

Management of the elements of technology for growing of sunflower in the Right-Bank Steppe of Ukraine

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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. The level of sunflower productivity is determined by the conditions of water and nutrient conditions of soil.

Water regime is formed by the weather conditions, the amount of soil moisture reserves, the amount and intensity of rainfall during the year, incl. during the growing season.

The moisture reserves available to plants in the meter layer of soil before sowing, in the flowering phase and before harvesting were different during the years of research, varied in terms of sowing and depended on the density of standing 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. During this period, sunflower intensively consumes available moisture from deeper layers of soil.

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

Application 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 favourable conditions for growing and developing sunflower plants and maintaining soil fertility.

Under these conditions, the LG 55.82 hybrid with a plant density of 60 thousand/ha formed the highest yield for the first sowing period – 3.85 t/ha.

Considering the economic indicators, it is efficient to grow LG 54.85 and LG 55.82 hybrids for the first sowing period. Forward and 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 temperature of 5–6°C and plant density of 60 thousand/ha. The net profit in this variant was 22043 UAH/ha, and 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 – 4.44.

Keywords: sunflower, hybrids, sowing time, plant standing density, soil nutrient regime, water regime of soil, yield

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 the existing elements of technology for crop cultivation (Pokoptseva, 2014; Polyakov, Nikitenko, Vakhnenko, 2014; Tkalich, Mamchuk, 2011; Tkalich, Tkalich, Kokhan, 2012).

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 (Kramarenko, Hlushchenko, Dudiak, 1998).

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 (Totskyi, 2014), and the moisture content of the soil in conditions of unstable moisture is limiting and one of the most important factors for creating favourable conditions for plant growth and development (Maliyenko, 2015; Melnyk, Hovorun, 2014).

The accumulation and rational use of soil moistening is most relevant in the Steppe zone with insufficient and unstable moisture, where its total losses on runoff and unproductive evaporation reach half of the annual rainfall rate. Under high anthropogenic loading, the water regime of soil can significantly deteriorate, so it is important to accumulate moisture reserves in the lower part of the root layer (100–150 cm), from where it gradually moves in the ascending direction under the action of gradients of different nature (Tsylyuryk, Desiatnyk, 2017).

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 (Pustovoi, 1975; Tsylyuryk, Sudak, 2017).

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 (Buriakov, 1992). The system of application of nitrogen fertilizers – doses, terms and methods of application vary depending on soil and climatic conditions, genetic characteristics of soils, but in all regions of Ukraine and on all types of soils their efficiency exceeds yields of phosphorus and potassium fertilizers (Nosko, 2013).

In the system of fertilizers in the Steppe areas, the main fertilizer should be dominated 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 (Hospodarenko, 2018).

The background of nutrition is one of the main elements in the technology of crop cultivation. Fertilizer 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 a positive effect on the processes of photosynthesis, provides normal growth and development of plants, crop formation and quality of seeds (Bailly, 2000).

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.

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

MATERIALS AND METHODS

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 the following was investigated: Factor A – medium-early

Forward sunflower hybrids, LG 56.32, LG 54.85, LG 5582; Factor B – early sowing time (soil temperature at a depth of 10 cm – 5–6°C, II – 7–8°C, III – 9–10°C); Factor C – the plant density of 50, 60 and 70 thousand/ha. Replication of the experiment is three times, the total area of the sowing area is 50.4 m², the accounting area is 25.2 m². The precursor is spring barley.

The main difference of the soil cover is the ordinary heavy soil loam. The humus content is 4.72%, easily hydrolyzing nitrogen 104, mobile phosphorus 191 and exchangeable potassium 142 mg per kg of soil, mobile forms of manganese, zinc and boron, respectively, 3.1, 0.35 and 1.76 mg per kg of soil. The reaction of soil solution is pH-5.8.

The climatic conditions of the Institute of IAS NAAS are typical for the Right-Bank Steppe of Ukraine with the 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.

The moisture content of soil was determined by the thermostatic-weight method.

The nitrogen content was determined by a ion selective ionometer I-160 M according to DSTU ISO 4729: 2007.

The content of mobile phosphorus was determined by Machigin (DSTU ISO 4114-2002), potassium by Maslova (GOST – 26210-91).

Statistical analysis of the results of studies was performed by the multivariate dispersion method, the calculations were performed using MS Excel Agcstat.

