MINISTRY OF AGRICULTURE OF THE RUSSIAN FEDERATION
Federal State Budgetary Educational Institution of Higher Education
"St. Petersburg State Agrarian University"
(FSBEI HE SPbSAU)

As a manuscript

Isawi Mohanad Bahr Awad

BIOLOGICAL RATIONALE FOR THE APPLICATION OF MODERN INSECTICIDES FOR THE PROTECTION OF WINTER WHEAT IN THE CONDITIONS OF THE STEPPE ZONE OF THE CAUCASUS

Speciality 4.1.3. Agrochemistry, agrosoil science, plant protection and quarantine

Dissertation for an academic degree
candidate of biological sciences

Scientific adviser:
Dolzhenko Tatyana Vasilievna
Doctor of Biological Sciences, Professor

St. Petersburg–Pushkin

2024

МИНИСТЕРСТВО СЕЛЬСКОГО ХОЗЯЙСТВА РОССИЙСКОЙ ФЕДЕРАЦИИ

Федеральное государственное бюджетное образовательное учреждение высшего образования «Санкт-Петербургский государственный аграрный университет»
(ФГБОУ ВО СПбГАУ)

На правах рукописи

Исави Моханад Бахр Авад

БИОЛОГИЧЕСКОЕ ОБОСНОВАНИЕ ПРИМЕНЕНИЯ СОВРЕМЕННЫХ ИНСЕКТИЦИДОВ ДЛЯ ЗАЩИТЫ ПШЕНИЦЫ ОЗИМОЙ В УСЛОВИЯХ СТЕПНОЙ ЗОНЫ ПРЕДКАВКАЗЬЯ

Специальность 4.1.3. Агрохимия, агропочвоведение, защита и карантин растений

Диссертация на соискание учёной степени
кандидата биологических наук

Научный руководитель:
Долженко Татьяна Васильевна
доктор биологических наук, профессор

Санкт-Петербург–Пушкин

2024

CONTENTS

INTRODUCTION

Relevance of the topic research. In terms of significance and output, wheat (*Triticum aestivum* L.) is considered one of the most important and strategic grain crops worldwide. This crop ranks first globally, followed by other strategic crops such as rice, corn, and barley. World wheat production is 784.7 million tons [1]. Of all grains, wheat *T. aestivum* L. It is highly strategic and valuable, being a staple food in most countries around the world. It contributes to 20% of the world's food calories and feeds almost 40% of the global population. Wheat's versatility and preference over other food products in different countries has made its economic importance soar in various industries such as baking, dietary, and pharmaceuticals. Moreover, it's an essential commodity in the international market [2]. The future of agriculture and food security in all countries is connected with many aspects. One of the crucial factors is the development of an effective system for protecting agricultural plants from pests [3]. Crop protection from harmful insects is a primary and pressing issue in maintaining grain yields across all countries in the world [4]. Currently, it is impossible to predict the steady success of any modern company if it does not offer dependable and efficient protection for cultivated crops, as this is accomplished by implementing the necessary special measures that minimize grain yield losses from harmful organisms to approximately 25% while also meeting the growing demand for higher grain yields, especially winter wheat, along with several climatic and environmental factors (short winters, high heat, the duration of the growing season, the presence of several crops - intermediate hosts of harmful organisms) provide conditions that are conducive to the growth and widespread reproduction of various types of pests [5,6].

A significant decline in the phytosanitary condition of several crops, especially winter wheat, was seen in different Russian areas throughout the 1990s, including the Pre-Caucasus. This was caused by changes in socio-economic and industrial relations in the agro-industrial complex. The use of mineral and organic fertilizers decreased, surface tillage was reduced to a depth of 8-12 cm, and shortened crop rotation cycles (5-

6-full) were adopted, leading to a decrease in soil fertility and biological activity, additionally, financial and economic difficulties emerged among agricultural producers. These factors harmed the cultivation of winter wheat, increasing the development and spread of pests of grain crops, including winter wheat [7,8].

In the steppe zone of Ciscaucasia in the Rostov region, there is a variety of pests that cause damage to winter wheat crops during their growth season. These pests include the sunn pest (*Eurygaster integriceps* Puton), grain aphid (*Sitobion avenae* Fabr.), greenbug aphid (*Schizaphis graminum* Rond.), striped cicada (*Psammotettix striatus* L.), wheat beetles such as kuzka (*Anisoplia austriacea* Hrbst.), Crusader (*Anisoplia agricola* Poda) and krasun (*Anisoplia segetum* Hrbst.), cereal leaf beetle (*Oulema melanopus* L.), and wheat flies (*Phorbia fumigata* Meigen.) and others. These pests are known to cause harm to grain crops from sowing to harvesting, especially winter wheat [9].

Mass reproduction of typical harmful pests is sparked by the degradation of phytosanitary conditions in winter wheat fields in recent years as a result of cultivation techniques and protective measure breaches [10]. Chemical pesticides have been used and are still used to control many harmful organisms. About 2 million tons of pesticides worth 35 billion US dollars are used annually in the world [11,12].

This requires finding ways and means to increase the effectiveness of these compounds, for instance, pesticides for pest control, and developing alternative plant protection strategies that are effective in reducing environmental damage. It also demands providing some solutions to intractable problems.

One such solution is combining pesticides from more than one active substance and most commonly used against insect pests in wheat fields. The topic is related to the use of modern pesticides in various preparative forms, which requires research to assess their biological effectiveness against insect pests in winter wheat fields.

The degree of development. An analytical review of the literature revealed that several pest groups feed on winter wheat during its growth season in the Steppe zone of Ciscaucasia in the Rostov area, which harms grain crops from sowing to harvesting [2,6,9,13–20]. There are many studies and practical methods of dealing with these pests

[15,16,21–25]. However, many aspects of development, harmfulness, control, and the regulation of their numbers on crops remain unclear: this required the search for alternative means of pest control and the development of effective methods of their destruction. One such solution is the study of modern combined pesticides. New innovative methods are also being introduced into pest control systems based on nanotechnology [26–36]. In particular, since agricultural applications rank highly on the list of these technologies' objectives, further study is needed to determine how successful these applications are biologically against insect pests [36–40].

The objective of this study:

1. Develop novel and innovative formulations, such as combinations, with active ingredients from different chemical groups to control pests on winter wheat.
2. Study the biological effectiveness of novel phytosanitary agents in protecting winter wheat against phytophages.
3. Establish regulations for the safe and effective usage of preparations to protect winter wheat from a complex of phytophages.
4. Evaluate the ecotoxicological indicators of new combined preparations for the protection of winter wheat from phytophages.

The scientific novelty. For the first time in the conditions of the steppe zone of Ciscaucasia, the effect of new, including combined, preparations from various chemical classes on the pest complex in winter wheat crops was studied: insecticides Meadows, oil dispersion (MD) (200 g/l acetamipride); Carnadine,water-soluble concentrate (VRK) (200 g/l acetamipride); Dexter Turbo, suspension emulsion (SE) (115 g/l acetamipride +106 g/l lambda-cyhalothrin + 70 g/l clothianidine); Mainstay, suspension emulsion (SE) (112 g/l of Bifenthrin + 37 g/l of sulfoxaflor); Factoria, microcapsulated suspension (MCS) (141 g/l thiamethoxam + 106 g/l lambda-cyhalothrin). High biological efficacy (up to 100%) of these preparations has been established.

Theoretical and practical . The study findings gained support for theoretical notions on the potential application of novel pesticides in winter wheat protection systems against phytophages.

Methodology and research methods. Methodological approaches based on the principles of phytosanitary optimization of agroecosystems, literature analysis, defining the goals and purpose of the study, organizing field and laboratory experiments, processing experimental data mathematically, and generalizing the findings were used to conduct scientific investigations. The studies were conducted in accordance with generally accepted methods of studying the effectiveness and safety of insecticides. Their detailed description is presented in the section «Conditions, materials and methods of research».

Basic provisions for defense:

- Effective modern pest management techniques for winter wheat cultivated in the steppe zone of Ciscaucasia.
- Regulations for the safe and efficient application of modern pesticides.

The degree of reliability and approbation of the results:

The significant results of the dissertation research were described at: The International Scientific and Practical Conference of Young Scientists and Students «Intellectual Potential of Young Scientists as a Driver of Agricultural Development» (St. Petersburg, SPbGAU, 2022, 2023); VII All-Russian Scientific and practical conference with international participation «Young researchers of agro–industrial and forestry complexes - regions», (Vologda, 2022); international scientific and practical conference of young scientists "Integrated plant protection system: status and prospects" (Almaty, 2022); International University Scientific Forum "Practice Oriented Science: UAE – RUSSIA – INDIA" (UAE, 2022).

Publications:

The dissertation research resulted in the publishing of eight articles, which were approved by the (VAK) and (Scopus), as well as other publications.

Author's contributions:

The author conducted his scientific investigation for his dissertation while pursuing his postgraduate degree. The planning and execution of field and laboratory investigations, accounting and observation, result analysis, dissertation writing, and scientific papers are all included in the dissertation.

Structure and scope of the dissertation:

The dissertation comprises an introduction, 4 section, a conclusion, recommendations for production, a list of references, and applications. The dissertation is presented on 147 pages and contains 48 tables, 24 figures, and 6 appendices. The list of cited literature includes 251 sources.

1 THE MAIN PESTS OF WINTER WHEAT AND MEANS OF THE CONTROL THEM (literature review)

1.1 Biological features

The sunn pest (*Eurygaster integriceps* Puton), grain aphid (*Sitobion avenae* Fabr.), greenbug aphid (*Schizaphis graminum* Rond.), striped cicada (*Psammotettix striatus* L.), wheat beetles such as kuzka (*Anisoplia austriacea* Hrbst.), Crusader (*Anisoplia agricola* Poda) and krasun (*Anisoplia segetum* Hrbst.), cereal leaf beetle (*Oulema melanopus* L.), and wheat flies (*Phorbia fumigata* Meigen.) and others they are the main pests on winter wheat in the steppe zone of the Caucasus [14].

The sunn pest It refers to the order Hemiptera, family Scutelleridae, genus *Eurygaster Latr*. [41–43].The species is characterized by stable mass reproduction so that it can be classified as a super-dominant species [44–46]. An insect with incomplete metamorphosis. During the year, one generation appears in all regions. Overwinters as adults in forest belts. [47,48]. The females deposit their eggs on the underside of cereal leaves (Figure 1), with a maximum clutch size of 14 eggs. Throughout their lives, they lay two clutches of eggs. The larvae hatch from the eggs after 10–15 days, molt five times, and develop for 30–40 days, depending on the conditions [49,50]. For the development of eggs during this period, the need for food is very high, since after wintering insects do not have enough fat reserves [51–53]. In the southern regions of the Russian Federation, The sunn pest feeds on wheat, mainly on winter wheat. eating only during the warm hours of the day (Figure 2), when the temperature is at least 20 °C. adult and larvae of the sunn pest damage wheat throughout the growing season, sucking the juice from different parts of the plant [54–56].

