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Dynamics of the availability of available moisture in soil by optimization of sowing time and density of statement of sunflower plants in the Right-Bank Steppe of Ukraine

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Abstract. The article presents the results of scientific researches on the influence of sowing time and density of standing of sunflower plants on the dynamics of the content of available moisture in soil in the conditions of the Right-bank Steppe of Ukraine.

One of the decisive factors for the achievement of high and sustainable crop yields in the conditions of unstable moistening of the Right-Bank Steppe of Ukraine is the accumulation and rational use of moisture, which is one of the most important unregulated factors limiting the yield.

On average, during the years of research, the most available moisture in the 0-10 cm soil layer was in the first sowing period - when it was heated to a depth of seed 5 - 6^0C and was 25.0 mm. It was found that the moisture available to plants in the meter layer of soil at the time of sowing remained high and significantly influenced the dynamics of emergence of seedlings. On average, during the years of research, the most available moisture in the 0-100 cm soil layer was during the first sowing period - for warming it to a depth of seed 5 - 6^0C - 178.6 mm. In such conditions, quite favorable conditions of moistening of the sowing layer of soil are created in order to receive friendly and complete seedlings when sowing in the first - second decade of April. However, at the end of the third decade of April, there is a significant decrease in gross moisture reserves in the sowing and deeper layers of soil, which limits the productivity of crops.

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, the sunflower intensively consumes the available moisture from the deeper layers of soil. Analyzing the results of the research, it should be noted that in most cases, a higher seed yield in sunflower hybrids was formed in those variants where the period from the formation of the basket to flowering occurred in June or the first decade of July, regardless of the year of fall medium long-term indicators.

It was also found 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. The highest moisture reserves available to the plants in the soil layer were 0-100 cm, in the crops of Forward hybrids, LG 56.32, LG 54.85, LG 55.82 were at planting densities of 60 thousand hectares, at the first sowing period - in the flowering phase - 127 mm.

The optimal sunflower sowing period for LG 55.82 and LG 54.85 hybrids in the Right Bank steppe is soil warming up to a depth of seed 5-6^0C, for Forward and LG 56.32 hybrids is warming up to, a depth of seed 9-10^0C, optimal density - 60 thousand on ha. Under these conditions, the LG 55.82 hybrid produced a yield of 3.85 t / ha, the LG hybrid 54.85 - 3.64 t / ha, the Forward - 3.09 t / ha, the LG hybrid 56.32 - 3.62 t / ha.

Taking into account the annual variation of weather conditions of spring sowing, it should be differentiated with regard to water and heat regimes.

Key words: sunflowers, hybrids, sowing time, plant stand density, available moisture, yield.

1. Introduction

In the conditions of the Right-Bank Steppe of Ukraine the value of the sunflower crop is formed under the influence of the well-ordered complex of natural and agricultural factors.

Among the natural factors that are holding back the growth of sunflower production by increasing crop yields in the steppe are the lack of moisture in the plants due to the aridity of the climate [3]. With climate change, there is a change in natural resources [5].

In such conditions, the presence of moisture in the soil is one of the limiting factors that determine the level of sunflower yield and its stability [9];[10];[13].

In most cases, soil water reserves are the primary cause of low or high sunflower productivity [12]

The productivity of field crops is directly proportional to their moisture content. With enough soil moisture, favorable conditions for the growth and development of field crops are formed, and eventually their yield increases [1];[2];[4];[8];[16;17].

Sunflower for formation of high seed yield requires deep soaking of the 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 [21].

High productivity of sunflower, formed at the expense of moisture reserves accumulated in deep layers of soil during the autumn-winter period and the first half of the growing season [15]; [20].

Autumn rains and snow in winter play a more significant role in soil moisture than spring, especially summer rainfall, which really creates unfavorable (extreme) conditions for plant growth [6];[10].

In the Steppe zone, it can fully use the productive moisture in the 0-150 cm layer accumulated during the cold season. The period of greatest need for crops in water lasts about 40 days. It begins when the diameter of the flower buds reaches about 3 cm and ends after full flowering of the plants. Insufficient water supply of plants in the phase of 3-6 pairs of leaves leads to a decrease in the number of flowers in the basket [18].

