by 16.1% and the $N_{40}P_{40}K_{40}$ variant by 48.5%.

Nitrogen (NO_3) content in soil was almost unchanged with $N_{40}P_{40}K_{40}$ and $N_{40}P_{40}K_{40}$ + PP, this indicator varied from 0.60 to 0.81 mg/kg of soil and was higher in the non-fertilizer version by 26%.

The introduction of $N_{40}P_{40}K_{40}$ increased the content of ammoniacal nitrogen (NH_4) by 6.3 mg/kg of soil or by 26.1% compared to the non-fertilizer variant.

Thus, when growing sunflower in 2016-2017, making $N_{40}P_{40}K_{40}$ + PP contributed to the increase in soil potassium content of 137.3 and 169.0 mg/kg of soil, which is 10.8 and 3.6% more than the $N_{40}P_{40}K_{40}$ variant, and by 30.1 and 35.2% compared to the non-fertilizer variant.

In 2018, the potassium content of soil was higher in the $N_{40}P_{40}K_{40}$ background and was 193.0 mg/kg, which was 24.9% more than in the $N_{40}P_{40}K_{40}$ + PP version. and by 21.3% in the fertilizer-free version.

5. Photosynthetic activity of sunflowers

An important showing of the intensity of sunflower growth is the net productivity of photosynthesis, which shows the ratio of daily growth of dry matter to the area of leaves (table 2). Studies have shown that the net productivity of photosynthesis varies widely depending on the phases of growth and development, the structure of sowing, nutrition and biological characteristics of hybrids.

Table 2

Net productivity of photosynthesis of sunflower, depending on the sowing time and density of plants, g/m2 per day (average for 2016-2018)

Hybrid	**Soil temperature 5-6°C**			**Soil temperature 7-8°C**			**Soil temperature 9-10°C**		
	Plant density, thousand pieces / ha								
	50	**60**	**70**	**50**	**60**	**70**	**50**	**60**	**70**
Forward (control, standard)	9,3	9,4	9,0	9,4	9,5	8,9	9,3	9,4	9,2
LG 56.32	9,5	9,8	9,3	9,5	10,0	9,5	9,6	9,9	9,7
LG 54.85	9,8	10,4	9,5	9,9	10,1	9,4	10,0	10,0	9,2
LG 55.82	10,3	11,1	9,7	10,0	10,7	9,9	9,9	10,2	9,9
NIR 05	factors A – 0,30; factors B – 0,26; factors C – 0,26; ABC – 0,91								

The highest net photosynthesis productivity was observed in the LG 55.82 hybrids (10.2-11.1 g/m^2 per day) and in the LG 54.85 (10.1-10.4 g/m^2 per day) hybrids. In other hybrids studied, the net productivity of photosynthesis was at the same level – 9.2-10.0 g/m^2 per day. The lowest productivity of this parameter was found in the hybrid Ford and LG 56.32.

The net productivity of photosynthesis in all variants increases to 60 thousand/ha, after which it decreases in the Forward hybrids by 2.2-6.4%, LG 56.32 by 2.1-5.2%, LG 54.85 by 8.0-8.7%, LG 55.82 by 3.0-12.7%, due to the features of their architectonics, in particular, the greater number of leaves.

Studied LG 54.85 and LG 55.82 sunflower hybrids provided the highest net productivity in the first sowing period, and the Forward, LG 56.32 sunflower hybrids in the second sowing period contributed primarily to appropriate moisture supply. In the third sowing period, net productivity decreased by 3.9-8.2% and 1.0-2.0%. Such decrease was caused by increase in air temperatures and lack of soil moisture.

The most objective indicator that allows to determine the possibility of using photosynthetically active radiation by crops during vegetation period is photosynthetic potential. It means the total leaf surface that participated in photosynthesis from the beginning of vegetation to the end of photosynthesis.

Studies have been established that the magnitude of photosynthetic potential was due to the characteristics of hybrids, sowing time and density of plants. During the vegetative period of sunflower, the crops of hybrids produced photosynthetic potential at the level of 2,04-2,55 million m^2/ha. (table 3). This gives grounds to affirm that the sunflower crops in the experiment were in good condition.

