

AGROECOLOGICAL EFFICIENCY OF SEED INOCULATION WITH BIOLOGICAL PRODUCTS AND COMPLEX FERTILIZERS WITH MICROELEMENTS IN RESOURCE-SAVING TECHNOLOGY OF CULTIVATION OF CLOVER OF PANNONIAN VARIETY ANIK

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Abstract

The article deals with the influence of biological products and complex fertilizers with microelements in a chelated form on the formation of parameters of photosynthesis, symbiotic activity and productivity of clover of the Pannonian variety ANIK. It was found that inoculation of seeds with biological products of the associative group and complex fertilizers with microelements in a chelated form activated growth, morphogenetic processes, symbiotic and photosynthetic activity of Pannonian clover plants. The number and weight of active nodules in relation to the control increased by 29.2-167.6 million pl./ha and 77.7-564.1 kg/ha, respectively. The maximum parameters of the symbiosis of the agroecosis of Pannonian clover (active nodules 221.8 million pl./ha with a weight of 893.7 kg/ha) were formed when clover seeds were inoculated with the biological product Gumariz together with the silicon-containing preparation NanoSilicon. The highest indicators of the leaf surface of clover, 53.6 thousand m²/ha, were observed during the complex seed treatment with Gumariz together with the NanoSilicon preparation, control - 28.7 thousand m²/ha. The highest productivity of Pannonian clover was obtained when seeds were inoculated with the biological product Gumariz together with the NanoSilicon preparation: dry matter - 12.48 t/ha, feed units - 9.05 t/ha, digestible protein - 1.39 t/ha; the yield of clover seeds was 786.8 kg/ha, which is 2.2 times higher than the control indicators; profitability for cultivation for seeds - 187.3%, for fodder purposes - 149.6%, energy efficiency coefficient - 2.24 and 1.89 units.

Key words: inoculation, Pannonian clover, biological products, productivity.

INTRODUCTION

The most important problem in agriculture is to increase the production of feed, improve its quality and energy saturation. As a result of the imperfection of the structure of the sown areas of forage crops, especially the low specific weight of leguminous grasses, the gross harvest and the quality of forage have now decreased.

Despite the richness of natural flora in the field cultivation of the country, the number of adaptive and productive forage legumes is still extremely small. Currently, no more than 25 species of plants are cultivated for fodder purposes, including perennial legumes - oriental goat's rue, red clover, Pannonian clover, alfalfa, sweet clover and others. The actual problem of modern plant growing is the search for the most effective growth regulators and optimal ways of using them.

Preparation of seeds of perennial legumes for sowing includes inoculation. Inoculation

consists in treating legume grass seeds with growth bioregulators, which include rhizotorfin, a preparation containing a culture of nodule bacteria. All seeds of perennial legumes, including Pannonian clover, are inoculated without fail, since there are no nodule bacteria in the soils at all that can enter into symbiosis with plants. For each culture, its own rhizotorfin is used, which is part of the growth biostimulant. It is necessary to process seeds with growth biostimulants with preparations of nodule bacteria immediately before sowing. Of the variety of ways of using biological products, namely, introduction into the soil, pre-sowing seed treatment and spraying of crops, pre-sowing seed treatment turned out to be the most acceptable for production, since it is well-technological, without requiring additional costs, while small doses of biological products are consumed (Kshnikatkina, 2020). Treatment of seeds before sowing with biological products activates the initial growth

processes, this contributes to a more intensive transition of seedlings from heterotrophic nutrition to autotrophic nutrition. There is an increase in germination energy by 1.2-5.3%, laboratory germination - 1.6-4.2%, sprout length - by 0.2-0.7 cm, embryonic root length - by 0.4-0.8 cm (Kshnikatkina, 2020). In addition, growth regulators have a multifunctional effect, since seeds at the time of germination have high plasticity and susceptibility to changes in environmental conditions.

There are four main forms of biologics: powder, granular, dry and liquid. Powder and dry biostimulants are not always effective, since they have low adhesion and uneven distribution on the seed surface, which affects the quality indicator of inoculation - processing completeness (at least 95%). In order for the particles to better adhere to the surface of the treated seeds, adhesives are added to the aqueous suspension of the preparation, which is not quite technological. Granular biological products are mainly introduced into the furrow during seed placement. With this method, bacteria can die due to high temperatures of the surface layer of the soil, a lack of moisture on the surface of the soil and an increased concentration of chemicals. The best in the method of seed treatment, in the method of application to the surface are liquid biological products, which are mixed with water and applied to the seeds.