Figure 1– **Eggs of sunn pest (Rostov region, Orig.)**

Figure 2 – **Adult of sunn pest on a spike of wheat (Orig.)**

Wheat beetles Order Coleoptera , family Scarabaeidae, genus Anisoplia: beetles such as kuzka (*Anisoplia austriacea* Hrbst.), Crusader (*Anisoplia agricola* Poda) and krasun (*Anisoplia segetum* Hrbst.) [57,58]. They are one of the most harmful pests of grain crops [14,59].Three species of wheat beetles feed mainly on winter and spring wheat [60–62]. A typical feature of the kuzka and Crusader beetles is a two-year development cycle, and krasun is a one-year development cycle [63,64]. The female places the eggs in a moist soil layer, at a depth of 9—20 см. Eggs take 3 weeks to develop. The larvae of the kuzka beetle and the crusader live in the soil for 23 months, and the larvae of the krasun live for 9—10 months. The larvae pass through three instars [63,65]. They overwinter in the larval phase of the first or second instar. Adult beetles colonize crops (Figure 3), they appear during the flowering period of grain filling and feed more on anthers and ripening grain [66].

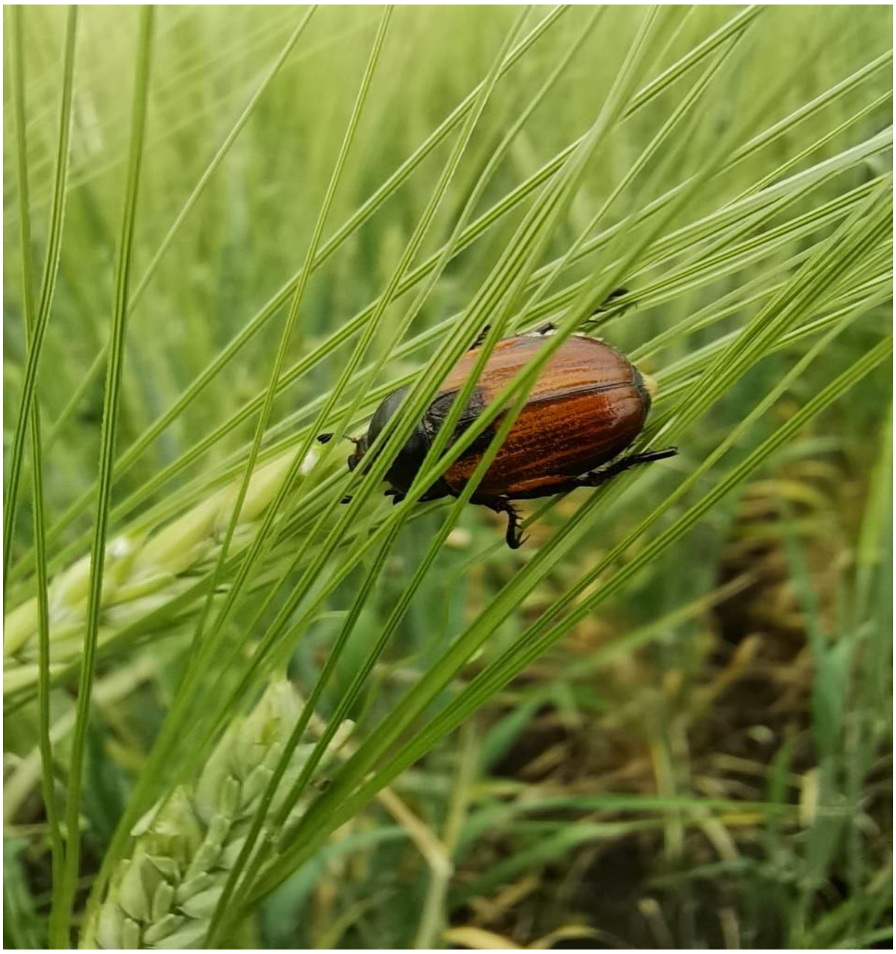


Figure 3 – **Adult of wheat beetle (Orig.)**

Cereal leaf beetle (*Oulema melanopus* L.), order Coleoptera, family Chrysomelidae, genus *Oulema.* A dangerous phytophage that harms winter wheat [67,68]. Cereal leaf beetle develops in one generation. Females lay about 100 eggs on the leaves of cereals in chains of several pieces [69]. Embryonic development lasts 14 days [70,71]. The larvae go through four instars. Beetles overwinter at a depth of 3-5 cm [72–74]. Beetles colonize grain crops (Figure 4 -5). Beetles and larvae damage the leaf surface of wheat. The larvae scrape off the flesh without affecting the veins [68,75,76].

Figure 4 – **Adult of Cereal leaf beetle (Orig.)**

Figure 5 – **larvae of Cereal leaf beetle (Orig.)**

Wheat fly (*Phorbia fumigata* Meigen), order Diptera, family Anthomyiidae [66,68,77] (Figure 6). This fly species is considered one of the most serious insect pests on winter wheat in the Rostov region [78]. The wheat fly develops in two generations, in autumn and spring, with both generations feeding mainly on winter wheat [79,80]. They overwinter in pupa in the soil at a depth of 3 cm or in the stems of winter wheat, females (autumn generation) lay eggs on winter wheat seedlings up to 25 eggs, the egg develops for 30 days, the larva develops for 25 days, the adult lives for 25–40 days [81,82].

Figure 6 – **Adult of the wheat fly (Orig.)**

Cereal aphids, order Homoptera, family Aphididae: grain aphid (*Sitobion avenae* Fabr.), greenbug aphid (*Schizaphis graminum* Rond.) and Bird-cherry-oat aphid (*Rhopalosiphum padi* L.) [83,84]. The metamorphosis is incomplete. Reproduction is bisexual and parthenogenetic. It develops up to 30 generations during the vegetation period [85,86]. In the first two species, eggs overwinter on the leaves of seedlings of winter cereals and on weeds .Cereal aphids colonize plants starting from the tillering period – stem extension stage. The maximum harmfulness of aphids is achieved during the tillering period – the milk ripeness of cereals. Aphids suck the juice from different parts of the spike (Figure 7).

Figure 7 – **Adult aphids on a spike of winter wheat (Orig.)**

Striped cicada (*Psammotettix striatus* L.), refers to the order Hemiptera, family Cicadellidae [66,75]. It is one of the dangerous pests of grain crops [87,88]. The length is 3.5–5 mm, the body is lanceolate above, the largest width is in the anterior half of the body; from gray-yellow to brownish, the legs are yellowish, the veins on the forewings are brown; the forewings are rounded, overwintering (eggs) in the incisions of the leaves of winter cereals. It develops in 1– 4 generations per year [89,90].

1.2 Distribution and harmfulness

Climate change has led to new types of pests (including invasive ones) in several regions of Russia and increased the harmfulness of recognized species. Knowledge of the spread of pests and their harmfulness zones is necessary to build an effective struggle against them. This was facilitated by the project to create an «Atlas of Pests and diseases of crops» in Russia and neighboring countries "http://www.agroatlas.ru" which was implemented by the staff of the All-Russian Scientific Research Institute of Plant Protection (VIZR) [14]. Atlas maps explain the distribution and harmfulness zones of pests of grain crops, for example, the sunn pest, wheat beetles, Cereal leaf beetle, wheat fly, and many species of aphids. The FAO standard color scheme was also used to illustrate the zones of harmfulness and spread of pests of grain crops (www.fao.org/ag/locusts-CCA/ru/index.html) [91].

The sunn pest *Eurygaster integriceps Puton*. It has been identified in North Africa and Central Asia, Europe, the CIS, Afghanistan, Pakistan, Turkey, Greece, and Iraq. In Russia - in the Chernozem region, the zone includes all grain-growing regions of the North Caucasus, Voronezh, Orenburg, Belgorod, Rostov regions (Figure 8) [91–93].

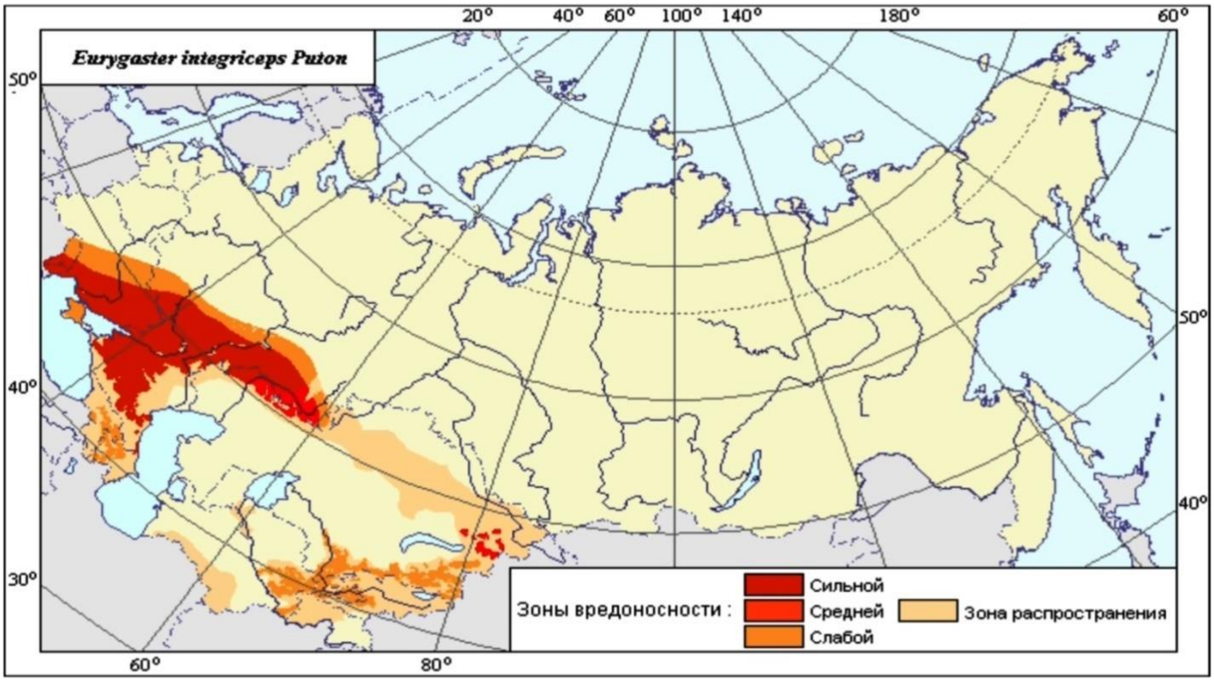


Figure 8 - **distribution and harmfulness of the sunn pest in the territory of the Russian Federation [www.agroatlas.ru]**

Since both sunn pest (adult and larvae) reduce yields, two periods of harmfulness can be distinguished [94–96]. The first is connected to adults who have overwintered, while the second is connected to larvae and adults who are new generations [97–99]. The primary source of agricultural losses is overwintered adults, which are most harmful to plants in the early stages of their development, plants often stop growing, turn yellow, and die [48,100].