Sunflowers, having a long growing season, when fully supplied with nutrients, uses a large amount of moisture to form a large mass, thereby ensuring high productivity of the crop.

The correlation coefficient between productive moisture reserves in the soil meter layer and the seed yield is on average 0.85 ± 0.12 [7].

The use of moisture by sunflower crops can be regulated by the sowing time and plant density to some extent [12].

In certain periods of development, plants can get into unfavorable conditions of moisture supply due to lack of rainfall, as well as due to changes in sowing periods, plant standing densities.

By changing the sowing time and selecting the optimal plant density, we change the conditions of growth and development of sunflower, bypassing the critical periods during the growth of cultivated plants [11].

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 regime of the soil in the conditions of the Right-Bank Steppe of Ukraine.

2. 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 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.

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

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

3. Results and discussion

Studies have found that weather conditions of the 2016-2018 years of studies have had a significant impact on the dynamics of soil moisture content, which differed both from each other and from the annual average in terms of rainfall and temperature regime (Fig. 1).

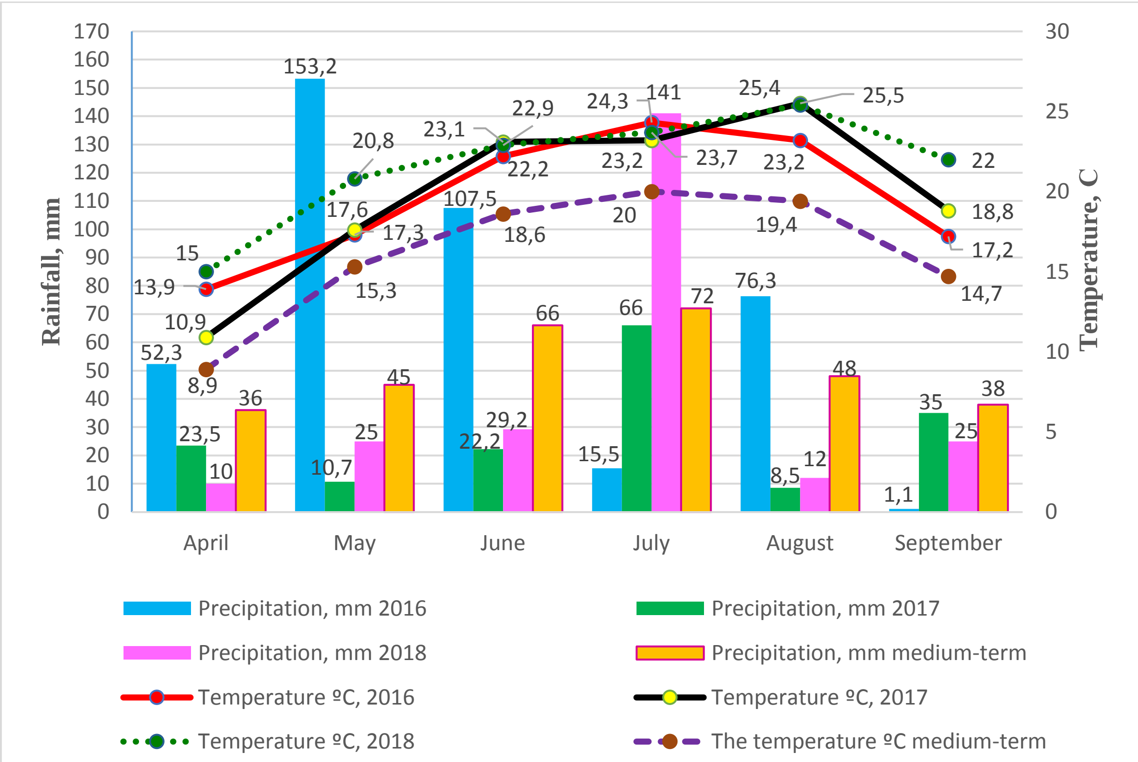

Fig. 1 Agrometeorological indicators of the sunflower vegetation period, 2016 - 2018.

The provision of sunflower plants with moisture and heat is evidenced by the hydrothermal coefficient (GTC) both in separate periods of growth and development of sunflower plants, and in general during the growing season Fig. 2.