RESULTS AND DISCUSSION

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.

The presence of moisture in soil is one of the limiting factors that ensure the yield. Its main source is atmosphere precipitation (Maliyenko, 2015).

Sunflower for formation of high seed yield requires deep soaking of soil in spring, presence of 165–185 mm of productive moisture in the root layer 0–150 cm and sufficient (300–400 mm) rainfall during the growing season (Tsyliuryk, 2018).

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

So in 2016, the moisture reserve for the first sowing period – 5–6°C (6 April) – was 181.9 mm, for the second – 7–8°C (10 April) – 178.8 mm,

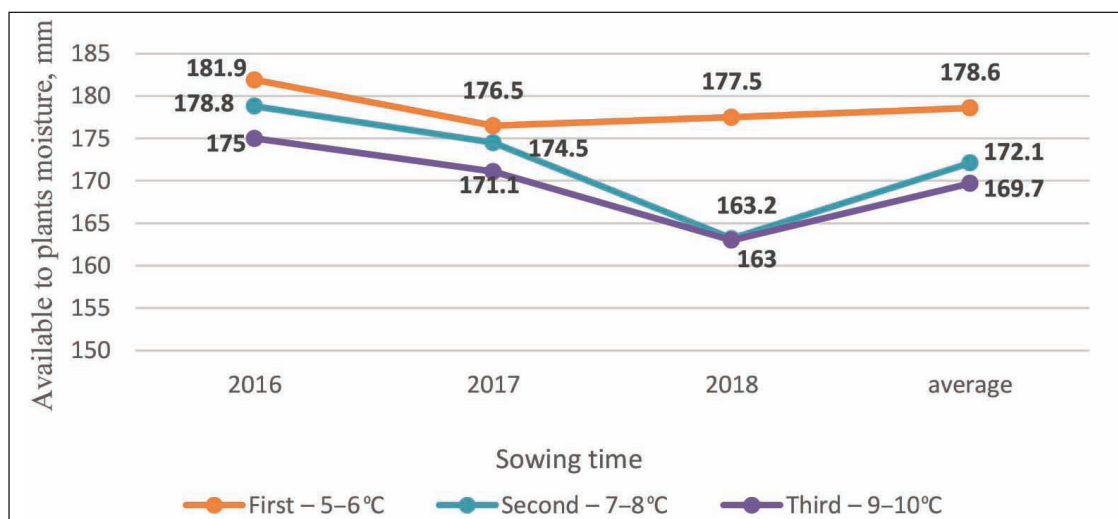


Fig. 1. The content of moisture available to plants in the soil layer 0–100 cm at the time of sunflower sowing

for the third – 9–10°C (13 April) – 175.0 mm; in 2017, respectively, for the first sowing period – 5–6°C (7 April) – it was 176.5 mm, for the second – 7–8°C (12 April) – 174.5 mm, for the third – 9–10°C (28 April) – 171.1 mm; in 2018, respectively, for the first sowing period – 5–6°C (6 April) – it was 177.5 mm, for the second – 7–8°C (12 April) – 163.2 mm, for the third – 9–10°C (24 April) – 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 it was 172.1 mm, and for the third sowing period it was 169.7 mm.

Moisture reserves in the 0–10 cm soil layer remained high at the time of sowing (Fig. 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, the moisture reserve was 25.0 mm, in the second it was 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.

In the flowering phase, sunflower plants are too sensitive to lack of moisture. During flowering, plants consume moisture from the soil layer 140–200 cm. With soil moisture deficiency, baskets of a smaller diameter are formed, the forma-

tion of new flowers is delayed, and the number of well-filled, full-fledged seedlings is sharply reduced. Insufficient moisture supply adversely affects the linear growth and development of the leaf area, which in turn affects the productivity of plants (Skydan, 2016).

The 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, varied in terms of sowing and depended on the density of plants (Fig. 3).

After forming the baskets and before the ripening of seeds, the water consumption is approximately 100–120 mm, and from the beginning of ripening to the full ripeness of seeds about 100–130 mm of moisture is used (Kartamyshev, Tymonov, Zelenyn, 2008). Water reserves of about 60 mm in the meter layer of soil in the flowering phase are not sufficient for good growth and development of plants (Skydan, Skydan, Kostromitin, 2013).