Puny grains are a sign of damage that occurred during the formation of the grain, the grains appear wrinkled, and a yellowish spot appears on the surface [101–104].

When completely ripe, the damage manifests in the form of a visible yellowish spot (Figure 9).

Figure 9 – **Winter wheat grain damaged by a sunn pest (Orig.)**

The most sunn pest causes gluten. Enzymes that are injected into the grain (adult and larvae), making an injection, reduce the baking qualities of the grain, and germination. Usually, a black dot is visible at the injection site (Figure 10) [102,105].

One of the most dangerous pests of grain crops can be called wheat beetles [106]. The three most common species of the genus are Anisoplia: kuzka beetle (*Anisoplia austriaca* Herbst.), crusader beetle (*Anisoplia agricola* Poda.), and krasun beetle (*Anisoplia segetum* Herbst.) [107]. Distribution: steppe and forest-steppe zones of the European part of Russia, Kazakhstan, and Eastern Europe (Figure 11) [14,66,108–110].

Figure 10 – **Grain of winter wheat damaged by a sunn pest - black dot at the injection site (Orig.)**

The different species of adult insects do varying forms of injury [111]. Beetles destroy grain at all phases; on spring crops, they even eat other crops' grain. However, they favor grain when it is in the milk ripeness phase [57,112]. After their production, the grains are consumed to varied degrees, the anthers and ovary are entirely consumed, and occasionally just the shell is left [113,114]. Only the grains that are waxy and ripe are nibbled by the insects. The primary cause of damage at the full ripeness period is the grain "knocking out" of grain from the spike scales and its shedding on the ground [115,116]. Grain is eaten to varying degrees during formation and in the phase of milk ripeness [117,118].

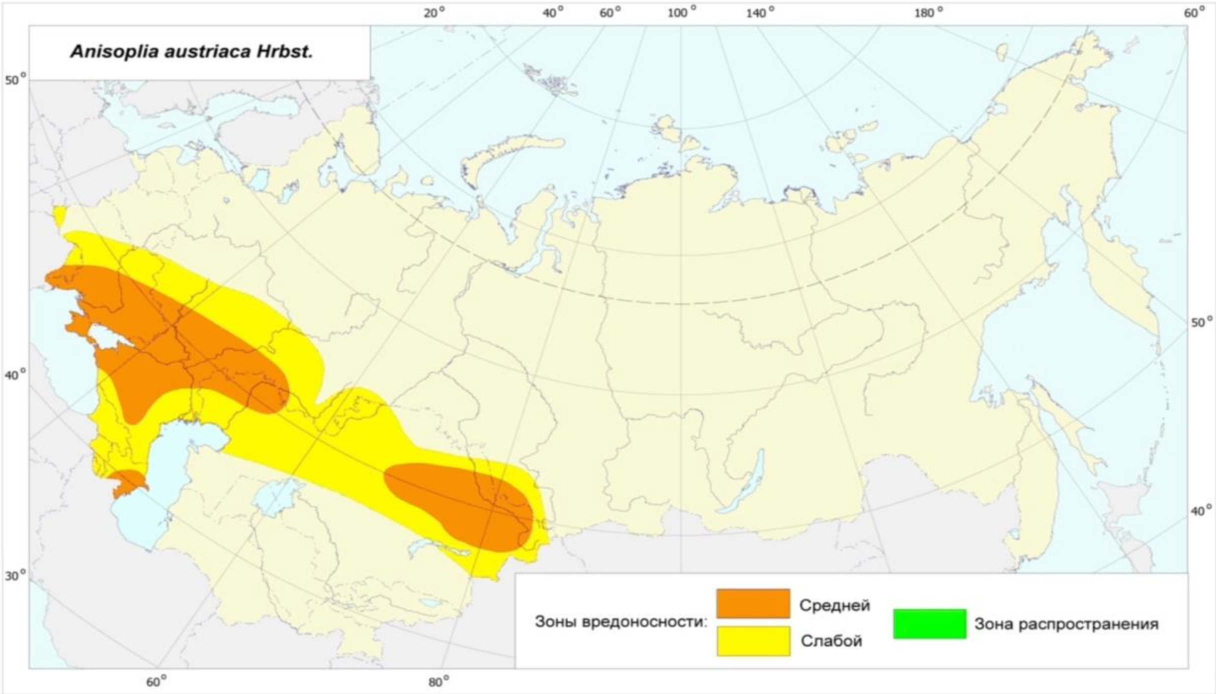


Figure 11 - **Distribution and harmfulness of wheat beetles [www.agroatlas.ru]**

Cereal leaf beetle *Oulema melanopus* L. It is also one of the main pests of winter wheat, distributed in the whole territory of the Russian Federation, the CIS, Europe, North Africa, and North America (Figure 12) [14,66,119]. Cereal leaf beetle - is a rather dangerous pest [120]. Adults and larvae feed on the leaves of grain crops. Adult beetles and larvae can destroy up to 10% of the leaf surface of a plant. The cereal leaf beetle is also dangerous because it is a vector of viruses [121,122].

The wheat fly *Phorbia fumigata* Meigen is considered one of the most serious insect pests affecting wheat in the territory of the Russian Federation (Figure 13) [123–125]. This species has been distributed in the Pre-Caucasus and southern Siberia, the CIS, North America, and North Africa [14]. On winter wheat, the central leaf turns yellow and dries up, and the fly larva makes a spiral course around the damaged stem, after which the shoot dies [126,127].

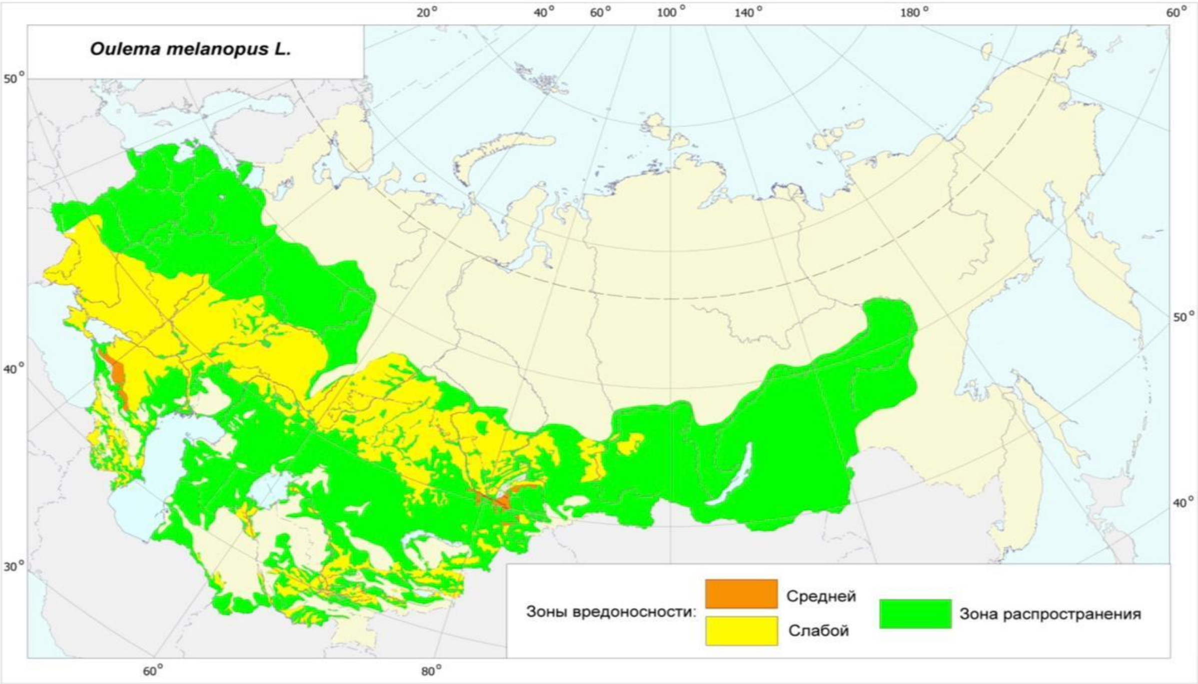


Figure 12 - **Distribution and harmfulness of cereal leaf beetle [www.agroatlas.ru]**

Figure 13 - **Distribution and harmfulness of wheat fly [www.agroatlas.ru]**

Cereal aphids are economically significant wheat pests in most wheat cultivation regions around the world, including the Russian Federation [128]. In the Russian Federation there are many species of aphids on cereal crops: greenbug aphid – *Schizaphis graminum* Rond., barley aphid– *Diuraphis noxia* (Mordvilko), grain aphid – *Sitobion avenae* (Fabr), corn leaf aphid – *Rhopalosiphum maidis* Fitch., Bird-cherry-oat aphid *Rhopalosiphum padi* L. and rose-grain aphid *Metopolophium dirhodum* Walk. The most harmful greenbug aphid – *Schizaphis graminum* Rond. and grain aphid – *Sitobion avenae* Fabr, colonizing wheat [129,130].

S. graminum Rond and *S. avenae* Fabr and *R. padi* L. (Figure 14, 15, 16) They are distributed all over the world, including in Russia [131]. These species are distributed mainly in the steppe and forest-steppe zone in the Russian Federation, the northern border of the range reaches Moscow [74,132,133]. It also harms in Central Asia, Transcaucasia, southern Siberia, and southern Primorye, and most often and severely harms in the Rostov, Saratov, and Volgograd regions [123,134,135]. *S. graminum* Rond and *S. avenae* Fabr and *R. padi* L. - sucking insects, when strongly colonized by them, plants are oppressed, various deformities, twisting, as well as indirect damage to the entire plant due to excessive formation of honeydew can be observed [136–138].

Striped cicada – *Psammotettix striatus* (L.) it is one of the main pests of winter wheat [139,140]. The species is widespread throughout the Russian Federation everywhere, except in the far north [141]. They are most harmful in steppe and forest-steppe areas . The striped cicada damages all spike crops by sucking the juice from the aboveground organs of the plant [142]. The damaged leaves of plants discolor and wither. also, it is a vector of viral diseases (winter wheat mosaic, white winter wheat mosaic, wheat dwarfism, pale green wheat dwarfism) [143,144].