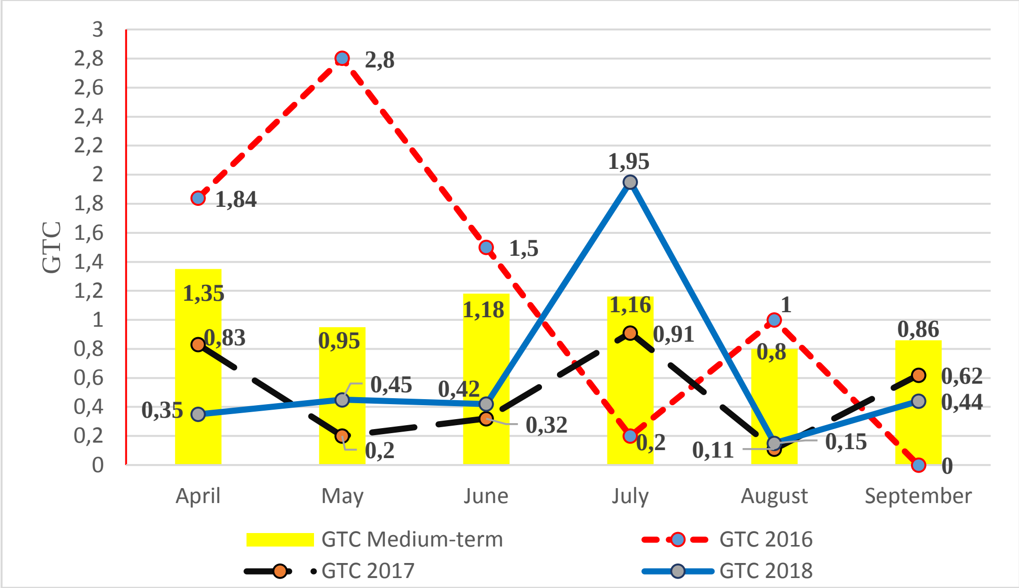

Fig. 2 Degree of moistening of the territory by hydrothermal coefficient GT Selyaninova, 2016 - 2018.

The average for the sunflower vegetation in 2016 this figure was 1.22 with medium long-term value of 1.05. In the critical period of growth and development of sunflower seeds, the GTC was 0.2 at the norm of 1.16, which was lower the long-term value by 82.7%. A GTC (hydrothermal coefficient) of less than 0.7 indicates a ground-to-air drought that adversely affects crop formation.

In 2017, the figure was 0.49, with medium long-term of 1.05. In the critical period of growth and development of sunflower seeds, GTC was 0.91 at the norm of 1.16, it was lower than the long-term value by 21.6%, which characterized a significant shortfall in rainfall and drought.

In 2018, this figure was 0.62, with an medium long-term value of 1.05. During the critical period of growth and development of sunflower seeds, GTC was 1.95, at 1.16, it was higher than the long-term value by 40.6%.

Thus, insufficient rainfall and irregular rainfall during critical sunflower periods (June and July) have led to a lack of sunflower crop. June was characterized by warm and deficient weather in 2017-2018. In July, the weather was unstable with precipitation in 2016.

Maturation and termination of vegetation occurred with good heat supply, but with limited soil moisture in the absence of rainfall.

Analyzing the results of the research, it should be noted that in most cases higher seed yield in sunflower hybrids was formed in those variants where the period from the formation of the basket to flowering occurred in June or the first decade of July, regardless of time of fall on medium long-term indicators.

All the studied sunflower hybrids provided the highest seed yield due to the available moisture. This is one of the advantages of early sunflower sowing.

In order to establish the optimal sowing time, sunflower hybrids were sown in time: in 2016, the first sowing period was 5-6^{0}C at a depth of 10 cm (April 6), the second one was 7-8^{0}C (April 10), and the third was 9-10^{0}C (April 13). In 2017, respectively, the first sowing period - 5-6^{0}C (April 7), the second - 7-8^{0}C (April 12), the third - 9-10^{0}C (April 28). In 2018, respectively, the first sowing period - 5-6^{0}C (April 6), the second - 7-8^{0}C (April 12), the third - 9-10^{0}C (April 24).

The available moisture in the meter layer of soil remained high during sowing and significantly influenced the emergence of seedlings (Fig. 3).

This is due to low temperatures, compensation for high relative humidity, low evaporation of soil moisture, autumn-winter moisture and rainfall during this period.

