Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 25, Issue 4, 2025
PRINT ISSN 2284-7995, E-ISSN 2285-3952

INFLUENCE OF WINTER WHEAT SEED TREATMENT AND BUDGET PLANNING ON PRODUCTION COMPETITIVENESS- A STUDY CASE IN THE REPUBLIC OF MOLDOVA

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Abstract

Cereal crops in the Republic of Moldova occupy areas of thousands of hectares, which also constitute a feeding ground for a wide range of phytopathogenic microorganisms and a multitude of pests with a diverse nutritional specialization, which requires recording and maintaining their density below the economic threshold of damage. The purpose of the study is to present the current state of winter wheat protection and to emphasize the need to carry out scientific work related to testing new preparations for plant protection.The paper includes the scheme of experiments, the name of the variants and their content, the characteristics of the pedoclimatic conditions during the testing work, the results obtained, budget planning, conclusions and recommendations.In the 2023-2024 growing season, weather conditions were favorable both for the growth and development of winter wheat crops, and for the spread and further development of the main pests of this crop. The results proved that the insecticide ST 36 SC, at an application rate of 1.0 L/t of seeds is the most effective in controlling wheat pests.

Key words: ***w****heat, pests control, biological efficacy, budget, cost, profit*

INTRODUCTION

Cereals are an important category of agricultural products with a high nutritive value and with a crucial role in assuring food security of the population and contribute to the growth of the national economy.

In the EU cereal production increased reaching a top level in 2019 [8], but then because of the climate change in years with high temperatures, heat waves and severe droughts it was recorded an output decline in many member states. Also, the high temperatures stimulated the attack of pests which also contributed to yield losses.

For this reason, new adapted technologies to climate change are required. Plant protection is a technological component to which farmers must pay a special attention.

In Romania, Lipianu et al (2023) [4] experimented new methods for wheat and corn protection. Also, Manole et al (2023) [5] adapted the whole wheat technology, and mainly regarding an earlier sowing date and special measures against pest attack.

Valean et al. (2018) [9], studying winter wheat in two agroecosystems from the center of Transylvania, identified insects, especially flies which could play a biological control in regulating pest population.

Therefore, the main task of plant protection is aimed at reducing losses caused by various harmful organisms. Crop losses are influenced not only by the level of nutritional specialization of pests, but also by the plant's ability to respond adequately and to resist, depending on the capacities and specific characteristics of each variety, cultural hygiene, cultivation technology, adherence to crop rotation, and other factors, including meteorological conditions [2, 6]. In cereal grain fields, various species of bugs from the families *Scutelleridae* and *Pentatomidae* are traditionally widespread and cause, in most cases, economically significant damage. These include the sunn pest - *Eurygaster integriceps Put.,* the wheat shield bug - *Eurygaster austriaca Schrank*, and the cereal bug - *Eurygastermaura* L. [1, 7].

In addition to bugs, other pests with piercing-sucking mouthparts can also be found in cereal crop fields, such as aphids, particularly the spring wheat aphid - *Schizaphis graminum Rond.,* and the English grain aphid - *Macrosiphumavenae*. The wheat ground beetle - *Zabrustenebrioides* represents a particularly significant pest of cereal crops, with larvae that attack the leaves. Click beetles - *Agriotes spp.* should also not be overlooked, as their larvae, known as wireworms, are polyphagous pests that damage the seeds and seedlings of cereal crops. Among soil-dwelling pests, darkling beetles - *Tenebrionidae* are also present, whose larvae in some cases cause substantial damage to cereal seedlings.

Research results obtained by several scientists, both in the Republic of Moldova and in most European Union countries, as well as the information presented earlier, have shown that winter wheat crops are susceptible to attack by more than ten species of flies, all belonging to the families *Cecidomyiidae, Chloropidae, Opomyzidae and Anthomyiidae.*Among all the fly species harmful to cereal crops, a special place is occupied by *Oscinella frit*, *Mayetiola destructor*, *Opomyzaflorum*, *Phorbiafumigata*, and *Leptohylemyiacoarctata*.

The integrated wheat pest management system for the above-mentioned pests includes a range of well-established methods that ensure population reduction below the economic injury threshold.

