Innovative aspects of stimulating the growth and development of grain and leguminous crops in Western Siberia

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Abstract. The results of three-year studies (2020-2022) on the effectiveness of pre-sowing seed treatment of grain crops (spring soft wheat, spring barley and oats) and legumes (soybeans) in terms of stimulating growth and development, increasing productivity and product quality are presented. The experiments were carried out on leached chernozem and gray forest soil of the Novosibirsk and Orda districts of the Novosibirsk region. In the experiments, we used the variety of spring soft wheat Likamero, spring barley Paustian, oats - Max and soybeans - SibNIIK 9. The largest leaf area parameters were noted in spring wheat against the background of presowing seed treatment with Lignohumate 80 g/t, followed by spraying in the tillering phase with Energia M 20 g/ha. The applied growth regulators significantly increased the yield of grain crops and soybeans. The highest yield was established in the variants with seed treatment with Lingvohumate followed by the use of Energia M in the tillering phase. The increase was 21% for spring wheat, 23% for barley and 24% for soybeans. The preparations used improved the yield structure of all crops.

1 Introduction

Cereals and leguminous crops are the leading ones in Western Siberia. The modern technology of cultivation of these crops is based on the use of high-yielding varieties and hybrids of an intensive type with the placement of crops according to the best predecessors, optimization of soil cultivation, fertilizer systems for a programmed crop under different soil and climatic conditions, the use of effective integrated plant protection against pests, normalized implementation of a complex of agricultural technology [1-5]. When cultivating these crops, their requirements for environmental factors, as well as the features of adaptive cultivation technology are taken into account [6, 7]. In order to stabilize grain production, innovative technologies are used to obtain a high yield of grain reproduction [8,9]. The use of mineral fertilizers and bacterial complexes helps to optimize the balance of nutrients in the soil [10-12]. Achieving the optimization of mineral nutrition and the macrobiotic status of the soil can significantly increase the productivity of grain and leguminous crops. Soy is an important crop in world and domestic agriculture. To provide the population of the country

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with high-quality protein, it is necessary to increase the area under crops for leguminous crops [15, 16]. Soy among leguminous crops occupies a leading position in terms of protein content and is second only to peanuts in terms of oil concentration in grain [17]. In this regard, the purpose of our research in 2020-2022 was an assessment of the effectiveness of the use of various growth stimulants in the cultivation of grain crops (spring soft wheat, spring barley and oats) and soybeans for grain on different soils of Western Siberia.

2 Materials and methods

Experimental work was carried out in different zones of the Novosibirsk region: the drained forest-steppe, which is part of the northern forest-steppe of the foothills, on the experimental plots of the Praktik in the Novosibirsk region and the Irmen breeding farm in the Ordynsky district of the forest-steppe zone, as well as on the gray forest soil of the Michurintsev Garden. The meteorological conditions during the years of the study of experimental work differed both in temperature regime and in the amount of precipitation. The soil of the research site is leached chernozem (weakly leached has a small share). The content of humus is 6.19% (medium humus chernozems), total nitrogen 0.32, phosphorus 0.23 and potassium 1.24%. The soil of the experimental fields has easily hydrolysable nitrogen 12.1 mg/100g, mobile phosphorus 21.6 and exchangeable potassium 19.8 mg/100g, pH - 6.43. The gray forest soil of the UPH "Garden Michurintsev" was medium loamy with a humus content of 4.68%, mobile phosphorus 11.6 mg/100g and exchangeable potassium 12.8 mg/100g at pH 5.97. During the research, phenological observations were carried out according to the method of the State variety testing of agricultural crops (1985). The photosynthetic potential of seeding was determined according to A.A. Nichiporovich [16]. The height of plants and the height of attachment of the lower beans, the number of seeds in a bean was determined by the method of the All-Russian Research Institute of Soybeans. Statistical processing was carried out according to the method of B.A. Dospekhov [18]. The accounting area of the plot in the experiments is 12.8 m^2, the repetition is four times, the location is randomized.

3 Results and discussion

In the experiments of 2020-2022 on leached chernozem and gray forest soil, pre-sowing seed treatment was carried out with a bacterial stimulant Nitro-fixP 0.01% 40 g/t, Lignohumate (B + Mo) 80 g/t and Novosil 100 ml/t, followed by treatment of plants in the tillering phase of cereals and brushwood soybean leaves with Energia M (organosilicon preparation) at a dose of 20 g/ha. Experiments were carried out with spring soft wheat of the Licamero variety, spring barley of the Paustian variety and oats of the Max variety, as well as with SibNIIK 9 soybean.