Increasing plant standing density from 50 to 60 thousand/ha provided growth of photosynthetic potential. In Forward hybrids, LG 56.32, LG 54.85, LG 55.82 it increased by 12.1–13.0%. At plant density of 70 thousand/ha, the photosynthetic potential decreased by 4.1–5.0% compared to the density of 60 thousand/ha. Sunflower sowing at soil temperature 5-6 and 7-8°C contributed to its higher performance in comparison with the third term by 4.1-1.8%. The largest photosynthetic potential was found in the LG 55.82 hybrid during the first sowing period at density of 60 thousand hectares – 2.55 million m^2 days / ha. The LG 54.85 hybrid is slightly smaller – 2.51 million m^2/ha. It was the smallest in the hybrids of Forward and LG 56.32 for the third sowing period with the placement of 50 thousand plants/ha –

Table 3

Photosynthetic potential of sunflower, depending on the sowing time and density of plants, million m² days / ha (average for 2016-2018)

Hybrid	Soil temperature 5-6°C			Soil temperature 7-8°C			Soil temperature 9-10°C		
	Plant density, thousand pieces / ha								
	50	60	70	50	60	70	50	60	70
Forward (control, standard)	2,15	2,40	2,35	2,09	2,35	2,28	2,07	2,34	2,24
LG 56.32	2,17	2,42	2,35	2,06	2,37	2,28	2,04	2,33	2,21
LG 54.85	2,21	2,51	2,37	2,07	2,44	2,34	2,04	2,37	2,27
LG 55.82	2,16	2,55	2,41	2,18	2,49	2,33	2,13	2,44	2,29

2.07 and 2.04 million m^2/ha, respectively. Therefore, the larger the leaf area and the duration of the vegetation, the higher the photosynthetic potential and better opportunities for gettng high yield.

6. Sunflower productivity depending on sowing time and plant standing density

Research established significant dependence of yield of sunflower hybrids on the density of plants, weather conditions, biological features of hybrids and sowing time (table 4).

In general, over the three years of research, the highest yields of the hybrids LG 5582, LG 54.85, LG 56.32, Forward was obtained at a density of 60 thousand plants/ha. In the first sowing period, the highest seed yield of 3.85 t/ha was provided by the LG 55.82 hybrid, which was 5.5% more than in the third term and 3.2% in the second sowing period. The plants of the LG 54.85 hybrid formed a seed yield of 3.64 t/ha for sowing in the first term, which is 0.9% more for the third term and 3.6% for the second sowing period. For the sowing in the third term, the highest seed yields were formed by hybrids of Forward and LG 56.32 – 3.09 and 3.62 t/ha, which is higher by 3.6 and 3.4% for the second term, 4.9 and 8.9%, respectively first term. Hybrids of sunflower LG 56.32, LG 54.85 and LG 55.82 by seed yield significantly exceeded the control variant. Thus, the LG 55.82 sunflower hybrid exceeded the Forward hybrid yield by 0.91 t/ha, or 23.7%; LG 54.85 at 0.7 t/ha, or 19.3%; LG 56.32 – up 0.53 t/ha, or 14.7%.

Table 4

Yield of sunflower hybrids, depending on sowing time and density of plants, t / ha (average for 2016-2018)

Hybrid	Year	Soil temperature 5-6°C			Soil temperature 7-8°C			Soil temperature 9-10°C		
		Plant density, thousand pieces / ha								
		50	60	70	50	60	70	50	60	70
Forward (control, standard)	2016	2,70	2,62	2,65	2,87	2,74	2,41	2,79	2,73	2,70
	2017	3,02	2,91	2,66	3,27	3,29	2,79	3,21	3,37	3,27
	2018	3,12	3,29	2,99	2,82	2,93	3,06	2,87	3,17	2,81
	average	2,94	2,94	2,76	2,98	2,98	2,75	2,95	3,09	2,92
LG 56.32	2016	2,79	2,75	2,68	3,06	3,62	3,29	3,24	3,41	3,35
	2017	3,11	3,42	3,56	3,19	3,47	3,23	3,30	3,55	3,7
	2018	3,46	3,76	3,46	3,28	3,51	3,33	3,53	3,90	3,30
	average	3,12	3,30	3,23	3,17	3,5	3,28	3,35	3,62	3,45
LG 54.85	2016	3,26	3,50	3,00	3,33	3,33	3,18	3,23	3,12	2,93
	2017	3,49	3,69	3,62	3,7	3,99	3,52	3,98	4,10	3,58
	2018	3,53	3,74	3,41	3,37	3,24	3,27	3,58	3,63	3,15
	average	3,42	3,64	3,34	3,46	3,51	3,32	3,59	3,61	3,22
LG 55.82	2016	3,22	3,27	2,70	3,26	3,21	3,38	3,28	2,96	3,38
	2017	3,95	4,04	3,74	3,91	4,16	3,54	3,69	3,98	3,59
	2018	3,74	4,24	3,58	3,47	3,83	3,84	3,86	3,99	3,79
	average	3,63	3,85	3,33	3,54	3,73	3,58	3,60	3,64	3,58
NIR 05, t/ha for	factors A 0,13 factors B 0,11 factors C 0,11 total ABC 0,40									

7. Economic and energy efficiency of improved elements of sunflower production technology

The calculation of the cost-effectiveness of growing sunflower confirmed that early sowing time leads to a higher level of profitability than late ones. The criteria for the degree of efficiency were: the level of cost of production, the amount of net profit per 1 ha, calculated as the difference between the cost of the crop per unit area and the cost of its production (table 5).