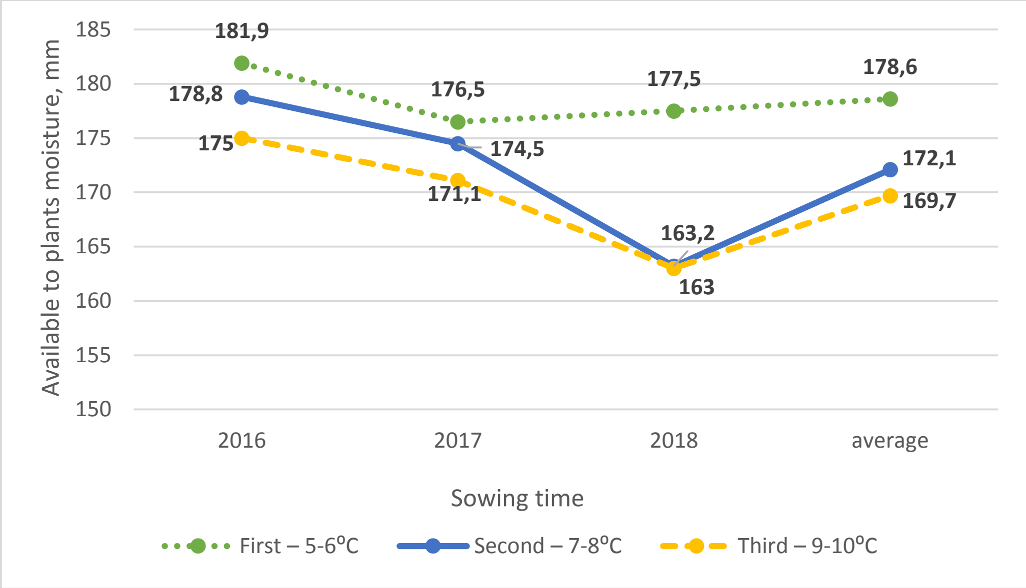

Fig. 3 Content of moisture available to plants in soil layer 0–100 cm at the time of sunflower sowing.

During 2016 - 2018 years of research of the most available moisture in the 0-100 cm soil layer, during the first sowing period, when the soil warmed up at a depth of seed 5 - 6^0C, the moisture reserves were 178.6 mm, which is 5% more than the third term and 3.7% for the second sowing period. During the second sowing period, when the soil warmed up at a depth of seed of 7 - 8^0C, the moisture reserves amounted to 172.1 mm, which is 1.4% more than in the third period. During the third sowing period, when the soil was heated at $9\text{-}10^0$C, the moisture reserves amounted to 169.7 mm.

The amount of water available to plants in the soil layer of 0–10 cm was 23.6 mm against 25.0 and 24.4 mm, respectively, during the third sowing period (Fig. 4), respectively, by 5.6% less for the first and second sowing periods for the first term and 3.3% for the second period of sowing, ie there was a gradual decrease in the amount of water available to plants in the sowing layer of soil.

