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Methods Of Soil Basic Cultivation And Photosynthetic Productivity Of Sunflow Hybrids On Black Earth Soils Of The Volgograd Region

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ABSTRACT

Investigations were carried out in 2018-2020 in the Volgograd region at the peasant farm enterprise "Dubovchenko O. I." Of the Elansky district, the Volgograd region.Goal of research: Elucidate the influence of the soil basic cultivation methods and fertilization on the development of the photosynthetic productivity main indices that estimate the crop yield in seeds of Tunka and Savanna sunflow hybrids. The experimental scheme makes provision for investigation of the influence of soil basic cultivation methods (dumped, surface, surface + chisel) on photosynthetic productivity in seeds of sunflow hybrids. Observations and considerations were carried out according to common methods. Soil of plots is southern black earth, medium-thick heavy-loamy (humus content from 4.81 to 4.98%). Provision with mobile forms of P_2O_5 — 22.4-26.5 mg/kg of soil, potassium from 330 mg/kg of soil. The applicable methods of soil basic cultivation for sunflow revealed insignificant changes in photosynthetic indices in seeds of Tunka and Savanna sunflower hybrids. The leaf area of studied hybrids grows up extensively from the anthodium formation phase to the mass flowering phase. The leaf area of Tunka hybrid reached an average of 29.5 thsm^2/ha over the past three years during the flowering phase with dumped cultivation. Below is the leaf area during the full flowering phase in the variant of fine processing, where it was for the Tunka hybrid 25.6 ths m^2/ha. In the hybrid Savanna crops, the average leaf area for dump processing reached 23.7 thousand m^2/ha in three years. Below is the value of the leaf area in the full flowering phase in the surface tillage processing variant, where it decreased in the Savanna hybrid, respectively, to - 21.2 thousand m^2/ha.

Studies have shown that the photosynthetic sowing potential (PhP) is closely related to the leaf area, which was higher in the sowing of the Tunka hybrid. So, in the dump processing, on average for three years, the PhP was from 1393 thousand m^2days/ha, with 1194 thousand m^2days/ha for surface tillage processing and 1320 thousand m^2days/ha for the surface tillage + chisel variant. On average, for three years, the yield is higher in the Tunka hybrid, so on the dump treatment option it was 2.71 t/ha on the control, with the use of Helios Nitrogen - 2.79 t/ha, Boron Molybdenum - 2.85 t / ha.

Keywords: leaf area, photosynthetic potential, net productivity of photosynthesis.

INTRODUCTION

Sunflower is the main oil crop in the Russian Federation, the share of sunflower in total production of vegetable oils in the country is up to 80%. In the last few years, in the Volgograd region, the sunflower cropped area significantly exceeds the scientific-based norms, which leads to non-observance in the crop sequence, but the implementation of new sunflower hybrids characterized by a complex resistance against basic pathogens ensures the annual stable gross collection. The high productivity of new sunflower hybrids is stipulated by positive signs of plant architectonics (height, number of leaves, size and ear grain content), which is the basis of the photosynthetic productivity of sunflower plants.

Elucidate the influence of the soil basic cultivation methods and fertilization on the development of the photosynthetic productivity main indices that estimate the crop yield in seeds of Tunka and Savanna sunflow hybrids. Preceding crop is winter wheat. The development of adaptive technologies for increasing the productivity of sunflower in the main regions of cultivation is reflected in publications of many authors (Drepa et al. 2020, Puzikov et al. 2019, Bochkovoy et al. 2019, Bushnev et al.2017, Vaschenko et al. 2020, Lukomets et al. 2016, Norov 2019,Solodovnikov et al. 2020, Savenkov et al. 2020, Tishkov et al. 2020, Trofimova et al. 2019, Dominguez et al. 2004, Gvodzenovic et al. 2009).

For the dry-steppe zone of the southern chernozem soils of the Volgograd region, the most effective methods of soil basic cultivation are scientifically justified. The main indices of photosynthetic activity in seeds of Tunka and Savanna hybrids are determined depending on studied techniques.

The following soil treatments are considered: 1. Dumped treatment by 0.28-0.30 m. 2. Surface tillage with BDM-4M to the depth of 0.12-0.14m. 3. Surface tillage with БДМ-4М + autumn cultivation by 0.30-0.32 m.

