THE INFLUENCE OF BIOORGANIC PREPARATIONS ON PLANT PRODUCTIVITY AND SOIL QUALITY

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Abstract:. *The global problem is that despite even the best efforts to eat a healthy balanced diet, most of our food sources no longer contain all necessary micronutrients, fulvic, humic and bio-active organic acids, minerals and other phytonutrients our bodies need to stay healthy because of soil degradation due to intensive industrial agriculture practics. Degraded soils cause poor nutrition value plants and poor nutrition value food cause human physical and mental degeneration. One of the ways to solve the problem is humic and fulvic acid preparations. The field experiment was conducted in 2016-2017 at the Rumokai Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry on a Bathihypogleyi-Calc(ar)ic Luvisol (LVk-gld-w) with predominant silt loam on clay loam. Mineral Ful and Ferbanat L were tested in the experiment. Mineral Ful is a high bioactive fulvic complex with 33 organic acids, and over 70 micronutrients that is free of chemicals. Mineral Ful produced water extraction method of leonardite. Ferbanat L contain humic and fulvic acids, vitamins, amino acids, enzymes, micro and macro elements and beneficial soil microorganism. The preparation obtained by the result of the transformations of organic waste by used of the worms. Test preparations had the influence on humus content in the soil. Mineral Ful and Ferbanat L increased sugar beets root yield from 1.33 to 7.11 t ha^{-1}. Cereal grain yield increased 2.6-1.,0 %.*

KEY WORDS: BIOLOGICAL PREPARATIONS, HUMUS, HUMIC ACID, SUGAR BEET, CEREAL CROPS

1. *Introduction*

Currently, farmers are widely using intensive field cultivation technologies. Abundant fertilisation, the use of pesticide and a failure to adhere to crop rotation causes a degradation of the soil. Negative changes of the soil biota and its biochemical processes take place as a result of a biological misbalance. This becomes a limiting factor for achieving the potential fertility of plants.

However, the optimum fertilisation based on a scientific understanding can help improve the quality of the soil and ensure its sustainable use [9, 6]. Not only the necessary quantities of various microelements that can be supplied to plants but also the quantity of the water, nutrients and air in the soil, as well as its temperature and the microbiological activity, can be adjusted by partially replacing chemical fertilisers with organic ones [4, 6]. One of the ways to increase the activity of the soil and the productivity of plants is to use biological preparations and bioorganic fertilisers [15, 11]. Such preparations activate the natural morphophysiological processes of plants and supply them with complete nutrients [10]. However, it is necessary to consider not only the influence of such biological preparations on the plants' fertility but also the fact that they improve the quality of the soil. Diseases spread less in healthy soil; therefore, fewer protective preparations are needed for the plants, and the environment becomes less polluted [13, 11]. Studies have shown that it is normally not possible to increase soil organic matter by more than 1 percent, but even an increase of this much can dramatically improve soil fertility [8]. During the formation of soil organic matter, nutrients such as nitrogen (N), phosphorus (P), and sulphur (S) are incorporated into the soil structure, allowing the soil to act as a reservoir of these and other nutrients.

Various biologically active agents of a natural origin have been developed during recent years, i.e. biostimulators which allow a reduction in the use of fertilisers and other chemicals in agriculture [14, 5]. Usually, biostimulators are made of natural raw materials and they contain elements of mineral nutrition, biologically active compounds and the spores of beneficial microflora. There are plenty of biostimulators, the main component of which is humic substances. They are used both by inserting them into the soil and by spraying them on the plant leaves. Due to their physical, chemical and biological properties, the humic and fulvic acids activate and improve the vitality of the microflora and microfauna in the soil and stimulate its activity, as well as having a positive impact on germination, strengthening the growth of the root system (especially deeper down) and developing the plants' immunity, thus improving the resistance to diseases and helping the plants absorb microelements.

2. *Objects and methods*

The field experiment was conducted in 2016-2017 at the Rumokai Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry. A spring barley cultivar 'Grace' was grown, the seed rate was 4.0-4.5 million ha-1. The sowing was carried out on 10-11 April. Preceding crop – sugar beets. Spring barley was harvested on 14-24 August. Spring barley was grown according to intensive technology, N100P60K60 fertilisers were applied before crop sowing. A sugar beet cultivar 'Lavenda' was grown. The pre-crop was winter wheat. The crop was sown on 15-20 April with a drill at a sowing density of 6–7 pelleted seeds per longitudinal meter with 45 cm interrow width. The sugar beet was grown in compliance with the recommendations of Institute of Agriculture [7]. Sugar beet was harvested on 10-14 October.

