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EFFICIENCY OF APPLICATION OF BIOTECHNOLOGICAL PREPARATIONS OF NITROGEN AND PHOSPHORIC NUTRITION OF WHEAT ON INDEXES OF QUALITY OF MACARONI FOODS

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The importance of cereals as a whole is outlined, the importance and benefits of spring durum wheat for the world economy and industry are highlighted. The reason for the unpopularity of growing durum wheat in Ukraine is given. The disadvantages of the application of mineral fertilizers in the cultivation of crops, affecting the ecological condition, quality of production, human health, were evaluated. An alternative to the use of mineral fertilizers – biological fertilizers – has been proposed. The main producer countries of durum wheat and Ukraine's place on the world market are indicated. The effect of microorganisms-diazotrophs and microorganisms-phosphate-mobilizers on the growth, development and yield of plants is briefly described. The biotechnology of nitrogen and phosphorus nutrition of plants is characterized. The microbial composition of the biological products has been investigated. Influence of biological preparations of nitrogen and phosphorus nutrition on quality of grain and pasta from spring wheat of Izolda and Spadshchyna was studied. The basic parameters of the experimental field are determined: precipitation distribution, the amount of productive moisture and other weather factors. The economic characteristics of the varieties involved in the study are given. The main indicators of quality of durum wheat grain and their standardized values are described. The influence of the content of grain components on the quality of final products is investigated. The description of the quality of pasta and the division into groups in accordance with the current regulatory and technical documentation. The effectiveness is analyzed and the application of biological and mineral fertilizers is compared. The use of new environmentally safe elements of technology for cultivation of spring durum wheat is proposed. *Key words:* spring wheat durum, pasta, nitrogen nutrition, phosphorus nutrition, Nitrogen, Phosphorus, variety Spadshchyna, variety Izolda, crop, quality of macaroni foods, grain quality indicators, biotechnology, *Azotobacter chroococcum*, *Azotobacter vinelandii*, *Azospirillum brasilense*, *Azospirillum lipoferum*, *Bacillus megaterium*, *Bacillus amyloliquefaciens*, *Trichoderma harzianum*.

Ефективність застосування препаратів азотного та фосфорного живлення пшениці за показниками якості макаронних виробів. **Чабанюк Я.В., Бровко І.С., Подгурська І.О., Спатару К.В., Нікіфоренко В.М.** Окреслено значення зернових культур загалом, виділено значення та переваги пшениці ярої твердої для світового господарства та промисловості. Наведено причину непопулярності вирощування твердої пшениці в Україні. Оцінено недоліки застосування мінеральних добрив під час вирощування сільськогосподарських культур, що впливають на екологічний стан, якість продукції, здоров'я людини. Запропоновано альтернативу застосування мінеральних добрив – біологічні добрива. Зазначено основні країни-виробники твердої пшениці та місце України на світовому ринку. Коротко охарактеризовано дію мікроорганізмів-діазотрофів і мікроорганізмів-фосфатмобілізаторів на ріст, розвиток і врожайність рослин. Охарактеризовано біотехнології азотного та фосфорного живлення рослин. Наведено мікробний склад біопрепаратів, що застосовувалися в дослідженні. Вивчено вплив біопрепаратів азотного та фосфорного живлення на якість зерна та макаронних виробів із пшениці ярої сортів Ізольда та Спадщина. Вказано основні параметри дослідного поля: розподіл опадів, кількість продуктивної вологи та інші погодні фактори. Наведено господарські ознаки сортів, які задіяні в дослідженні. Описано основні показники якості зерна твердої пшениці та їхні стандартизовані значення. Досліджено вплив вмісту компонентів зерна на показники якості кінцевої продукції. Наведено характеристику показників якості макаронних виробів і поділ на групи згідно з чинною нормативно-технічною документацією. Проаналізовано ефективність і здійснено порівняння застосування біологічних та мінеральних добрив. Запропоновано використання нових екологічно-безпечних елементів технології вирощування сортів ярої твердої пшениці. *Ключові слова:* пшениця яра тверда, макаронні вироби, азотне живлення, фосфорне живлення, Азот, Фосфор, сорт Спадщина, сорт Ізольда, урожай, якість макаронних виробів, показники якості зерна, біотехнологія, *Azotobacter chroococcum*, *Azotobacter vinelandii*, *Azospirillum brasilense*, *Azospirillum lipoferum*, *Bacillus megaterium*, *Bacillus amyloliquefaciens*, *Trichoderma harzianum*.

