

Technology selection for cultivation of sunflower hybrids in Central Black Earth region

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Abstract. This study applies a number of technologies to cultivation of sunflower hybrids with variable soil properties, weather conditions and farm locations in Central Black Earth: Kursk, Orel and Voronezh regions. The three-year research identified reactions of sunflower hybrids from different manufacturers to cultivation technology and weather conditions; we made relevant observations; analysed yield structure, yield and seed quality parameters; forecast prospects of using CLEARFIELD and ExpressSun technologies for sunflower cultivation in Central Black Earth region. Overall, the experiment revealed the advantage of CLEARFIELD® (EURO-LIGHTNING®) technology in Kursk region. Hybrids from main producers had a superior average result compared to the standard hybrid SI Bacardi (Syngenta) over three years of research: this is an increase of 0.6 t/ha or 24% (hybrid P64LC108), 1.3 t/ha or 52% (hybrid EC Generalis), and 0.9 t/ha or 36% (hybrid MAS 89 IR). In Orel region hybrids cultivated with ExpressSun (Express® 75 v.y.) or Sumo showed better performance. The hybrid P62LE122 gave an increase of 0.4 t/ha or 20% and the hybrid EC Argentis - 0.3 t/ha or 15% compared to the standard hybrid Sumiko (Syngenta). In Voronezh region hybrids cultivated by ExpressSun (Express® 75 v.y.) or Sumo technology had yield advantage. Increases were between 0.5 and 1.0 t/ha, or between 15 and 29%, depending on the sunflower hybrid cultivated

1 Introduction

Sunflower is the main oilseed crop in Russia. It accounts for 75% of the sown area of all oilseeds and up to 80% of vegetable oil production. In Kursk and Orel regions sunflower was sown on 140-150 thousand hectares each (about 10% each), in Voronezh region 436 thousand hectares were sown, which is 30% of Central Federal District area.

The Central (27.5 centners per hectare) and Southern (21.8 centners per hectare) federal districts had the highest sunflower yields. The increase was 167 and 90%, respectively. By comparison, the Russian Federation had a yield of 18.3 Centners per hectare in 2019, with an increase of 106%. The gross sunflower harvest tripled in Russia between 2010 and 2019 to 39183 thousand centners (growth of 270%). Voronezh (32%) and Tambov (22%) regions were the record-holders in sunflower cultivation in 2019. In Kursk Region, the gross harvest was 4,269 thousand centners (11%).

The productivity of modern sunflower hybrids depends significantly on the cultivation technology, as well as the soil and weather conditions in the region. This paper analyses the productivity of sunflower hybrids in the Kursk, Orel and Voronezh regions. The research was conducted at Avangard-Agro-Orel LLC (farming enterprise Livenskoye 1), Avangard-Agro-Kursk LLC (Zolotukhinsky district farming enterprise

Kazanka), Avangard-Agro-Voronezh LLC (farming enterprise Buturlinovka 1)

2 Problem Statement

Stable price and high liquidity have made sunflower cultivation attractive. Oilseed sunflower remains a highly profitable crop even if production volumes increase. New technologies for sunflower cultivation have been developed to ensure high yields and product quality while reducing production costs [1].

Sunflowers are highly ecologically malleable. It develops a strong root system, penetrating to a depth of 150-300 cm. This allows it to utilise the moisture of deep soil horizons that is inaccessible to many other field crops. The sunflower is relatively drought-resistant. It absorbs up to 1200-1800 tonnes of water from the soil per 1 tonne of seed, for a total of 3000-6000 tonnes/ha. 20-30% of this water is from seedlings to budding, 40-50% is from budding to flowering and 30-40% is from flowering to ripening. The sunflower transpiration factor is 470-570.

Sunflowers consume moisture from a soil layer 60-150 cm deep after the budding phase (150-250 cm after flowering). Therefore, sufficient moisture supply during the flowering - seed ripening period is crucial for the formation of a complete crop. Lack of moisture in the soil at this time is one of the reasons for emptiness in the centre of the baskets. Sunflower

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requirements for thermal resources necessary for ripening are determined by the sum of active (above 10°C) temperatures ranging from 1850 to 2400°C, depending on the genetic characteristics of the variety. Sunflowers consume large quantities of nutrients from the soil. They consume 50-60 kg of nitrogen, 20-25 kg of phosphorus, and 100-120 kg of potassium to produce 1 ton of seed. Sunflowers require particularly high amounts of nutrients during the period from budding to flowering, when intensive growth takes place and plants rapidly accumulate organic matter [2,3].