It was shown that the parameters of the maximum leaf area were higher when using seed treatment with a growth regulator in comparison with the control by 16-23%. In particular, the indicators of leaf area increased against the background of the treatment of seeds of grain crops (spring soft wheat of the Licamero variety, spring barley of the Paustian variety and oats of the Max variety) with Lignohumate 80 g/t, followed by spraying in the tillering phase with Energia M 20 g/ha and with treatment seeds with the drug Novosil 100 ml/t and with the introduction of the drug Energia M 20 g/ha during the growing season. In experiments with soybean cultivar SibNIIK 9, the preparation Nitro-fixP 0.01% 40 g/t (biopreparation) was isolated during seed treatment in comparison with grain crops.

According to the parameters of the average leaf area and FSP, the increase from the use of growth regulators was 18–27% (Tables 1-2).

Table 1. Photosynthetic parameters of plants depending on the treatment with growth stimulants. Average for 2020-2022

Variant	Spring wheat			Spring barley		
	Leaves square		FSP thous. m^2 days/ha	Leaves square		FSP thous. m^2 days/ha
	Max	Average		Max	Average	
Control	21.2	14.2	1349	20.8	12.6	1159
Seed treatment Nitro-fixP 0.01% 40 g/t	21.6	14.6	1402	20.7	12.5	1151
Seed treatment lignohumate 80 g/t	21.8	14.8	1421	21.4	13.0	1196
Novosil 100 ml/t	21.4	14.7	1411	21.6	13.2	1214
Nitro-fixP 0.01% 40g/t Energy M 20 g/ha for vegetation	21.8	14.9	1430	21.8	13.3	1224
Lignohumate 80 g/t + Energy M 20 g/ha for vegetation	21.9	15.0	1442	20.9	12.9	1187
Novosil 100 ml/t + Energy M 20 g/ha	21.9	14.7	1412	21.4	13.4	1233
HCP_{05}	0.12	0.14	19.6	0.23	0.17	24.6

Table 2. Photosynthetic parameters of oat and soybean plants depending on the treatment with growth stimulants. Average for 2020-2022

Variant	Oats			Soya		
	Leaves square		FSP thous. m^2 days/ha	Leaves square		FSP thous. m^2 days/ha
	Max	Average		Max	Average	
Control	19.6	11.6	1056	23.4	15.3	1498
Seed treatment Nitro-fixP 0.01% 40 g/t	20.2	11.8	1086	23.6	15.6	1529
Seed treatment lignohumate 80 g/t	20.4	11.9	1095	23.8	15.6	1518
Novosil 100 ml/t	20.2	12.3	1132	23.5	15.5	1539
Nitro-fixP 0.01% 40g/t Energy M 20 g/ha for vegetation	20.5	11.9	1094	23.6	15.7	1558
Lignohumate 80 g/t + Energy M 20 g/ha for vegetation	20.3	12.2	1122	23.9	15.9	1579
Novosil 100 ml/t + Energy M 20 g/ha	20.7	12.4	1141	24.0	16.1	1549
HCP_{05}	0.14	0.13	23.8	0.18	15.8	26.8

The greatest increase in yield from the use of growth stimulants in the treatment of seeds of grain crops was found against the background of Novosil 100 ml/t in spring wheat - 19% and spring barley - 17%. The maximum effect of increasing yields was noted against the background of the use of Lignohumate 80 g/t followed by the use of Energia M in the tillering

phase with an addition to the control in spring wheat - 21% and barley - 23%. Against the background of the last variant of the use of the growth regulator, the number of grains in the ear increased by 19%, the weight of grain in the ear increased by 22%, the weight of 1000 grains increased by 23%, with an increase in protein in the grain by 0.3% in absolute terms (Table 3).