In this context, the purpose of the present study was to investigate the biological efficacy of certain preparations, used as insecticides for wheat seed treatment. To achieve this goal, the following tasks were set: determination of the phytosanitary condition of cereal crops; establishment of the experimental plot for testing the insecticide ST 36 SCas a seed treatment product for controlling cereal crop pests; monitoring of pests in the experimental plot; chemical treatment of seed material; determination of the biological efficacy of ST 36 SC as a seed treatment insecticide.

Also, it was determined the budget of income and expenditures, gross margin and cash flow per one hectare cultivated with winter wheat to show the economic efficiency of the plant protection measure applied.

MATERIALS AND METHODS

Scientific research aimed at determining the biological efficacy of the insecticide ST 36 SC, as a wheat seed treatment for controlling autumn wheat pests, was carried out in the autumn of 2023. The experiments were conducted in the southern region of the Republic of Moldova, in the fields of SRL "Moroz Alla", located in Sărăteni village, Leova district. As seed material, the elite seeds of the Pandia variety from the Odessa Breeding Institute were used. Seed treatment was performed mechanically: the quantity of seeds required to sow 4 plots – 8 kg – was placed into a plastic container, to which the necessary amount of the preparation was added, followed by thorough mixing.

Autumn wheat was sown on September 28, using the narrow-row method, with a seeder of 4.2 m width. Thus, each plot was 4.2 m wide and 24.0 m long. For this purpose, 8 kg of treated seeds were poured into the seeder for each sowing, which was used to plant 4 strips, each 24 m long[1, 3]. The experiment included four variants: V_1 - control, untreated; V_2 - standard, insecticide Force 20 CS(tefluthrin, 200 g/l), application rate 1.0 L/t seeds; V_3 - insecticide ST 36 SC(tefluthrin, 200 g/l), application rate 0.8 L/t; V_4 - insecticide ST 36 SC (tefluthrin, 200 g/l), application rate 1.0 L/t.

The main economic indicators related to this experiment have been: net sales, variable costs especially regarding the inputs, gross margin and cash flow, which have been calculated for one unit of cultivated land.

RESULTS AND DISCUSSIONS

Most grain flies cause damage to seedlings in the fall, soon after emergence. The larvae attack the growth cone in the fall and as a result the central leaf turns yellow and later turns brown and dries out. The information presented in Table 1 indicate that, in the records made on the 3rd day after the emergence of seedlings, the minimum value of cereal fly larvae was marked in the 4th variant, where this index reached only 0.11 ex. per 2 m of row length. In the 3rd variant, the density of live larvae during this period was 0.56 ex/2m row.

Table 1. Biological efficiency of wheat seed treatment with insecticide ST 36 SC in control grain flies(based on larval evidence)

No	Experimental variants	Application rate, L/t	Larval density per 2 m of row length, at ... day after seedling emergence|				Reduction in larval density, %, compared to the control, at ... day			
			3	7	14	21	3	7	14	21
1.	Control	-	4.18	10.36	26.13	36.88	0.0	0.0	0.0	0.0
2.	Standard, Force 20 CS	1.0	0.14	0.88	3.00	4.88	96.65	91.72	88.52	86.76
3.	ST 36 SC	0.8	0.56	1.75	5.00	8.13	86.60	83.54	80.86	77.96
4.	ST 36 SC	1.0	0.11	0.75	2.88	4.75	97.37	92.94	88.98	87.12
LSD, 95%			0.40	0.81	1.94	3.18	3.54	4.68	5.21	6.14

Source: developed by the group of authors.

Analyzing the results received in the record from the 7th day after the emergence of seedlings demonstrates that the minimum value of larvae in this period was marked in the 4th variant, constituting 0.75 ex. per 2m length. In the standard and the 3rd variant this index constituted correspondingly -0.88 and 1.75 ex per 2m length of the row. The results of the records carried out on the 14th and 21st days after the emergence of seedlings demonstrated the same trend.

So, it can be seen that the lowest population of grain flies during all the records was marked in the 4th variant and is at the level of the standard. The numerical value of the flies in the 3rd variant is much higher and essentially yields to both the 4th variant and the standard.

The experimental results presented in table 1, indicate that, on the 3rd day after seedling emergence, in variant 4 the biological efficacy reached 97.37%, a value comparable to the standard (control treatment). In variant 3, the biological efficacy was only 86.60%, a value significantly lower than both the standard and variant 4.

The experimental results obtained on the 7th day after seedling emergence show that, in variant 4, the biological efficacy reached 92.94%, which is at the level of the standard. In variant 3, the biological efficacy was only 83.54%, a value significantly lower than both the standard and variant 4.