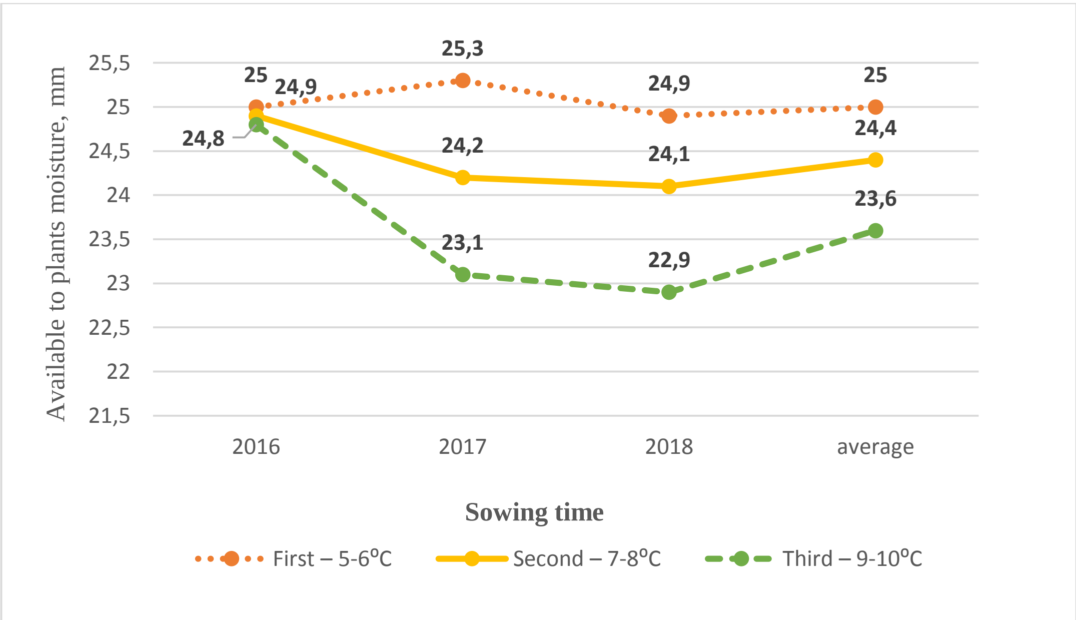

Fig. 4 Content of moisture available to plants in the soil layer 0–10 cm at the time of sunflower sowing.

The content of productive moisture in the soil layer 0-100 cm for the growth and development of plants becomes especially important after the phase of basket formation, when the sunflower intensively consumes productive moisture from the deep soil layers [12];[14].

Drought in the period from the beginning of budding to flowering adversely affects the rate of accumulation of aboveground mass of plants, reducing their productivity by 30-35%. Poor moisture conditions during flowering and filling of seeds cause the formation of small baskets, reduce their greenness, fullness, yield and quality of seeds [18];[19].

Studies show that the moisture available to plants in the meter layer of soil in the flowering phase and before harvesting was uneven during the years of research and varied in terms of sowing and depended on the density of plants (Fig. 5).