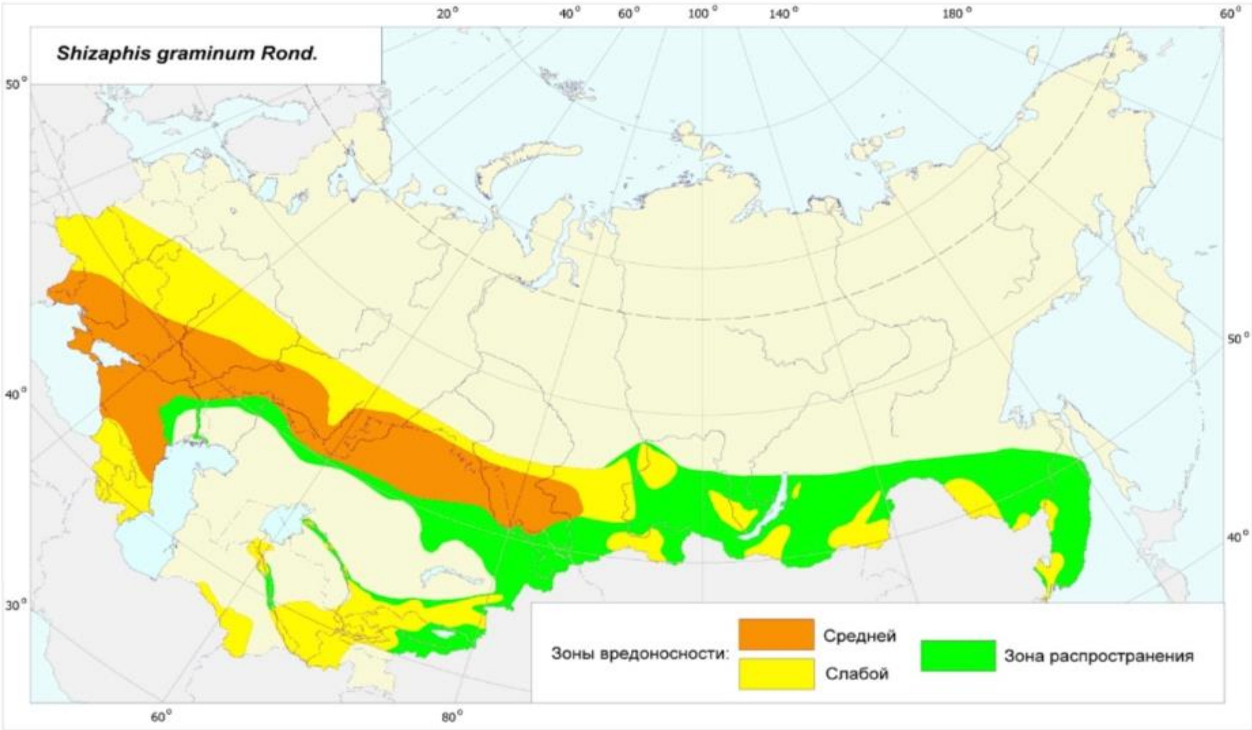


Figure 14 - **Distribution and harmfulness greenbug aphid**

[www.agroatlas.ru]

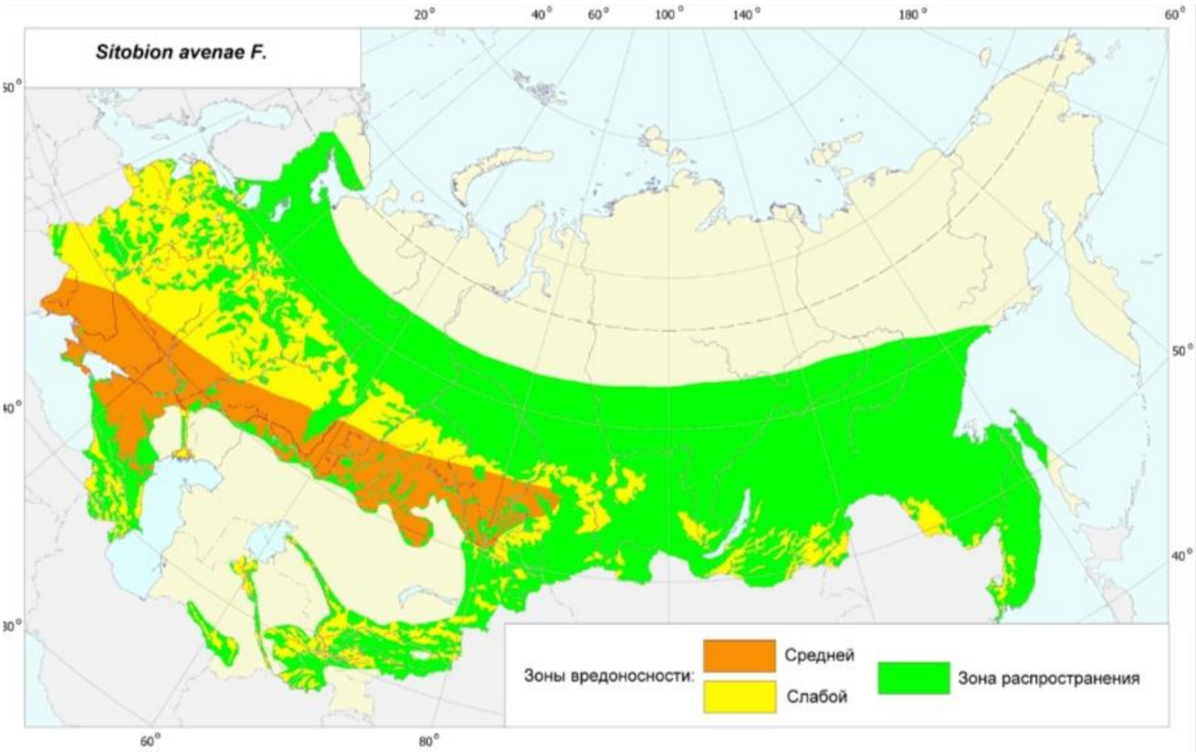


Figure 15 - **Distribution and harmfulness grain aphid**

[www.agroatlas.ru]

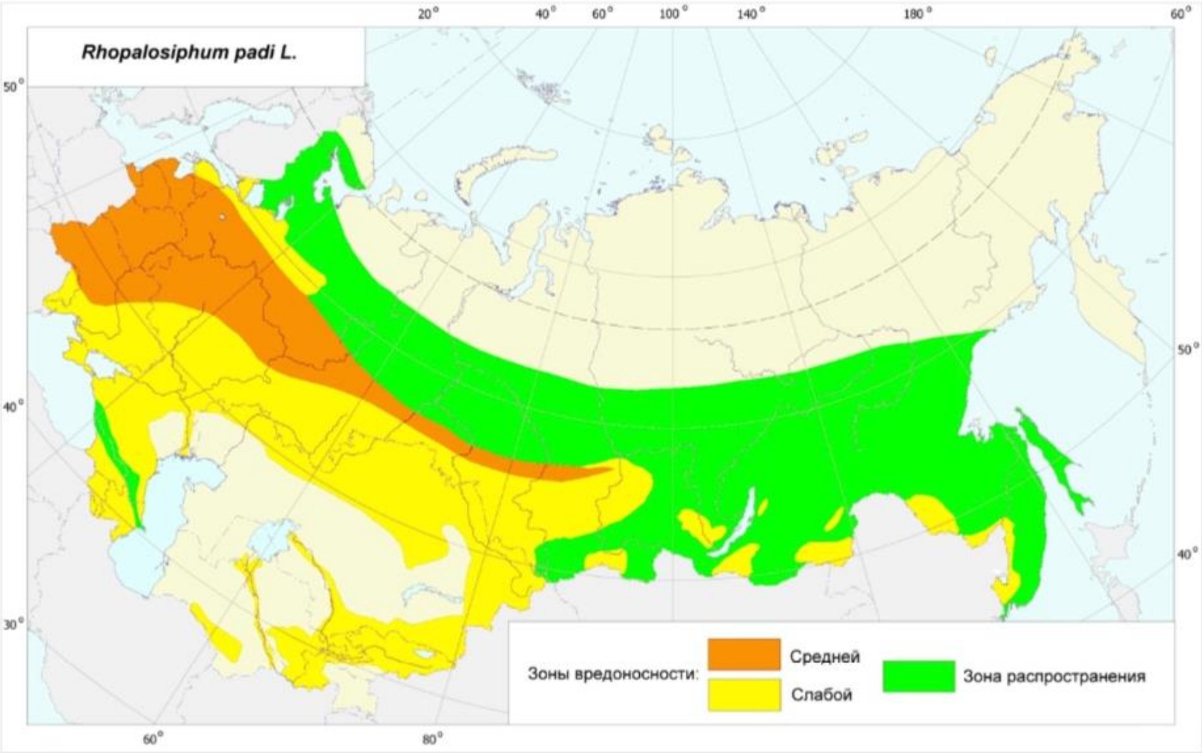


Figure 16 - **Distribution and harmfulness Bird-cherry-oat aphid [www.agroatlas.ru]**

1.3 Control methods

1.3.1 Agriculture practices

The agriculture practices is one of the main methods and includes crop rotation, appropriate tillage, fertilizer system, seed preparation, etc. [145].These techniques are preventive, preventing reproduction, and some directly destroy harmful insects. Therefore, the purpose of agriculture practices techniques is to create conditions favorable for the growth and development of grain crops and to prevent the reproduction and spread of pests [146]. For example, to limit the population of sunn pests, it is advisable to sow crops early [147].

Crop rotation - the rotation of crops, is one of the most important factors in reducing the number of phytophages. Permanent cultivation of grain crops for several years in a row contributes to increased reproduction and spread of pests . For example, the larvae of wheat beetles live in the soil for two years. With permanent grain crops, favorable conditions are created for increased reproduction of the pest. Therefore, the alternation of grain crops limits the reproduction of wheat beetles, since during the change of crops unfavorable conditions are created for their development and many larvae and pupae die [112]. Permanent cultivation of grain crops leads to an increase in the reproduction and spread of cereal flies [17].

It is necessary to observe the spatial isolation of crops from the places of previous cultivation of grain and spring grain from winter crops at a distance of at least 1 km. The best predecessors for grains are clean and busy steam, crops of leguminous crops, and a layer of perennial grasses [148].

Tillage is one of the most important potent techniques in regulating the number of insects in the fields of grain crops. Tillage is extremely important in the struggle against cereal flies, larvae of wheat beetles, aphids, and other pests. Post-harvest tillage exterminates some cereal pests [149,150].

Long-term experience has shown that spring crops sown by winter plowing are better than those sown by spring plowing, and are more resistant to pests. This technology promotes the development of plants and increases their resistance to pests [14].

Fertilizers are also one of the factors that effectively increase the resistance of grain crops to pests. Crops are less damaged by stem pests, become more hardy, and die less when the main stem is damaged in well-fertilized areas. Phosphorus and potash fertilizers accelerate the ripening of cereals and increase the resistance of stems to damage, which reduces crop losses from harmful insects [151].

The timing of sowing is one of the agriculture practice methods. The sowing time, seeding rate, and sealing depth are important for pest control of grain crops. Optimal sowing times reduce yield losses from many harmful insects: cereal flies, sunn pests, cereal leaf beetle, aphids, wheat beetles, etc. [152].

The timing and quality of harvesting, reduction of grain losses, timely removal of straw from the fields — all this is crucial in the fight against pests of grain crops, therefore timely harvesting is extremely important in the fight against grain pests. Long-term harvesting of grain crops allows the sunn pest to complete its growth and store enough fat mass for wintering. As the harvest is delayed, the loss of grain from wheat beetles increases and this also contributes to their reproduction [66].