According to the Penza Research Institute of Agriculture, an effective method for increasing the productivity of perennial legumes on soils poorly supplied with microelements is the treatment of seeds with liquid complex biological products Mikromak. The increase in dry matter yield of alfalfa variety Camellia of the 1st year of use was 26.2% and exchange energy - 31.8%, meadow clover variety Pelikan - 29.1%, 45.5% and 34, 9%, sweet clover of the hairy variety Solnyshko - 26.2%, 40.9% and 32.4%, respectively (Kshnikatkina et al., 2020). From the above it follows that the problem of strengthening the fodder base by pre-sowing treatment of seeds of perennial legumes with biological products in order to increase seed germination is relevant and practically significant for the agro-industrial complex of the Russian Federation.

In this regard, it is important to organize adaptive forage production due to highly productive new types of leguminous grasses, which have ecological plasticity, high nitrogen-fixing ability, high fodder values, rationally use the bioclimatic resources of the region, with sustainable seed production (Kshnikatkina, 2015; Kshnikatkina et al., 2018).

One of the main factors in the ecologization and biologization of agriculture is the fixation of nitrogen by the rhizome symbiosis of legumes. The use of biological nitrogen in agriculture provides a reduction in energy consumption, saving material resources, and reduces environmental pollution by products of nitrogen fertilizer degradation (Fedorov, 1952, Mishustin, 1979, Posypanov, 1993).

By optimizing the conditions for the functioning of the legume-rhizome symbiosis, it is possible to increase the efficiency of nitrification (Trepachev, 1980).

An important element of adaptive, resource-saving technologies of forage crops is the inoculation of seeds with bacterial preparations, the use of complex fertilizers with microelements in a chelated form and growth regulators that provide plants with missing microelements, contribute to an increase in the efficiency of legume-rhizome symbiosis, yield and resistance to stress factors of the external environment and pathogens (Kshnikatkina et al., 2013, Kshnikatkina et al., 2007). One of the directions is the use of nanotechnology, active nanoadditives, in which microelements are used as activators of metabolic processes and growth stimulators (Fedorenko, 2011, Semina et al., 2017).

In this regard, the study of an increase in the nitrogen-fixing activity of agrocenoses of the Pannonian variety ANIK is of scientific and practical importance.

Research goal is to study the effect of seed inoculation with bacterial preparations and complex fertilizers with microelements in a chelated form on the formation of parameters of symbiotic activity and productivity of Pannonian ANIK clover.

MATERIALS AND METHODS

The studies were carried out in LLC Agrofirma "Biokor-S" of the Mokshansk district of the

Penza region on leached medium-humus heavy loamy chernozem, the humus content in the arable layer is 6.5%, mobile phosphorus - 55 mg/kg of soil, exchangeable potassium - 177 mg / kg of soil, availability of mobile forms of micronutrient fertilizers are low, pH(KCL) 5.4. The object of research is Pannonian clover variety ANIK. The predecessor is winter wheat, the plot area is 15 m², the replication is four times, the distribution of plots is systematic. Seed inoculation with bacterial preparations and treatment with micronutrient fertilizers were carried out on the day of sowing. Experimental agrotechnics are generally accepted for perennial legumes in the Penza region. The concentration of the drug was taken according to the established recommendations: Megamix-Semena (2 l/t), Megamiks-Nitrogen (1 l/t). NanoSilicon (1 l/t), Cytovit (1 l/t), Simiplant (1 l/t), Humate K/Na (0.15 l/t), Agriculture + microelements (1 l/t), Rizotorfin 600 g, Gumariz 600 g (hectare norm).

The processing of seeds of clover of the Pannonian variety ANIK was carried out using environmentally friendly biotechnology and a fundamentally new design with an inoculator for pre-sowing treatment of seeds of perennial legumes with biological products. Treatment of seeds of perennial leguminous grasses with an inoculator with a high-pressure fog system with the completeness of seed treatment up to 100% and without damaging them, will increase the germination of seeds up to 98%. The high-pressure fog system (70 to 100 bar) produces a droplet with a diameter of 5-10 microns. Such a drop is kept in the working chamber for a long time, falls on the surface of the seed and easily penetrates to the embryo, thereby provoking the germination of the seed. This biotechnology makes it possible to use for processing any types of seeds of perennial legumes and any types of biological products in liquid form, since there is a system for preparing biostimulants before feeding them into the working chamber. Spray humidification with control and management of the moisture level will prevent excessive waterlogging of seeds during treatment with an inoculator before sowing and immediately sow them into the soil. The technological scheme of the inoculator is based on the following technical solutions:

- for transporting seeds inside the working chamber in the form of a pipe, an axleless screw auger is used;

- for the treatment of seeds with biological products in the working chamber, a high-pressure fog system with nozzles is used.