Excess fertiliser, especially nitrogen fertiliser, makes the plants less resistant to drought and disease. It also reduces the oil-bearing capacity of the sunflower seeds. The application of innovative sunflower cultivation technologies should take into account the genetic basis of these technologies. The right choice of herbicides will help to obtain a fertile and high-quality sunflower oilseed crop, as well as help to control weeds, including aggressive races of beechdrops [4,5].

3 Research Questions

The subjects were CLEARFIELD® and ExpressSun (Sumo) technologies.

The CLEARFIELD® production system is a unique combination of the EURO-LIGHTNING® herbicide (imidazoline group with the active ingredient imazapir 15 g/l + imazamox 33 g/l) and high-yielding sunflower hybrids. EURO-LIGHTNING® has a systemic and soil effect on annual and perennial weeds. The ExpressSun technology (Express® 75) or Sumo consists in the treatment of the herbicide Express® 75 (tribenuron-methyl 750 g/kg). The advantages of the use of the herbicide Express® 75 are in the ability to control a fairly wide range of annual dicotyledonous weeds in the interval of 2-8 pairs of leaves in the crop and flexibility in the rate of application in one or two periods;

The hybrids studied were produced using CLEARFIELD® technology: SI Bacardi (Syngenta); P62LE122 (Pioneer); EC Argentic (Euralis); MAS 89 IR (MAS Seeds). There are hybrids produced using ExpressSun technology: Sumiko (Syngenta); P64LC108 (Pioneer); EC Generalis (Euralis); MAS 85 SU (MAS Seeds).

All hybrids are of recent years of release (2015 to 2019), medium to early maturing. All hybrids are released for Region 5 (Central Black Earth Region), except for hybrids P64LC108 (Pioneer) and EC Argentic (Euralis).

4 Purpose of the Study

The purpose of the study was to investigate sunflower hybrids cultivation using different technologies, taking into account the location of farms in the Central Black Earth Region.

5 Research Methods

The experience was conducted under the production conditions of the farms listed above. All the requirements of the tested technologies were implemented using online monitoring on the Avangard-Agro website.

6 Findings

Sunflower hybrids were monitored under the conditions of three regions of the Central Black Earth Region. The most favourable conditions for the development of their vegetative mass during the growing season of the studied years were in Voronezh region (in 2018 and 2019 there was sufficient rainfall and satisfactory temperature regime, especially during the spring period of sunflower hybrids development). Less favorable conditions for sunflower growth and development were in Kursk Region.

Among the hybrids cultivated using the CLEARFIELD® technology, it is necessary to note the hybrids ES Generalis and MAS 89 IR (originators Euralis and MASSeeds). In these hybrids, all the parameters of the vegetative mass were most developed. Plant height reached 178-179 cm, stem diameter was 4.3-4.5 cm, number of leaves was 29-30 pieces per plant and leaf length was from 37 to 39 cm and width was up to 38-40 cm, while the length of the roots was 41-43 cm with a biomass of 1 plant of 2.9-3.1 kg.

The smallest indices of vegetative mass for all sunflower hybrids were noted in the Kursk region (LLC Avangard-Agro-Kursk, agricultural enterprise Kazanka). Plant height reached 171-172 cm, stem diameter was 4.1-4.3 cm, number of leaves was 25-26 pieces per plant, leaf length was from 35 to 36 cm and width was up to 36-38 cm, while the length of roots was 39 cm with 1 plant biomass of 2.6-2.8 kg. To a greater extent, the growing season of 2017 was dry and had a strong negative effect.

CLEARFIELD® hybrids such as P64LC108 (Pioneer company) and SI Bacardi (Syngenta company) showed the lowest performance.

The above mentioned patterns for CLEARFIELD® hybrids were also applied to ExpressSun or Sumo hybrids. Only the indicators of the vegetative mass of these hybrids were somewhat less, regardless of the cultivation areas of the Central Black Earth Region.

It is necessary to note that hybrids ES Argentic and MAS 85 SU (originators Euralis and MASSeeds) also stand out in terms of vegetative mass. We determined the highest indicators for these hybrids in the Voronezh region. Plant height reached 170-175 cm, stem diameter was 3.5-4.0 cm, number of leaves was 23-25 pieces per plant, leaf length was from 27 to 32 cm, and width was up to 35-37 cm, while the length of the roots was 36 cm (better soil fertility affects) with 1 plant biomass of 2.4-2.5 kg.

In order to estimate the future yield, it is necessary to calculate the photosynthetic sowing potential (PSP)

and net photosynthetic productivity (NPP).

