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The economic efficiency of using protective measures in combating rice pests

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Abstract. In the conducted research in the conditions of the Karatal District of the Zhetysu Region, an analysis of the economic efficiency of rice pest control methods was performed. Among the main pests damaging the crops are the coastal fly, barley miner, and rice midge. The use of the insecticide dimethoate led to a significant reduction in damage from the coastal fly, increasing the biological efficiency to 90.9-94.2%. This, in turn, resulted in an increase in yield by 2.7-3.6 tons/ha compared to the control group. Data analysis also showed that the application of dimethoate is accompanied by a reduction in rice cultivation costs and an increase in net income. The profitability level of using this insecticide was 69.4%, indicating its high effectiveness in terms of agricultural economics. Additionally, the return on additional expenses for protecting rice crops using dimethoate reaches 2.1 times, confirming the economic feasibility of this protection method. Thus, the research results underscore the importance of applying modern rice protection methods and their positive impact on the economic outcome in the region's agriculture. They also justify the need for further research in this area to optimize the rice cultivation process considering economic aspects.

Keywords: rice, economic efficiency, profitability, pest control, insecticide.

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Экономическая эффективность применения защитных мер в борьбе с вредителями риса

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Аннотация. В научном исследовании был проведен анализ экономической эффективности методов борьбы с вредителями риса в условиях Каратальского района Жетысуской области. Среди основных вредителей, повреждающих посевы, - береговая муха, ячменный минер и рисовая мошка. Применение инсектицида диметоата привело к значительному снижению ущерба от прибрежной мухи, повысив биологическую эффективность до 90,9-94,2%. Это, в свою очередь, привело к увеличению урожайности на 2,7-3,6 т/га по сравнению с контрольной группой. Анализ данных также показал, что применение диметоата сопровождается снижением затрат на выращивание риса и увеличением чистого дохода. Уровень рентабельности использования этого инсектицида составил 69,4%, что свидетельствует о его высокой эффективности с точки зрения экономики сельского хозяйства. Кроме того, окупаемость дополнительных затрат на защиту посевов риса с использованием диметоата достигает 2,1 раза, что подтверждает экономическую целесообразность данного метода защиты. Таким образом, результаты исследования подчеркивают важность применения современных методов защиты риса и их положительное влияние на экономические результаты в сельском хозяйстве региона. Они также обосновывают необходимость дальнейших исследований в этой области для оптимизации процесса выращивания риса с учетом экономических аспектов.

Ключевые слова: рис, экономическая эффективность, рентабельность, борьба с вредителями, инсектицид.

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INTRODUCTION

In the Republic of Kazakhstan, rice cultivation occupies a modest but important place in the structure of grain crops, accounting for 2.2% of the total gross harvest volume. Despite maize, wheat, and barley remaining the main grain crops, rice farming significantly influences the country's food security. The main rice plantations are located in three regions, predominantly along the Ili and Syrdarya rivers, with the Kyzylorda region, producing 85-88% of all rice in the country, being its main producer. For sustainable development and ensuring food security in Kazakhstan, rice farming becomes strategically important. This is reflected in the Agricultural Complex Development Program 2021-2025, aimed at increasing the competitiveness of agricultural products. However, one of the main problems facing rice growers is protecting the crop from pests, diseases, and weeds both during the growing season and during grain storage. In this context, particular attention is paid to studying and combating rice pests. However, until now, pests have not been sufficiently studied. Therefore, the purpose of this article is to conduct phytosanitary monitoring of the main rice pests in this region, study their biological characteristics, and develop effective measures to combat them.

MATERIALS AND METHODS OF RESEARCH

Rice crops are subject to attack by more than 20 species of insects and crustaceans [1-4]. Among polyphagous pests, locusts, the common cutworm, and the stem corn borer can be distinguished [5]. In addition, rice is susceptible to attacks by common grain crop pests such as the common cereal aphid, dark leafhopper, Swedish fly, and others [6]. Specialized pests pose a particular danger. To survey rice crops for pests, a two-stage study is conducted. In the first stage, during the seedling phase, seedlings are examined for the presence of the rice leaf folder, rice midge, barley stem borer, and crustaceans. At the second stage, during the heading-milky ripeness period, the population of locusts, stem corn borers, thrips, and leafhoppers is checked. The species composition of insects and crustaceans, as well as the dynamics of the main species' population, are studied in field conditions in accordance with generally accepted entomological methods. For this purpose, inspections of 100 plants are carried out twice a week, insects found are collected, standard entomological nets are used for catching, and the number of insects on 25x25 cm plots and in 0.5-liter water samples is counted. Eight samples are taken in rice checks, and in each of them, damaged and undamaged plants, as well as the number of larvae and pupae, are counted. Samples are taken along two diagonals of the check. Shiten and leptestereia are accounted for by sweeping with a 15 cm diameter aquatic net. When counting eggs, larvae, and pupae of the barley stem borer, a pass is made along the diagonal of the rice check, and the count is performed at various locations on the leaf surface of the crop. The number of pests, the percentage of damaged plants, and the degree of damage are recorded. Ten samples are taken for each count, which is carried out during tillering, heading, and grain ripening of rice.