Resistant varieties are one of the factors for pest control. The sunn pest damages the grain of late wheat varieties more [153,154].

Overall, agriculture practice are a powerful factor affecting agroecosystem and these techniques should be used to reduce the reproduction and spread of insect pests.

1.3.2 Biological control

In agroecosystems, each phytophagus has its own natural enemies (predatory and parasitic) and pathogens (bacteria, fungi, viruses). This method of controlling harmful insects is called the biological method, it involves the use of natural enemies - predatory and parasitic insects and pathogens [15,155,156]. On grain crops, most parasitic insects belong to the order Hymenoptera and Diptera, representatives of the order Coleoptera predominate among predators [157]. The number of sunn pest and cereal aphids is influenced by about 80 species of specialized entomophagous (aphidophagous) and more than 90 species of polyphagous [6,158].

The study on the identification of various types of predators and parasites in grain fields indicated 12 species of Coccinellidae, 6 species of mites,5 species of syrphid flies, 2 species of Nabid bugs, 15 species of ground beetles, two species of Green lacewings, as well as three species of parasites [159,160]. The 7-point ladybug *Coccinella septempunctata* L. is widely represented in crops, which actively and easily finds its prey and flies over long distances [161,162]. Chrysopidae are also of great importance, for example, Green lacewings *Chrysoperla carnea* Steph [163]. The parasites include Hymenoptera from the family Aphidiidae - *Aphidius avenae* Hal. [164]. Adult of the wheat fly is killed by assassin flies [165].

Significant progress has been achieved in the last ten years in the use of natural enemies, even though present techniques to manage the sunn pest are mostly reliant on chemical control. The most significant agents of biological control of phytophagous organisms are the Scelionidae (Hymenoptera), particularly those belonging to the genus *Trissolcus spp*[166–168].

Trissolcus semistriatus - is the most popular parasite of sunn pest eggs in Iran, Syria, Turkey, and Iraq, where winters are mild and summers are warm [169]. A limited number of studies have focused on a new species of nematode *Hexamermis sp*. (Nematoda: Mermithidae) on the sunn pest [170,171].

The use of biopesticides—such as insect growth regulators (IGR), anti-juvenile hormones, and plant components to control sunn pests—has drawn more attention in recent years [172,173].

We conclude that the development of strategies that improve the efficacy of the complete complex of entomophagous as well as its component groups is one of the prerequisites for the creation of a biological approach for the control of grain pests. The most effective way to conserve beneficial arthropods in agrobiocenosis should be through the use of pesticides in an ecologically responsible manner. [174].

1.3.3 Chemical control

A chemical insecticide is defined as a substance or group of chemicals that are used to reduce the number of insects [175,176].

Chemical control is the most widely used method in most areas for the spread of pests of grain crops. The successful use of pesticides in any pest control program helps to achieve pest control on time before they reach economically harmful levels [177].

Many systemic, contact pesticides belonging to different chemical groups (pyrethroids, carbamates, organophosphates, insect growth regulators, neonicotinoids, and others) have been tested in the control against aphids, sunn pests, wheat beetles, cereal leaf beetles, and cereal flies, and some of them have shown good effectiveness in control them in different areas the world [178,179].

Chemical plant protection products will retain their importance in the future as a measure to ensure the preservation of yields with an increase in the threshold number of pests, despite the numerous negative consequences of their use, including on cereals, determined in recent years. In this regard, the task of further improving chemical control measures and developing regulations for their use remains urgent [180].

The following preparations were registered in the control, aphids, sunn pests, wheat beetles, cereal leaf beetles, and cereal flies in the Russian Federation's official list of agrochemicals and pesticides that are permitted for use on its territory, 2023 (table 1).

Table 1 – **Preparations for the protection of winter wheat from pests (State Catalog of pesticides..., 2023)**

Active ingredient	Trade name content of the active ingredient
Acetamiprid	Grind, SP (200 g/kg); Snake, SP (200 g/kg); Mospilan, SP (200 g/kg); Agent, WDG (200 g/kg); Meadows, OD (200 g/l).
Acetamiprid + lambda-cyhalothrin	Harpoon, SC (115 + 106 g/l).
Acetamiprid+ lambda-cyhalothrin+clothianidin	Dexter Turbo, SE (115 + 106 + 70 g/l).
Acetamiprid + fludioxonyl + ciproconazol	King Combi, SC (100 + 34 + 8,3 g/l).
Acetamiprid + prochlorase +propiconazol+azoxystrobin	Quartet, SC (150 + 100 + 39 + 39 g/l).
Acetamiprid + prochloras + tebuconazol+ pyraclostrobin	Polaris Quatro, SME (150 + 100 + 20 + 15 g/l).
Dimethoate	Bishka, EC (400 g/l); Bimmer, EC (400 g/l); Binadin, EC (400 g/l); Eurodim, EC (400 g/l); Bi-58 Top, EC (400 g/l); Danadim Expert, EC (400 g/l); Tagore, EC (400 g/l); Sirocco, EC (400 g/l); Discharge, EC (400 g/l); Tod, EC (400 g/l); Dimefos, EC (400 g/l); Alpha Director, EC (400 g/l); Dimethus, EC (400 g/l); Dimetron, EC (400 g/l); Rangoli-Duncan, EC (400 g/l); Di-68, EC (400 g/l); Rogor-S, EC (400 g/l); Fostran, EC (400 g/l); Dimetek, EC (400 g/l); Ditox, EC (400 g/l).

Imidacloprid	Taboo, WSC (500 g/l); Akiba, WSC (500 g/l); Vitax, SC (600 g/l); Imidacid, SC (600 g/l); Confiboy, WSC (200 g/l); Confidor Extra, WDG (700 g/kg); Commander, WSC (200 g/l); Tanrek, WSC (200 g/l); Imidor Pro, SC (200 g/l); Imidor, WSC (200 g/l); Imiprid, WSC (200 g/l); Monsoon, WSC (200 g/l); Nuprid 600, SC (600 g/l); Picus, SC (600 g/L); Imidashance-S, SC (600 g/l); Imidashans, WSC (200 g/l); Contador, WSC (200 g/l); Contador Maxi, SC (600 g/l); Conrad, SC (600 g/l); Confidor Extra, WDG (700 g/kg); Sidor, WSC (200 g/l); Sidopride, FS (600 g/l); Rangoli-Imidacloprid, WSC (200 g/l); Coyote, SC (600 g/l); Street, SC (600 g/L); Bullfighter Maxi, SC (600 g/l); Forcer Anto, SC (600 g/l); Imidabel, WSC (200 g/l).
Imidacloprid + Bifenthrin	Imidalite, FP (500+50 g/l); Galil, CS (250+50 g/l).
Lambda-cyhalothrin + thiamethoxam	Molnia Duo, SC (106 + 141 g/l); Gothic, SC (106 + 141 g/l); Currito, SC (106 + 141 g/l); Solam, SC (106 + 141 g/l); Factoria, MCS (106 g/l + 141 g/l).
Clothianidine	Clothiamet, WDG (500 g/kg); Clothiamet-C, SC (350 g/l); Tucker, SC (600 g/kg); Taishin, WDG (500 g/kg); Clothianidin Pro, SC (350 g/l).
Clothianidine + lambda-cyhalothrin	Clothiamet Duo, SC (140 + 100 g/l); Gladiator Super, SC (140 + 100 g/L); Vostork, SC (140 + 100 g/l).
Thiamethoxam	Aktara, WDG (250 g/kg); Kaytox, SC (350 g/l); Krugozor, SC (600 g/l); Cruiser, SC (350 g/l); Cruiser, SC (600 g/l); Tiara, SC (350 g/l); Tiara, SC (350 g/l); Kaiser, SC (350 g/l); Instivo, SC (350 g/l); Panzir, SC (600 g/l); Saber, CS (350 g/l); Tiamax, SC (240 g/l); Harita, SC (600 g/l); Keeper, SC (350 g/l); Timaterr, SC (350 g/l).
Cypermethrin	Patrium, EC (250 g/l) ; Cyperus, EC (250 g/l); Cipi, EC (250 g/l) ; Cyrax, EC (250 g/l); Sharpey, ME (250 g/l); Arrivo, EC (250 g/l) ; Cytox, EC (250 g/l).
Alpha Cypermethrin	Alfamethrin, EC (100 g/l) ; Alfacin, EC (100 g/l) ; Alpha-Cipi, EC (100 g/l); Alterr, EC (100 g/l); Alfatec, EC (100 g/l); Accord, EC (100 g/l); Atrix, EC (100 g/l) ; Mamba, EC (150 g/l); Ostrog, OC (100 g/l); Fascord, EC (100 g/l).
Deltamethrin	Decis Expert, EC (100 g/l); Orbit, EC (25 g/l).
Diazinon	Diazinone Express, EC (600 g/l); Diazol, EC (600 g/l); Praktik, EC (600 g/l) .

The assortment of wheat protection products is quite wide and allows you to effectively control harmful organisms, however, the choice of specific preparation should be carried out by specialists and will depend on the area of cultivation of the crop, the presence of types of harmful organisms and their harmfulness, the type and variety of wheat, the economic capabilities of the business entity and other factors. Only strict compliance with the regulations for the use of preparation will allow plant protection measures to be economically profitable, effective, and environmentally acceptable [180,181].

2 CONDITIONS, MATERIALS AND RESEARCH METHODS

The dissertation work was carried out at the Department of Plant Protection and Quarantine of St. Petersburg State Agrarian University.

The effectiveness and safety of insecticides were studied during the growing seasons 2019-2022, in the Salsky district of the Rostov region (Figure 17).

Figure – 17 **A field of winter wheat in LLC "Success Agro" (orig.)**

2.1 Agroclimatic conditions of the research site

It is impossible to evaluate crop formation conditions and strategies for raising grain crop yields in tandem with increased agricultural activity without taking into account the local climate, natural characteristics, and meteorological conditions of each given year [182,183].

Geographically, the Rostov region is located in the south of European Russia in the region of the South Russian Plain, and in its southern part, it merges with the Cis-Caucasian plain steppes. Its area is about 100.97 thousand km2, and it is a flat steppe, at an altitude of 30 to 300 m above sea level, the research was carried out in LLC "Success Agro" Salsky district, in the rural settlement of Giant in the southeast of the Rostov region [184].

The climate of the region is moderately continental. It is characterized by a combination of excess heat with a relative lack of humidity. Average annual temperatures for the growing season range between 29 -31°C. There is relatively little rainfall, and thus most of the area is characterized by insufficient and unstable humidity; About a third of the region is characterized by drought. In the Rostov region, two types of soils predominate chernozem and chestnut. [185].