The work was carried out by the Federal State Budgetary Institution - Volgograd State Agrarian University by the post-graduate student of the Department of Horticulture, Selection and Seed development under the guidance of Professor of the Department Churzin V. N. Experimental studies were conducted at the peasant farm enterprise "Dubovichenko O. I." Elansky district of the Volgograd region in 2018-2020.

MATERIAL AND METHODS

The soils of the research plot can be classified as clay by their mechanical composition, so the fraction of physical clay (the sum of particles less than 0.01 mm) in the plow layer is 68.7%, in the

subsurface layer is 66.3%. The content of small fractions 0.25-0.05 mm in size in the plow layer is no more than 1.0%.

The humus content in plots was from 4.81 to 4.98%. Down the profile, the humus amount decreases. Provision with mobile forms of P_2O_5 — 22.4-26.5 mg/kg of soil, potassium from 330 mg/kg of soil.

One of the reserves for increasing the yield of sunflower is the methods of basic tillage, the use of highly productive sunflower hybrids and the use of liquid fertilizers HeliosNitrogen and BoronMolybden, which have a positive effect on the main indicators of photosynthetic productivity in sunflower crops.

Studies have established the leading role in the creation of a crop such important indicators of photosynthetic activity of plants in crops as the area of assimilating surface and photosynthetic potential (PhP) crops, which is important from the point of view of absorption by leaves of light energy for photosynthesis.

Differences in the years of research on precipitation affected the development of plants and the productivity of sowing, more significant deviations in precipitation during the growing season were noted in 2019-2020(Figure 1).

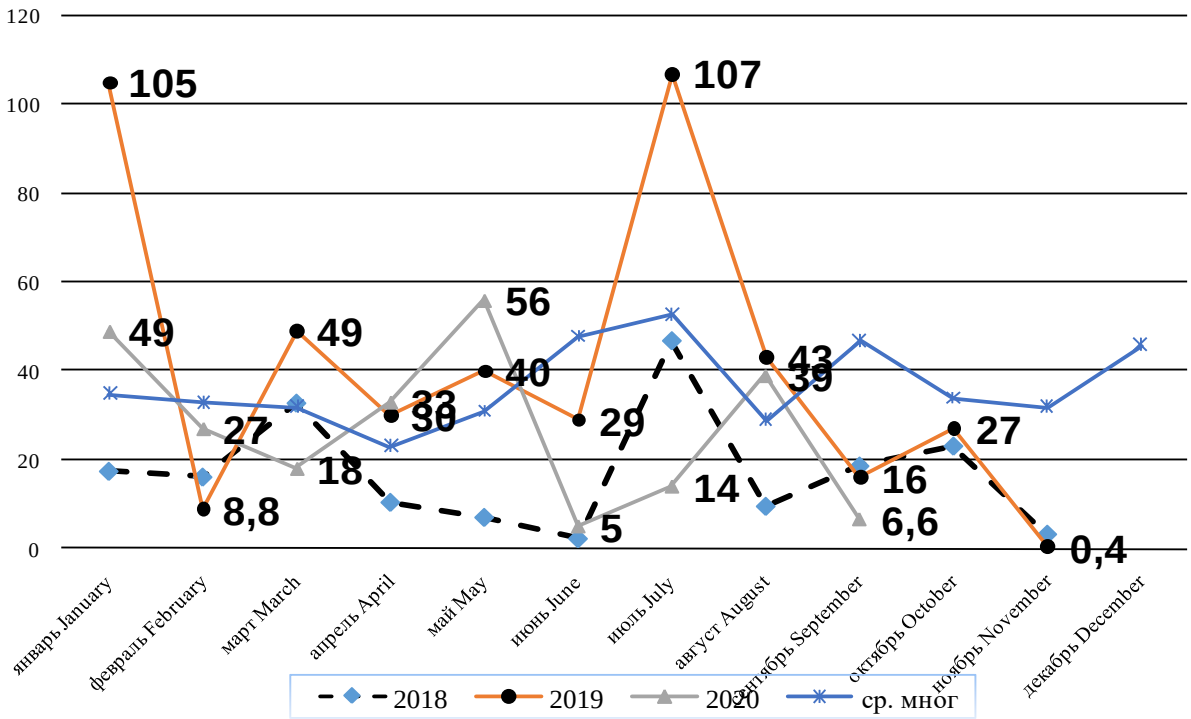

Figure 1. Monthly precipitation (mm) in the years of research (Elanskaya AMS)