Thrips, locusts, Swedish flies, and other insects are counted using entomological nets. Collected thrips are packed in special bags for subsequent analysis in the laboratory, where their numbers are counted. When counting the number of thrips, triops, and leptestheriidae in wintering places, ten samples are taken, which are then sieved through a special sieve. Then, kerosene diluted with water is applied to the residue on the surface of the sieve to distinguish eggs, larvae, pupae, and adult stages of soil pests.

When counting rice pests, their entomophages and parasites should also be collected separately, and the percentage of pests infected with parasites should be separately counted. The intensity of phytophagous pest damage is determined according to the methodology of L. A. Kotlyarova et al., where 50 accounting plants are taken in each repetition. The intensity of damage is assessed on a 5-point scale.

Table 1. Scale for assessing the intensity of rice damage by the rice leaf folder and rice midge.

Damage indicators	Score
No changes observed in the root system and leaf surface	1
Root system damaged (by rice leaf folder larvae) or leaf surface (by rice midge larvae)	
up to 25%	2
26-50%	3
51-75%	4
over 75%	5

In 2021, systematic monitoring of pests damaging rice crops was carried out in rice-growing farms of the Karatal District. Field research was conducted at the "Bakyt" LLP, while laboratory analyses were performed at the Karatal Branch of the "Methodological Center for Phytosanitary Diagnostics and Forecasts" of the Zhetysu Region. Various agronomic practices were employed during fieldwork to combat pests and diseases of rice, including soil treatment, varying sowing dates, adjusting water regimes, applying mineral fertilizers, and implementing crop rotation strategies. These measures aimed to reduce pest and disease levels and increase rice yields. Special attention was given to analyzing the effectiveness of different pest control methods and their impact on agricultural indicators [6, 7]. The research findings provide valuable information for developing recommendations to optimize rice cultivation processes considering the specific conditions of the Karatal District.

RESEARCH RESULTS

As part of the conducted research in the Karatal District of the Zhetysu Region, an analysis of the species composition of rice pests was carried out jointly with the staff of the Karatal Branch of the "Methodological Center for Phytosanitary Diagnostics and Forecasts." Thirteen species of pests were identified in rice fields in this district. Over the past twenty-five years, large rice farms have been transformed into small farms of various ownership forms, but new fallow and reclaimed areas for rice cultivation are also being developed. These processes significantly influence the formation of insect fauna.

The expansion of dry areas in recent years has contributed to the creation of reservoirs for the rice leaf folder, various midge species, bugs, and other insects, whose development is closely linked to water availability. This, in turn, triggers the migration of many insect species from natural habitats to rice fields. The development of fallow lands also leads to the elimination of many wild plant species, increasing the economic significance of pests.

Monitoring to refine the species composition of rice pests was conducted jointly with specialists from the "Republican Methodological Center for Phytosanitary Diagnostics and Forecasts" of the Karatal Branch of the Zhetysu Region. Surveys were conducted during the rice growing season at the PSKH "Experimental," LLP "Ushtobinsky," LLP "Shygys Karatal," LLP "Syrttan," and several private farms in various rural districts of the region.

The analysis of materials from [5] shows that among the rice pests, significant damage is caused by the rice leaf folder (Ephydra macellaria Egg.), followed by the barley midge (Hydrellia griseola Flln.), rice midge (Chironomus Sp.), and on some plots, special damage is caused by the polyphagous species: Asian locust (Liocusta migratoria L.), corn or stem borer (Pyrausta nibilalis Hb), as well as the Swedish fly (Oscinell pusilla Mg). In certain rice fields, the economic significance is attributed to the lucerne weevil (Phytonomus varabilis Hbst).