Introduction. Wheat is one of the most important crops in the whole world. The main value of cereals is that they are not only indispensable and indispensable food for humans (bread, cereals, pasta, confectionery and other products), but also the most important factor in providing people with high-calorie food of animal origin – meat, milk, eggs and other products, because cereals provide livestock with green fodder, silage [1].

Spring wheat grain has high baking and cereals quality, contains a lot of protein. The grain of soft and firm spring wheat has a high protein content (14–16% soft, 15–18% durum) and gluten – 28–40%. Soft flour is used for baking bread. Durum wheat grain is used to produce the best varieties of pasta, vermicelli, semolina [2].

Ukraine is one of the major suppliers of grain to the world market. A significant factor in the development of agricultural

production in Ukraine is the natural potential: large areas of high quality land, favorable climate and so on. Grain production directly forms the basis of the agrarian economy of Ukraine with a significant contribution to GDP (UAH 63.4 billion or 3.2% of GDP) [3].

However, in recent years durum wheat has hardly been grown on the territory of Ukraine, but in almost every region there are pasta factories that operate only on imported raw materials. In addition, the lack of own raw materials leads to a deterioration of finished products, since pasta is made with the addition of soft wheat flour.

Problem statement and relevance of the research. Durum wheat has many advantages over soft (almost no shedding, less affected by disease and pests, more resistant to lodging), but yields less fertileharveston medium fertile land. This is one of the main reasons for the unpopularity of durum in Ukraine and leads to the production of pasta mainly from flour of soft wheat and imported durum wheat.

In order to improve the quality, productivity and yield of wheat, it is necessary to enrich the soil with macro and microelements contained in various fertilizers. The use of mineral fertilizers can cause undesirable effects on the environment. This type of fertilizer may contain impurities in the form of heavy metal salts, radioactive isotopes or organic compounds. Toxic elements may include arsenic, cadmium, lead, fluorine, strontium, which should be considered as potential sources of environmental pollution and strictly taken into account when mineral fertilizers are introduced into the soil. Dangerous fertilizers in mineral fertilizers lead to environmental degradation, agricultural production, and human health. The harmful effect of mineral fertilizers occurs when they penetrate into water sources, accumulation in the above norms in plants, phytotoxic action and violation of the natural cycle of elements [4].

To improve the quality of wheat grain, it is advisable to use biological products, which significantly reduces the negative impact of humans on the environment. It is possible to investigate the efficiency of application of biological products for durum spring wheat by the quality of the grain itself, as well as by the quality of the products made from it, namely – pasta.

Literature review. Over the last 15 years, world agriculture has seen an increase in the sown area for durum wheat from 15.5 to 18.3 million hectares, which is about 5–7 percent of the world's total wheat wedge.

The leading producers of durum wheat are the EU countries, which account for 28–36% of world production of durum, the main production is concentrated in Italy – 4,0 million tons. In addition, durum is still grown in Spain – 1,8, France – 1,5 and Greece – 1.5 million tons. Canada accounts for 4.4 million tons of gross production; Turkey – 3.0 million tons; Syria – 2.6 million tons; US – 2.4 million tons; Mexico – 1.4 million tons; North African countries (Egypt, Libya, Morocco and Tunisia – 4.4 million tonnes; Australia – 0.5 million tons) [5].

Spring hard grain and its processing products are a source of protein, vital amino acids, carbohydrates, minerals and vitamins extremely beneficial to humans.