Soil was Bathihypogleyi-Calc(ar)ic Luvisol (LVk-gld-w) with predominant silt loam on clay loam. The top of the carbonate horizon and the gleyicity traces were determined at the 60 cm depth. The pH value in the arable soil layer ranged from 6.4 to 6.6. Soil pH was determined in 1 N KCL extraction using a potentiometric method. The content of plant-available P2O5 at the 0-20 cm layer was 239.0-268.0 mg kg^{-1} and the content of plant-available K_2O was 183.0-194.0 mg kg^{-1}. The content P_2O_5 and K_2O was determined using Egner-Riehm-Domingo (A-L) method.

Two preparations were used in our research: Mineral Ful and Ferbanat L. Mineral Ful is a high bioactive fulvic complex with 33 organic acids, and over 70 micronutrients that is free of chemicals. Mineral Ful produced water extraction method of leonardite. The organic biostimulator Ferbanat L. is made of a biologically clean natural raw material – vermicompost (a decomposed organic waste processed by earthworms) – using modern technologies which are based not on a chemical but on a physical effect. The use of vermicompost extracts improves the growth and development of plants [3, 1, 2]. Ferbanat L. contains: 0.058 percent nitrogen, 0.05 percent phosphorus and 0.37 percent potassium, 38.36 percent organic carbon, 18.60 percent humic and 2.47 percent fulvic acids. It also contains microelements, biologically active agents of a natural origin, beneficial microflora and microorganisms such as: bacteria, fungi, yeast, algae, etc.

Meteorological conditions. The average day temperature of April in 2016 was +7.8°C, it is close to standard climate normal (SCN). The precipitation was 56,6 mm (SCN – 36 mm). Warm and humid weather after the sowing was favorable for the sugar beets and spring barley germination. The weather of May was warm. The precipitation of the month was close to SCN, although all precipitation (36.7 mm) occurred in the 2st decade. June and July were warm with sufficient amount of precipitation. The temperature in August was close to SCN, the precipitation was 104.0 mm (SCN – 81 mm). The big amount of precipitation made it very difficult to harvest barley. The weather of September was favorable for raising sugar beets; the average day temperature was close to SCN, without significant fluctuations, the amount of precipitation was close to SCN.

The average day temperature of April in 2017 was +6,2 °C. The amount of precipitation was 65,7 mm. Although all precipitation occurred in the 1st and 2st decades, therefore, the sowing of plants was delayed. Could and dry weather of May impeded the germination and development of plants. June and July were warm and dry. The weather of September was warm. The amount of precipitation was 119,7 mm (SCN – 72 mm).

The data of the research were evaluated using the dispersion analysis method (ANOVA) with the SELEKCIJA software package [12].

3. Results and discussion

Mineral Ful and Ferbanat L were tested in sugar beet crops.

The number of sugar beet plants after germination were 99.36-109.94 thousand plants per hectare (Table 1). The Ferbanat L fertilizer was applied at a later stage of beet growth and therefore had no influence on germination. Mineral Ful increased number of plants 2.1 – 3.2 %. The density of the sugar beets before harvesting them varied from 90.00 to 105.83 thousand plants per hectare in the experiment with Ferbanat L. The plants were stronger and more resistant to unfavourable environmental conditions in the sections where the Ferbanat L fertiliser was used. 0.04 – 2.80% of the plants perished during their vegetation in these sections while 9.40% perished in the control sections.

