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COMPARATIVE EFFECTIVENESS OF NITRAGIN KM AND AMMONIUM NITRATE IN BELGORODSKAYA 8 SOYBEAN CULTIVATION IN THE FOREST-STEPPE OF THE CENTRAL BLACK EARTH (CBE) ECONOMIC REGION

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Abstract:

In the field experiments of the Department of Plant Production, Selection and Vegetable Growing of the Belgorod SAU in 2015-2016, we found out the following facts at a comparative study of the effect of Nitragin KM and ammonium nitrate on the growth and development of Belgorodskaya 8 soybean:Processing of soybean seeds with Nitragin KM, created in NTTS BIO LLC (Shebekino, Belgorod region), significantly (from 25 in control to 34 pcs/plant) increased the number of active nitrogen-fixing nodules on plant roots. This increased the intensity of increasing the mass of plants and the area of leaves, increased the yield from 27.5 c/ha in control to 30.7 c/ha (by 11.6 percent), improved the quality of grain (protein content increased by 2.9 abs.%, oil content - by 3.1 abs.%), increased the protein harvesting from 935 kg/ha in control to 1,112 kg/ha and the collection of oil in the seed yield -from 479 kg/ha to 618 kg/ha. The duration of soybean vegetation decreased from 111 (in control) to 102 days, the cost of production decreased by 8.1%, the profit increased by 17.2%, the profitability increased by 20%. Surface top dressing of soya with ammonium nitrate (2 c/ha) shortly before budding also improved growth, leafiness and increased plant productivity (but to a lesser extent than seed Nitraginization) -yield increased from 27.5 to 29.2 kg/ha, protein content -from 39.6 to 42%, oil content -from 20.3 to 22.2%. At the same time, protein harvesting increased from 935 to 1,055 kg/ha, oil -from 479 to 557 kg/ha. At the same time, the vegetation period of soybean plants increased from 111 days to 116 days.The use of domestic Nitragin KM for inoculation of soybean seeds, the retail price of which is 2-3 times less than foreign analogues, is very promising. Nitrogen soybean fertilizer, if necessary, can be an alternative or additional method of increasing the yield and quality of soybean grain products.The goal of our study is to reveal the comparative effect of soybean seed treatment with Nitragin KM and late nitrogen fertilizer on plant development, yield, protein content and soybean oil content in the forest-steppe of the CBE economic region.

Key words: *soybean, Nitragin KM, inoculation, ammonium nitrate, fertilizer, yield, protein content, oil content, cost, profit, profitability.*

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INTRODUCTION:

It is known that soybeans, like other beans, use two types of nitrogen nutrition:–symbiotrophic (as a result of symbiosis with nodule bacteria on the roots) and autotrophic (nitrogen absorption from fertilizers and soil). These two sources of nitrogen nutrition supplement each other, being, as a rule, in an intercompensation ratio [5]. With an abundance of mineral nitrogen in the soil at the beginning of vegetation period, for example, in the pre-sowing application of nitrogen fertilizer, the autotrophic consumption is used greater by the soybeans. At the same time, the soybean plants lay fewer nodules or do not form them at all. In the future, when the content of mineral nitrogen decreases in the soil, the soybean plants, having few nodules and experiencing nitrogen starvation, will decrease their yield and product quality by the time of maximum demand in it, during the budding, flowering, bean formation and seed filling. Therefore, it is very important to use the pre-sowing infection (inoculation) of soybean seeds with a highly virulent active soybean race of nodule bacteria of *Bradyrhizobium japonicum* genus at the soybean cultivation. The plants use the nodule nitrogen mainly in the second half of the vegetation period as the need for it grows. The inoculation of seeds is especially necessary in the absence of virulent race of nodule bacteria in the soil (and not only).

If there are few nodules on the soybean roots, for some reason, it is quite possible to prevent the nitrogen supply shortage during the critical period for soybeans by the late (before budding) nitrogen fertilizing [1, 2, 3, 4, 6, 7]. These issues studied by us have not lost their novelty and relevance to the present time.

METHODS, MATERIALS AND CONDITIONS OF THE STUDY:

A comparative study of the effect of seed treatment with Nitragin KM and late nitrogen fertilizing of soybean plants was carried out in 2015-2016 in the Gorin Belgorod Agrarian University at the Department of Plant Production, Selection and Vegetable Growing.

Five soybean varieties were included in the experiment (Belgorodskaya 48, Belgorodskaya 6, Belgorodskaya 7, Belgorodskaya 8 and Bara), which were tested on three feeding grounds: seed inoculation with Nitragin KM (without nitrogen fertilizer), addition of ammonium nitrate (without inoculation) and control. However, this article gives the experiment results only for one cultivar - Belgorodskaya 8. This is a new early-ripe (sometimes –mid-ripe) high-yielding cultivar in the State Register from 2013.

