

# Sunflower productivity and gross oil production on the grey forest soil of the republic of Tatarstan under the use of growth regulators

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**Abstract.** An important source for increasing the sunflower yield and getting high economic efficiency consists of improving agricultural techniques for cultivation, in particular, soil and climatic conditions. Using growth regulators is one such technique. This research studies the effectiveness of the complex use of growth regulators when the treatment of seeds before planting is combined with the sprinkling of actual plants. During the whole period of the 4-year study, the maximum yield of seeds (3.233 tons/hectare), the highest oil content (52.95 %), and the gross oil production level (1713.8 kg/hectare) were obtained under the use of Zirkon growth regulator.

## 1 Introduction

Within 15–20 years sunflower has become one of the main crops cultivated globally. It is a perspective oil crop for both the Russian Federation and the Republic of Tatarstan. One of the ways to increase the yield of sunflower and the effectiveness of its cultivation is to improve the agricultural techniques for a particular soil and climatic zone.

In the last years, the protection of agricultural crops has been getting complicated. This happens because protection products become more expensive while new plant diseases and pests appear. The use of high doses of products disturbs the biological equilibrium and affects the environment [1, 2].

Currently, the environmentalization of crop farming is gaining bigger relevance. Farmers can decrease the cost of agricultural production by using growth regulators instead of more expensive chemicals. Among growth regulators, there is a preference for natural substances produced from plants, fungi, and micro-organisms on the one hand or growth stimulators on the other hand [3–5]. The new generation growth regulators have triple action: stimulating biological processes, increasing plant resistance to unfavorable factors, and boosting non-specific immunity [6, 7].

Based on his research, V.P. Lukhmenov [8] argues that natural origin substances influence the metabolism of plants, changing the processes of growth and development of plants as well as increasing their resistance to stress factors.

Growth regulators can't replace fertilizers but complement them in the nutritional system of

agricultural crops. They also increase the ratio of nutrients absorbed from the soil and fertilizers [1, 9].

Currently, the major gap between potential and actual sunflower yield makes scientists search for ways to eliminate it in conditions of particular regions.

This research mainly aims at finding ways to increase sunflower productivity using growth stimulators to treat seeds and plants in the Zakamye region of the Republic of Tatarstan.

The achievement of this aim requires studying the influence of different regulators on the growth, development, yield, and content of fat in sunflower seeds.

## 2 Conditions, materials, and methods of research

The research was carried out in 2015–2018 on the experimental fields of the department of crop production and horticulture at Kazan Federal University. The land of the experimental plot is of forest type with middle loamy, granulometric texture. The salt extract pH is 5.5–5.7. The nutritional properties of soil are the following: humus level is 5.1–5.6 %, labile phosphorus content is 126–146, exchange potassium content is 142–161 mg/kg of soil. The preceding crop is winter wheat. The total area of the plot is 280 m<sup>2</sup>, while the accounting area is 140 m<sup>2</sup>. The agricultural methods used in the experiment are common for this region. The ratio of introduced mineral fertilizers is N<sub>70</sub>P<sub>50</sub>K<sub>70</sub>.

The seeds in the research were treated with the following regulators: Albit – 30 ml/t, Biosil – 40 ml/t,

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Epin-extra – 4 ml/t, Zirkon – 4 ml/t. The consumption rate of water solution was 10 l/g.

At the stage of 2–4 true leaves we sprinkled the plants with Albit – 30 ml/t, Biosil – 40 ml/t, Epin-extra – 4 ml/t, Zirkon – 4 ml/t. The consumption rate of water solution was 200 l/hectare.

### 3 The aim and tasks of research

The research aimed at increasing the yield of seeds and the content of oil using different ways for growth regulation under the conditions of grey forest soils of the Zakamye region in the Republic of Tatarstan.

#### Research tasks:

- find the influence of growth regulators on the growth and development of sunflower plants;

- determine the dependency between the yield and the oil content of sunflower from applying growth regulators.