The pasta includes (in %): carbohydrates – 70–79, proteins – 9–13, fats – about 1,0, minerals – 0,5–0,9, cellulose – 0,1–0,6, humidity – up to 13. Energy value is on average 1.5 * 10-3 kJ per 100 g. Nutritional value depends on the type of flour and enrichment additives [6].

In Ukraine, the actual total harvested area occupied by durum wheat varied within 500,000 hectares with a gross production of 1.5–2.3 million tons.

In Ukraine, the genetic potential of spring wheat varieties can potentially yield a crop with a protein content of 16–19%. However, due to various reasons, which can be attributed to unfavorable natural and climatic conditions (drought in recent years), the high cost of purchasing mineral fertilizers, lack of agricultural soil so far, the protein content of grain is about 10–12%. This is the main reason for the decrease in the price of Ukrainian wheat and leads to a decrease in the profitability of the grain industry [5].

An integral part of improving the efficiency of export activities of grain producers is to improve their competitiveness, first of all, in quality. For this purpose it is necessary to use modern technologies of cultivation of grades of firm spring wheat. One such option is the use of biotechnology for nitrogen and phosphorus plant nutrition.

Microorganisms-diazotrophs as the basis of biological products are a significant factor in improving plant nitrogen nutrition and replenishing the soil nitrogen background. In addition, the activities of diazotrophs make it possible to substitute a portion of nitrogen for mineral fertilizers with cheap and environmentally friendly, biological nitrogen. But a thorough study of their effect on the microbial coenosis of the rhizosphere of inoculated plants will allow a fuller understanding of the patterns of interaction of native microflora with the bioagents of microbials.

The introduction of phosphate microorganisms into the rhizosphere contributes to the conversion of soluble mineral and organic phosphorus compounds into doses. The plants are dull in shape, and therefore their productivity increases.

It should be noted that the positive effect of phosphate-mobilizing microorganisms on the growth, development and yield of plants is associated not only with the increase of their mineral (in particular phosphorus) nutrition. A number of experiments observed an increase in plant yields without a simultaneous increase in their phosphorus content. This is due to the ability of phosphate-mobilizing microorganisms to produce vitamins and phytohormones.

General scientific importance. The conducted research is the basis for the development of effective biological products aimed at improving the macaroni properties of wheat grain, as well as solving the problem of contamination of fields with mineral fertilizers.

Materials and Methods. The research was conducted on the basis of the research field of the Department of Agroecology and Biosafety of the Institute of Agroecology and Environmental Management of NAAS. The study area is characterized by unstable and uneven distribution of rainfall during the growing season. Years with early spring drought often change with enough moisture. The average annual rainfall is 520–590 mm, the average annual rainfall during the growing season is 284 mm. The lowest humidity is in May, the highest in August.

Snow cover ranges from 15–25 cm. Stocks of productive moisture in the soil at the beginning of active vegetation in the zone averages 90–120 mm, or 60–70% of the lowest field moisture capacity, which means insufficient moisture reserves. Stocks of productive moisture in the autumn range from 50 to 60 mm. The negative impact is not only a deficit of moisture, but also its excess. In particular, it causes the lodging of plants, the germination of grain at the roots. Losses from them reach 25–60% of a crop. Other external weather factors that negatively affect spring wheat plants include rainfall, hail, rainfall in the summer.

Therefore, under these conditions, varieties that combine high yields, disease resistance and drought resistance are preferred, and they must be fairly ripe.

We have selected Izolda and Spadshchyna varieties for research. Isolda – the originator of the The V.M. Remeslo Myronivka institute of wheatNAAS Crafts. Economic and biological characteristics: Plant height 95–115 cm. Sortotype: medium-grown, semi-intensive. Grain quality: weight of 1000 grains 45–50 g, grain nature 800 g / l, gluten content 36,0–39,0%, protein 16,6%. Location areas: Forest-steppe and Steppe of Ukraine [7].

Variety Spadshchyna originatorThe Plant Production Institute nd. a. V.Ya. Yuryev of NAAS. Medium-ripe, drought-resistant variety with high productivity potential. The height of the plant is from 95 to 100 centimeters. Vegetation period 110 days.