Table 3. The main economically valuable features of grain crops when using growth stimulants. Average for 2020-2022

Variant	Spring wheat						Spring barley					
	yield, t/ha	number of grains in an ear, pcs	weight of grain in an ear, g	weight of 1000 grains, g	number of ears in an ear, pcs	protein content in grain, %	yield, t/ha	number of grains in an ear, pcs	weight of grain in an ear, g	weight of 1000 grains, g	number of ears in an ear, pcs	protein content in grain, %
Control (water)	4.12	23	1.38	39	27	13.12	3.89	25	1.19	40	25	11.28
Seed treatment nitro-fixP 0.01% 40 g/t	4.48	27	1.35	40	30	13.10	4.08	24	1.26	44	28	11.16
Seed treatment Lignohumate 80 g/t	4.74	29	1.48	41	33	13.36	4.39	26	1.28	43	29	11.38
Novosil 100 ml/t	4.78	28	1.52	42	31	13.28	4.42	28	1.23	45	30	11.33
Nitro-fixP 0.01% 40 g/t + Energy M 20 g/ha for vegetation	4.65	29	1.54	42	32	13.30	4.68	27	1.25	43	27	11.30
Lignohumate 80 g/t + Energy M 20 g/ha for vegetation	4.95	27	1.61	43	34	13.42	4.75	29	1.28	44	28	11.42
Novosil 100 ml/t + Energy M 20 g/ha for vegetation	4.88	28	1.57	42	32	13.37	4.70	28	1.27	45	29	11.40
HCP_{05}	0.19	1.86	0.09	1.25	0.65	0.28	0.12	1.14	0.05	1.46	1.25	0.07

It was established statistically that the yield of spring wheat depended on the use of a growth regulator by 34% and the conditions of the year by 26% with interaction - 19.8% and spring barley - 37, 24 and 17.6%, respectively.

In experiments with soybean variety SibNIIK 9, the maximum increase in seed treatment was achieved in the variant with the bacterial preparation Nitro-fixP 0.01% 40g/t. When using preparations with seed treatment and vegetation, the Lignohumate 80 g/t variant is distinguished, followed by the use of Energia M 20 g/ha in the six-leaf phase - an increase of 24% to the control. The number of beans per 1 plant is higher in the variants of Nitro-fixP

for seeds and with subsequent treatment with Energia M 20 g/ha for vegetation. In variants with double application of drugs, the weight of 1000 soybean seeds increased (Table 4).

Table 4. Yield and crop structure of soybeans. Average data for 2020-2022.

Variant	Yield			Pre-harvest density, thousand units/ha	Number of beans per plant	Weight of grains from 1 plant, g	Number of grains in a bean, pcs	Weight of 1000 seeds, g
	t/ha	increase to control						
		t/ha	%					
Control (water)	2.63	-	-	268	15	4	6.8	138
Seed treatment: Nitro-fixP 0.01% 40 g/t	3.10	0.47	18	279	16	5	6.9	143
Seed treatment Lignohumate 80 g/t	3.02	0.39	15	286	17	6	7.0	148
Seed treatment Novosil 100 ml/t	2.93	0.30	11	282	16	5	7.7	149
Nitro-fixP 0.01% 40 g/t + Energy M 20 g/ha for vegetation	3.10	0.47	19	294	17	6	8.2	154
Hygnohumate 80 g/t + Energy M 20 g/ha for vegetation	3.24	0.61	24	290	18	7	8.0	152
Novosil 100 ml/t + Energy M 20 g/ha for vegetation	3.14	0.57	20	288	16	6	7.9	160
HCP_{05}	0.19	-	-	-	0.3	0.8	0.17	4.9

4 Conclusion

In the conditions of the forest-steppe of Western Siberia, in the production of grain crops and soybeans on leached chernozem and gray forest soil, it is effective to use the Licamero spring soft wheat variety, Paustian spring barley, Max variety oats and SibNIIK 9 soybean for grain.

The maximum leaf area parameters were achieved in spring wheat against the background of presowing seed treatment with Lignohumate 80 g/t followed by spraying in the tillering phase with Energia M 20 g/ha with an average leaf area of 15 thousand m2/ha and FSP 1442 thousand m^2 day/ha in spring wheat varieties Likamero. In experiments with barley, oats and soybeans, a variant was distinguished with seed treatment with Novosil and subsequent spraying during the growing season with Energia M.

The studied growth regulators increased the yield of cereals and soybeans relative to the control. The maximum increase in yield was noted against the background of the use of Lignohumate 80 g/t for seed treatment, followed by the use of Energia M in the tillering phase (increase to control in spring wheat 21% and barley - 23%, in soybeans - 24%).

Analysis of variance found that the yield of spring wheat depended on the use of growth regulators by 34-37% and the conditions of the year by 24-26%.

The studied preparations increased the parameters of the crop structure, the number of grains per ear, the mass of grains per ear, the weight of 1000 grains, the number of spikelets per ear, and increased the protein content in the grain.

In studies with soybeans, the use of growth regulators increased the number of beans per plant, the number of seeds per bean, the weight of grain per plant, and the weight of 1000 seeds.

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