Table 1*. The effect of bioorganic preparations on sugar beet density*

Treatment	Number of plants, 1000 ha^{-1} after germination	Number of plants, 1000 ha^{-1} before harvesting	Change in plant number during vegetation, %
Ferbanat L			
Control	99.36	90.00	-9.40
FL 3 lha^{-1} BBCH 12-14+ FL 2 lha^{-1} BBCH 18-20 + FL 2 lha^{-1} BBCH 35	103.00	102.96	-0.04
FL 2 lha^{-1} BBCH 12-14+ FL 2 lha^{-1} BBCH 18-20 + FL 1 lha^{-1} BBCH 35	100.58	97.78	-2.80
FL 1 lha^{-1} BBCH 12-14+ FL 1 lha^{-1} BBCH 18-20 + FL 1 lha^{-1} BBCH 35	105.83	105.63	-0.20
LSD_{05}	5.854	3.874	
Mineral Ful			
Control	106.57	105.24	-1.25
MF 1 lha^{-1} before sowing + MF 1 lha^{-1} BBCH 14-16 + MF 1 lha^{-1} BBCH 18-20	108.77	108.89	+0.11
MF 1.5 lha^{-1} before sowing + MF 1 lha^{-1} BBCH 14-16 + MF 1 lha^{-1} BBCH 18-20	109.63	105.41	-3.85
MF 2 lha^{-1} before sowing + MF 1 lha^{-1} BBCH 14-16 + MF 1 lha^{-1} BBCH 18-20	109.94	106.15	-3.44
LSD_{05}	4.215	5.378	

The harvest of the root crops varied from 83.41 to 101.26 t ha^{-1} (Table 2.). The highest harvest was obtained when the sugar beets were fertilised with Ferbanat L three times during their vegetation using the maximum amount of fertiliser (3+2+2 lha^{-1}). The highest harvest with Mineral Ful was obtained when sugar beets were fertilised using the average rates of fertiliser (1.5+1.0+1.0 lha^{-1})

The sugar content of the root crops varied from 18.00 to 18.57%. A trend of a reduction of the sugar content was observed when using the Ferbanat L fertiliser. However, these changes were small and insignificant. Mineral Ful increased sugar content 0.8-1.5%, however, however, this increase was not statistically significant.

The highest amount of white sugar (15.52 tha^{-1}) was obtained when the sugar beets were fertilised with Ferbanat L three times during their vegetation using the maximum amount of fertiliser. Ferbanat L increased the white sugar yield 1.6-4.0% and Mineral Ful – 5.2-9.7% compared to control sections.

Table 2*. The effect of bioorganic preparations on sugar beet on sugar beet root yield and sugar content*

Treatment	Root yield t ha^{-1}	Sugar content, %	White sugar yield t ha^{-1}
Ferbanat L			
Control	97.11	18.22	14.92
FL 3 lha^{-1} BBCH 12-14+ FL 2 lha^{-1} BBCH 18-20 + FL 2 lha^{-1} BBCH 35	101.26	18.00	15.52
FL 2 lha^{-1} BBCH 12-14+ FL 2 lha^{-1} BBCH 18-20 + FL 1 lha^{-1} BBCH 35	98.44	18.07	15.16
FL 1 lha^{-1} BBCH 12-14+ FL 1 lha^{-1} BBCH 18-20 + FL 1 lha^{-1} BBCH 35	100.49	18.18	15.51
LSD_{05}	3.075	0.456	0.487
Mineral Ful			
Control	83.41	18.29	13.23
MF 1 lha^{-1} before sowing + MF 1 lha^{-1} BBCH 14-16 + MF 1 lha^{-1} BBCH 18-20	87.41	18.49	13.92
MF 1.5 lha^{-1} before sowing + MF 1 lha^{-1} BBCH 14-16 + MF 1 lha^{-1} BBCH 18-20	90.52	18.43	14.37
MF 2 lha^{-1} before sowing + MF 1 lha^{-1} BBCH 14-16 + MF 1 lha^{-1} BBCH 18-20	89.33	18.57	14.51
LSD_{05}	2.891	0.387	0.401

In spring barley crops was tested only Ferbanat L.

The count of the productive stems varied from 802 to 875 number m^{-2} in our investigation (Table 3). The most productive stems were produced in the sectors where the Ferbanat L fertiliser was sprayed three times during the vegetation of plants at 2 l ha^{-1}. When the crops were sprayed with 3 l ha^{-1} Ferbanat L during the BBCH 12-14, 2 l ha^{-1} during the the BBCH 23-29 and with the amount of Ferbanat L reduced to 1 l ha^{-1} during the the BBCH 32-33, the barley had 5.8% less productive stems than in the control sections. This can be explained by the fact that larger quantities of fertiliser in the beginning of the vegetation intensified the tillering of the barley; however, they later lacked the nutrients needed for the development of stems. Ferbanat L had no statistically significant effect on number of grains per ear.