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 and LG 55.82, was at the density of standing plants 60 thousand per ha, for the first sowing period – in the flowering phase it was 127 mm, for the second sowing period 121 mm, for the third sowing period 121 mm. For plant densities of 50 thousand per ha for the first sowing period – 5–6°C, in crops

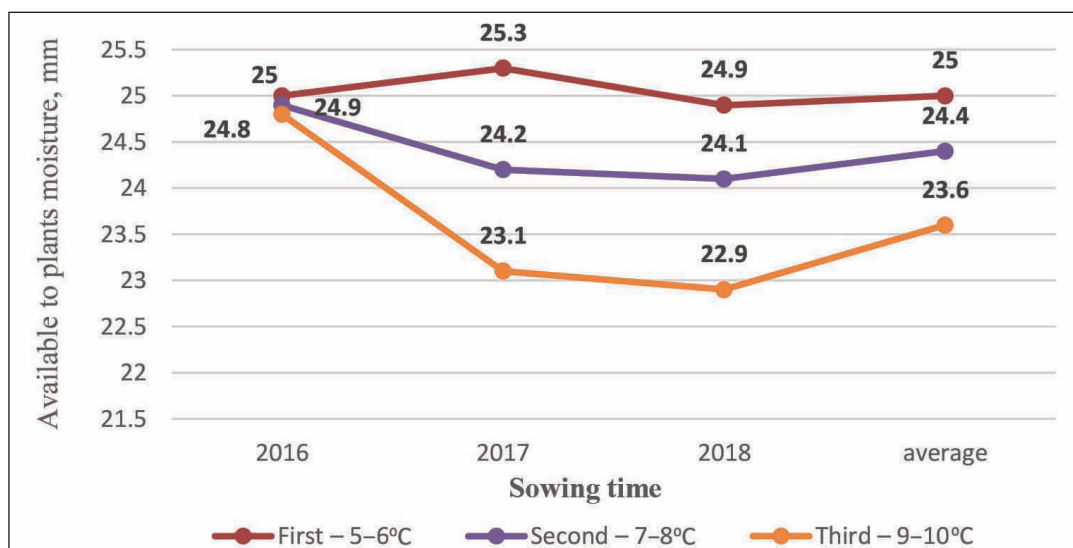


Fig. 2. The content of moisture available to plants in the soil layer 0–10 cm at the time of sunflower sowing

