Economic and environmental benefits of protection winter wheat with the use of biological preparations

N I Naumova¹ and D O Morozov¹,²

¹All-Russian institute of plant protection (FSBSI VIZR) Podbelskogo, 3, St.Petersburg, Pushkin, Russian Federation
²LLC Research and Testing Center “Agrobiotechnology”, ul. Collective farm 3/1, room 4, Churaevo, Shebekinsky urban district, Belgorod region, Russian Federation

E-mail: nin@iczr.ru

Abstract. In the work we presented, based on field production experiments conducted in the Belgorod region, an economic assessment of various winter wheat protection systems is given. In particular, crop protection systems with treatment only with chemical preparations (chemical) and with the integrated use of biological and chemical preparations (integrated) were studied. The most important economic indicators have been calculated, allowing to determine the most profitable, from the point of view of financial costs, systems. As a result, we found that the highest profit was obtained with using the integrated winter wheat protection system - 4446.7 rubles / ha, the profitability of these treatments was 95%. It was also found that the introduction of an integrated system is the most preferable from the point of view of protecting the environment from pollution. When applied on crops, the pesticide load on the soil is reduced, since the amount of applied chemicals is more than halved in comparison with the chemical protection system.

1. Introduction
The use of new biological products is becoming a prerequisite for modern agricultural production. The search of new technologies and modern plant protection products is necessary for the production of food products that should not contain substances harmful to humans [1, 2]. More and more effective biological preparations are being developed and introduced that allow not only preserving the crop, but also not having a negative impact on the environment [3, 4].

Currently, work is underway in all countries to search for new formulations for biological plant protection and soil improvement [5, 6, and 7]. However, in the case of mass distribution and development of harmful objects, the use of chemical protective equipment is still necessary. A competent combination of biological and chemical preparations allows guaranteed protection of crops.

The main objective of our research was to determine an economically more profitable and environmentally friendly system for protecting winter wheat from pests, diseases and weeds during experimental treatments throughout the growing season of the crop.

2. Objects and methods of research
Studies on the economic efficiency of the use of various systems for the protection of winter wheat varieties “Thunder” were carried out in the Belgorod region on the experimental field of the Scientific and Testing Center “Agro biotechnology” LLC.
In the article, we present economic indicators for only two options of experience: chemical and integrated winter wheat protection systems. Experimental processing of crops was carried out on plots of 100 m² in 4-fold repetition. In the control variant, due to the large contamination of the crops, the treatment only with the herbicide Ballerina, SE was carried out.

The combination of biological and chemical drugs that were used according to the options experience (protection systems) in the treatments are presented in Table 1.

### Table 1. Scheme of the use of preparations according to the test options on winter wheat.

| Preparations                       | Options (winter wheat protection systems) |
|-----------------------------------|------------------------------------------|
|                                   | Chemical | Integrated | Control |
| Seed dressing, drug consumption rate: kg / t, l / t |
| Vial TrustT, VSK                  | 0.4 l / t + | 0.3 l / t + | Without treatments |
| Tabu, VSK                         | 0.8 l / t | 0.4 l / t + | 20 g / t |
| Vitaplan, SP                      |           |            | |
| Weed Treatment, herbicide consumption rate: l / ha, kg / ha |
| Ballerina, SE                     | 0.4 l / ha | 0.3 l / ha | 0.4 l / ha |
| Pest treatment, insecticide consumption rate: l / ha, kg / ha |
| Break ME                          | 0.1 l / ha | 0.1 l / ha | Without treatments |
| Disease treatment, fungicide consumption rate: l / ha, kg / ha |
| Kolosal PRO, KME -                | 0.4 l / ha twice | - | |
| Alirin-B, F                       | 2 l / ha + | - | Without treatments |
| Trichocin, SP                     | 40 g / ha + | - | |
| Vitaplan, SP                      | 40 g / ha | - | |

The following are more complete characteristics of the experimental preparations.