The amount of atmospheric precipitation during the growing season (May-September) revealed their role in the development of plants and the formation of the main indicators of photosynthetic productivity in sunflower crops. The growth and development of plants in 2018, in the absence of precipitation during the beginning of flowering (June - 2.2 mm), provided spring reserves of available moisture. A significant amount of precipitation in 2019 during the period of mass flowering (107.0 mm) guaranteed the stability of the soil reserves of available moisture and in subsequent growth phases. Significant precipitation in the month of September, as observations have shown, can also have a negative impact on production processes. In 2020, for the period May-September, 120.6 mm of atmospheric precipitation fell, which is significantly lower in relation to this period for 2018-2019 (Figure 1), which negatively affected the development of plants. The formation of crops is available in terms of the size of the leaf area, on which the optical density of crops depends, which is very important from the point of view of the absorption of light energy by leaves for photosynthesis. However, a large area of leaves does not always correspond to a high level of crop productivity, as their lighting deteriorates, the assimilation of carbon dioxide and NPP (net photosynthetic productivity) deteriorates, which can lead to a decrease in yield.

RESULTS AND DISCUSSION

Observations show that the leaf area formation according to variations of the basic tillage methods differed insignificantly, excluding the surface treatment where the leaf area was lower both in Tunka hybrid and Savanna hybrid seeds (Table 1, 2).

Table 1. Dynamics of the leaf area formation in seeds of sunflower by research years, Tunka hybrid

Tillage variations	Leaf surface area by phases, thous. m^2/ha			
	Formation of the anthodium	Flowering	Plumpness of seeds	Economic maturity
2018				
Dump treatment	9.8	32.0	24.2	2.5
Surface tillage	8.4	30.8	21.5	1.1
surface tillage + chisel	10.2	30.8	22.3	1.4
2019				
Dump treatment	9.5	31.2	21.0	1.6

Surface tillage	7.8	24.6	20.2	0.9
surface tillage + chisel	8.0	26.5	20.5	1.2
2020				
Dump treatment	7.6	25.2	18.1	1.8
Surface tillage	6.3	21.4	14.1	0.9
surface tillage + chisel	6.8	22.0	14.8	1.3
The average for the 2018-2020				
Dump treatment	8.9	29.5	21.1	2.0
Surface tillage	7.5	25.6	18.6	1.1
surface tillage + chisel	8.3	26.4	15.8	1.3

Table 2. Dynamics of the leaf area formation in seeds of sunflower by research years, Savanna hybrid

Tillage variations	Leaf surface area by phases, thous. m^2/ha			
	Formation of the anthodium	Flowering	Plumpness of seeds	Economic maturity
2018				
Dump treatment	8.5	27.8	21.0	2.1
Surface tillage	7.3	26.7	18.7	0.9
Surface tillage + chisel	8.8	26.9	19.4	1.2
2019				
Dump treatment	8.0	24.9	17.8	1.3
Surface tillage	6.6	20.9	17.1	0.7
Surface tillage + chisel	6.8	22.5	17.4	1.0
2020				
Dump treatment	5.7	18.4	13.5	1.4
Surface tillage	4.7	16.0	10.5	0.7
Surface tillage + chisel	5.1	16.5	11.0	0.9
The average for the 2018-2020				
Dump treatment	7.4	23.7	17.4	1.6
Surface tillage	6.2	21.2	15.4	0.8
Surface tillage + chisel	6.4	22.0	16.0	1.0

Analysis of the data in Table 1 and Table 2 shows that the leaf surface of the studied hybrids actively increased from the stage of formation of a anthodium to the phase of mass flowering. Thus, in the Tunka hybrid, the leaf area reached an average of 29.5 thousand m^2/ha during the flowering phase of the dump treatment in three years. Below is the leaf area during the full flowering phase in the variant of fine processing, where it was for the Tunka hybrid 25.6 ths m^2/ha,

In the hybrid Savanna crops, the leaf area for dump processing reached 23.7 thousand m^2/ha on average over three years. Value of the leaf area in the full flowering phase in the surface tillage processing variant is below, where it decreased in the Savanna hybrid, respectively, to - 21.2 thousand m^2/ha.