The rice midge (Cricotopus silvestris Fabr.) is a harmful insect for rice crops in the Kyzylorda, Almaty regions, and Zhetysu regions. Its adult individuals measure from 2.5 to 6 mm, have transparent wings, and yellowish-brown eggs ranging in size from 0.23 to 0.36 mm. The larvae of this insect damage rice plants by eating the parenchyma of leaves, which can reduce yields. The optimal temperature for their development is 18-20°C, and a sharp decrease in larval numbers is observed when the water temperature exceeds 30°C. Damage from the barley midge is especially noticeable on the upper side of the leaves, where larvae create longitudinal tunnels, leaving only veins and epidermis, leading to wilting and death of leaves. To protect rice crops, it is important to maintain the optimal water level in fields, use high-quality seeds, carry out proper cultivation, and weed control. Chemical treatment is also recommended during seedling emergence, while the use of natural enemies of the midge can help reduce its population.

Protective measures against rice pests and the effectiveness of insecticides in combating the shore fly

Protective measures against pests during the seedling and early stages of rice development, such as the shore fly, barley midge, rice midge, etc., should adhere to a series of mandatory agronomic practices [4]:

- When sowing, it is necessary to observe the standard depth of seed burial so that at least 80% of the seeds are buried at a certain depth.
- Regulating irrigation regimes in accordance with weed control methods.

- Clearing weeds from irrigation system elements before creating a constant layer of water on the fields.
- Regularly inspecting seedlings with "floating" leaves for pest infestation, and if increased pest numbers are detected, lowering the water level for several days.
- Using high-quality seed material from rice-free areas.
- Systematically removing weed vegetation from the ridges of rice fields and canal banks.
- Field treatment after rice harvesting, including straw and plant residue removal, deep plowing, and seed cleaning before sowing.
- Preventing the formation of temporary water bodies around rice fields, which can serve as breeding grounds for pests.

Crop rotation and the use of diverse predecessors to reduce the saturation of rice rotation. As mentioned above, in the current year, 13 species of pests were found in rice fields in various economic entities of the Karatal District of the Almaty Region. The main regulating factor for the occurrence and abundance of pests is the predecessor and saturation of the crop rotation with rice. This issue was studied by us in 2021 at the "Experimental" PSKH. For example, after plowing with sweet clover as a cover crop (37.5% rice saturation), the Swedish fly, rice midge, and barley midge predominated; after three years of lucerne and spring wheat + sweet clover rotation (50.0% rice saturation), these species were also dominant; after spring wheat (50.0% rice saturation), the same species predominated.

Chemical control measures are recommended based on surveys of rice fields and pest population assessments. Pre-sowing treatment of seeds with the fungicide Fundazole, 80% c.p. (2 kg/ton of seeds) against root rots, and adding phosphamide, 40% a.i. (at a rate of 0.15 kg/ton of seeds) as an insecticide. To these preparations, 5-8 liters of water + 1 kg of OP-7 (liquid soap) are added. Seed dressing is carried out in seed treatment machines: PSSH-3, PSSH-5, PS-10, Mobitos, etc.

The larvae of the shore fly gnaw the roots of young rice seedlings. This pest is particularly dangerous to the underdeveloped root system of the crop. At this time, damaged plants easily detach and, driven by the wind, collect on the edge of the rice ridges. The destructive activity of shore fly larvae leads to thinning of crops. Ultimately, this results in reduced crop yields. A 2-fold decrease in rice tillering due to larvae damage results in a 3-fold loss of straw mass.

In the conditions of the Karatal District of the Zhetysu Region, along with agronomic measures, chemical protection of crops against overwintered adult shore flies is applied. For this purpose, around rice fields within a radius of 200 m, spring treatment with insecticides is carried out during the mass emergence of shore flies. The paper [6] shows the results of treatment around rice fields against adult shore flies. Treatment was conducted on May 6, 2016. The area of experimental plots was 10,000 m^2, with a 4-fold repetition.

The results in [7] show that on experimental plots, when using Dimethoate, 70% a.i. (0.02-0.03 l/ha), the biological effectiveness against adult shore flies 7 days after treatment ranged from 90.9% to 94.2%, and the yield in adjacent rice plots was 30.3-31.2 t/ha, which is slightly higher than in the control (Actellic 500, a.i. - 0.5 l/ha) – 87.6% and 29.3 t/ha. It should also be noted that reducing the application rate of Dimethoate, 70% a.i., from 0.03 l/ha to 0.02 l/ha reduces both the biological effectiveness and the yield increase.

