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FORMATION OF CORN PRODUCTIVITY DEPENDING ON THE USE OF MODERN BIOLOGICAL FERTILIZERS IN THE FOREST-STEPPE RIGHT BANK

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Corn is one of the oldest agricultural crops. It is one of the most productive cereals of universal purpose, which is grown for food, feed and technical purposes. In the countries of the world about 20% of corn grain is used for food needs, 15-20% for technical needs, 60 - 65% for fodder for farm animals.

In our country, corn is the most important fodder crop. At its expense, livestock is provided with concentrated feed, silage and green mass. The most valuable feed is corn grain, which contains 9-12% protein, 65-70% carbohydrates, 4-8% oil, 1.5% minerals. 100 kg of it contains 134 feeds, units, up to 8 kg of digestible protein.

In the current conditions of agricultural production, biological fertilizers and drugs with different mechanisms of action on plants are in increasing demand among agricultural producers. Particular attention is paid to biological products that promote the active settlement of root and root zone mycorrhizal fungi and saprophytic rhizosphere bacteria, one of which is Melanoriz and complex fertilizers based on potassium humate type Gumifrend, which are created with additional content of beneficial microorganisms and their products. These biological preparations ensure the development of soil biota, increase soil fertility, while activating its suppression against phytopathogens, increase crop yields, including corn.

The research was conducted with the use of modern promising biological products, manufactured by BTU Center, which were used for pre-sowing seed treatment and application to foliar fertilization. Based on the obtained results, it was found that the treatment of seeds before sowing with Melanoriz with a rate of 3 l / t and the application of humic fertilizer Gumifrend (0.5 l / ha) and its combination with plant growth regulator Stimpo (25 ml / ha) provided the best plant productivity parameters. Under these growing conditions, the maximum plant height in the experiment was 236.1 cm, leaf surface area 44.6 thousand m 2 / ha, grain weight from the beginning of 152.6 g, weight of 1000 grains 286.6 g and grain yield 11, 75 t ha^{-1}.

Key words: *corn, fertilizer system, humic fertilizer, mycorrhizal agent, yield.*
Tab. 5. Lit. 9.

Formulation of the problem. High potential yields of corn determine its wide distribution in the world. In Ukraine, the area under corn has been gradually increasing in recent years. In particular, in 2021 it amounted to 5.3 million hectares. Maize yield in Ukraine is 6.0–9.0 t ha^{-1} of grain and 30.0–50.0 t ha^{-1} of green mass, but the potential is 10.0–14.0 t ha^{-1} of grain and 70.0–90, 0 t ha^{-1} of green mass [12].

Corn grain is a valuable concentrated feed for all farm animals and poultry: 1 kg corresponds to 1.34 feed units and contains 70 g of digestible protein. Grain, silage and green mass of corn are well digested and assimilated by animals: 100 kg of green mass of corn, collected in the stage of milk-wax ripeness, correspond to 32 feed units [1, 13].

In this regard, an important aspect of the use in the production of maize hybrids is to determine and apply the optimal parameters of their cultivation, specific only to specific biological types. In the complex of agrotechnical measures an important place is occupied by precursors, tillage, doses of mineral fertilizers, sowing dates, use of biological products and plant growth regulators and other technological factors [19, 34].

Recently, the interest of agricultural producers in modern mycorrhizal biopreparations such as Melanoriz is growing rapidly. Its feature is the formation of endo-ectomycorrhiza with high adsorption capacity, increased bactericidal and fungicidal action [4, 5].

An important issue in the cultivation of such a strategic crop as corn is a broader study of growth and development of plants, as well as the formation of their productivity depending on biological fertilizers and mycorrhizal biopreparation, which is studied for the first time in the region

Conditions and methods of conducting research. Field studies on the influence of biological preparations on the formation of corn productivity were conducted at the experimental field of the Faculty of Agronomy and Forestry of the Vinnytsia National Agrarian University, which is located in the center of the Vinnytsia region in the village of Agronomichne, the territory of the experimental field has a flat topography.

The aim of the work – is to establish the dependences of plant productivity and corn yield depending on the influence of complex fertilizers based on potassium humate Gumifrend and mycorrhizal biopreparation Melanorizin the experimental field of VNAU.