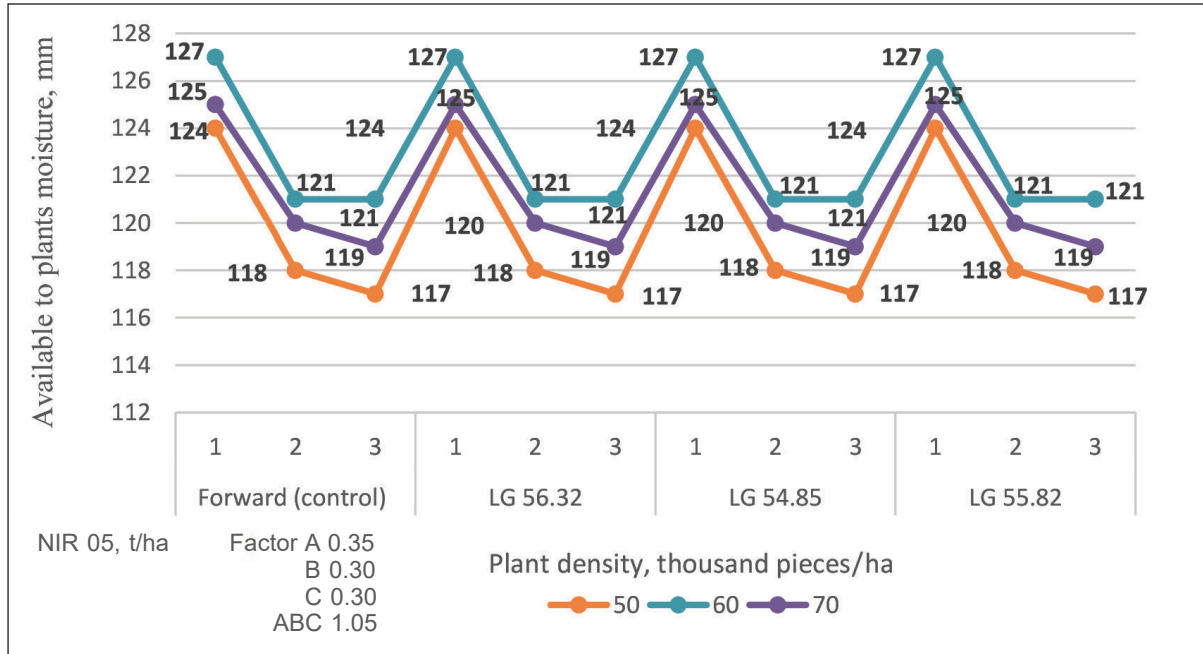


Fig. 3. The content of available moisture in the 0–100 cm layer of soil, mm, depending on the sowing time and density of standing sunflower plants in the flowering phase (average for 2016–2018)

of Forward hybrids, LG 56.32, LG 54.85 and LG 55.82 the available moisture in the flowering phase was 124 mm, for the second sowing period – 7–8°C – 118 mm, and for the third sowing period – 9–10°C – 117 mm. In the case of the increase of plant standing density up to 70 thousand per ha, the reserve of moisture available to plants was 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.

Influence of elements of nutrition on the fertility of soil and productivity of sunflower

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 kg of 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 (Kovalenko, 2016).

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 of 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 NO₃ (0.60–6.60 mg/kg), ammonium nitrogen at the average level of NH₄ (17.5–28.4 mg/kg), phosphorus and potassium at high and high levels of safety (P₂O₅ – 166.9–324.0 mg/kg; K₂O – 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 N₄₀P₄₀K₄₀ + 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 N₄₀P₄₀K₄₀ it was 195.3 mg/kg of soil, respectively.

The introduction of N₄₀P₄₀K₄₀ contributed to the reduction of phosphorus by 37.5 mg/kg of soil or by 16.2% compared to the variant N₄₀P₄₀K₄₀ + PP and 15.6 mg/kg of soil or 7.4% compared to the fertilizer-free version.

Making N₄₀P₄₀K₄₀ + PP contributed to the increase of nitric nitrogen (NO₃) content by 1.35 mg/kg of soil or by 37.5% compared to the version without fertilizers. Ammonium

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 ₂ O ₅ mg/kg	K ₂ O 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 + PP	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 + PP	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 + PP	0.60	17.6	324.0	145.0

* PP, by-products of the predecessor.

nitrogen (NH₄) content in the soil was higher when N₄₀P₄₀K₄₀ 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 N₄₀P₄₀K₄₀ 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 N₄₀P₄₀K₄₀ + PP on 99.6 mg/kg soil or 37.4%.

The introduction of N₄₀P₄₀K₄₀ contributed to an increase in the nitrate nitrogen (NO₃) content of 3.1 mg/kg soil or 47.0% compared to the non-fertilizer version and 6.1% with the N₄₀P₄₀K₄₀ + PP variant. Ammonium nitrogen (NH₄) content in soil was higher when N₄₀P₄₀K₄₀ + PP was applied and amounted to 28.4 mg/kg of soil, up by 34.6% compared to the non-fertilizer version.

Making N₄₀P₄₀K₄₀ + PP while growing sunflower in 2018 significantly increased the phosphorus content of the fertilizer-free background and the N₄₀P₄₀K₄₀ background. The phosphorus content was 324.0, 271.9 and 166.9 mg/kg of soil, which is more than the fertilizer-free version by 16.1% and the N₄₀P₄₀K₄₀ variant by 48.5%.

Nitrogen (NO₃) content in soil was almost unchanged with N₄₀P₄₀K₄₀ and N₄₀P₄₀K₄₀ + 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 N₄₀P₄₀K₄₀ increased the content of ammoniacal nitrogen (NH₄) 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 N₄₀P₄₀K₄₀ + PP contributed to the increase in the soil potassium content of 137.3 and 169.0 mg/kg of soil, which was by 10.8 and 3.6% more than the N₄₀P₄₀K₄₀ 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 N₄₀P₄₀K₄₀ background and was 193.0 mg/kg, which was by 24.9% more than in the N₄₀P₄₀K₄₀ + PP version and by 21.3% in the fertilizer-free version.