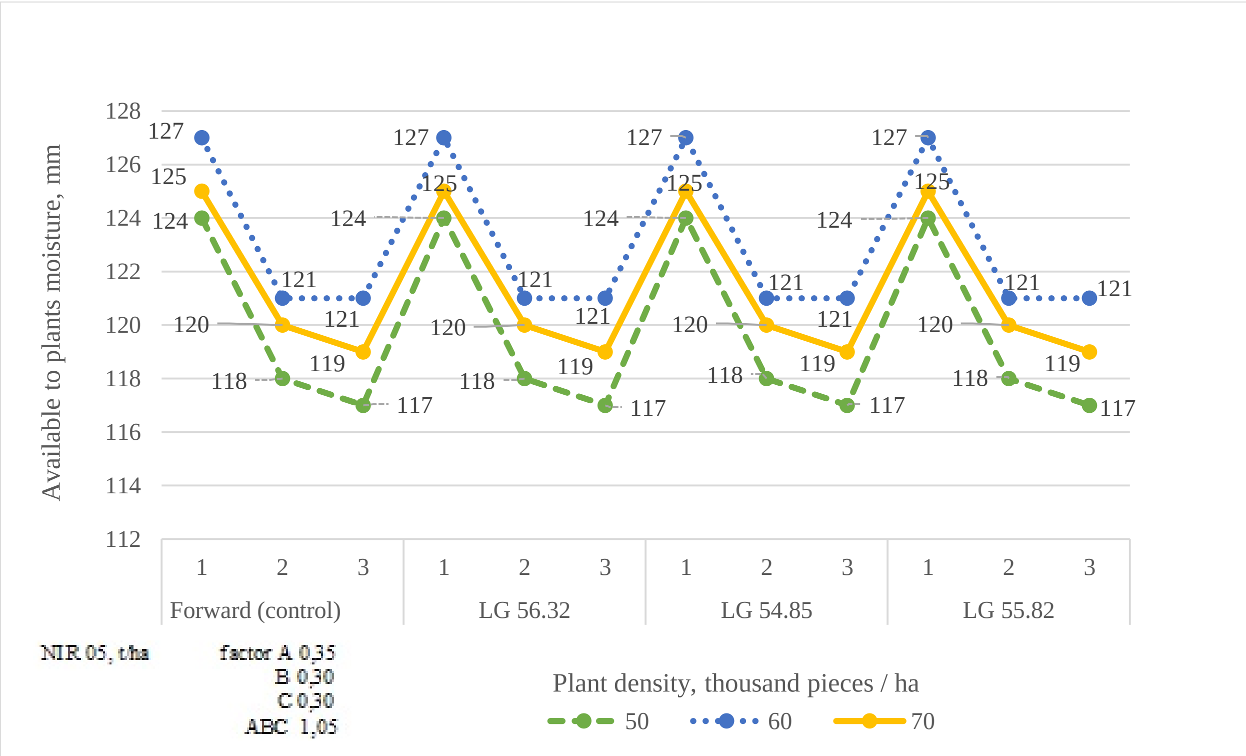

Fig. 5 Content of available moisture in 0-100 cm layer of soil, mm, depending on the sowing time and density of standing sunflower plants in flowering phase (average for 2016-2018).

On average, during the years of research, the highest reserves 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 phase flowering was 127 mm, which is 4.8% more than the third term and the second sowing period.

For plant densities of 50 thousand hectares for the first sowing period - 5-6 ^{0}C, in crops of Forward hybrids, LG 56.32, LG 54.85, LG 55.82 the reserves of available moisture in the flowering phase amounted to 124 mm, which is 5.7% more than third and 4.9% second sowing. With plant densities up to 70 thousand hectares, the moisture available to plants in the first sowing period was 125 mm, which is 4.8% more than in the third term and 4.0% in the second sowing period.

The highest reserves of moisture available to the plants before harvesting were at plant densities of 60 thousand hectares, 115 mm for the first sowing period, 114 mm for the second sowing period, and 113 mm for the third sowing period. With a plant density of 50 thousand hectares, the available moisture reserves were 112 mm for the first sowing period, 113 mm for the second sowing period, and 112 mm for the third sowing period. With plant density of 70 thousand hectares, the moisture reserves available to plants were 113 mm for the first sowing period, 114 mm for the second sowing period, and 113 mm for the third sowing period.

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Variation of sunflower yield depends greatly on weather conditions during the years of research, moisture supply, hybrids, plant densities and conditions of critical periods under different sowing periods (Fig. 6).