The soil cover of the experimental field is represented by gray forest medium-loam soils. The depth of the arable layer is 30 cm, the density is in the range from 1.33 to 1.42 g/cm 3. According to the results of agrochemical examination of the soil of the experimental field has the following physicochemical parameters: alkaline-hydrolyzed nitrogen content (according to Cornfield) - 62 mg / kg, humus content (according to Turin) 2.06%, exchangeable potassium (according to Chirikov) and mobile phosphorus, respectively, 80 and 149 mg per 1 kg of soil, pH salt. Hoods are 5.9. Hydrolytic acidity – 1.15 mg-eq per 100 g of soil.

The work program of scientific research was to study the peculiarities of growth, development and formation of grain productivity of corn depending on the treatment of seeds with biological products and foliar fertilization with complex fertilizers and its combination with plant growth regulator.

The ratio of the studied factors is 2: 3, the repetition of the experiment is four times. Placement of options is systematic in two tiers. Corn cultivation techniques are generally accepted for the forest-steppe zone, except for the factors studied.

In the experiment, seeds of maize hybrid P 8409 Brevant Seeds, which is characterized by high grain yield, were sown. Maturity group: medium early, use: grain / silage, grain type: siliceous type of adaptability: medium plastic.

Harvesting was carried out in the stage of full ripeness of the grain.

Table 1

Scheme of field experiment

Factor A - pre- sowing seed treatment	Factor B - pre-sowing seed treatment
1. Without proceesing (controle) 2. Melanoriz Seed treatment (3 l /t).	1. Spraying crops with water (control); 2. Spraying Gumifrend (0.5 l / ha); 3. Spraying Gumifrend (0.5 l / ha) + Stimpo (25 ml/ha).

the source is formed on the basis of own research results

According to the research program, the following observations and records were conducted in the field experiment:

- phenological observations were carried out in accordance with the "Methods of state varietal testing of crops." Stages of growth and development of plants were noted. The beginning of the stage was noted when it occurred in 10 % of plants and the complete stage in 75 % of plants;

- plant height was determined by measuring on pegged 25 plants in the main stages of growth and development of maize plants in two non- contiguous repetitions;

- leaf surface area was determined using the method of A.A. Nichyporowicha

- Mathematical processing of the obtained research results was performed using variance and correlation-regression analyzes using modern software packages Excel, Agrostat and Statistica;

- determination of economic efficiency was performed based on technological maps of corn cultivation.

Research results.

According to the results of our research conducted during 2020 - 2021 in the experimental field of VNAU, the height of corn plants increased depending on the treatment of seeds and foliar fertilizers.

The maximum height was recorded in the stage of milk ripeness and was 226,4 - 230,3 cm, and with the use of fertilizer Gumifrend increased to 231, 7 -234,5 cm. For use in the complex of humic fertilizer and growth stimulant plant height was 232,6 – 236,1 cm. The height of corn plants in the stage of 12 leaves in the control was 138.1 cm, and with the use of Melanoriz in increased to 140,2 cm When using Melanoriz in combination with Gumifrend + Stimpo height increased to 143.3 cm in the flowering stage, the height of plants was 219,2 cm in the control version, and with the use of a set of drugs Gumifrend + Stimpo plant height was 226.8 cm. see In the phase of milk ripeness, the height of corn plants was 226,4 cm, and with the use of foliar feeding Gumifrend + Stimpo height increased by 6,2 cm compared to the control variant. And due to the treatment of seeds, the height of corn increased to 230,3 cm. 9,7 cm.

Thus, based on the results of our research, it can be concluded that the maximum height of 236,1 cm of corn plants was achieved by pre- sowing treatment of mycorrhizal seeds with Melanoriz in combination with foliar fertilization with Gumifrend and Stimpo growth stimulant. An important condition for the formation

Table 2

Height formation by stages of growth of maize plants depending on seed treatment and foliar fertilization (average for 2020 - 2021), cm

Pre-planting treatment seeds (factor A)	Fertilizing over leaf (factor B)	Stages of growth		
		V12	VT	R3
Without processing	Without processing	138,1	219,2	226,4
	Gumifrend	139,6	225,9	231,7
	Gumifrend + Stympo	141,7	226,8	232,6
Melanoriz	Without processing	140,2	222,6	230,3
	Gumifrend	142,4	227,7	234,5
	Gumifrend + Stympo	143,3	229,4	236,1

the source is formed on the basis of own research results

of high yields of crops, including corn, is to increase the productivity of their photosynthesis, ie the amount of synthesized organic matter per unit area of leaf surface per day. One of the main tasks in achieving this goal is the formation of crops with the most developed leaf apparatus, which would be for a long time (maximum) in an active state both at the beginning and end of the growing season. It is known that a well-developed photosynthetic apparatus, optimal in terms of volume and dynamics of functioning, is one of the factors in obtaining high and stable yields of crops. It should be characterized by high intensity and productivity in all phases of plant growth and development [8].