### 4 Results and discussion

The most important factor in getting the high yield is timely and concurrent germination of sunflower. The successful growth and development of sunflower plants depend on the right choice of growth stimulators for pre-sowing treatment. The germination ability in different variants of the experiment varied between 89.76 % for the control variant without using growth regulators and 93.83 % in the case of Zirkon regulator. On average, during 4 years of research, the pre-sowing treatment of seeds with growth regulators increased the germination ability by 2.09–3.93 % in comparison with the control variant (table 1).

**Table 1.** The number of germinated seeds and survivability of sunflower plants depending on the manner of application of growth regulators, 2015–2018

Product	Treatment method	Number of germinated seeds, thousand seedlings per hectare	Germination rate, %	Number of plants before harvesting, %	Plant survivability, %
Control	–	58.39	89.76	55.10	94.34
Albit	Treatment of seeds	59.70	91.85	56.75	95.06
	Sprinkling of plants	58.74	90.37	55.91	95.14
	Treatment of seeds + sprinkling of plants	59.97	92.26	57.30	95.53
Biosil	Treatment of seeds	60.24	92.68	56.97	94.72
	Sprinkling of plants	59.01	90.79	56.35	94.68
	Treatment of seeds + sprinkling of plants	60.50	93.08	57.83	95.56
Epin-extra	Treatment of seeds	60.27	92.72	56.98	94.52
	Sprinkling of plants	58.69	90.28	55.74	94.95
	Treatment of seeds + sprinkling of plants	60.44	92.98	57.66	95.39
Zirkon	Treatment of seeds	60.9	93.69	58.08	95.36
	Sprinkling of plants	59.13	91.72	56.32	95.23
	Treatment of seeds + sprinkling of plants	60.99	93.83	58.23	96.27

**Table 2.** The surface of sunflower leaves depending on the manner of application of growth regulators, 2015–2018

Product	Treatment method	Sunflower plant development stage		
		budding	anthesis	economic maturity
Control	–	22.48	39.54	7.64
Albit	Treatment of seeds	27.94	42.52	8.04
	Sprinkling of plants	27.65	41.61	8.66
	Treatment of seeds + sprinkling of plants	29.62	43.05	9.02
Biosil	Treatment of seeds	28.16	41.48	7.95
	Sprinkling of plants	27.25	40.64	7.98
	Treatment of seeds + sprinkling of plants	29.11	42.72	8.11
Epin-extra	Treatment of seeds	28.74	42.88	8.14
	Sprinkling of plants	27.82	41.58	7.96
	Treatment of seeds + sprinkling of plants	27.62	44.24	9.15
Zirkon	Treatment of seeds	30.36	45.16	9.46
	Sprinkling of plants	29.72	44.86	9.24
	Treatment of seeds + sprinkling of plants	32.65	46.28	9.66

The survivability of sunflower seeds before harvesting was quite high. Even in the control variant without treatment by growth regulators, it was 92.99 %. The highest survivability (96.27 %) was in the case of

combined treatment with Zirkon (treatment of seeds + treatment of plants).

A.A. Nichiporovich [10, 11] and T.N. Kulakovskaya [12] indicate that high yields are formed only in the case

of the optimal surface of foliage which remains active during vegetation and uses accumulated macronutrients to form productive plant organs.

While studying sunflower hybrids, V.S. Seferyan [13] found that the maximum surface of foliage (17.85–28.00 thousand m<sup>2</sup>/hectare) formed at the stage of anthesis. The surface then decreased due to the death of lower leaves. The same results were obtained by A.V. Germogenov [14], who denotes that the foliage surface grew most intensively before anthesis. After reaching the maximum value, it started to decrease gradually when lower leaves started dying.

The formation of the assimilative surface in the case of sunflower plantlets was influenced by different factors, including growth regulators.

In our studies, the foliage surface was quite large already at the stage of budding. It varied between 22.48 thousand m<sup>2</sup>/hectare in the control variant and 32.65 thousand m<sup>2</sup>/hectare in the case of treatment by Zirkon (table 2).