The Ferbanat L fertiliser had the tendency to increase the 1000 grain weight. The highest mass of 1000 grains were found in the sectors when the crops were sprayed with 3 l ha^{-1} Ferbanat L during the BBCH 12-14, 2 l ha^{-1} during the the BBCH 23-29 and with the amount of Ferbanat L reduced to 1 l ha^{-1} during the the BBCH 32-33

***Table 3**. The effect of Ferbanat L on spring barley productivity indicators*

Treatment	Number of productive stems per m^{-2}	Number of grains per ear	1000 grain weight g
Control	851	20.6	49.33
FL 3 lha^{-1} BBCH 12-14+ FL 2 lha^{-1} BBCH 23-29 + FL 1 lha^{-1} BBCH 32-33	802	21.1	51.01
FL 2 lha^{-1} BBCH 12-14+ FL 2 lha^{-1} BBCH 23-29 + FL 2 lha^{-1} BBCH 32-33	875	20.5	50.50
FL 2 lha^{-1} BBCH 12-14+ FL 2 lha^{-1} BBCH 23-29 + FL 2 lha^{-1} BBCH 339	873	20.7	50.07
LSD_{05}	33.01	0.60	0.67

In our research, the yield of spring barley varied from 6.572 to 7.232 t ha^{-1} (Table 4). The biggest yield of grains was obtained when the spring barley was additionally fertilised by the Ferbanat L fertiliser three times during its vegetation at 2 l ha^{-1} (with the last fertilisation during the stage of the flag leaf BBCH 39).

The amount of protein in the grains varied from 11.2 to 11.5%. A higher protein content was obtained in the sectors where the Ferbanat L fertiliser was sprayed on the barley for the last time during the stage of the flag leaf. The usage of nutrients on the flag leaf improves the quality of the grains, which is supported by the research conducted by other scientists. The weight of the dry measure increased by 0.5-2.1% after the use of the Ferbanat L fertiliser.

***Table 4**. The effect of Ferbanat L on spring barley yield and quality*

Treatment	Grain yield t ha^{-1}	Increase %	Crude protein %
Control	6.572	-	11.2
FL 3 lha^{-1} BBCH 12-14+ FL 2 lha^{-1} BBCH 23-29 + FL 1 lha^{-1} BBCH 32-33	6.884	0.312	11.3
FL 2 lha^{-1} BBCH 12-14+ FL 2 lha^{-1} BBCH 23-29 + FL 2 lha^{-1} BBCH 32-33	6.753	0.181	11.3
FL 2 lha^{-1} BBCH 12-14+ FL 2 lha^{-1} BBCH 23-29 + FL 2 lha^{-1} BBCH 339	7.232	0.660	11.5
LSD_{05}	0.222		0.62

We sampled the soil after the harvesting in order to identify the influence of biopreparations on the pH and humus of the soil (Table 5.) Ferbanat L had no effect on soil quality. Mineral Ful in 2016 increased amount of humus and humic acid. In 2017 this preparation had no effect on the amount of humus but increased amount of humic acid, too.

***Table 5**. The effect of the biopreparations on quality of the soil*

Treatment	pH	Humus %	Humic acids %	Fulvic acids %
	2016			
Control	6.8	2.21	0.28	0.14
Ferbanat L	6.7	2.25	0.26	0.16
Control	7.0	2.00	0.24	0.10
Mineral Ful	7.1	2.65	0.36	0.12
	2017			
Control	6.4	1.89	0.21	0.10
Ferbanat L	6.5	1.92	0.23	0.09
Control	6.1	1.70	0.14	0.04
Mineral Ful	6.1	1.72	0.19	0.05

4. Conclusion

In our research, the organic biopreparations Ferbanat L and Mineral Ful increased sugar beets root yield from 1.33 to 7.11 t ha^{-1}. Mineral Ful improved quality of sugar beet root: sugar content increased 0.8-1.5%. The organic biostimulator Ferbanat L increased the spring barley grain yield 2.6-10.0 %.

Mineral Ful increased the amount of humus and humic acids content in the soil.

5. *Reference*

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