Thick chernozems of carbonate are formed in the southwest of the area, and a dry steppe with dark chestnut and chestnut soils may be found in the southeast of the Rostov area. In the Rostov region, chernozem soils (62%) and chestnut soils (23%) are the most common soil types, in the arable layer, 0.8-0.13 mg of mobile phosphorus and 36.4-46.2 mg of exchangeable potassium per 100 g of soil are accounted for per 100 g of soil [186].

The climate of the Salsky district in the Rostov area is shaped by the Azov and Black Seas, as well as by winds that bring cold air in the winter and dry, heated air in the summer. As a result, the weather is dry. The town of "Giant"'s agrometeo station states that the annual precipitation ranges from 330 to 600 mm, with an average value of

450 mm. The 188-day frost-free period starts in mid-April and concludes in mid-October [187].

The average temperature in January is minus 4.8 °C, with occasional lows of - 34 °C. The winters are moderate. Around the end of December, stable snow cover begins to build; during other seasons, it doesn't form at all. The snow cover is often less than 13 centimeters high [188].

Meteorological data for the years of research are presented in (Tables 2-5).

Table 2. **Meteorological data for 2019**

Main parameters	Months and decades											
	April			May			June			July		
	1	2	3	1	2	3	1	2	3	1	2	3
Air temperature, ^{0}C averagemulti-year	9,6	11,0	12,5	14,6	16,6	17,9	19,7	21,1	21,7	22,7	23,4	24,1
b) the current year	8,5	10,2	14,3	16,3	19,6	20,0	24,6	26,0	25,9	24,5	20,6	24,0
Rainfall, mm a) averagemulti-year	11	16	21	16	18	21	16	19	26	20	17	21
b) the current year	3,3	29,3	3,2	43,2	0,0	37,4	0,5	0,0	3,3	0,2	31,4	47,7
Air humidity, % a) averagemulti-year		66			60			58			54	
b) the current year	74	74	48	72	63	65	49	35	41	42	69	62

Table 3. **Meteorological data for 2020**

Main parameters	Months and decades											
	April			May			June			July		
	1	2	3	1	2	3	1	2	3	1	2	3
Air temperature, ^{0}C averagemulti-year	9,6	11,0	12,5	14,6	16,6	17,9	19,7	21,1	21,7	22,7	23,4	24,1
b) the current year	5,6	9,7	11,4	16,2	15,8	16,0	20,9	24,9	24,3	28,2	25,0	26,1
Rainfall, mm a) averagemulti-year	11	16	21	16	18	21	16	19	26	20	17	21
b) the current year	0	7,3	0,1	22,7	0,9	44,3	32,8	43,7	14,0	5,7	16,5	5,2
Air humidity, % a) averagemulti-year		66			60			58			54	
b) the current year	44	50	46	67	55	71	63	51	50	38	50	36

Table 4. **Meteorological data for 2021**

Main parameters	Months and decades											
	April			May			June			July		
	1	2	3	1	2	3	1	2	3	1	2	3
Air temperature, ^{0}C averagemulti-year	9,6	11,0	12,5	14,6	16,6	17,9	19,7	21,1	21,7	22,7	23,4	24,1
b) the current year	8,6	10,9	11,4	15,5	17,4	20,3	17,9	22,7	26,7	25,6	29,7	26,2
Rainfall, mm a) averagemulti-year	11	16	21	16	18	21	16	19	26	20	17	21
b) the current year	21,8	47,6	27,1	6,9	72,9	9,8	32,5	3,2	0,0	31,4	0,0	11,3
Air humidity, % a) averagemulti-year		66			60			58			54	
b) the current year	76	87	72	62	73	69	78	68	52	55	31	47

Table 5. **Meteorological data for 2022**

Main parameters	Months and decades										
	April			May			June			July	
	1	2	3	1	2	3	1	2	3	1	2
Air temperature, ^{0}C averagemulti-year	9,6	11,0	12,5	14,6	16,6	17,9	19,7	21,1	21,7	22,7	23,4
b) the current year	11,5	11,7	14,0	11,2	14,4	17,9	23,4	23,5	21,7	24,6	23,9
Rainfall, mm a) averagemulti-year	11	16	21	16	18	21	16	19	26	20	17
b) the current year	7,2	33,5	19,6	30,2	16,6	0,1	0,0	3,2	21,8	0,3	8,1
Air humidity, % a) averagemulti-year		66			60			58			54
b) the current year	63	76	70	67	63	64	48	48	62	38	57

2.2 Materials and methods of research

The objects of our research were the following phytophages on winter wheat crops in the North Caucasus region: Sunn pest (Eurygaster integriceps Puton), Wheat beetles–kuzka (Anisoplia austriacea Hrbst.), crusader beetle (wheat beetles such as kuzka (*Anisoplia austriacea* Hrbst.), Crusader (*Anisoplia agricola* Poda) and krasun (*Anisoplia segetum* Hrbst.), cereal leaf beetle (*Oulema melanopus* L.), grain aphid (*Sitobion avenae* Fabr.), greenbug aphid (*Schizaphis graminum* Rond.), Bird-cherry-oat aphid *Rhopalosiphum padi* L.[189,190]. The determination of phytophages and the study of their population dynamics were carried out following generally accepted entomological research methods [191–195].

The research was conducted on winter wheat crops of Svarog, Yuka, and Grom varieties. The following indicators characterize these varieties:

- Svarog variety – bred by the National Grain Center named after P. P. Lukyanenko. It is included in the State Register of Breeding Achievements in the North Caucasus region, the year of registration is 2017. It is recommended in the Northern and Southern foothill zones of the Krasnodar Territory and the Azov and Southern zones of the Rostov region. Svarog is a medium-sized, strong wheat, resistant to brown rust, powdery mildew and yellow rust. It is moderately affected by ear fusarium and hard smut. The baking properties and qualities are excellent. The weight of 1000 grains is 37-46 g. The maximum yield is 97.5 kg /ha and above [196–199].

- Yuka variety – bred by the National Grain Center named after P. P. Lukyanenko. It has been included in the State Register of Breeding Achievements in the North Caucasus region since 2012. It is recommended in the Krasnodar Territory, the Central, Azov, Southern, and Eastern zones of the Rostov region, the Republic of Adygea, and the Central and Eastern zones of the Stavropol Territory. Yuca is a medium-sized, strong wheat, resistant to brown rust, powdery mildew and yellow rust. It is moderately affected by ear fusarium and hard smut. The baking properties and qualities are good. Valuable wheat. The weight of 1000 grains is 36-47 g. The maximum yield is 89.2 kg /ha and above [196–199].

- Grom variety – bred by the National Grain Center named after P. P. Lukyanenko. It is included in the State Register of Breeding Achievements in the North Caucasus region, the year of registration is 2010. It is recommended in the Central and Southern foothill zones of the Krasnodar Territory, the Central zone of the Stavropol Territory, the Azov, Southern and Eastern zones of the Rostov region, the Republic of Adygea, the Republic of Kalmykia. Thunder is a medium-ripened variety. Good baking qualities and valuable wheat. Moderately resistant to brown rust. It is affected by hard smut. Highly resistant to powdery mildew and yellow rust. Moderately resistant to septoria and fusarium ear. It is susceptible to stem rust. The weight of 1000 grains is 33-48 g. The maximum yield is 81.8 kg /ha and above [196–200].

Characteristics of the active ingredients of insecticides

During the period from 2019 to 2022, five insecticides were studied as a means of control the main pests of winter wheat in the steppe zone of Ciscaucasia.

The characteristics of the active ingredients of the insecticides used in our research are given by the work [201–208]

Meadows, OD. (200 g/l acetamipride)

Preparation form: oil dispersion (OD).

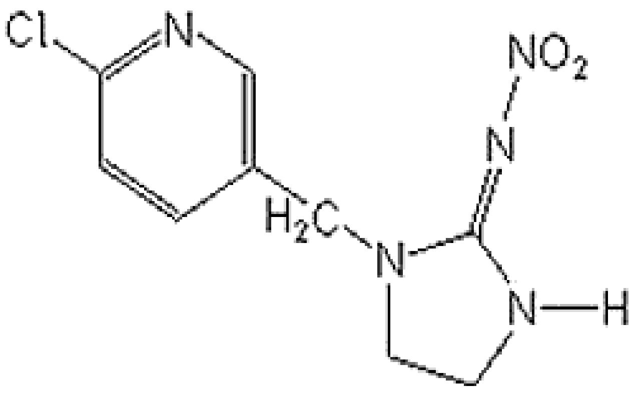
The active ingredient (a.i.) – acetamipride.

Chemical formula (a.i.) – acetamiprid (E)-N1-[(6-chloro-3-pyridyl) methyl]-N2-cyano-N1-methylacetamidine.

Chemical class: neonicotinoids.

Active Ingredient (a.i.) – Acetamiprid

Active Ingredient – Acetamiprid



Chemical formula (a.i.) – C10H11ClN4. Relative molecular weight: 222.68.(E)-N1-[(6-chloro-3-pyridyl)methyl]-N2-cyano-N1-methylacetamidine (IUPAC) [209–211].

Physico-chemical properties: colorless crystals. The melting point is 98.9 °C. Solubility (25 °C) in water 4.25 g/l, in acetone, methanol, dichloromethane > 200 g/l [212].

Toxicological properties: LD50 oral for rats 146-217 mg/kg, for mice 184-198 mg/kg. LD50 dermal for rats > 2000 mg/kg. It does not irritate the skin and mucous membranes of the eyes of rabbits. LD50 for Virgin Partridge 180 mg/kg. SK50 (24-96 h) for carp > 100 mg/l. SK50 (24 h) for daphnia > 200 mg/l [213].

Mechanism of action: acetamiprid is a neurotoxic substance. It interferes with the transmission of nerve impulses by binding to acetylcholine receptors on the postsynaptic membranes of insect nerve cells [214].

Pesticide properties: Insecticide is systemic and acts on the digestive tract [213].

Acetamiprid determination method: Estimation of acetamiprid residue amounts using high-performance liquid chromatography" [215,216].

Phytotoxicity: Does not appear when established recommendations are strictly followed [213,217].

Resistance: Strict adherence to the established regulations prevents the resistance issue from emerging. It is advised to combine these preparations with treatments from other chemical classes that have a different mode of action in alternating schemes.

Carnadine, WSC (200 g/l acetamipride)

Preparative form: water-soluble concentrate (WSC).

Purpose: insecticide.

Active ingredient (a.i.) – acetamipride. The characteristic of the active substance is given above .

Dexter Turbo, SE (115 g/l acetamipride + 106 g/L lambda-cyhalothrin + 70 g/L clothianidine)

Preparation form: SE (suspension emulsion).