The maximum surface of foliage (39.54–46.28 thousand m<sup>2</sup>/hectare) formed at the anthesis stage. The efflux of nutrients started from lower leaves that gradually became dry. By the time of economic maturity, the foliage surface had significantly decreased.

The value of the foliage surface was influenced by growth regulators. Regardless of the used method, they

had a great impact on its increase. For example, the foliage surface in the control variant was 39.54 thousand m<sup>2</sup>/hectare. After treatment by Albit, it increased by 2.07–3.51 thousand m<sup>2</sup>/hectare depending on the use manner. The treatment by Zirkon was the most effective. In its case, the value of the surface grew by 5.32–6.74 thousand m<sup>2</sup>/hectare depending on the use manner.

The research showed that growth regulators have some impact on the yield of sunflower seeds. If the yield in the control variant was 2.425 t/hectare during 4 years of experiment, the use of growth regulators even in small doses increased it.

In this case, Zirkon was the most effective with the yield of 3.223–2.911 t/hectare depending on the use manner. On average the increase of yield during 4 years of research was 0.486 t/hectare in the case of plant treatment and 0.798 t/hectare in the case of combined (seeds + plants) treatment (Table 3).

In the case of Albit, the yield was 2.715–2.964 tons per hectare depending on the use manner. The increase in comparison with the control variant was 0.290–0.539 tons/hectare. The research showed that growth regulators also impact the content of the oil. According to our data, their influence in field conditions is due to external factors. There is a dependency between the percentage of oil, the meteorological conditions during vegetation, and the use of regulators.

**Table 3.** The yield of sunflower seeds depending on the manner of application of growth regulators, 2015–2018

Product	Treatment method	Yield, tons per hectare				
		2015	2016	2017	2018	average
Control	–	2.952	2.658	1.524	2.564	2.425
Albit	Treatment of seeds	3.282	3.114	1.616	3.021	2.758
	Sprinkling of plants	3.236	2.876	1.784	2.962	2.715
	Treatment of seeds + sprinkling of plants	3.442	3.164	2.016	3.232	2.964
Biosil	Treatment of seeds	3.244	2.984	1.576	3.234	2.760
	Sprinkling of plants	3.198	2.675	1.590	3.008	2.618
	Treatment of seeds + sprinkling of plants	3.308	3.165	1.846	3.315	2.909
Epin-extra	Treatment of seeds	3.414	3.034	1.719	3.224	2.848
	Sprinkling of plants	3.362	2.784	1.735	3.117	2.750
	Treatment of seeds + sprinkling of plants	3.446	3.286	1.982	3.315	3.007
Zirkon	Treatment of seeds	3.512	3.268	1.888	3.228	2.974
	Sprinkling of plants	3.434	3.122	1.962	3.125	2.911
	Treatment of seeds + sprinkling of plants	3.702	3.445	2.224	3.521	3.223
LSD <sub>05</sub> A		0.08	0.06	0.08	0.06	
LSD <sub>05</sub> B		0.04	0.04	0.02	0.02	
LSD <sub>05</sub> AB		0.07	0.14	0.11	0.11	

**Table 4.** The content of oil in seeds depending on the manner of application of growth regulators, 2015–2018

Product	Treatment method	Oil content, %				
		2015	2016	2017	2018	average
Control	–	53.62	51.43	47.57	52.46	51.27
Albit	Treatment of seeds	54.24	51.72	49.54	53.22	52.18
	Sprinkling of plants	53.81	51.62	49.50	52.72	51.91
	Treatment of seeds + sprinkling of plants	54.63	52.12	49.74	53.60	52.52
Biosil	Treatment of seeds	53.82	51.54	50.12	52.86	52.09
	Sprinkling of plants	53.53	51.32	50.21	52.58	51.91
	Treatment of seeds + sprinkling of plants	54.14	51.83	50.44	53.18	52.40
Epin-extra	Treatment of seeds	53.92	51.83	49.37	52.96	52.02
	Sprinkling of plants	53.74	51.62	49.22	52.24	51.71
	Treatment of seeds + sprinkling of plants	54.41	51.74	49.68	53.12	52.19
Zirkon	Treatment of seeds	54.43	52.14	50.22	53.18	52.49
	Sprinkling of plants	53.92	51.91	50.34	52.87	52.26
	Treatment of seeds + sprinkling of plants	54.84	52.52	50.82	53.62	52.95