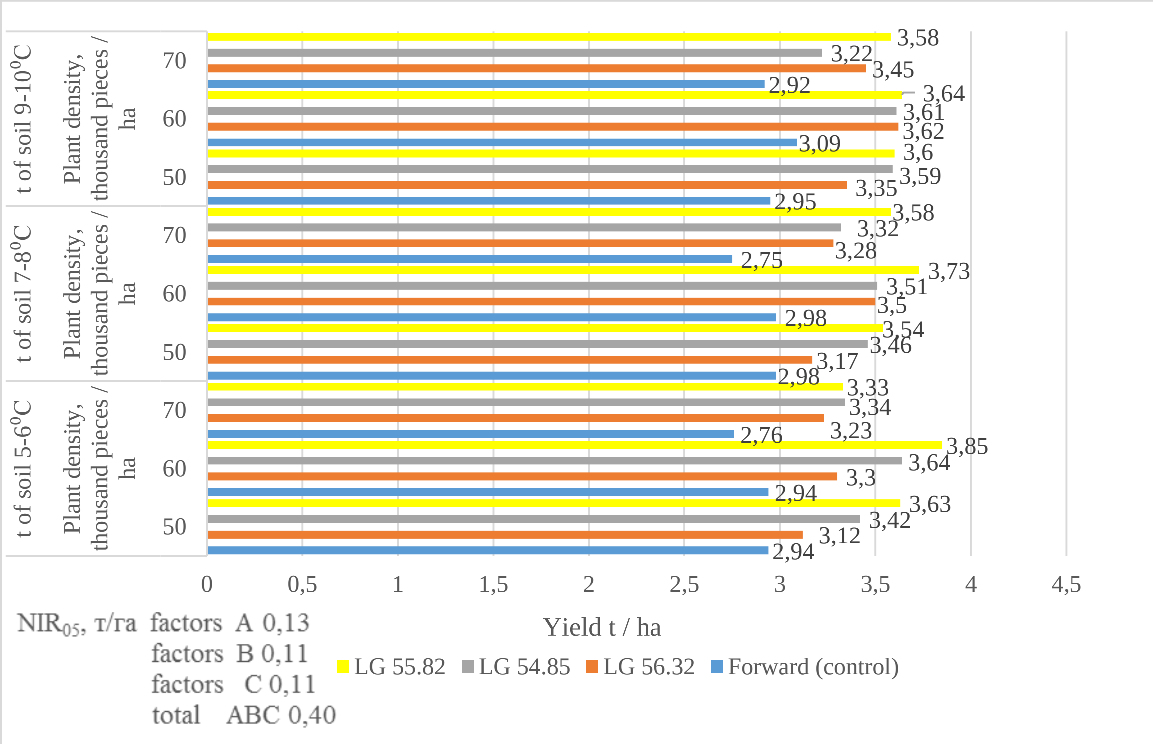

Fig. 6 Yield of sunflower hybrids, depending on the sowing time and plant density, t / ha (average for 2016-2018).

On average, over the years of research, the highest seed yield of 3.85 t / ha was provided by the LG 55.82 hybrid for the first sowing period, which is 5.5% more for the third sowing period and 3.2% for 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 for the first term.

The highest yield of hybrids LG 5582, LG 54.85, LG 56.32, Forward was obtained at a density of 60 thousand plants / ha.

Table 1. Results of 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
NIR 05, t/ha for	factor					
	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	

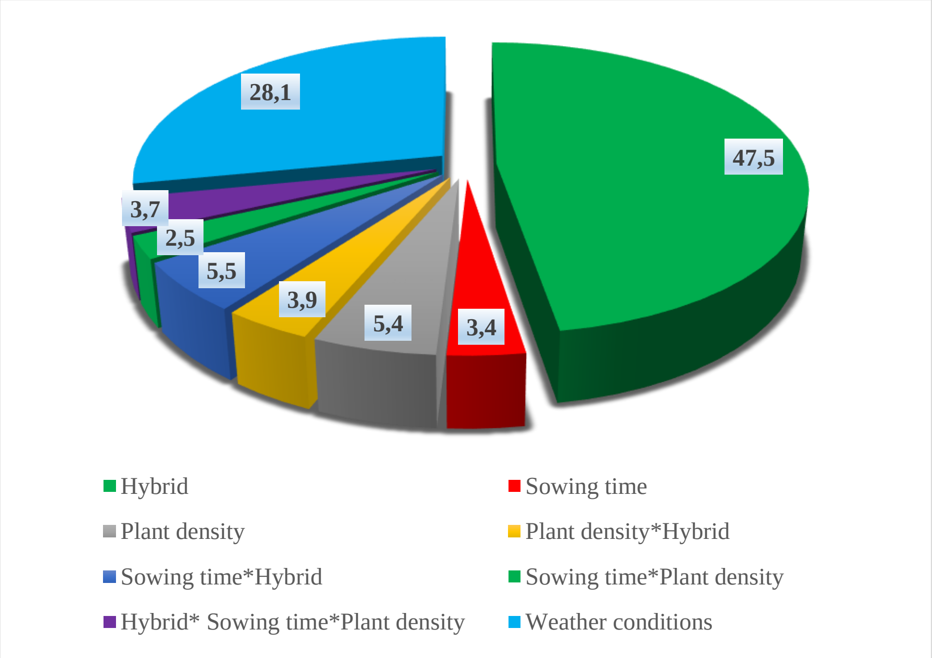

Fig. 7 Part of influence of factors on the yield of sunflower seeds (average for 2016-2018)

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. 7).

4. Conclusions

The available moisture in the soil is a major factor in relationship between soil and plant, which is crucial for obtaining friendly seedlings and further vegetation of crops.

The moisture available to plants in the meter layer of soil at the time of sowing remained high and significantly influenced the dynamics of emergence of seedlings.

On average, during the years of research, the most available moisture in the 0-100 cm soil layer was during the first sowing period - for warming it to a depth of seed 5 - 6^{0}C - 178.6 mm. The most available moisture in the 0-10 cm layer of soil was during the first sowing period - when it was heated to a depth of seed 5 - 6^{0}C and was 25.0 mm.

The highest moisture reserves available to the plants in the soil layer were 0 -100 cm, in the crops of Forward hybrids, LG 56.32, LG 54.85, LG 55.82 were at planting densities of 60 thousand hectares, during the first sowing period - in the flowering phase - 127 mm.

Under these conditions, plantings with a 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.

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