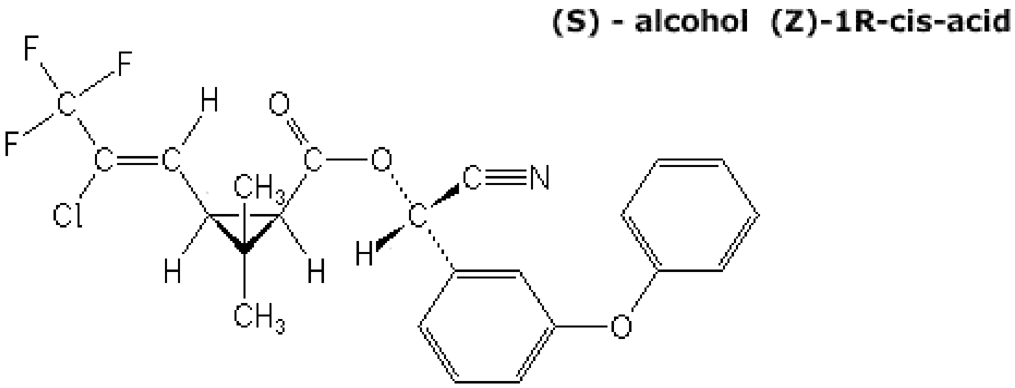
Purpose: insecticide.

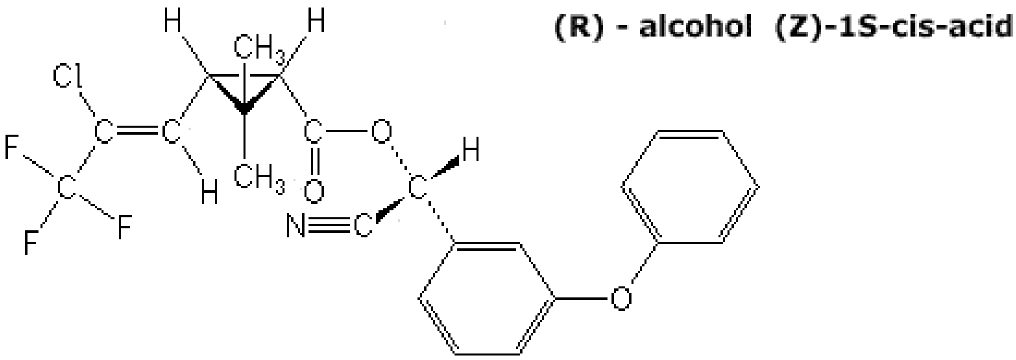
Active ingredient (a.i.) – acetamiprid + lambda-cyhalothrin + clothianidine.

The characteristic of the active ingredient acetamiprid is given above.

Active Ingredient (a.i.) – lambda cyhalothrin.

Active Ingredient – lambda cyhalothrin.





Chemical formula (a.i.) – $C_{23}H_{19}C_{l}F_{3}NO_{3}$ .A mixture of (1:1) cyhalothrin isomers: (S)-α-cyano-Z-phenoxybenzyl (Z)-(1R,3R)-3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2 dimethylcyclopropancarboxylate and (R)-α-cyano-3-Phenoxybenzyl (Z)-(1S,3S)-3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropancarboxylate [218,219].

Chemical Class: Pyrethroids [219].

Physico-chemical properties: colorless, odorless crystalline substance. The melting point is 49.2 °C. Solubility in water is 4.1 g/l. Steam pressure at (20 °C) 200 nPa (1.5·10-9 mmHg) .Solubility (20 °C) in water: 0.005 (at pH=6.5) and 0.004 mg/l (at pH=5.0).

At 21 °C, it dissolves in the majority of popular solvents. When kept at temperatures between 5 and +35 °C in its sealed original packaging, it remains stable for a minimum of two years [220,221].

Toxicological properties: Rats' LD_{50} oral lambda-cyhalothrin is 79 mg/kg for males and 56 mg/kg for females; rats' LD_{50} dermally is 632–696 mg/kg. Mallard duck LD_{50} > 3950 mg/kg. SK_{50} (96 h) for eared perch 0.21 mcg/l, for rainbow trout 0.36 mcg/L. SK50 (48 h) for daphnia 0.36 mcg/l. [222].

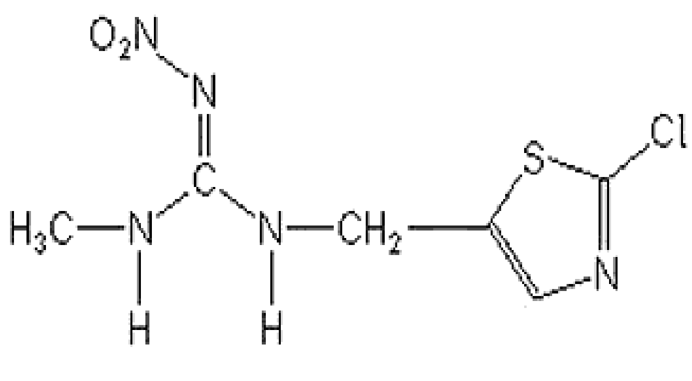
Mechanism of action: similar to all pyrethroids. harmful substance for neurons. in the arthropods, it stops nerve impulses from traveling down the axon by obstructing the flow of sodium ions across membranes [223,224].

Pesticide properties: Intestinal pesticide [225].

Phytotoxicity: Does not appear when established recommendations are strictly followed [226].

Resistance: Strict adherence to the established regulations prevents the resistance issue from emerging of lambda-cyhalothrin. It is advised to combine these preparations with treatments from other chemical classes that have a different mode of action in alternating schemes.

Active Ingredient – clothianidin.



Chemical formula (a.i.) – (E)-1-(2-chloro-1,3-thiazole-5-ilmethyl)-3-methyl-2-nitroguanidine.

Chemical Class: Neonicotinoids [227].

Physico-chemical properties: colorless, odorless powder. The melting point is 176.8 °C. Solubility in water 0.3 g/l (20 °C), in acetone 15.2 g/L, in methanol 6.26 g/L, in ethyl acetate 2.03 g/L, in dichloromethane 1.32 g/L (25 °C) [228,229].

Toxicological properties: Clothianidin is a low-toxicity substance with an LD_{50} dermal for rats > 2000 mg/kg and an LD_{50} oral for rats > 5000 mg/kg and mice 425 mg/kg, respectively. [230].

Mechanism of action: Clothianidine, it interferes with the transmission of nerve impulses by binding to acetylcholine receptors on the postsynaptic membranes of insect nerve cells [231].

Pesticide properties: Pesticide properties: Insecticide is systemic and acts on the digestive tract [227].

Phytotoxicity: Does not appear when established recommendations are strictly followed [232].

Resistance: Strict adherence to the established regulations prevents the resistance issue from emerging. It is advised to combine these preparations with treatments from other chemical classes that have a different mode of action in alternating schemes.

Factoria, (MCS) (141 g/l thiamethoxam + 106 g/l lambda-cyhalothrin)

Preparation form: microcapsulated suspension (MCS)

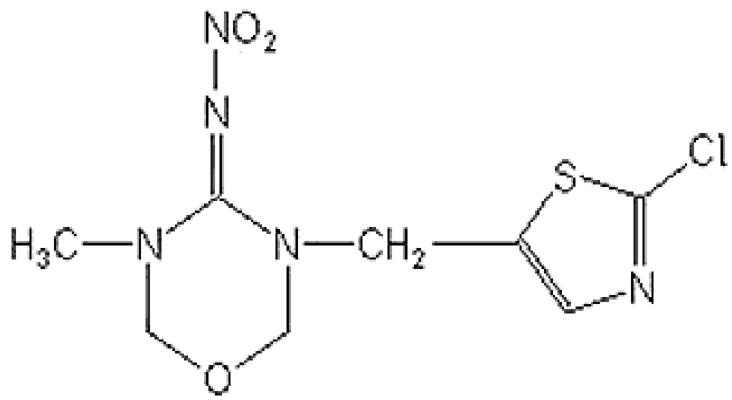
Purpose: insecticide.

Active ingredients – thiamethoxam + lambda–cyhalothrin.

Chemical formula (a.i.) – 3-(2-chloro-1,3-thiazole-5-ilmethyl)-5-methyl-[1,3,5]-oxadiazinane-4-ylidene-N-nitroamine + mixture of (1:1) cyhalothrin isomers: (S)-α-cyano-3-phenoxybenzyl (Z)-(1R, 3R)-3-(2-chloro-3,3,3-trifluoropropenyl)-2,2 dimethylcyclopropanecarboxylate and (R)-α-cyano-3-phenoxybenzyl (Z)-(1S, 3S)-3-(2-chloro-3,3,3-trifluoropropenyl)-2,2-dimethylcyclopropanecarboxylate.

Chemical classes: neonicotinoids + pyrethroids.

Active Ingredient – thiamethoxam



Chemical formula (a.i.) – $C_8H_{10}C_lN_5O_3S$. 3-(2-chloro-1,3-thiazole-5-ilmethyl)-5-methyl-1,3,5-oxadiazinan-4 ylidene(nitro)amine.

Chemical Class: Neonicotinoids [228,229].

Physico-chemical properties: thiamethoxam – an odorless crystalline powder. The molecular weight is 291.7. The melting point is 139.1 °C. Solubility in water (25 °C) 4.1 g/l. Solubility (25 °C) in acetonitrile 5.74 g/l, in ethanol 3.21 g/l, in toluene 0.63 g/l. Steam pressure at 25 °C is 6.6×10-6 MPa (5.0×10-8 mmHg) [233].

Toxicological properties: when sprayed, it is completely redistributed over the plant leaf after 20 hours. When applied under the root, after 1-3 days it turns out to be in the lower and upper tiers of the plant. Thiamethoxam penetrates mainly into the leaves, and practically does not enter the fruits. LD50 orally for rats 1563 mg/kg, LD50 dermally for rats > 2000 mg/kg. SK50 (96 h) for rainbow trout 100 mg/l, for eared perch 114 mg/l. SK50 (48 h) for daphnia > 100 mg/l. LD50 for bees 0.024 mcg/individual [228].

Mechanism of action: Like all neonicotinoids, thiamethoxam is a neurotoxic compound, it interferes with the transmission of nerve impulses by binding to acetylcholine receptors on the postsynaptic membranes of insect nerve cells [234].

Pesticide properties: Insecticide is systemic and acts on the digestive tract [227].

Phytotoxicity: Does not appear when established recommendations are strictly followed [232].

Resistance: Strict adherence to the established regulations prevents the resistance issue from emerging. It is advised to combine these preparations with treatments from other chemical classes that have a different mode of action in alternating schemes.

The characteristic of lambda cyhalothrin is given above.

Mainstay, SE (112 g/l bifenthrin + 37 g/l sulfoxaflor)

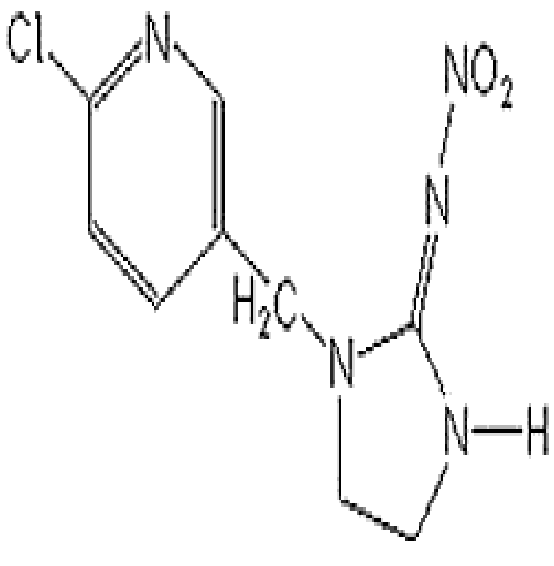
Preparation form: suspension emulsion (SE).