The advantage of regulators is that they actively influence the metabolism of plants as well as growth, physiological, and form-building processes. The regulators also boost immunity. All this makes plants more resistible to stress situations, fungal, bacterial, and viral diseases.

The rationale behind the evaluation of oil content in kernels is explained by the fact that the oil of seed husk is different from the oil of kernels in content. Also, the

percentage of huskiness varies by year which influences the percentage of oil in seeds. The content of oil varied by year. In 2015 it was higher in comparison with 2016 and 2018 and, especially, 2017 (table 4).

In the control variant of the experiment, the total production of oil for 4 years was 1254.6 kg/hectare on average (table 5). The highest production of 1713.8 kg/hectare was achieved in the case of Zirkon growth regulator used for combined treatment.

**Table 5.** The total production of oil depending on the manner of application of growth regulators, 2015–2018

Product	Treatment method	Oil production, kg/hectare				
		2015	2016	2017	2018	average
Control	–	1582.3	1366.2	725	1345.0	1254.6
Albit	Treatment of seeds	1778.8	1609.9	800	1607.8	1449.1
	Sprinkling of plants	1741.0	1484.0	883	1561.6	1417.4
	Treatment of seeds + sprinkling of plants	1879.3	1648.4	1003	1732.4	1565.8
Biosil	Treatment of seeds	1745.3	1536.8	790	1709.5	1445.4
	Sprinkling of plants	1710.9	1372.3	798	1581.6	1365.7
	Treatment of seeds + sprinkling of plants	1789.6	1639.5	931	1762.9	1530.8
Epin-extra	Treatment of seeds	1840.1	1571.6	847	1707.4	1491.5
	Sprinkling of plants	1805.4	1436.5	854	1628.3	1431.1
	Treatment of seeds + sprinkling of plants	1874.6	1698.9	985	1760.9	1579.9
Zirkon	Treatment of seeds	1910.5	1702.6	948	1716.7	1569.5
	Sprinkling of plants	1850.9	1620.3	988	1652.2	1527.9
	Treatment of seeds + sprinkling of plants	2028.7	1808.6	1130	1888.0	1713.8

## 5 Conclusion

The field germination ability of seeds strongly depended both on meteorological conditions and the use of growth regulators. The germination ability in different variants of the experiment varied between 89.76 % for the control variant without using growth regulators and 93.83 % in the case of Zirkon regulator. On average, during 4 years of research, the pre-sowing treatment of seeds with growth regulators increased the germination ability by 1.96–4.07 % (depending on the product used) in comparison with the control variant.

The survivability of sunflower seeds before harvesting was quite high. Even in the control variant without treatment by growth regulators, it was 94.34 %. The highest survivability (96.27 %) was in the case of combined treatment with Zirkon (treatment of seeds + treatment of plants).

On average, all growth regulators gave an increase in yield during 4 years of research. The highest increase was in the case of Zirkon regardless of the use manner. In comparison with the control variant, the pre-sowing treatment of seeds increased the yield by 0.549 t/hectare, the treatment of plants increased the yield by 0.486 t/hectare, and the combination of these methods gave the increase by 0.798 t/hectare.

The production of oil was also higher after treatment with Zirkon. In the case of the treatment of seeds, the increase was 314.0 kg/hectare. The treatment of plants raised the production of oil by 273.3 t/hectare and the combined treatment – by 459.2 t/hectare.

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