As a seed inoculum, we studied Nitragin KM, which was created in NTTS BIO LLC (Belgorod Region, Shebekino), approved for use by the Ministry of Agriculture. This dry biopreparation contains a natural highly virulent strain of soybean nodule bacteria *Bradyrhizobium japonicum*206. It is supplied with a liquid organomineral complex (OMC), which is necessary to ensure the nitragin adhesion to the seeds, the preservation and additional nutrition of nodule bacteria (and plants). 1.5 litres of water were consumed per hectare of seeds (150 kg), adding 100 ml of OMC and 80 g of Nitragin KM to the water. Such an aqueous suspension was used to inoculate the soybean seeds.

Ammonium nitrate was used on the option with the use of mineral nitrate fertilizer, which was put manually shortly before budding of soybean plants at the rate of 2 c/ha (N_{68}) or 20 g/m^2.

In the control option neither nitragin nor ammonium nitrate were used (the seeds were treated with pure water).

The experiments were laid on the collection nursery according to the method of field experiment. The experiment has six-fold repeatability, the area of the registered land plot is 6 m^2.

The soybean was grown according to the technology generally accepted in the CBE economic region. The spring wheat is a precursor. The soil was treated with an autumn plowing of 25 cm, early spring harrowing, pre-sowing cultivation of 4-5 cm.

The soybean sowing was carried out with SS-11 "Alpha" drill in the first decade of May in the usual ordinary way (with a row spacing of 15 cm). Seeding rate - 0.9 mln. seeds per 1 ha (14 seeds per 1 m row), depth of sowing - 4-5 cm. The density of plant standing in the crops before harvesting was approximately 80 pcs./m^2. The height and weight of plants were determined according to 25 measurements on an average, the number and weight of nodules –to 10 plants on an average, the leaf area – using a personal computer, scanner and "Areas" program.

In 2015, the weather was hot and arid. In 2016, the weather was more favorable hot, but more moisture-proof.

The soil of the experimental site is represented by typical black earth, medium-heavy, heavy loamy,

humus content in the arable layer –4.54%, easily hydrolyzable nitrogen –137.2 mg/kg, mobile phosphorus –137 mg/kg, exchange potassium –126.0 mg/kg.

Study results. Treatment of soybean seeds with an aqueous suspension of Nitragin KM caused an increase in the number and weight of active nitrogen-fixing nodules. This pattern was manifested in both years of research during all phases of soybean growth (Table 1).

The number and weight of the nodules increased during the stalking phase, reaching a maximum toward the flowering and fruiting phase. After that, we observed dying-off of a part of the nodules.

Table 1: The number and weight of active nodules on the roots of soybean plants in the main phases of growth, depending on the feed background.

Option	2015		2016		Average	
	number, pcs./plant	weight, g/plant	number, pcs./plant	weight, g/plant	number, pcs./plant	weight, g/plant
Stalking phase						
Nitragin KM	17.5	0.62	31.5	0.86	24.5	0.74
Ammonium nitrate	13.2	0.48	23.8	0.67	18.5	0.58
Control (without fertilizer)	11.2	0.32	16.8	0.45	14.0	0.38
Flowering phase						
Nitragin KM	22.8	0.83	45.1	1.21	34.0	1.02
Ammonium nitrate	18.7	0.52	37.0	0.76	27.8	0.64
Control (without fertilizer)	18.5	0.74	31.5	1.08	25.0	0.91
Bean formation phase						
Nitragin KM	23.8	0.72	43.4	0.95	33.6	0.84
Ammonium nitrate	16.4	0.42	31.3	0.55	23.8	0.48
Control (without fertilizer)	19.5	0.73	32.5	0.93	26.0	0.83

In the experiments, where the seed inoculation was not performed, the nodules on the roots of soybean plants were also formed. This indicated that there were free-living nodule bacteria, virulent for soy, in the soil of the experimental site. This was quite understandable, given that soybean was cultivated in the experimental area in previous years. This is all the more interesting because a positive effect of Nitragin KM has been shown on such soil, which has improved the development of soybean plants in both years of research (Table 2).

The seed treatment with Nitragin KM caused a more intensive increase in the height, mass and leaf coverage of soybean plants. This, of course, is due to the improvement of their nitrogen nutrition. The same regularity in the increase in the mass and leaf coverage of plants was also evident in the ammonium nitrate nitrogen fertilizer. However, the introduction of nitrogen fertilizer contributed to some reduction in plant height in comparison with the control, which was explained by an increase in their branching.