The leaf area of corn in the phase of 12 leaves under control (without treatments) was 25.0 thousand m ^{2} / ha, which is 19.5% less than with the use of a complex of microfertilizers Gumifrend and biostimulator of plant growth Stimpo. And when using only Gumifrend, this figure increased by 14.0% compared to the control. With the use of mycorrhizal preparation Melanoriz for pre-sowing seed treatment, the leaf surface area increased to 25.3 thousand m ^{2} / ha. In the case of joint treatment of Melanoriz seeds and treatment of vegetative plants with the combination Gumifrend + Stimpo, the leaf surface area of corn was 30.1 thousand m ^{2} / ha. During the flowering phase, the leaf surface area under control increased to 39.2 thousand m ^{2} / ha. With the use of microfertilizer Gumifrend this figure increased by 10.4%, and with the use of microfertilizer in combination with biostimulator Stimpo growth leaf area increased to 44.7 thousand m ^{2} / ha. The leaf surface area in the phase of milk ripeness during the treatment of vegetative crops with the composition Gumifrend + Stimpo was 44.0 thousand m^2/ ha, which is 13.4% more than the control. And with the use of the drug Melanoriz leaf area was 39,3 thousand m ^{2} / ha. When combined with pre-sowing treatment with Melanoriz and treatment of vegetative plants Gumifrend + Stimpo leaf area was 44,6 thousand m 2 / ha, which is 13,4% more than only for seed treatment with Melanoriz and 14,9 % more than in the control. In the wax ripeness phase, the leaf surface area under control was 34,8 thousand m ^{2}/ha, which is 11,5% less than in the milk ripeness phase.

Table 3

Maize leaf surface area depending on seed treatment and foliar fertilization (average for 2020 - 2021), thousand m^2/ha

Pre-planting treatment seeds (factor A)	Fertilizing over leaf (factor B)	Stages of a plant			
		V12	Blooming	VT	R6
Without processing	Without processing	25,0	39,2	38,8	34,8
	Gumifrend	28,5	43,3	42,6	35,3
	Gumifrend + Stympo	29,7	44,7	44,0	40,3
Melanoriz	Without processing	25,3	40,0	39,3	34,6
	Gumifrend	28,8	45,2	43,2	37,4
	Gumifrend + Stympo	30,1	46,7	44,6	39,6

the source is formed on the basis of own research results

Structural elements of yield are an integral part of crop productivity of all crops, including corn. The impact of any agronomic measure on yields and product quality is directly reflected in these indicators. Some elements of the structure are more affected by technological operations, and the rest of the elements change less. The study of the regularity of changes in yield indicators will clearly assess the effectiveness of a particular agricultural measure. On average, over the years of research, a detailed analysis of crop structure elements showed that pre-sowing seed treatment and foliar fertilization had a direct impact on the formation of the main elements of corn harvest, namely the length and diameter of the beginning, cob weight and 1000 grain weight (Table 4).

During foliar feeding with Gumifrend + Stimpo, the length of the cob increased to 18.8 cm and its diameter to 5.5 cm, while the grain weight of the cob and the weight of 1000 grains increased to 143.9 g and 283.2 g, respectively.

The joint diameter of the cob increased to 5.7 cm, which is 0.3 cm more than the control, and the length of the cob increased to 19.2 cm, which is 0.9 cm. exceeded the control, while the weight of the grains of the cob was 152.6 g, which is 18.9 g more

Table 4

Individual productivity of corn plants depending on seed treatment and foliar fertilization (average for 2020 - 2021)

Pre-planting treatment seeds (factor A)	Fertilizing over leaf (factor B)	Hight of a Ear, cm	Diametr of a Ear, cm	Weight of the seeds from the Ear	1000 grain weight gr
Without processing	Without processing	18,3	5,4	133,7	275,3
	Gumifrend	18,6	5,5	141,5	280,4
	Gumifrend + Stympo	18,8	5,5	143,9	283,2
Melanoriz	Without processing	18,6	5,3	141,8	278,6
	Gumifrend	19,0	5,6	150,3	283,7
	Gumifrend + Stympo	19,2	5,7	152,6	286,6

the source is formed on the basis of own research results

control variant, and the weight of 1000 grains was 286.6 g, which is 11.3 g more than the control. Thus, based on the results of two years of research, it is established that under pre- sowing seed treatment with Melanoriz in combination with foliar fertilization with Gumifrend + Stimpo, the genetic potential of plants , including indicators of crop structure, is maximized.