During the experimental treatments, chemical pesticides were used. For the treatment of wheat seeds there is Vial TrustT, VSK (60 g / l tebuconazole + 80 g / l thiabendazole), Tabu, VSK (500 g / l imidacloprid). For spraying, there is the herbicide Ballerina, SE (410 g / l 2, 4-D (2-ethylhexyl ether) + 7.4 g / l florasulam), insecticide Break, ME (100 g / l lambda-cygalotrin), and fungicide Kolosal PRO KME (300 g / l propiconazole + 200 g / l tebuconazole).

In addition, biological preparations were used for the treatments. For seed dressing there is Vitaplan, SP (titer 10 CFU / gm of Bacillus subtilis strain VKM B-2604D + 10⁹ CFU / gm of Bacillus subtilis strain VKM V-2605D). For spraying crops there is Alirin-B, Zh (titer of at least 10⁸ CFU / ml Bacillus subtilis, strain B-10 VIZR), Trichocin, SP (titer 10⁶ CFU / gm Trichoderma harzianum, strain G30 VIZR), Vitaplan, SP (titer 10¹⁰ CFU / gm Bacillus subtilis strain VKM B-2604D + 10⁹ CFU / gm Bacillus subtilis strain VKM B-2605D).

In the plots of landings during the experimental treatments, well-known methods were followed.

Economic calculations were performed using the new approved VIZR developments [8, 9] and the works of foreign authors [10].

Economic calculations took into account: technical characteristics of the tractor and agricultural machines, their annual load and norms of deductions for depreciation, storage and technical repair, the
number of staff, their salary and other indicators, which were determined from the reference documentation taking into account the practice and technological maps of the enterprise.

At market prices, the costs of fuel, electricity, and water were calculated.

The most important initial operational characteristics of the tractor and agricultural machines for economic calculations are presented below (tables 2 and 3).

For sowing, wheat seeds were treated using a seed dresser PS-5, which was served by 2 people. To calculate the cost of seed treatment, we took into account the normative deductions for the operation and repair of the machine, the consumption of electricity and water and their cost specifically for the enterprise.

### Table 2. Performance characteristics of the PS-5 pickling machine winter wheat seed.

| №   | The name of indicators                                      | For seed treatment for sowing in all plant protection systems |
|-----|-------------------------------------------------------------|-------------------------------------------------------------|
| 1   | Protectant brand                                           | PS-5 “Farmer”                                                |
| 2   | Carrying amount, thousand rubles:                          | 135.0                                                        |
| 3   | Productivity in 1 hour (on wheat):                         |                                                              |
|     | • main time, t / h                                         | 5.0                                                          |
|     | • operating time, t / h                                    | 3.4                                                          |
| 4   | Tank capacity, liters                                      | 120                                                          |
| 5   | The rate of flow of the working fluid, l / t               | 10                                                           |
| 6   | Standard annual charge of the protectant, hour.            | 30                                                           |
| 7   | Standards for deductions for depreciation, repairs and maintenance, at PS-5,% | 25                                                           |
| 8   | Power consumption, no more, kW                             | 2.0                                                          |
| 9   | The cost of 1 kW, rubles / kW * hour                       | 5.33                                                         |
| 10  | Electricity costs, rub / t                                 | 3.13                                                         |

Work on the processing of vegetative crops of winter wheat in the fight against weeds, pests and diseases was carried out with an aggregate consisting of an MTZ-82 tractor and a mounted sprayer OP-600. The characteristics of this unit are presented below.

### Table 3. The operational characteristics of the unit for the protection of winter wheat.

| №   | The name of indicators                                      | For all experience options                             |
|-----|-------------------------------------------------------------|--------------------------------------------------------|
| 1   | Unit composition                                           | Sprayer OP-600 + tractor MTZ-82                        |
| 2   | Book value, rubles:                                        | 75 000                                                  |
|     | • sprayer;                                                 | 1 200 000                                               |
|     | • tractor;                                                 |                                                        |
| 3   | Productivity of OP-600 for an hour of the main time,       | 1.6–8.0                                                  |
|     | hectare / hour                                             |                                                        |
| 4   | Standard annual loading of a tractor, hour                  | 1 200                                                    |
|     |                                                             | 200                                                      |
| 5   | Standards for deductions for depreciation, repairs and      | 22                                                       |
|     | maintenance, %                                             | 31                                                       |
|     | • tractor                                                  |                                                        |
|     | • sprayer                                                  |                                                        |
Table 4: Economic indicators of preparing for spraying