The experimental results obtained on the 14th and 21st day after seedling emergence confirmed the previously observed trend. Therefore, it can be concluded that the highest reduction in cereal fly larvae was recorded in variant 4, with values comparable to the standard. variant 3 lagged significantly behind both the standard and variant 4.

According to multiple research findings, it is well established that, for determining the biological efficacy of plant protection products in controlling cereal flies, an important evaluation criterion is also the level of seedling infestation. For this purpose, additional assessments of infested seedlings were carried out in the experimental plots. The results are presented in Table 2.

The data from Table 2 show that, on the 3rd day after seedling emergence, the lowest recorded number of infested plants was in variant 4, with 0.38 specimens. In variant 3 and in the standard treatment, the density of infested plants was 0.88 and 0.45 specimens per 2 linear meters, respectively.

The results obtained on the 7th day after seedling emergence indicate that, during this period, the lowest number of infested plants was also recorded in variant 4, with 1.50 specimens, a value at the level of the standard. In variant 3, the density and number of infested plants reached 3.0 specimens per 2 meters of row, significantly higher than both the standard and variant 4.

According to the data, on the 14th day after seedling emergence, the lowest number of infested plants was again recorded in variant 4, at 3.88 specimens, a value close to the standard. In variant 3, the density and number of infested plants was 5.0 specimens per 2 meters of row, significantly higher than both the standard and variant 4.

Thus, it can be concluded that the lowest number of infested plants was recorded in variant 4, with values at the level of the standard. The number of infested seedlings in variant 3 was considerably higher, significantly exceeding both variant 4 and the standard.

Experimental results show that, on the 3rd day after seedling emergence, the highest biological efficacy was recorded in variant 4, reaching 94.57%, a value comparable to the standard. In variant 3, the reduction in the number or density of infested plants compared to the untreated control was below 90%, at only 87.43%, which is significantly lower than both the standard and variant 4.

Calculations of the reduction in infested seedlings relative to the control show that, on the 7th day after seedling emergence, the highest biological efficacy was recorded in variant 4, at 90.70%, a value at the level of the standard. In Variant 3, the reduction in the number or density of infested plants compared to the control was only 81.40%, again lower than both the standard and variant 4.

Further experimental results show that, on the 14th day after seedling emergence, the highest biological efficacy was recorded in variant 4. In variant 3, the reduction in the number or density of infested plants compared to the untreated control was only 82.07%, lower than both the standard and variant 4.

Comparative analysis of the subsequent results shows that, on the 21st day after seedling emergence, the highest biological efficacy was again recorded in Variant 4, at 84.21%, a value at the level of the standard. In variant 3, the reduction in the number of infested plants compared to the untreated control was below 80%, at only 75.49%.

Therefore, it can be concluded that the highest reduction in seedlings infested by cereal fly larvae was recorded in variant 4, with values comparable to the standard. variant 3 lagged significantly behind both the standard and variant 4.

Table 2. Biological efficacy of the insecticide ST 36 SC, based on the assessment of seedlings infested by cereal flies

No	Experimental variants	Application rate, L/t	Total number of plants examined	Reduction in the density of seedlings infested by cereal flies, %, relative to the untreated control			
				3	7	14	21
1.	Control	Untreated	57.71	0.0	0.0	0.0	0.0
2.	Standard, Force 20 CS	1.0	58.50	93.57	89.89	85.65	83.54
3.	ST 36 SC	0.8	58.25	87.43	81.40	82.07	75.49
4.	ST 36 SC	1.0	59.00	94.57	90.70	86.08	84.21
LSD, 95%, p-5%;				3.81	4.50	3.18	5.63

Source: developed by the group of authors.

Table 3. Biological efficacy of wheat seed treatment with the product ST 36 SC in controlling larvae of the wheat wireworm and wireworms (click beetle larvae).

No	Experimental variants	Application rate, L/t	Before treatment		Reduction in larval density, % relative to untreated control			
			Wheat wireworm larvae	Wireworm larvae	Wheat wireworm larvae		Wireworm larvae	
					7th day	14th day	7th day	14th day
1.	Control	Untreated	2.03	3.71	0.0	0.0	0.0	0.0
2.	Force 20 CS Standard	1.0	2.17	4.08	95.11	89.23	95.80	88.11
3.	ST 36 SC	0.8	2.55	4.33	83.11	79.46	82.40	77.97
4.	ST 36 SC	1.0	2.42	4.46	96.00	90.57	96.40	88.69
LSD, 95%, p – 5%					4.63	5.25	4.88	6.21

Source: developed by the group of authors.