The highest photosynthetic activity values were observed for sunflower hybrids cultivated using the CLEARFIELD® technology (in the Voronezh region the PSP is 13.8-22.0 million m²/ha x day; in the Kursk region 14.3-16.5 million m²/ha x day; and in the Orel region 11.6-16.5 million m²/ha x day). The photosynthetic potential (PDP) values were lower under the ExpressSun (Ekspress ® 75 v.y.) or Sumo technologies (in Voronezh region - 8.3-12.9 mln. m²/ha x day; in Kursk region - 5.1-9.2 mln. m²/ha x day; respectively, in Orel region - 6.0-8.7 mln. m²/ha x day). The maximum NPF was observed in the sunflower hybrids cultivated with the ExpressSun (Express® 75 v.d.) or Sumo technologies (regardless of the region of cultivation). It was significantly lower in the CLEARFIELD® technology (1.54-2.15 g/m² /day), which may have a negative impact on the sunflower seed yield.

In the Kursk region, sunflower hybrids of the major manufacturers (except Syngenta) cultivated by CLEARFIELD® technology have a more developed basket with a large number of seeds (1010-1060 pieces) with a smaller non-productive part (0.3-0.7%), compared with the ExpressSun technology. Maximum basket parameters were noted for hybrids EC Generalis and Sumiko, as well as for ExpressSun technology (Express® 75 v.g.) or Sumo in Voronezh region. The lowest values for the number of seeds and weight of

seeds in 1 basket for both technologies were observed in the Orel region.

It is necessary to pay attention to the SI Bacardi (Syngenta) and ES Generalis (originator Euralis) hybrids cultivated according to the CLEARFIELD® system, as well as Sumiko (Syngenta) Mas 85 SU hybrids (originator MASSeeds). These hybrids are characterized by a large mass of baskets with a sufficient number of seed pods and a low percentage of the unproductive part. The maximum values of the mass of seeds from 1 basket were obtained in 2019, regardless of the cultivation technology and the area of the Central Black Earth Region. The lowest values were in 2017, the most unfavorable year for the development and growth of sunflower. The mass of seed pods in 1 basket is in full accordance with the number of seed pods, regardless of the technology and area of the Central Black Earth Region. Cultivation technologies in certain weather conditions significantly affect the weight of seeds in 1 basket.

In the model experiment (we used in our work only a part of the hybrids out of 60 sunflower hybrids laid down by the years of research), the Si Bacardi hybrid was used as a standard in the CLEARFIELD® production system (EURO-LIGHTNING®) and the Sumiko hybrid based on the ExpressSun technology (Express® 75) or Sumo.

Biological yield is presented in Tables 1-2.

Table 1. Effect of cultivation technologies on the biological yield of sunflower hybrids in the experiment by years of research, t / ha

Hybrids	Kursk region			Oryol region			Voronezh region		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
Production system CLEARFIELD® (EURO-LIGHTNING®)									
SI Bacardi (st)	2,3	2,5	2,7	1,3	1,5	1,8	2,8	3,1	3,4
P64LC108	2,8	3,1	3,4	-	-	-	3,0	3,3	3,6
ES Generalis	3,5	3,8	4,1	1,5	1,6	1,7	3,3	3,5	3,7
MAS 89 IR	3,1	3,4	3,7	-	-	-	3,3	3,4	3,5
HCP ₀₅	0,1	0,2	0,3	0,2	0,1	0,1	0,3	0,2	0,1
Technology ExpressSun (Express® 75) or Sumo									
Sumiko (st)	2,1	3,0	3,8	1,7	2,0	2,2	3,0	3,5	4,0
P62LE122	2,7	3,3	3,9	1,9	2,4	2,8	3,6	3,9	4,2
ES Agrentic	3,1	3,6	4,1	1,9	2,3	2,7	4,0	4,2	4,4
Mas 85 SU	3,4	3,8	4,3	-	-	-	4,1	4,4	4,7
HCP ₀₅	0,2	0,3	0,1	0,2	0,2	0,3	0,2	0,3	0,1

In the Kursk region, all hybrids for all the years of research showed a better result compared to the standard hybrid SI Bacardi (increase for P64LC108 0.5 t/ha or 22% in 2017, 0.6 t/ha or 24% in 2018 and 0, 7 t/ha or 26% in 2019). All increases are significant.

For the ESGeneralis hybrid, they amounted to 1.2 t/ha (52%) in 2017, 1.3 t/ha or (50%) in 2018 and 1.4 t/ha (51%) in 2019. For the MAS 89 IR hybrid, the increases were also significant (0.8 t/ha; 0.9 t/ha and 1.0 t/ha, respectively).