|   |                                          |       |
|---|------------------------------------------|-------|
| 6 | Capacity of a working tank of a sprayer, l | 600   |
| 7 | The rate of flow of the working fluid, l / ha | 200   |
| 8 | Tractor power, hp | 75.0 |
| 9 | Specific fuel consumption, kg / hp | 0.185 |
| 10 | Consumption of fuel and lubricants during spraying, l/ha | 2.5  |
| 11 | Fuel cost, rubles / l | 47.0 |
| 12 | Cost of water, rubles / m³ | 32.33 |
| 13 | Number of staff | 1+1 |
| 14 | Operating speed, km / h | 10 |
| 15 | Coverage of spraying, m | 12 |

The obtained economic indicators of our research are presented below.

3. Results and discussion

As a result of the analysis of the purchase prices for preparations, we determined for the test cases the costs incurred by the producer for their purchase for the processing of winter wheat, including VAT.

It has been established that most of the financial resources for the purchase of preparations are required for chemical protection of the crop for seed dressing 1413.85 rubles / ha and for spraying crops - 1852.85 rubles / ha. The costs for the purchase of preparations in the integrated system amounted to 798.68 rubles / ha and 1451.57 rubles / ha, respectively. The reduction of costs, in particular when processing vegetative plants, in the integrated wheat protection system was facilitated with a more than two-fold reduction in the amount of applied chemicals (0.4 l / ha) compared to the chemical protection system (0.9 l / ha). This is a clear advantage of integrated plant protection in terms of environmental protection. Similarly, for seed dressing for an integrated system, 0.7 liter of pesticides was spent per 1 ton, for a system using only chemicals it was 1.2 l / t.

An analysis of the costs of protecting both winter wheat and other crops [9] showed that the costs of the preparations are the most significant item of producer costs. During our experimental treatments, the cost of preparations that are necessary for the whole range of protective measures ranged from 59% (integrated protection) to 65% (chemical protection system).

During the growing season in the experimental plots, the number of sprayings of crops for the options was carried out four times. Therefore, the costs of processing drugs for all options were the same - 978.76 rubles / ha. In the control, only one treatment of weeds with an herbicide was carried out; therefore, the costs were significantly less - 244.69 rubles / ha.

Data on labor remuneration, fuel consumption, electricity are determined based on technological maps of the enterprise. In addition, when calculating the costs of the enterprise, taxes were taken into account VAT, overhead costs (20%) and payroll (30.2%). The salary during spraying at the enterprise amounted to 64.73 rubles / ha. For this enterprise, where pilot treatments were carried out, as follows from the technological maps, a significant part of the costs was paid for the work of two workers; this is 250 rubles for seed treatment per hectare. Only 0.78 rubles / ha was spent on electricity during seed treatment for experimental treatments. The cost of water during seed dressing amounted to 0.08 rubles / ha. When spraying crops with a working fluid flow rate of 200 l / ha, 6.46 rubles / ha were spent.

As follows from our calculations, when spraying vegetative crops, diesel fuel costs were significant - 117.50 rubles / ha (with VAT %), at its cost 47 rubles / liter.

Final calculations on the economic efficiency of our experimental treatments are presented in table 4.
Table 4. Cost-effective use of various protection systems winter wheat, rub/ha.

| №  | The name of indicators                                         | Chemical  | Integrated | Control |
|----|---------------------------------------------------------------|-----------|------------|---------|
| 1  | Productivity, c / ha                                         | 63.9      | 65.8       | 53.2    |
| 2  | Yield increase due to plant protection measures, c / ha       | 10.7      | 12.6       | –       |
| 2  | The purchase price of grain, rubles / t                       | 8000.00   | –          |         |
| 3  | Proceeds from the sale of stored crops, rubles / ha           | 8 560     | 10 080     | –       |
| 4  | Total costs of plant protection, rubles / ha                  |           |            |         |
|    | • seed dressing                                              | 1 747.43  | 1 132.26   | –       |
|    | • crop processing                                            | 2 831.61  | 2 430.33   | 816.80  |
|    | Beero                                                        | 4 579.04  | 3 562.59   | 816.80  |
| 5  | The cost of cleaning and processing additional crops, rubles / ha | 321       | 378        |         |
| 6  | Overhead, 20%                                                | 915.80    | 712.50     | 163.36  |
| 7  | Total costs, rubles / ha                                     | 5815.84   | 4653.10    | 980.20  |
| 8  | Profit earned, taking into account the costs of control, rubles / ha | 1763.90   | 4446.70    | –       |
| 9  | Profitability,%                                              | 30.3      | 95.0       | –       |