Sunflower productivity depending on sowing time and plant standing density

One of the main levers of combating the high variability of sunflower yields over the years is not only a broad focus on achieving the potential productivity of new hybrids, but also taking into account the general and specific adaptability of plants to the conditions of the regions (Nosenko, 2011). During the rapid onset of warm spring early sowing crops provided no less than the average. Sowing at a later date (except for some years) led to a decrease in yield (Kovalenko, 2005; Mynkovskyy, Polyakov, 2007).

The research established a significant dependence of yield of sunflower hybrids on the density of plants, weather conditions, biological features of hybrids and sowing time (Table 2).

In general, over the three years of research, the highest yields of the hybrids LG 5582, LG 54.85, LG 56.32 and Forward was obtained at a density of 60 thousand plants/ha. In the first sowing period,

Table 2. Yield of sunflower hybrids, depending on the 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						

the highest seed yield of 3.85 t/ha was provided by the LG 55.82 hybrid, which was by 5.5% more than in the third term and by 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 by 0.9% more for the third term and by 3.6% for the second sowing period. For the sowing in the third term, the highest seed yields were

Table 3. Results of the three-factor analysis of dispersion (average for 2016–2018)

Source of variation	Sum of squares	Degrees of freedom	Dispersion	F _{fact}	F _{tab095}	Influence, %
Factor A	8.0	3.0	2.6	44.9	2.7	47.5
Factor B	0.6	2.0	0.3	4.7	3.1	3.4
Factor C	1.0	2.0	0.4	8.4	3.1	5.4
A*B	0.9	6.0	0.1	2.2	2.2	5.5
A*C	0.7	6.0	0.1	1.8	2.2	3.9
B*C	0.4	4.0	0.1	1.8	2.5	2.5
A*B*C	0.6	12.0	0.0	0.7	1.9	3.7
Factor						
NIR 05, t/ha for	Year	A	B	C	ABC	
	2016	0.15	0.13	0.13	0.45	
	2017	0.12	0.10	0.10	0.36	
	2018	0.13	0.11	0.11	0.39	

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, and by 4.9 and 8.9%, respectively, for the first term. Hybrids of sunflower LG 56.32, LG 54.85 and LG 55.82 significantly exceeded the control variant by seed yield. Thus, the LG 55.82 sunflower hybrid exceeded the Forward hybrid yield by 0.91 t/ha, or 23.7%; LG 54.85 by 0.7 t/ha, or 19.3%; LG 56.32 up to 0.53 t/ha, or 14.7%.

Thus, sunflower productivity varied significantly under the influence of the morphobiological features of the hybrid (the proportion of impact was 47.5%), weather conditions (28.1%), density of standing plants (5.4%), sowing time (3.4%); plant density * hybrid and sowing time * hybrid had a significant effect (Fig. 4).

Economic and energy efficiency of the improved elements of sunflower production technology

The introduction of new hybrids with a high adaptive potential of both domestic and foreign breeding, using of high quality seeds and using of modern growing technologies should ensure a high level of production efficiency due to a significant increase in yield at the optimal level of acreage (Kyrychenko, Kolomats'ka, Maklyak, Syvenko, 2010). Of great importance is the concentration of crops in the regions with the most favourable con-

ditions, which is why sunflower production is one of the most profitable (Sharkovs'ka, 2017).

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 4).

It should be noted that production costs increased from the first to the third sowing periods due to the additional sowing cultivation in the second term and 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.