The main indicator of the effectiveness of growing any crop is its yield. Problems of increasing the yield of corn plants are solved not only by breeding and genetic methods, fertilizers and pesticides, but also by regulators of plant growth, microfertilizers and bacterial preparations that are increasingly becoming integral elements of intensive corn cultivation technologies [7].

Carrying out growth regulators allows to realize the potential of corn plants, inherent in nature and selection, to improve product quality and increase yields [23].

Corn grain yields during the research period were higher in 2021. In the control, the average yield for 2020 - 2021 was 10.66 t ha^{-1}, and foliar fertilization with humic fertilizer increased the average yield by 0.43 t ha^{-1} compared to the control. In turn, the integrated implementation of microfertilizer Gumifrend and biostimulator of growth Stimpo increased the average yieldat 0.72 t ha^{-1}. During pre- sowing treatment of seeds of maize plants, the average yield increased to 11.02 t ha^{-1}, which is 0.36 t ha^{-1} higher than the control.

Table 5

Maize grain yield depending on seed treatment and foliar fertilization, t ha^{-1}

Pre-planting treatment seeds (factor A)	Fertilizing over leaf (factor B)	Years		An avarage	± before controle
		2020	2021		
Without processing	Without processing	9,94	11,37	10,66	-
	Gumifrend	10,33	11,85	11,09	0,43
	Gumifrend + Stympo	10,52	12,09	11,31	0,72
Melanoriz	Without processing	10,28	11,75	11,02	0,36
	Gumifrend	10,75	12,31	11,53	0,87
	Gumifrend + Stympo	10,97	12,53	11,75	1,09
LSD_{05} (t ha^{-1}) = A – 0,19 ; B –0,26 ; AB – 0,29 .					

the source is formed on the basis of own research results

The maximum yield of corn grain in the experiment of 11.75 t ha^{-1} was recorded in the complex application of foliar fertilization of plants with Gumifrend + Stimpo and pre-sowing seed treatment with Melanoriz. The increase in control was 1.09 t ha^{-1}.

The quality of crop products depends on the combined combination of many weather, climatic, soil and technological factors. In order to successfully regulate and improve the quality of grain products, it is necessary to carefully understand the processes that take place in plants in different phases of their growth and development in order to further regulate them. Depending on the direction of use of corn grain, the criteria for its evaluation by quality indicators are determined. If we consider the production of bioethanol, an important indicator is the high content of starch in grain, for food and feed purposes - the

content of protein and fat [22].

The chemical composition of corn grain differs from other cereals by lower protein content, higher fat content and significantly lower fiber content. Due to the high content of starch, fat and the least amount of fiber, the best digestibility of all corn nutrients is determined, especially nitrogen-free extractives, which make up the bulk of grain.

Corn grain contains relatively little low-quality protein due to the low content of critical amino acids - lysine and tryptophan. A very valuable energy component of feed for all species of animals is corn grain. Grain per unit mass contains the largest amount of metabolic energy.

In the grain of corn under control, the starch content was 74.04%, in the case of foliar fertilization with organo-mineral fertilizer and biostimulator of growth, the starch content was 71.76%. The content of crude fat in corn grain in the control variant was 4.35%, and in the application of microfertilizers and growth stimulants the content of crude fat was 4.15%. During the complex pre-sowing treatment of seeds with Melanoriz and foliar feeding with Gumifrend + Stimpo, the crude fat content was 4.57%.

The yield of crude fat in the control was 0.48 t ha^{-1}, and when carrying out foliar feeding with drugs Gumifrend + Stimpo yield of crude fat increased to 0.54 t ha^{-1}.

Table 6

Qualitative indicators of corn grain depending on seed treatment and foliar feeding (average for 2020 - 2021)

Pre-planting treatment seeds (factor A)	Fertilizing over leaf (factor B)	Starch content,%	Crude fat content,%	Crude fat content,%
Without processing	Without processing	74,04	4,35	9,83
	Gumifrend	73,01	4,46	10,47
	Gumifrend + Stympo	72,89	4,15	10,65
Melanoriz	Without processing	72,28	4,23	10,97
	Gumifrend	72,03	4,44	11,13
	Gumifrend + Stympo	71,76	4,57	11,37

the source is formed on the basis of own research results

The content of crude protein in the grain under control was 9.83%, and the yield of crude protein was 1.04 t ha^{-1}. During foliar feeding with Gumifrend + Stimpo, the crude protein content was 10.65%, and the yield of crude protein increased to 1.20 t ha^{-1}. The largest increase in crude protein content and yield of 11.37% and 1.42 t ha^{-1} was achieved due to the complex application of foliar fertilization with Gumifrend + Stimpo and pre-sowing seed treatment with Melanoriz.