Table 3.The main indicators of photosynthetic activity in Tunka hybrid crops by the years of research, (control without/t)

Variants of tillage	Maximum leaf area, thousand m^2/ ha	PhP, thousand m^2days/ha	Dry weight yield, t/ha	NPP of sowing, g/m^2day	Average daily dry weight gain, kg	EFFICIENCY* * of the incoming photosynthetic active radiation, %*
2018						
Dump treatment	32.0	1520	9.74	6.41	101.5	1.44
Surface tillage	30.8	1386	7.30	5.27	79.3	1.07
surface tillage + chisel	30.8	1416	7.28	5.14	76.6	1.06
2019						
Dump treatment	31.2	1375	9.10	6.62	88.3	1.34
Surface tillage	24.6	1107	7.40	6.68	74.4	1.08
surface tillage + chisel	26.5	1377	7.45	5.41	72.3	1.09
2020						
Dump treatment	25.2	1285	6.56	5.10	64.3	0.96
Surface tillage	21.4	1091	5.00	4.58	49.0	0.74
surface tillage + chisel	22.0	1122	6.03	5.37	59.1	0.88
The average for the 2018-2020						
Dump treatment	29.5	1393	8.47	6.08	84.7	1.25

Surface tillage	25.6	1194	6.57	5.50	67.6	0.96
surface tillage + chisel	26.4	1320	6.92	5.24	69.3	1.01

* - caloric content of 1 kg of dry matter – 18.63 MJ

** - incoming of photosynthetic active radiation (PAR) during the growing season – 126.5 kJ/cm^2

It was found that the photosynthetic sowing potential (PhP) and the net productivity of photosynthesis (NPP) determined the value of the yield. The value of PhP on average for three years reached the hybrid Tunka for dump plowing - 1393 thousand m^2•days/ha, for fine processing PhP decreased to 1194 thousand m^2•days/ha and increased by the option of fine processing + chisel to 1320 thousand m^2•days/ha (Table 3).

Analysis of the data on the accumulation of dry aboveground biomass in the Tunka hybrid according to the variants of soil cultivation in the years of research and on average for three years (2018-2020) shows that in terms of the amount of accumulation of dry mass, crops by moldboard cultivation and surface cultivation + chisel are more productive.

So, on average, over three years, the yield of dry aboveground mass in the Tunka hybrid on the option of moldboard plowing was 8.47 t/ha, for the option of surface tillage it was significantly lower - 6.57 t/ha, for the option of surface tillage + chisel the yield of dry biomass was 6.92 t/ha. The increase in the biomass of plants from germination to the formation of the anthodium is slow. From the anthodium formation phase, there is a noticeable acceleration of dry matter growth, primarily due to the growth of leaves and stem mass. At the beginning of flowering, the growth of dry matter increases due to the stems, the leaves took the second place. During the ripening period, the largest increase in dry matter was due to the anthodium and, to a lesser extent, due to the stems.

According to the research of a number of authors, the most intensive agricultural crops utilize only up to 1-2% of solar energy. A comparative analysis of the efficiency of the photosynthet active radiation (PAR) allows us to conclude that this indicator for the variants of the experiment reached from 0.65 % to 1.44 %, the higher efficiency of the PAR is characteristic of the dump treatment option, on average for three years the efficiency of the PAR was up to 1.25 % in the Tunka hybrid crops.

Environmental factors had different effects on processes of photosynthetic activity and physiological state of sunflower plants and in Savanna hybrid seeds (Table 4).

Table 4. Basic indicators of photosynthetic activity in Savanna hybrid seeds by research years, (control without limitation)

Variants Of tillage	Maximum leaf area, thousand m^2/ ha	PhP, thous.m^2·days/ha	Dry weight yield, t/ha	NPP of sowing, g/m^2day	Average daily dry weight gain, kg/ha	EFFICIENCY* * of the incoming photosynthetic active radiation, %*
2018						
Dump treatment	27.8	1251	8.6	6.87	90.5	1.22
Surface tillage	26.7	1134	6.58	5.80	73.1	0.94
surface tillage + chisel	26.9	1183	6.80	5.75	73.9	0.97
2019						
Dump treatment	24.9	1270	8.52	6.70	83.5	1.22
Surface tillage	20.9	1024	6.65	6.49	67.8	0.95
surface tillage + chisel	22.5	1125	6.52		65.2	0.93
2020						
Dump treatment	18.4	920	5.45	5.79	54.5	0.77
Surface tillage	16.0	800	4.58	5.72	45.8	0.65
surface tillage + chisel	16.5	825	5.12	6.20	51.2	0.73
The average for the 2018-2020						
Dump treatment	23.7	1147	7.53	6.56	76.2	1.07
Surface tillage	21.2	986	5.94	6.02	62.2	0.85
surface tillage + chisel	22.0	1044	6.15	5.89	63.4	0.87