Practical signs. The gluten content is 34–36%, the protein is 14.5–16.5%. Spadshchyna variety has good pasta qualities. It has exceptional environmental plasticity. Variety is the standard of the national public service for the protection of plant variety rights in all zones of Ukraine [7].

Biologicals used:

BioNorma PHOSPHORUS is intended for providing full phosphorus nutrition of crops, increasing the degree of absorption of phosphorus from both soil and mineral fertilizers. Bacteria – the active agents of the drug have a record high ability to synthesize organic and mineral acids, as well as enzymes-phosphatases, which contribute to the conversion of poorly soluble phosphorus compounds into soil solution available for absorption by the plant root system.

The functioning of the drug is provided by the complex action of the spore bacteria *Bacillus megaterium* and *Bacillus amyloliquefaciens* and micromycetes *Trichoderma harzianum*.

BioNormaNITROGEN is a preparation of free-living and associative nitrogen-fixing bacteria for improving the nitrogen supply of a wide range of crops. Free-living nitrogen-fixing bacteria: *Azotobacter chroococcum*, *Azotobacter vinelandii*, associative nitrogen-fixing bacteria *Azospirillum brasilense*, *Azospirillum lipoferum*. The composition of nitrogen-fixing bacteria is characterized by a complex effect on plants.

Determination of the nature of the grain was made according to Interstate Standard 10840-64 [8], vitreousness – according to Interstate Standard10987-76[9]. Protein content Measurements of total protein content were carried out in series by two modern conventional approaches, the infrared spectrometry (NIR) method [10] and the Kjeldahl method [11]. Determination of gluten content was carried out by the manual method according to Interstate Standard13586.1-6 [12], determination of quality indicators of pasta according to Interstate Standard 14849-69 [13].

The main material (Results and Discussion). Due to the high content of gluten in wheat in spring durum wheat, pasta made from such raw material retains its shape during cooking, does not slip and has a nice lemon-yellow or amber color.

Depending on flour, which is used in accordance with the valid specifications and technical documentation made pasta products of three groups:

- with flour from durum wheat (durum) and flour of higher grade increased dispersion of hard wheat (under special technical conditions) – Group A;
- soft glass wheat flour – Group B;
- Group B wheat flour and cereals made from soft wheat (cereals) according to special technical conditions [9].

The vitreousness was largely influenced by the weather conditions during the ripening period. The maximum glassiness of the grain is noted in the variety Spadshchyna *Table 4*.

Nature determines the grain's fullness. High-precious grain gives greater yield of semolina. High-grade wheat grains contain less ash than fine-grained wheat [10; 11].

Table 1

Durum wheat grain quality indicators according to State Standard 3768: 2010 "Wheat. Specifications" [8]

Indicator	Characteristics and norm for durum wheat by grade				
	1	2	3	4	5
Hectolitre weight, g / l, not less than	750	750	730	710	Not limited
Vitreousness, %, not less than	70	60	50	40	Not limited
Protein mass fraction, in terms of dry matter, %, not less than	15.0	13,0	12,0	11,0	Not limited
The number of falls, s, is not less than	220	200	150	100	Not limited

Table 2

Effect of fertilizer on the nature and vitreousness of spring wheat grain

	Version	Hectolitre weight, g / l, not less than	Vitreousness, %, not less than
Izolda variety			
1	Control	765	54
2	Phosphorus	774	54
3	Nitrogen	776	57
4	Phosphorus + Nitrogen	783	58
5	$N_{30}P_{30}K_{30}$	769	56
6	$N_{60}P_{60}K_{60}$	792	61
Variety Spadshchyna			
7	Control	772	71
8	Phosphorus	779	69
9	Nitrogen	798	73
10	Phosphorus + Nitrogen	801	79
11	$N_{30}P_{30}K_{30}$	783	74
12	$N_{60}P_{60}K_{60}$	794	77

Pasta properties of wheat depend not only on the amount and quality of protein and gluten. The structural features of the endosperm and its hardness play an important role. In the endosperm of high quality durum wheat, unlike the soft, starch grains, the protein particles and the walls of the cells are firmly connected, forming a solid mass without air inclusions and voids. Durum wheat grains are crushed into large particles with sharp edges as a whole, solid body while grinding, whereas in soft wheat the cell walls break down and the starch grains fall out, creating pores and micro-cracks [12].