Conclusions. Based on research, it was found that the maximum height of corn plants 236.1 cm was formed on variants where pre-sowing treatment of seeds with biological preparation Melanoriz in combination with foliar fertilizers with complex fertilizer Gumifrend and biostimulator Stimpo growth. The highest leaf surface area in the experiment of 44.6 thousand m 2 / ha was observed in the flowering phase

when treating vegetative plants with a combination of Gumifrend + Stimpo, which is more than the control by 14.9%.

Based on the experiment, it was found that the pre-sowing treatment of seeds Melanorize with foliar fertilization Gumifrend with plant growth regulator Stimpo, effectively reveals the biological potential of corn plants, including elements of crop structure, under these conditions the grain weight from the beginning was 152, 6 g and mass 1000 grains 286.6 g. The highest yield of corn grain in the experiment of 11.75 t ha^{-1} was formed with the combined use of foliar fertilization of plants with drugs Gumifrend + Stimpo against the background of pre-sowing treatment of seeds with mycorrhizal drug Melanoriz. Under these conditions, the increase in yield before control was 10.2%. It was found that in the experimental field of VNAU on gray forest soils the combination of seed treatment and foliar fertilization with the studied biofertilizers significantly improves the quality of corn grain and yield per unit area: starch, crude fat, protein.

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АННОТАЦІЯ

ФОРМУВАННЯ ПРОДУКТИВНОСТІ КУКУРУДЗИ ЗАЛЕЖНО ВІД ВИКОРИСТАННЯ СУЧАСНИХ БІОЛОГІЧНИХ ДОБРИВ В УМОВАХ ЛІСОСТЕПУ ПРАВОБЕРЕЖНОГО

Кукурудза – одна з давніх землеробських культур. Вона є однією з найбільш продуктивних злакових культур універсального призначення, яку вирощують для продовольчого, кормового і технічного призначення. У країнах світу для продовольчих потреб використовується приблизно 20 % зерна кукурудзи, для технічних 15-20 %, на корм сільськогосподарським тваринам 60 - 65 %.

У нашій країні кукурудза є найважливішою кормовою культурою. За її рахунок тваринництво забезпечується концентрованими кормами, силосом і зеленою масою. Найбільш цінний корм – зерно кукурудзи, яке містить 9 – 12 % білків, 65-70 % вуглеводів, 4 –8 % олії, 1,5 % мінеральних речовин. У 100 кг його міститься 134 корм, од., до 8 кг перетравного протеїну

В сучасних умовах розвитку аграрного виробництва все більшим попитом серед виробників аграрної продукції користуються біологічні добрива та препарати з різним механізмом дії на рослини. Особлива увага приділяється біологічним препаратам які сприяють активному заселенню кореневої та прикореневої зони мікоризними грибами та сапрофітними ризосферними бактеріями, одним із яких є Меланоріз та комплексним добривам на основі гумату калію типу Гуміфренд, які створені з додатковим вмістом корисних мікроорганізмів та продуктів їх метаболізму. Дані біологічні препарати забезпечують розвиток ґрунтової біоти, сприяють підвищенню родючості ґрунтів, при цьому активізують його супресивність по відношенню до фітопатогенів, підвищують рівень урожайності сільськогосподарських культур у тому числі і кукурудзи.

Дослідження проводились із використанням сучасних перспективних біологічних препаратів, виробництва компанії БТУ Центр, які використовувались для передпосівної обробки насіння і внесення у листове підживлення. На основі отриманих результатів встановлено, що обробка насіння перед сівбою препаратом Меланоріз з нормою використання 3 л/т та за внесення гумінового добрива Гуміфренд (0,5 л/га) та його поєднання із регулятором росту рослин Стимпо (25мл/га) забезпечили формування найкращих параметрів продуктивності рослин. За даних умов вирощування формувалась максимальна у досліді висота рослин 236,1 см, площа листової поверхні 44,6 тис. м^2 /га, маса зерна з качана 152,6 г., маса 1000 зерен 286,6 г. та урожайність зерна 11,75 т/га.

Ключові слова: *кукурудза, система удобрення, гумати, мікориза, урожайність.*

Табл. 6. Літ. 16.

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