Based on multiannual research, it is well established that, for controlling larvae of the *Agriotes spp*. and both true and false wireworms, the most effective method is seed treatment prior to sowing.

At this stage, the wheat wireworm is in its first larval instar, which is highly sensitive to insecticide action.

In the autumn of 2023, winter wheat was sown in the second decade of September. During this period meteorological conditions were not the most favorable for oviposition, larval hatching, and development.

Larval counts in the experimental plot were carried out by analyzing four samples taken from the center of each plot. The calculation of biological efficiency was performed according to the previously used formula. The results of observations and records are presented in Table 3.

Data from the table indicate that, before sowing, the population density of the cereal ground beetle larvae was relatively uniform, ranging from 2.03 specimens/m² in the control variant to 2.55 specimens/m² in variant 3.

Records taken on the 7th day after seedling emergence showed that the number of cereal ground beetle larvae in treated variants was significantly reduced, ranging from 0.09 specimens/m² in variant 4 to 0.38 specimens/m² in variant 3. On the 14th day after emergence, larval numbers in treated variants remained significantly lower, ranging from 0.28 specimens/m² in variant 4 to 0.61 specimens/m² in variant 3.

The population density of true and false wireworms was also relatively uniform, ranging from 3.71 specimens/m² in the control to 4.46 specimens/m² in variant 4. On the 7th day after emergence, the number of true and false wireworms in treated variants was significantly reduced, ranging from 0.18 specimens/m² in variant 4 to 0.88 specimens/m² in variant 3. In the standard (etalon) variant, this indicator was 0.21 specimens/m², while in the control it continued to increase, reaching 5.00 specimens/m² during this period. On the 14th day after emergence, the number of wireworms in treated variants was still significantly reduced, ranging from 0.58 specimens/m² in variant 4 to 1.13 specimens/m² in variant 3. In the standard variant, the value was 0.61 specimens/m², while in the control it continued to rise, reaching 5.13 specimens/m².

The calculation of the biological efficiency of treating wheat seeds with two application rates of the insecticide ST 36 SC showed that, on the 7th day after emergence, the highest reduction in cereal ground beetle larvae was recorded in variant 4, amounting to 96.00%, which was comparable to the standard. A similarly high reduction in wireworms was also recorded in variant 4, amounting to 96.40%.

Based on the larval counts of cereal ground beetles and wireworms, it was determined that the most effective method of controlling these pests was pre-sowing seed treatment with ST 36 SC insecticide at a rate of 1.0 L/t of seed.

Long-term plant protection practices have clearly established that, in order to determine the biological efficacy of insecticides in controlling cereal ground beetle larvae and true and false wireworms, it is necessary to record not only larval numbers but also the frequency and intensity of seedling infestation. Therefore, in this study, in addition to recording larval counts, plant counts were also taken. For this purpose, both the total number of plants and the numbers of healthy and infested plants were recorded.

The data from Table 4 show that the number of seedlings per square meter ranged from 27.30 specimens/m² in the standard to 27.67 specimens/m² in variant 4, indicating that plant density was fairly uniform across all experimental variants.

On the 14th day after emergence, it was found that the density of seedlings infested by cereal ground beetle larvae ranged from 0.53 specimens/m² in the standard to 1.25 specimens/m² in variant 3. In variant 4, the number was 0.47 specimens/m², while in the control this indicator reached 7.00 specimens/m², equivalent to 25.41% of the total recorded plants.

It is noteworthy that, in variant 3, the density of infested seedlings was 1.25 specimens/m², which is 5.60 times lower than in the control, but still considerably higher than in all insecticide-treated variants. On the 14th day after emergence, the density of seedlings infested by true and false wireworms ranged from 0.54 specimens/m² in variant 4 to 7.50 specimens/m² in the control. In variant 3 and in the standard, the values were 1.38 and 0.58 specimens/m², respectively.