Economic justification of research results

The economic efficiency of agricultural production is a complex category. Economic efficiency refers to the ratio of economic effects or results to resources or costs. Many factors and conditions that affect both production results and costs are summed up in the category of economy.

Economic efficiency is determined by the ratio of economic effect to resources, or vice versa – the ratio of resources to the magnitude of the economic effect.

Economic efficiency = (effect (result)) / (resources (costs))
or
Economic efficiency = (resources (costs)) / (effect)(result)).

The level of economic efficiency provides an idea of the cost of resources required to achieve the economic effect. The higher the effect and the lower the resources expended, the higher the economic efficiency of production, or vice versa.

The profitability level shows the efficiency of production in terms of obtaining profit per unit of material and labor costs for the production of agricultural products and its realization.

For a comprehensive characterization of production efficiency, indicators such as labor productivity and production cost are used, as well as the efficiency of investment funds and capital investments are calculated.

According to the methodology of M.T. Shishkov, an assessment of the economic efficiency of protecting rice crops from adult shore fly was given [8]. The calculation of the economic efficiency of protecting rice crops from the aforementioned pest in the "Ushtobinsky" LLP of the Karatal District of the Almaty Region showed the following results:

- Control – no chemical preparations were used;
- Standard – Actellic 500, a.i. (0.5 l/ha) was used to combat adult shoreflies;
- Variant – Dimethoate, 70% a.i. (0.03 l/ha) was used to combat adult shoreflies.

Calculation results

The rice yield in the control was 27.6 t/ha, in the standard (Actellic 500, a.i. 0.5 l/ha) was 29.3 t/ha, and in the experimental group (Dimethoate, a.i. 0.03 l/ha) was 31.2 t/ha (see Table 2).

At the time of rice harvesting, the cost of 1 ton of rice is 6000 tenge. Multiplying the rice yield by the cost of 1 ton of the crop will yield the value of the rice harvest: in the control – 165600 tenge.

Table 2. Economic efficiency of the insecticide Dimethoate, 70% a.i. (0.03 l/ha) against adult shore flies (Almaty Region, Karatal District, "Ushtobinsky" LLP, 2016).

No	Economic Indicators	Control (no treatment)	Standard (Actellic 500, a.i. - 0.5 l/ha)	Variant (Dimethoate, a.i. - 0.03 l/ha)
1	Rice yield, t/ha including additional yield, t/ha	27.6	29.3 (+1.7)	31.2 (+3.6)
2	Cost of 1 ton of rice, tenge	6000	6000	6000
3	Value of rice harvest, including additional, tenge	165600	175800 (+10200)	187200 (+21200)
4	Costs of rice cultivation, tenge	108950	109200 (+4070)	110500 (+6920)
5	Net income, tenge, including additional, tenge	56650	66600 (+6130)	76700 (+14280)
6	Profitability level, %	52.0	61.0	69.4
7	Payback of additional costs	-	1.5	2.1

In the control group, the net income was 566,500 tenge, in the standard group (using Actellic 500, EC - 0.5 l/ha) it was 666,000 tenge, and in the experimental group (using Dimethoate, 70% a.i. - 0.03 l/ha) it was 767,000 tenge. The profitability level, calculated as net income divided by the cost of rice cultivation and multiplied by 100%, was 52.0% in the control group, 61.0% in the standard group, and 69.4% in the experimental group. The payback of additional expenses, calculated as additional net income divided by the cost of additional yield, was 1.5 times in the standard group and 2.1 times in the experimental group.

CONCLUSION

In conclusion, the study of rice production efficiency in the Karatal District of the Zhetysu Region emphasizes the importance of the economic aspect in the agricultural sector. The use of chemical agents to combat rice pests such as the rice leaf roller, barley miner, and rice midge can significantly increase yield and profitability.

The research findings demonstrate that the use of Dimethoate, 70% a.i., to combat the rice midge shows high effectiveness, substantially increasing rice yield and net income. The profitability level of production also noticeably increases, indicating the success of employing this insecticide.

Economic analysis also allows for the assessment of the payback of additional costs incurred in protecting rice crops from pests. In this case, the use of Dimethoate shows a significant increase in cost-effectiveness, indicating its efficacy as a tool for protecting rice crops.

Thus, such studies not only contribute to increasing agricultural production levels but are also essential for developing economically viable strategies in the agricultural sector, contributing to its sustainable development.

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