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

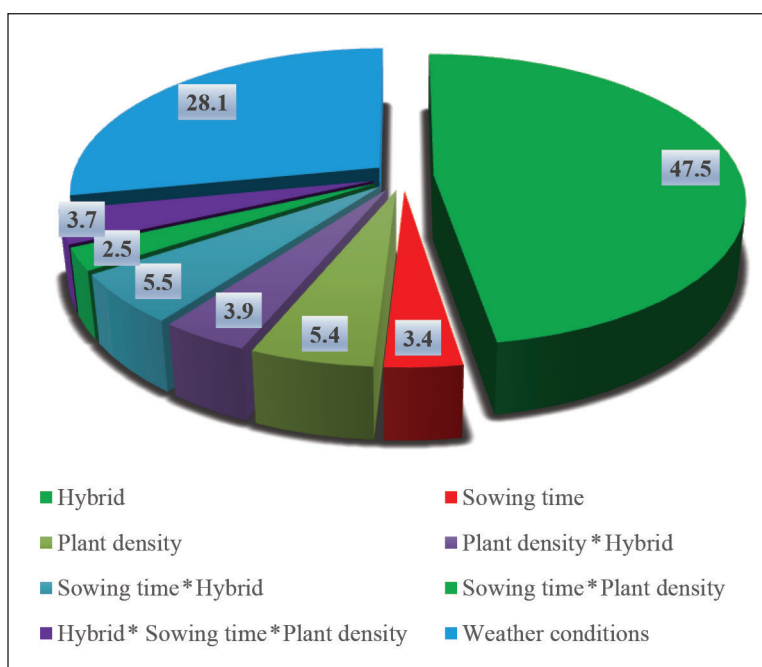


Fig. 4. Part of the influence of factors on the yield of sunflower seeds (average for 2016–2018)

Table 4. Economic efficiency of the cultivation of sunflower at standing density of 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

In addition to the economic evaluation of the technology of sunflower cultivation, the 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) was carried out. The 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 in the third period it was from 3.13 to 3.69.

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. during the vegetative period. To a large extent, soil's water regime depends on the morphological features of the hybrids, the plant standing 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 hybrids – 3.64 t/ha, 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 favourable 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 and LG 55.82 hybrids for the first sowing period. Forward and 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, and 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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SAULĖGRĄŽŲ AUGINIMO TECHNOLOGIJOS UKRAINOS DEŠINIOJO KRANTO STEPĖSE

Santrauka

Straipsnyje pateikiami technologinių elementų valdymo mokslinių tyrimų rezultatai ir jų įtaka saulėgrąžų produktyvumui Ukrainos dešiniojo kranto stepėse. Tyrimai buvo atlikti NAAS žemės ūkio institute, kuris yra juodosios žemės zonoje (Ukrainos dešiniojo kranto stepė).

Saulėgrąžų produktyvumą lemia vandens ir dirvožemio santykis. Vandens režimą formuoja oro sąlygos, dirvožemio drėgmės atsargų ir kritulių kiekis, jų intensyvumas. Augalų

drėgčio atsargos metro dirvožemio sluoksnyje prieš sėją, žydėjimo fazėje ir prieš derliaus nuėmimą tyrimų metais buvo skirtingos ir priklausė nuo auginamų augalų tankio. Saulėgrąžoms ypač svarbus drėgmės kiekis 0–100 cm dirvožemio sluoksnyje, kai suformuoja krepšelius. Šiuo laikotarpiu saulėgrąžos intensyviai naudoja turimą drėgmę iš gilesnių dirvožemio sluoksnių.

Azoto, fosforo ir kalio kiekis bėgant metams smarkiai skyrėsi ir buvo jaučiama skirtingų trąšų fono įtaka. Azoto trąšų derinimas su fosforu ir kaliumi $N_{40}P_{40}K_{40} + PP$ ir $N_{40}P_{40}K_{40}$ gerina dirvožemį, sukuria palankesnes sąlygas saulėgrąžoms augti ir vystytis. Tokiomis sąlygomis didžiausias derlius buvo gautas iš LG 55.82 hibrido, augalų tankis siekė 60 tūkst. ha, per pirmąjį sėjos laikotarpį – 3,85 t/ha.

Atsižvelgiant į ekonominius rodiklius yra efektyvu auginti LG 54.85 ir LG 55.82 hibridus pirmąjį sėjos laikotarpį. LG 56.32 saulėgrąžų hibrido didžiausias ekonominis efektyvumas pasiekiamas trečiąjį sėjos periodą. Tarp hibridų ekonomiškai tinkamiausia auginti LG 55.82, kai sėjama esant 5–6 °C dirvos temperatūrai ir 60 tūkst./ha augalų. Šio varianto grynas pelnas buvo 2 2043 UAH/ha, pelningumo lygis siekė 224,1 %.

Didžiausias energijos efektyvumo santykis buvo pirmąjį LG 55.82 hibrido sėjos periodą ir sudarė 4,44 t/ha.

Raktažodžiai: saulėgrąžos, hibridai, sėjos laikas, auginamų augalų tankis, dirvožemio maistinių medžiagų režimas, dirvožemio vandens režimas, derlius