Table 4. Biological efficacy of wheat seed treatment with the insecticide ST 36 SC in controlling cereal ground beetle and wireworms, based on the assessment of infested seedlings

No.	Experimental variants	Application rate, L/t	Number of plants, specimens/m²				Reduction in the number of infested plants compared to the control, % for:	
			Total	Of which				
				Uninfested	Infested by:			
					Cereal ground beetle	Wireworms	Cereal ground beetle	Wireworms
1.	Control	-	27.55	13.05	7.00	7.50	0.0	0.0
2.	Standard, Force 20 CS	1.0	27.30	26.19	0.53	0.58	92.43	92.27
3.	ST 36 SC	0.8	27.42	24.79	1.25	1.38	82.14	81.60
4.	ST 36 SC	1.0	27.67	26.66	0.47	0.54	93.29	92.80
LSD, 95%					0.69	0.76	4.63	5.13

Source: developed by the group of authors.

Based on the conducted research and the obtained results, it was found that pre-sowing treatment of winter wheat seed with the product ST 36 SC at an application rate of 1.0 L/t of seed ensures a biological efficacy of 93.29% in reducing the number of plants infested by the cereal ground beetle and 92.80% in reducing the number of plants infested by wireworms. The same product, applied at a rate of 0.8 L/t, performs significantly worse compared to both variant 3 and the standard.

Table 5. Budget and cash flow analysis for winter wheat cultivation per hectare

Specification	Amount, euro/ha	Consumptionstructure, %	Cash flow for the months of the year, euro / ha											
			January	February	March	April	May	June	July	August	September	October	November	December
Initial cash flow	**X**	**X**	**0.0**	**0.0**	**0.0**	**-130.1**	**-234.3**	**-322.6**	**-364.1**	**-435.8**	**-107.6**	**44.8**	**373.0**	**211.5**
I. Net sales	**987.2**	**X**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**329.1**	**329.1**	**329.1**	**0.0**	**0.0**
II. Cost of inputs	417.8	53.9%	0.0	0.0	122.6	89.7	74.7	0.8	0.8	0.8	127.6	0.8	0.0	0.0
III. Cost of machinery services	150.9	19.5%	0.0	0.0	0.0	9.5	9.5	33.0	61.9	0.0	37.0	0.0	0.0	0.0
IV. The cost of manual operations	10.6	1.4%	0.0	0.0	1.4	0.0	0.0	0.0	5.6	0.0	3.6	0.0	0.0	0.0
V. Other costs and fees	159.5	20.6%	0.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	153.8	0.0
VI. Unforeseen ((II+III+IV+V)*5 %)	36.9	4.8%	0.0	0.0	6.2	5.0	4.2	2.0	3.4	0.0	8.4	0.0	7.7	0.0
VII. Variable cost (II+III+IV+V+VI)	**775.7**	**100.0 %**	**0.0**	**0.0**	**130.1**	**104.1**	**88.3**	**41.5**	**71.7**	**0.8**	**176.7**	**0.8**	**161.5**	**0.0**
VIII: Gross margin (profit) (VIII-VII)	**211.5**	**X**	**0.0**	**0.0**	**-130.1**	**-104.1**	**-88.3**	**-41.5**	**-71.7**	**328.2**	**152.4**	**328.2**	**-161.5**	**0.0**
IX: Gross margin (I / VII*100%)	27.3%	X	X	X	X	X	X	X	X	X	X	X	X	X
X. Unit cost, euro/t	141.0	X	X	X	X	X	X	X	X	X	X	X	X	X
Cash flows final	**X**	**X**	**0.0**	**0.0**	**-130.1**	**-234.3**	**-322.6**	**-364.1**	**-435.8**	**-107.6**	**44.8**	**373.0**	**211.5**	**211.5**

Source: Developed by the group of authors [10, 11, 12].

Competition is extremely important for the sustainable development of agriculture (and not only), it requires farmers to invest and develop value chains aimed at increasing the competitiveness of cereal products and increasing adaptation to different resilience (especially climatic and economic).

Based on the research conducted for the winter wheat crop and the calculated income and expenditure budget, it was possible to determine the economic efficiency, which profit is a minimum of 211.5 euros/ha, with a minimum economic profitability of 27.3% and a unit cost of 1 ton of wheat of 141 euros/t, which requires the farmer to ensure impeccable agro-technological discipline to achieve these results

The winter wheat crop is characterized by low economic efficiency, due to high direct costs, namely: material resources 53.9%, other costs (the main one is the rent payment) 20.6% and the cost of mechanized services 19.5%, which is very risky in the current agricultural conditions and with the application of the conventional farming system.

Figure 1 presents the structure of direct costs per hectare for winter wheat cultivation by cost items.