Spring durum wheat is characterized by a very firm and dense vitreous endosperm and is therefore particularly suitable for the production of semolina. Its main advantage is that it requires less water to form dough. Since any amount of added water must then be removed in the drying process of the finished product, it is clear that the smaller the water dough, the easier the drying process. For the production of pasta, it is desirable to have high protein content in the grain. To obtain semolin with a protein content of at least 13%, wheat must contain at least 14.0–14.5% protein. At low protein content in semolin, water absorption proceeds slowly, therefore a longer period of water absorption and a longer mixing period are required [12].

Color is an important quality feature in the pasta industry. Amber-yellow or cream without gray is the preferred color for pasta. Absolutely unusable pasta in gray. The color of the pasta is due to the carotenoid pigment xanthophyll. The concentration of these pigments in endosperm of durum wheat is almost twice that of baking wheat. Too pale, whitish endosperm

Table 3

Influence of fertilizer on spring wheat grain quality indicators

Version		Protein, %	Gluten, %	Gluten quality, group
Izolda variety				
1	Control	14,0	28,4	1
2	Phosphorus	13,8	28.5	1
3	Nitrogen	15.6	30.6	1
4	Phosphorus + Nitrogen	16,2	32.3	1
5	$N_{30}P_{30}K_{30}$	14,8	31.1	1
6	$N_{60}P_{60}K_{60}$	15.1	33,0	1
	Variety Spadshchyna			
7	Control	14.3	29.2	1
8	Phosphorus	14.5	28,9	1
9	Nitrogen	15.7	30,8	1
10	Phosphorus + Nitrogen	16.6	33.1	1
11	$N_{30}P_{30}K_{30}$	15.5	32,7	1
12	$N_{60}P_{60}K_{60}$	16.4	33.6	1

Table 4

Impact of fertilizer on quality of pasta

Version		Strength of pasta, g	Color pasta, ball	Color boiled pasta, ball
Izolda variety				
1	Control	1402	6 , 5	5.5
2	Phosphorus	1381	6 , 5	5.5
3	Nitrogen	1434	6 , 5	5.5
4	Phosphorus + Nitrogen	1459	6 , 5	5.5
5	$N_{30}P_{30}K_{30}$	1415	6 , 5	5.5
6	$N_{60}P_{60}K_{60}$	1496	6 , 5	5.5
	Variety Spadshchyna			
7	Control	1525	7	6.5
8	Phosphorus	1512	7	6.5
9	Nitrogen	1548	7.5	7
10	Phosphorus + Nitrogen	1597	8.5	8
11	$N_{30}P_{30}K_{30}$	1536	7.5	7
12	$N_{60}P_{60}K_{60}$	1584	7.5	7

and colorless gluten cause white pasta, and with a dark brown shade of endosperm they turn dark. The enzyme lipoxidase in the process of making pasta destroys part of the yellow pigment. With high lipoxidase activity, especially with a low content of yellow pigment, the pasta turns pale, grayish-white [11] .

Conclusions and prospects of the research. Based on the studies of the influence of the use of biotechnological preparations of nitrogen and phosphorus nutrition on the quality of pasta, it was found that pasta made from wheat of the heritage variety for the use of biological products have quality indicators that exceed those of pasta grown with mineral fertilizers and without fertilizers at all. Thus, durum wheat Izolda and Spadshchyna have high adaptability and high productivity potential that can be realized in production conditions. Provided they are grown on leguminous precursors using biological products, they are not inferior in yield to mineral fertilizer technologies.

It should be noted that as a result of the conducted researches new ecologically safe elements of technology of cultivation of spring durum wheat with high level of productivity, with excellent quality of grain and macaroni have been proposed.

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