The technological process of environmentally friendly biotechnology of inoculation of seeds of perennial legumes includes two devices:

- high pressure installation;

- seed inoculator.

The experiments were set up and the studies were carried out in accordance with the methodological instructions (Dospekhov, 1989, Bogomazov, 2014).

RESULTS AND DISCUSSIONS

Seeds at the moment of germination have high plasticity and susceptibility to changes in environmental conditions, therefore, inoculation of Pannonian clover seeds with bacterial preparations and treatment with micronutrient fertilizers had a multifunctional effect. Field germination on average for two years in relation to the control increased by 5.6-12.4%.

The greatest stimulating effect was exerted by the treatment of seeds with the biological product Gumariz together with the microelement fertilizer NanoSilicon, the indicators of field germination increased by 12.6%, the safety of plants at the end of the growing season - 13.2%, after overwintering - 12.6%, the mass of dry roots increased by 2, 4 times.

When analyzing the formation of symbiotic activity of agrocenoses of Pannonian clover of the first year of use, it was found that inoculation of seeds with biological products and microelement fertilizers promoted the activation of symbiotic activity, the number and mass of active nodules in relation to the control according to the variants of the experiment increased by 29.2-167.6 million pcs. and 77.7-564.2 kg/ha. The maximum parameters of symbiosis of agrocenosis of active Pannonian clover nodules of 221.8 million pcs/ha with a weight of 893.7 kg/ha were formed when clover seeds were inoculated with Gumariz together with NanoSilicon preparation. Similar indicators of symbiotic activity differ in agrocenoses of second-year Pannonian clover.

The largest number of active nodules is 275.4 million pcs/ha with a mass of 1105.

Table 1. The number and mass of active nodules of agrocenoses of Pannonian clover (budding phase)

Option	First year (2019-2020)	Second year (2020)
Without processing(k)	54.2 / 329.6	68.2 / 411.6
Rhizotorfin seed treatment	83.4 / 407.3	105.3509.7
Seed treatment with Humariz	167.6 / 598.4	210.4 / 998.6
NanoSilicon	184.7 / 668. "	235.6 / 832.8
Megamix-Seeds	179.6 / 658.3	226.7 / 82.5
Citovit	177.2 / 656.5	220.3 / 818.9
Rizotorfin + NanoSilicon	218.2 / 883.5	275.4 / 1105.8
Rizotorfin_Megamix-Seeds	212.8 / 848.6	264.3 / 1060.3
Rizotorfin + Cytovit	206.8 / 813.7	258.9 / 1018.4
Gumariz + NanoSilicon	221.8 / 893.7	283.4 / 1119.6
Gumariz + Megamix-Seeds	217.6 / 878.9	274.3 / 1098.7
Gumariz + Citovit	212.7 / 844.6	362.7 / 1059.3

A.A. Nichiporovich (1970) claims that in the process of photosynthesis up to 90-95% of dry biomass of plants is formed, therefore, this process plays a leading role in the formation of the yield (Nichiporovich, 1970).

The search for methods that provide favorable conditions for the absorption and maximum use of solar energy is an urgent task. Studies have shown that bacterial preparations and microelement fertilizers provide an increase in the parameters of photosynthesis of Pannonian clover agrocenoses. Thus, the leaf area of agrocenoses of Pannonian clover of the first year of use according to the experimental options, on average for two years, amounted to 37.6-53.6 thousand m²/ha, in relation to the control increased by 8.9-24.9 thousand m²/ha or 1.3-1.9 times. The highest indices of the leaf surface of Pannonian clover, 53.6 thousand m²/ha, are different when seeds are inoculated with Gumariz together with the preparation NanoSilicon, control - 28.7 thousand m²/ha (Table 2).

Optimization of the conditions of legume-rhizobaric symbiosis, intensive formation of photosynthesis parameters, caused by exogenous treatment of seedlings with biological products and complex microelements, contributed to an increase in the productivity of Pannonian clover.

Table 2. Photosynthetic activity of Pannonian clover agrocenoses

Option	Leaf area, thousand m ² /ha		FP, mln m ² days/ha		PPF, g/m ² per day	
	First year p. (2019-2020)	Second year (2020)	First year p. (2019-2020)	Second year (2020)	First year p. (2019-2020)	Second year (2020)
Without seed treatment	28.7	36.2	1.58	1.19	2.91	3.34
Rhizotorfin seed treatment	37.6	43.7	1.62	1.86	2.98	3.39
Seed treatment with Humariz	43.2	48.6	1.79	2.06	3.92	4.58
NanoSilicon	44.6	50.8	1.98	2.23	4.28	4.82
Megamix-Seeds	44.3	49.4	1.91	2.14	4.16	4.65
Citovit	43.9	48.7	1.89	2.11	4.13	4.58
Rizotorfin + NanoSilicon	49.5	55.9	2.18	2.49	4.82	5.35
Rizotorfin + Megamix-Seeds	48.2	54.8	2.05	2.41	4.73	5.17
Rizotorfin + Cytovit	47.5	53.6	2.01	2.36	4.59	5.08
Gumariz + NanoSilicon	53.6	60.5	2.29	2.58	5.06	5.87
Gumariz + Megamix-Seeds	52.1	58.9	2.13	2.43	4.92	5.68
Gumariz + Citovit	51.9	57.2	2.08	2.39	4.81	5.78