Table 2: Plant condition in the sowings of Belgorodskaya 8 soybean with the use of Nitragin KM, ammonium nitrate and without them in the phase of bean formation.

Option	2015	2016	Average
	Period from rising to ripening, days		
Nitragin KM	101	103	102
Ammonium nitrate	115	117	116
Control	110	112	111
	Plant height In the bean formation phase, cm		
Nitragin KM	52.3	94.1	73.2
Ammonium nitrate	47.8	78.9	63.4
Control	48.9	91.0	70.0
	Air-dry mass of the plant in the bean formation phase, g		
Nitragin KM	24.8	25.6	25.2
Ammonium nitrate	20.4	20.8	20.6
Control	15.4	15.9	15.6
	Leaf area in the bean formation phase, cm^2		
Nitragin KM	1,123	1,191	1,157
Ammonium nitrate	986	976	981
Control	966	821	894

It was found that nitraginization of soybean seeds significantly shortened the vegetation duration of soybean plants, accelerating their ripening in comparison with the control for 9 days (by 8.1%). This interesting trend manifested itself both in the arid 2015 and in the wet 2016.

The introduction of ammonium nitrate increased the soybean growth period by 5 days compared to the control and by 14 days (by 12.6%) – with respect to the use of Nitragin KM. This biopreparation effect is evidently due to the presence of stimulants, biologically active substances, macro- and microelements in it, which not only increases the fixation of atmospheric nitrogen, but also increases the intensity of physiological processes that ensure the acceleration of ripening with high plant productivity (Table 3).

Table 3: Elements of Belgorodskaya 8 soybean production structure, cultivated with and without Nitragin KM, ammonium nitrate.

Option	Number of beans on the plant, pcs.	Number of seeds on the plant, pcs.	Number of seeds in a bean, pcs.	Seed weight on the plant, g	Weight of 1,000 seeds, g
2015					
Nitragin KM	19.8	42.6	3.2	5.7	134
Ammonium nitrate	18.3	39.4	2.9	5.1	130
Control	17.9	38.2	2.8	5.0	131
2016					
Nitragin KM	24.7	49.8	2.3	6.5	131
Ammonium nitrate	22.4	45.5	2.0	6.0	131
Control	21.5	43.2	2.0	5.6	131
Average for two years					
Nitragin KM	22.3	46.2	2.8	6.1	133
Ammonium nitrate	20.4	42.5	2.5	5.5	131
Control	19.7	40.7	2.4	5.3	131

Nitragynization of seeds, increasing the build-up of the above-ground mass, caused the formation of a greater number of beans and seeds, contributed to an increase in the number of seeds in the bean and the seed weight on the plant. This trend was noted in both studies.

In relation to control, the number of beans on the plant increased by an average of 2.6 pcs. (by 13.2%); the number of seeds –by 5.5 pcs./plant (13.5%), the number of seeds in the bean –by 0.4 pcs. (16.7%), the seed weight on the plant –by 0.8 g (15.1%).In 2015 there was a trend to increase the weight of 1,000 seeds –by 3 g (2.3%). However, it did not manifest itself in 2016. The surface application of ammonium nitrate (2 c/ha) prior to budding of soybean plants less markedly increased the formation of elements of its productivity: average number of beans for 2 years –by 0.7 pcs./plant (by 3.6%), the number of seeds on the plant –by 1.8 pcs. (4.7%), the seed weight on the plant –by 0.2 g (3.8%). This, respectively, determined the different yields, and the quality of grain production of soybeans (Table 4).

Table 4: Yield, protein and oil content of Belgorodskaya 8 soybean, cultivated with the use of Nitragin KM, ammonium nitrate and without them.

Option	2015	2016	Average
Yield, c/ha			
Nitragin KM	22.6	38.8	30.7
Ammonium nitrate	21.5	36.9	29.2
Control	19.4	35.6	27.5
HCP_{05}	1.9	1.4	1.4
HCP_{05}	1.6	1.0	1.1
Protein content in grain products, %			
Nitragin KM	43.8	41.2	42.5
Ammonium nitrate	42.7	41.2	42.0
Control	40.8	38.3	39.6
Oil content in grain products, %			
Nitragin KM	24.1	22.6	23.4
Ammonium nitrate	23.3	21.0	22.2
Control	19.9	20.7	20.3

The soybean yield was highly dependent on weather conditions. It averaged 37.1 c/ha in terms of experience in wet 2016, and 21.2 c/ha in less moisture-proof 2015, that was, 15.9 c/ha or 75 percent less. Moreover, the relative yield decrease under arid conditions was significantly higher in the control option (without inoculation and fertilizers) (83.5%) than with the use of Nitragin KM (71.7%) and ammonium nitrate (71.6%).