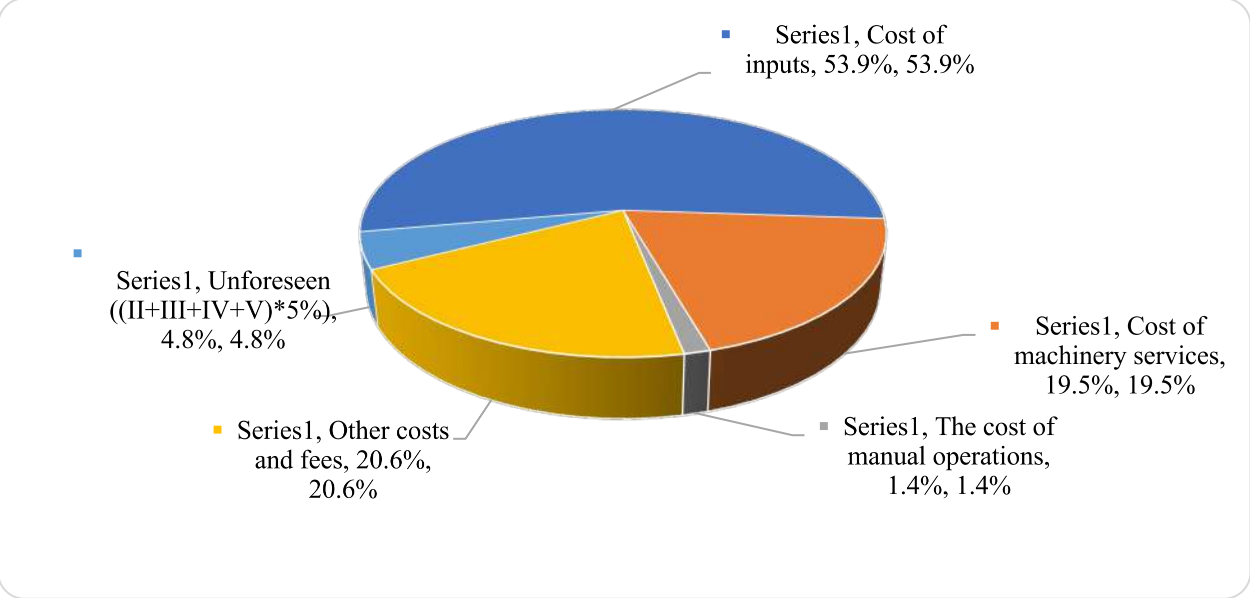

Fig. 1. Structure of direct costs per hectare for winter wheat cultivation by cost items, %
Source: Developed by the group of authors [10, 11, 12].

CONCLUSIONS

The obtained results of this research, allowed us to set up the following conclusions:

-The meteorological conditions of the 2023-2024 season were relatively favorable for the spread and development of cereal flies, the cereal ground beetle, and wireworms.

-In the research year, the density of cereal flies, the cereal ground beetle, and wireworms exceeded the economic threshold (ET), which made it possible to conduct experiments on testing plant protection products.

-The product ST 36 SC, at an application rate of 0.8 L/t of seeds, does not provide satisfactory efficacy in reducing wheat pests.

-The most effective in controlling wheat pests is the insecticide ST 36 SC, at an application rate of 1.0 L/t of seeds.

-The insecticide ST 36 SC can be included in the integrated protection system for autumn wheat by treating the seed material before sowing, to control cereal flies, the cereal ground beetle, wireworms, and other pests, at an application rate of 1.0 L/t of seeds.

Strategic for the domestic cereal sector is to increase the efficiency of the sector and, most importantly, its competitiveness through the following actions:

-Promoting and facilitating the implementation of environmentally friendly agricultural systems, which allow increasing resistance toeconomic resilience and especially climate resilience for the plant sector (field crops in this case winter wheat).

-Oriented to maintaining and improving soil fertility by implementing ecological and conservative agricultural systems (no-till, mini-till, strip-till);

-Increasing the number of field crops in rotation and ensuring a true rotation, as it is extremely important for increasing soil quality and good precursors for increasing the level of harvests per unit area;

-Facilitating and supporting producers of domestic seed material, which is much more accessible especially for small and medium-sized farmers and is primarily resistant to drought.

Facilitating and encouraging qualitative business cooperation, especially among small and medium-sized farmers, where operational cooperation oriented towards joint business development is lacking (necessary for cost optimization).

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