On average, over two years, the collection of dry matter of Pannonian clover of the first year of use according to the options of the experiment was 7.29-12.48 t/ha, feed units - 5.25-9.05 t/ha, digestible protein - 0.81 - 1.39 t/ha, exchangeable energy - 58.69-100.47. The highest productivity of Pannonian clover was obtained when seeds were inoculated with a biological product Gumariz together with NanoSilicon: dry matter - 12.48 t/ha, feed units - 9.05 t/ha, digestible protein - 1.39 t/ha. Control, respectively - 5.35, 3.86, 0.60 (Table 3).

With the complex exogenous treatment of seeds with the biological product Gumariz, together with the microelement fertilizers NanoSilicon, Megamiks-Semena and Tsitovit, more favorable conditions were formed for the formation of structural elements and seed productivity of clover of the Pannonian variety ANIK than with mono-treatment with the studied agrochemicals.

Table 3. Productivity of Pannonian clover

Option	First year of use			Second year of use			Seed yield, kg/ha		
	SV, t/ha	Feed units, t/ha	PP, t/ha	OE, GJ	SV, t/ha	Feed units, t/ha		PP, t/ha	OE, GJ
Without seed treatment	5.35	3.86	0.60	42.85	5.84	4.18	0.65	46.6	359.4
Rhizotorfin seed treatment	7.29	5.25	0.81	58.69	7.75	5.58	0.87	62.1	528.6
Seed treatment with Humariz	9.28	6.69	1.03	74.72	10.15	7.27	1.13	81.3	658.9
NanoSilicon	9.76	7.05	1.08	78.59	10.68	7.65	1.19	85.5	667.5
Megamix-Seeds	9.46	6.84	1.05	76.16	10.35	7.42	1.16	82.9	658.3
Citovit	9.39	6.74	1.04	75.61	10.27	7.36	1.15	82.2	650.2
Rizotorfin + NanoSilicon	11.06	7.96	1.23	89.05	12.10	8.67	1.35	96.9	716.8
Rizotorfin + Megamix-Seeds	10.23	7.35	1.14	82.36	11.19	8.02	1.25	89.6	704.5
Rizotorfin + Cytovit	9.76	7.08	1.09	78.58	10.68	7.65	1.19	85.5	698.7
Gumariz + NanoSilicon	12.48	9.05	1.39	100.47	13.65	9.78	1.52	109.3	786.8
Gumariz + Megamix-Seeds	11.89	8.57	1.32	95.72	13.01	9.32	1.04	104.2	774.6
Gumariz + Citovit	11.28	8.14	1.26	90.81	12.34	8.84	0.97	98.8	762.8

At the same time, the number of generative shoots according to the variants of the experiment was 4.18-4.72 million pcs/ha, seeds in the head - 43-49 pieces, seeds per plant - 179-223 pieces, productivity of an individual plant - 0.69 - 0.98 g, weight of 1000 seeds - 3.96-4.25 g.

Yield is an integral indicator characterizing the influence of various factors on growth, morphogenesis and physiological-biochemical processes in plants.

The yield of seeds of Pannonian clover of the first year of use on average for two years varied according to the variants of the experiment from 528.6 to 786.8 kg/ha, the excess in relation to the control was 169.2-437.4 kg/ha. The highest yield of seeds of Pannonian clover 786.8 kg/ha was obtained with complex seed inoculation with the biological product Gumariz together with NanoSilicon, which is 2.2 times higher than that of the control variant (Table 3).

The greatest economic and energy effect was obtained with the binary treatment of Pannonian clover seeds with the bacterial preparation Gumariz together with the microelement fertilizer NanoSilicon, when cultivating for seeds the level of profitability was 187.3%, for fodder purposes - 149.6%, the energy efficiency coefficient, respectively - 2.24 and 1.89 units.

CONCLUSIONS

Inoculation of seeds with bacterial preparations and complex microelement fertilizers contributed to an increase in seed and fodder productivity of clover of the Pannonian variety ANIK.

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