Improvement of the soybean nitrogen supply caused not only an increase in stability, but in the magnitude of its yield as well. It was higher in both years of experience when using seed inoculation with Nitragin KM, that was, a biological source of nitrogen nutrition of soybeans with the help of nodule bacteria. On average, the yield of soybeans was 30.7 c/ha, which was 3.2 c/ha (11.6%) more than in control in this option for two years.

The mineral nitrogen fertilizer (N_{68}) increased the yield of soybean by 1.7 c/ha or by 6.2% in relation to the control. However, it was 1.5 c/ha (5.1%) less effective than seed inoculation with Nitragin KM.

The protein content in soybean grain production increased markedly with the improvement of nitrogen nutrition of plants, both by inoculation and late nitrogen fertilizing. Nitraginization of seeds increased the protein content of soybean grain production by 2.9 abs.% on an average in comparison with the control (from 39.6 to 42.5%), and slightly increased the application of ammonium nitrate by 2.4 abs.% (from 39.6 to 42.0%).

The protein harvesting in the soybean grain yield was significantly higher on average for two years with the use of Nitragin KM (1,122 kg/ha), less high (1,055 kg/ha) with the introduction of ammonium nitrate, and the smallest (935 kg/ha) - in the control (without inoculation and nitrogen fertilizing).

The oil content in the soybean seed yield also increased significantly, both with the use of Nitragin KM (by 3.1 abs. %), and ammonium nitrate (by 1.2 abs. %). The oil harvesting was also the greatest with the use of seed nitragination (618 kg/ha), less significant (557 kg/ha) - with the addition of ammonium nitrate and the smallest (479 kg/ha) - in the control.

The calculation of economic efficiency of the agro-methods studied showed that pre-sowing nitragination of seeds proved to be more effective, profitable and highly profitable agricultural method (Table 5).

Table 5: Economic efficiency of inoculation of Belgorodskaya 48 soybean seeds with Nitragin KM and top dressing of plants with ammonium nitrate, 2015-2016.

Option	Yield, c/ha	Cost of products, ths. roubles/ha	Production costs, ths. roubles/ha	Cost price, ths. roubles/ha	Profitability, roubles/ha	Level of profitability, %
Nitragin KM	30.7	67.31	24.88	8.10	42.43	170
Ammonium nitrate	29.2	64.02	27.31	9.35	36.72	134
Control	27.5	60.29	24.08	8.76	36.21	150

The relatively inexpensive domestic Nitragin KM, the market price of which is 2-3 times smaller than foreign analogs, has ensured higher yields with lower production costs and lower cost price, allowing the maximum profit (42.4 ths. roubles/ha) and the highest profitability (170%) in comparison with other options of the experiment.

The use of ammonium nitrate as an alternative to Nitragin KM ensured a smaller increase in the yield of soybeans due to a significant increase in production costs that raised the cost price and lowered the profitability of production. As a result, the cost price was 6.7% higher, and the level of profitability was 16% lower than in the control option (without inoculation and ammonium nitrate).

CONCLUTION:

The results obtained make it possible to draw the following conclusion.

1.Pre-sowing treatment of Belgorodskaya 8 soybean seeds with Nitragin KM, created in NTTS BIO LLC, significantly increased the number of active nitrogen-fixing nodules on plant roots. Their number in seed inoculation averaged 34 pcs./plant for 2 years, whereas without seed inoculation (control) - 25.0 pcs./plant. This increased the intensity of increasing of the air-dry mass of plants from 15.6 g to 25.2 g/plant; an increase in the leaf area - from 894 to 1,157 cm^2; an increase in the yield of soybeans from 27.5 to 30.7%. At the same time, the duration of soybean vegetation decreased from 111 (in control) to 102 days, the cost price decreased by 8.1%, the profit increased by 17.2%, the profitability increased by 20 abs. %.

2The introduction of ammonium nitrate (2 c/ha) shortly before soybean budding also contributed to an improvement in plant growth, leaf coverage and productivity, albeit to a lesser extent than seed nitragination. Mineral nitrogen increased the yield by 1.7 c/ha (6.2%), protein content - by 2.4 abs. %, oil content - by 1.9 abs. %. However, at the same time, production costs increased by 13.4%, the cost price increased by 6.7%, the level of profitability decreased by 16 abs. %.

3.Nitrogen fertilizing, if necessary, can be an alternative to seed inoculation, but it is better if it is used as an addition to it, especially when it have been planted little active nodules on the soybean roots for some reason.

4.The use of domestic Nitragin KM for soybean inoculation, the market price of which is 2-3 times less than foreign analogues, is a promising economically advantageous reserve for increasing the yield, protein content and seed oil content when cultivating a new Belgorodskaya 8 soybean genus (and not only).

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