* - caloric content of 1 kg of dry matter – 18.63 MJ

** - incoming of PAR (photosynthetic active radiation during the growing season – 130.5 kJ/cm^2

In the crops of the Savannah hybrid, on average, over three years, the leaf area was 23.7 thousand m^2/ha for moldboard processing, 21.2 for surface treatment and 22.0 thousand m^2/ha for surface tillage + chisel. The value of FP on average for three years was lower and amounted to 1147 thousand m^2 · days/ha for dumping, 986 thousand m^2 · days/ha for surface tillage and 1044 thousand m^2 days/ha for surface tillage + chisel, respectively.

In the crops of the Savannah hybrid, on average for three years, the dry weight on the moldboard cultivation option was 7.53 t/ha, for surface tillage respectively - 5.94 t/ha and surface tillage + chisel - 6.15 t/ha.

The efficiency of the PAR according to the variants of the experiment ranged from 1.07% for moldboard processing and up to 0.85-0.87%, respectively, for surface tillage and surface tillage + chisel processing.

Table 5. Yield of sunflower hybrids by years of research, t / ha

Variants Options	Tunka			Savannah		
	2018	2019	2020	2018	2019	2020
Dump plowing at 0.28 – 0.30 m (control).						
Control (no-tillage)	3.04	3.00	2.10	2.60	2.62	1.80
HeliosNitrogen	3.13	3.10	2.15	2.71	2.72	1.84
BoronMolybdenum	3.19	3.15	2.21	2.74	2.75	1.89
Fine processing + Numbers at 0.30-0.32 m.						
Control (no-tillage)	2.35	2.33	1.93	2.29	2.30	1.69
HeliosNitrogen	2.42	2.40	1.97	2.39	2.41	1.74
BoronMolybdenum	2.42	2.44	2.02	2.41	2.43	1.78
Fine processing at 0.12-0.14 m.						
Control (no-tillage)	2.33	2.29	1.60	2.08	2.10	1.51
HeliosNitrogen	2.39	2.35	1.63	2.11	2.14	1.52
BoronMolybdenum	2.39	2.37	1.67	2.14	2.17	1.54

2018 year. HCP_{05} (total) - 0.23, A (hybrids) - 0.08, B (processing) - 0.09, C (nutrition) - 0.05, AB - 0.16, AC - 0.13, BC - 0.06, ABC - 0.09.

2019 year. HCP_{05} (total) - 0.23, A (hybrids) - 0.08, B (processing) - 0.09, C (nutrition) - 0.09, AB - 0.16, AC - 0.13, BC - 0.27, ABC - 0.09.

2020 year. HCP_{05} (total) - 0.03, A (hybrids) - 0.01, B (processing) - 0.01, C (nutrition) - 0.01, AB - 0.01, AC - 0.01, BC - 0.01, ABC - 0.01.

CONCLUSION

The applicable methods of soil basic cultivation for sunflow revealed insignificant changes in photosynthetic indices in seeds of Tunka and Savanna sunflower hybrids. The leaf area of studied hybrids grows up extensively from the anthodium formation phase to the mass flowering phase. The leaf area of Tunka hybrid reached an average of 29.5 thsm^2/ha over the past three years during the flowering phase with dumped cultivation. Below is the leaf area during the full flowering phase in the variant of fine processing, where it was for the Tunka hybrid 25.6 ths m^2/ha, In the hybrid Savanna crops, the leaf area for dump processing reached 23.7 thousand m^2/ha on average over three years. Value of the leaf area in the full flowering phase in the surface tillage processing variant is below, where it decreased in the Savanna hybrid, respectively, to - 21.2 thousand m^2/ha.

Studies have shown that the photosynthetic sowing potential (PhP) is closely related to the leaf area, which was higher in the sowing of the Tunka hybrid. So, in the dump processing, on average for three years, the PhP was from 1393 thousand m^{2}days/ha, with 1194 thousand m^{2}days/ha for surface tillage processing and 1320 thousand m^{2}days/ha for the surface tillage + chisel variant.

On average, for three years, the yield is higher in the Tunka hybrid, so on the dump treatment option it was 2.71 t/ha on the control, with the use of Helios Nitrogen - 2.79 t/ha, Boron Molybdenum - 2.85 t/ha.

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