It should be noted that production costs increased from the first to the third sowing period due to the additional sowing cultivation in the second term and two – in the third. Costs were also determined by the pre-harvesting moisture of grain. Costs for the first sowing period fluctuated within 8677-9835 UAH/ha, for the second – 8793-9951 UAH/ha and for the third increased to 8909-10067 UAH/ha.

Table 5

Economic efficiency of cultivation of sunflower at standing density of 60 thousand/ha at different sowing periods (average for 2016-2018)

Hybrid	Sowing time	Yield, t/ha	The cost of the crop, UAH / t	Cost of seeds, UAH / t	Costs, UAH / ha	Net profit, UAH / ha	Profitability level,%
Forward (control, standard)	5-6°C	2,94	24343	2951,3	8677	15666	180,5
	7-8°C	2,98	24674	2950,6	8793	15881	180,6
	9-10°C	3,09	25585	2883,1	8909	16676	187,1
LG 56.32	5-6°C	3,30	27324	2827,8	9332	17992	192,7
	7-8°C	3,5	28980	2699,4	9448	19532	206,7
	9-10°C	3,62	29973	2641,9	9564	20409	213,3
LG 54.85	5-6°C	3,64	30139	2701,0	9832	20307	206,5
	7-8°C	3,51	29062	2834,1	9948	19114	192,1
	9-10°C	3,61	29890	2787,8	10064	19826	196,9
LG 55.82	5-6°C	3,85	31878	2554,5	9835	22043	224,1
	7-8°C	3,73	30884	2667,8	9951	20933	210,3
	9-10°C	3,64	30139	2765,6	10067	20072	199,3

The lowest seed cost was obtained when growing the hybrid LG 55.82 – 2554.5 UAH / t for the first sowing period, and this variant recorded the highest profitability in the experiment – 224.1%. Among hybrids, it is most economicaly feasible to grow LG 55.82 when sowing at 5-6°C soil temperatures. The net profit in this variant was 22043 UAH / ha, the level of profitability was 224.1%.

In addition to the economic evaluation of the technology of sunflower cultivation was carried out and energy assessment of the level of total energy costs, the cost of production of 1 centner of seeds, energy output per hectare, as well as the level of energy efficiency (LEE). The energy efficiency ratio was the highest during the first sowing period and was 3.38-4.44. In the second term, the value of LEE ranged from 3.22 to 4.03 and the third period from 3.13 to 3.69.

8. Conclusions

The water regime is formed by weather conditions, the amount of soil moisture reserves, the amount and intensity of rainfall during the year, incl. and during the vegetative period. To a large extent, soil's water regime depends on the morphological features of the hybrids, the plant standsng density, the sowing time, and the cultivation technology. Under these conditions, crops with plant density of 60 thousand/ha, contributed to the formation of the highest yield, compared with other options.

For the first sowing period, the highest seed yields were provided by the LG 55.82 3.85 t/ha and LG 54.85 – 3.64 t/ha hybrids, while the Forward and LG 56.32 hybrids for the third term sowed 3.09 and 3.62 t/ha, respectively.

Application of nitrogen fertilizers in combination with phosphorus and potassium $N_{40}P_{40}K_{40}$ + PP and the $N_{40}P_{40}K_{40}$ improves soil nutrition and creates more favorable conditions for the growth and development of sunflower plants and for maintaining soil fertility.

Considering the economic indicators, it is efficient to grow LG 54.85, LG 55.82 hybrids for the first sowing period. Forward, LG 56.32 Sunflower Hybrids provide the highest economic performance for the third sowing period.

Among the hybrids, it is most economically appropriate to grow LG 55.82 when sowing at soil temperatures of 5-6°C and plant density of 60 thousand/ha. The net profit in this variant was 22043 UAH/ha, the level of profitability was 224.1%.

The energy efficiency ratio was the highest in the first sowing period of the LG 55.82 hybrid and was 4.44.

Thus, the high requirements of sunflower for environmental resources do not exclude early sowing, but rather confirm the relevance of research on their effectiveness.

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