In the Oryol region, the ES hybrid Generalis showed the results at the level of the standard hybrid. In the Voronezh region, the standard SI Bacardi hybrid in the CLEARFIELD® production system (EURO-LIGHTNING®) was surpassed by new tested hybrids. The tested hybrids using the ExpressSun technology (Express® 75) or Sumo in all the areas of the Central Black Earth region showed a higher result than the

standard Sumiko hybrid. For example, a hybrid of the Pioneer company - P62LE122, tested in the Oryol region showed the following results: the yield in 2017 was 1.9 (the increase of 0.2 t/ha or 12%), in 2018 it was 2.4 t/ha respectively (the increase of 0.4 t / ha or 20%) and in 2019 it was 2.8 t/ha (the increase of 0.6 t / ha or 27%).

Table 2. Effect of cultivation technologies on the biological yield of sunflower hybrids, t / ha (average for 2017-2019)

Hybrids	Kursk region			Oryol region			Voronezh region		
	Average for 3 years	Increase, t/ha %		Average for 3 years	Increase, t/ha %		Average for 3 years	Increase, t/ha %	
Production system CLEARFIELD® (EURO-LIGHTNING®)									
SI Bacardi (st)	2,5	-	-	1,5	-	-	3,1	-	-
P64LC108	3,1	0,6	24	-	-	-	3,3	0,2	6
ES Generalis	3,8	1,3	52	1,6	0,2	13	3,5	0,4	13
MAS 89 IR	3,4	0,9	36	-	-	-	3,4	0,3	10
Technology ExpressSun (Express® 75) or Sumo									
Sumiko (st)	3,0	-	-	2,0	-	-	3,4	-	-
P62LE122	3,3	0,3	10	2,4	0,4	20	3,9	0,5	15
ES Argentic	3,6	0,6	20	2,3	0,3	15	4,2	0,8	24
Mas 85 SU	3,8	0,8	27	-	-	-	4,4	1,0	29

Experience has shown the advantage of CLEARFIELD® (EURO-LIGHTNING®) technology in the Kursk region. The averages for the three years of research showed that hybrids from the major manufacturers had a positive result compared to the standard hybrid SI Bacardi (Syngenta). For hybrid P64LC108 the gain was 0.6 t/ha or 24%, for hybrid EC Generalis 1.3 t/ha or 52% and for hybrid MAS 89 IR 0.9 t/ha or 36%.

Hybrids cultivated using ExpressSun (Express®75 v.y.) or Sumo technology performed better in Orel oblast. Hybrid P62LE122 gave an increase of 0.4 t/ha or 20%, hybrid EC Argentic - 0.3 t/ha or 15% compared with the standard hybrid Sumiko (Syngenta).

Hybrids cultivated by technology ExpressSun (Express® 75 v.y.) or Sumo had an advantage in yields in Voronezh region. Increases were between 0.5 and 1.0 t/ha, or between 15 and 29%, depending on the sunflower hybrid cultivated.

The maximum values for 1000 seeds weight were noted: for hybrids ES Generalis (75.5 g) and Mas 85 SU (89.4) in Voronezh region; for hybrid P62LE122 (52.5 g) in Orel region and for ES Generalis and MAS (79.2 g and 82.8 g) in Kursk region, depending on the cultivation technology.

The lowest rates of huskiness were noted for hybrids CLEARFIELD® and ExpressSun: EC Generalis (25.4%) and Mas 85 SU (22.1%) in Kursk region and for the same hybrids (29.4% and 25.1%) in Voronezh region.

Quality indicators (1000 seed weight, seed oil content and grain nature) were higher for the ExpressSun (Express® 75 v.y.) or Sumo technology in all regions of the Central Black Earth Region,

especially in Voronezh Region.

Sunflower hybrids are most cost-effective to cultivate using the ExpressSun (Express® 75 v.y.) or Sumo technologies (the cost fell from 560 to 506 rubles per quintal of seeds, the profitability level rose from 275 to 315% for the hybrid EC Argentine, which showed the best results for both technologies in the Kursk region.

7 Conclusion

We recommend the application of ExpressSun or Sumo technology in all areas of Central Black Earth region with the addition of the herbicide Express® 75 v.g. (750 g/kg tribenuron-methyl; DuPont) at a rate of 10 g/ha and 15 g/ha at the 2nd and 8th pairs of true leaves. The working fluid consumption is 200 l/ha (MTZ 82.1; Amazone UG 3000 NOVA) for sunflower hybrid PR64E83 and other hybrids containing this herbicide resistance gene.

References

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