In order to determine the economic efficiency of the treatments carried out with the compared wheat protection systems, it was necessary to determine not only the costs of the pilot treatments, but also the income of the enterprise received from the sale of additionally obtained products.

The yield of wheat seeds in all variants of plant protection systems was high (table 4), but the most significant yield of wheat seeds was obtained using an integrated wheat protection system - 65.8 c / ha. The smallest amount of seeds were collected in the control variant, without the necessary protective treatments against pests and diseases – 53.2 c / ha.

Excluding grain quality, its purchase price is accepted for our calculations - 8000 rubles per ton.

The difference between the yield in the control and other options is an indicator of the stored or additionally obtained crop. Multiplying the stored crop by the purchase price of grain allows you to evaluate the income of the enterprise. With the integrated wheat protection system, due to protective measures, the highest yield increase was obtained – 12.6 c / ha, therefore, the largest revenue, as established with the calculations, amounted to 10,080.00 rubles / ha. In this regard, the profit, taking into account the costs of processing in the control, in the integrated system was higher than 4,446.70 rubles / ha (table 4).

Profitability during the integrated winter wheat protection system amounted to 95%, while for chemical protection – 30.3%.

From our economic calculations, it follows that the main economic efficiency indicators (profit and profitability) for plant protection measures are determined, first of all, with the preparations chosen for experience (table 1), their biological effectiveness, purchase price, crop effect and their other properties.

Therefore, in connection with the established regularity, the complex of other chemical and biological preparations in these experimental winter wheat protection systems can significantly change these indicators.
4. Conclusion
Our studies have established that the use of an integrated winter wheat protection system with a set of biological and chemical preparations that were used in the experiments is economically and environmentally more profitable in comparison with the winter wheat chemical protection system. The profitability of these treatments amounted to 95%; profit from the sale of the stored crop yield was 4,446.70 rubles / ha.

An indisputable advantage for the integrated winter wheat protection system as compared to chemical treatment is, from the point of view of environmental protection, the reduction of the pesticidal load on the soil with more than two times, i.e. reduction of environmental pollution with decay products of chemicals.

When a set of preparations, both chemical and biological, changes in plant protection systems, the economic and environmental effectiveness of treatments can change significantly, since the financial costs of acquiring the preparations make up a large part of the enterprise’s total cost of protective measures.

References
[1] Gagkaeva T Yu, Gavrilova O, Orina A, Lebedin Yu, Shanin I, Petukhov P and Eremin S 2019 Toxins 11 (5) 252
[2] Brili F, Bacctli and Loreto F 2019 Frontiers in plant sience 10 (jun/ 1–8)
[3] McGehee G S, Raudales R E, McAvoy R J and Elmer W H 2019 Crop protektion 121 96–102
[4] Moshi A P and Matoju I 2018 Crop protektion 105 16–28
[5] Belakhov V V, Boikova I V, Novikova I I and Kolodyaznaya V A 2018 Russian Journal of General Chemistri. 88 (13) 2982–89
[6] Belakhov V V, Garabadzhiu A V, Boikova I V and Novikova I I 2017 Russian Journal of General Chemistr. 87 (13) 3151–55
[7] Novikova I I, Titova Yu A, Boykova I V and Krasnobaeva I L 2019 Vavilovsky Journal of Genetics and Breeding 23 (3) 328–36
[8] Goncharov N R 2017 Bulletin of plant protection 93 (3) 44–54
[9] Goncharov N R, Lysov A A, Naumova N I and Kornilov T V 2019 Economics of agricultural and processing enterprises 3 54–57
[10] Lopez J A, Rojas K and Swart J 2016. Crop protektion 89 35–42