Purpose: insecticide.

Active ingredients – bifenthrin + sulfoxaflor.

Chemical class : pyrethroids + sulfoxamines.

Active ingredient – Bifenthrin.



Chemical formula (a.i.) – [2-methyl-3-ilmethyl(Z)-(1RS, 3RS)-3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropancarboxylate].$C_{23}H_{22}CIF_3O_2$..

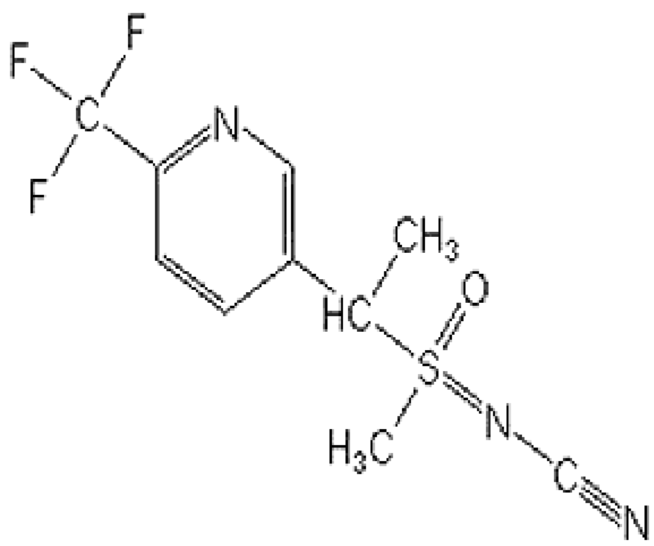
Chemical Class: pyrethroids [219,235].

Physico-chemical properties: viscous oily solidifying liquid of light brown color. The molecular weight is 423.0. The melting point is 68–70.6°C. Steam pressure (at 25 °C) 0.024 MPa (1,81-10-7 mmHg) [220,221].

Toxicological properties: highly toxic, LD_{50} oral for rats 54.5 mg/kg, dermal for rabbits more than 2000 mg/kg, does not irritate the skin and eyes. Highly toxic to fish, and low toxic to humans. It is sedentary in the soil, as it binds, and does not penetrate groundwater [225].

Mechanism of action: Bifenthrine, like other pyrethroids, affects the nervous system. The symptoms of the lesion are very similar to those of organochlorine insecticide poisoning: severe arousal followed by paralysis. The phenomenon of knockdown is often noted. Bifenthrin disrupts the exchange of sodium ions in the presynaptic membrane, which leads to the release of excessive amounts of acetylcholine during the passage of a nerve impulse through the synaptic cleft [223,224].

Active ingredient – sulfoxaflor.



Chemical formula (a.i.) – $C_{10}H_{10}F_3N_3O_S$. [Methyl (oxo) {1- [6 (trifluoromethyl) -3-pyridyl] ethyl} -λ 6- sulfanilidene] cyanamide.

Chemical Class: Sulfoxamines [236,237].

Physico-chemical properties: sulfoxaflor. A white powder with a pungent odor. Molecular weight 277.27 g/mol. Melting point 112 °C (purity 99.7%). Solubility – practically soluble in water and soluble in heptane, xylene, dichloroethane, methanol, acetone, ethyl acetate, octanol (all at 20 °C). Steam pressure is 1.4×10^{-6} Pa at 20 °C /1.05×10^{-8} mmHg [237].

Toxicological properties: acute toxicity in animals is low, LD_{50} is oral, but high doses for rats are 1405 mg/kg, and mice are 750 mg/kg. With reduced application rates and other restrictions on use, it will not lead to unjustified adverse effects on people or the environment [238].

Mechanism of action: sulfoxaflor acts as a neurotoxin. The binding of sulfoxaflor to acetylcholine causes uncontrolled nerve impulses, leading to muscle tremor followed by paralysis and death. Since sulfoxaflor binds much more strongly to insect neuron receptors than to mammalian neuron receptors, this insecticide is selectively more toxic to insects [239].

The St. Petersburg, 2009 "Methodological guidelines for registration tests of insecticides, acaricides, molluscicides, and rodenticides in agriculture" were followed in evaluating the biological effectiveness of the pesticides under study [240].

By this method, the following experimental options were provided: the studied preparations in different application standards; the standard - a registered preparation with proven effectiveness; control - without treatment with insecticides. The area of the experimental plot is 50 m^2, and the location of the experimental plots is randomized. The number of repetitions (4). The agricultural technology of the experimental plots corresponded to the one adopted in this region.

The experimental locations were sprayed with insecticides using a knapsack pneumatic sprayer (Solo 456) with a working fluid flow rate of 300 l/ha.

Pest counts were carried out before treatment, on 3, 7, and 14, days after treatment, and before harvesting [42,117,240].

The Henderson-Tilton formula was utilized to compute the biological effectiveness (1) [241].

$$Э = 100 \times (1 - OnKд/OдKn), \quad (1)$$

Harvesting method: manually, 4 samples of 1 m2 in size in each repeat of the experiment, followed by threshing and determination of the mass of 1000 grains in grams or recalculated per 1 ha (Figure 18).

Figure 18. **Harvesting of winter wheat in experimental plots (Rostov region) (orig.)**

Procedure for sampling and storage settings to ascertain residual amounts of insecticides active ingredients

The sample was taken in compliance with the 08/21/1979 No. 2051-79 "Unified Rules for sampling agricultural products, food, and environmental objects for the determination of small amounts of pesticides" that were authorized. The study of the residual amounts of active ingredients of pesticides in the winter wheat crop was carried out in the analytical laboratory of the Center for Biological Regulation of the Use of Pesticides of the Federal State Budgetary Institution of the Russian Academy of Sciences (FSBSI VIZR). The chosen samples of the green mass were frozen at -18°C and kept at the same temperature before analysis. Samples were taken separately from each repetition of the experiment, as well as from control variants not treated with pesticides. Selected seed samples were stored at room temperature in linen bags.

Methods for determining residual amounts of insecticide active ingredients in winter wheat

As per the "Methodological guidelines for the determination of residual quantities of **acetamiprid** in water, soil, tops, and tubers of potatoes, grain, and straw of grain crops by HPLC", 4.1.1850-04, the samples were analyzed to determine their acetamiprid content.The detection limit of acetamipride in grain is 0.01 mg/kg, in straw 0.04 mg/kg, in green mass 0.02 mg/kg.

The quantitative determination of acetamipride was carried out on an ultra-efficient liquid chromatograph "Acquity" (Waters) with a fast-scanning UV detector. The analytical column Acquity UPLC BEH C18 (100 x 2.1) mm, 1.7 microns (Waters). The temperature of the column is 30 °C. Elution in the acetonitrile - 5 mM orthophosphoric acid system in the isocratic mode: 20:80, respectively. The flow rate of the eluent is 150 µl/min. The working wavelength of the UV detector is 244 nm. The volume of the injected sample is 10 µl.

Hygienic standards: The (MPL) of acetamipride in grain cereals is 0.5 mg/kg. Samples were taken separately from each plot according to variants, an average sample was prepared from them (one per variant) and two parallel samples were made in the laboratory for each sample.

Determination of residual quantities of **lambda-cyhalothrin** in water, grain, straw and green mass of cereal crops, grain and green mass of corn, cabbage, pea grain, root crops and tops of sugar and fodder beet, in seeds and oil of rapeseed, soy and mustard by the method gas-liquid chromatography GC" 4.1.1430-03 was followed in the analysis of the samples for lambda-cyhalothrin content.

The limit of determination of lambda-cyhalothrin in grain is 0.005 mg/kg, in straw 0.01 mg/kg, in green mass 0.005 mg/kg.

Using an electron capture detector (ECD), a gas chromatograph (GC) named "Crystal 5000.2 NP" was used to quantify lambda-cyhalothrin. 30 m long, 0.32 mm inner diameter quartz capillary column (RTX-5, 0.25 microns). The column thermostat program mode allows it to be adjusted from 200 °C (1 minute) to 270 °C (7 minutes) at a rate of 20 degrees per minute. Additionally, the evaporator and detector have temperatures of 250 and 330 degrees respectively, and the purge gas pressure is 130 kPa. The column's carrier gas is nitrogen, and its flow through the column is 3 ml/min (in constant flow mode) with a flow division of 1:10. 1 µl is the chromatographic volume.

Hygienic standards: (MRL) of lambda-cyhalothrin in grain of cereals 0.01 mg/kg. Samples were taken separately from each repetition of the experiment, an average sample was prepared from them (one per variant) and two parallel samples were made in the laboratory for each sample.

In compliance with the recommendations "Methodology for measuring the residual content of **clothianidin** in grain and straw of grain crops by high-performance liquid chromatography HPLC", 4.1.2921-11, was followed in the analysis of the samples for clothianidin content.

Analysis of the green mass using the recommendations for methodology "Measurement of the residual quantities of clothianidin in green mass, corn grain and oil, seeds, oil and green mass of sunflower by HPLC", 4.1.3063 to 13.

The limit of determination of clothianidine in grain is 0.02 mg/kg, in straw 0.05 mg/kg, in green mass 0.05 mg/kg.

Quantitative determination of clothianidin was carried out on an Alliance liquid chromatograph (Waters) with a UV detector. The analytical column Acquity UPLC BEH C18 (100 x 2.1) mm, 1.7 microns (Waters). The temperature of the column is 30 °C. Elution in the acetonitrile - 5 mM orthophosphoric acid system in the isocratic mode: 20:80, respectively. The volume of the injected sample is 10 μl.

Hygienic standards: The (MRL) of clothianidine in grain cereals is 0.2 mg/kg. Samples were taken separately from each repetition of the experiment, an average sample was prepared from them (one per variant) and two parallel samples were made in the laboratory for each sample..

Determination of residual amounts of **thiamethoxam** and its metabolite (CGA 322704) in water, soil, potatoes, grains, and straw of grain crops, apples, cucumbers, tomatoes, peppers, eggplants, peas, and sugar beet by high-performance liquid chromatography HPLC", 4.1.1142-02, was followed in the analysis of the samples.

The detection limit in grain is 0.01 mg/kg, in straw 0.05 mg/kg, in green mass 0.02 mg/kg.

The quantitative determination of thiamethoxam was carried out on an ultra-efficient liquid chromatograph "ACQUITY" by Waters with a fast-scanning UV detector. The column ACQUITY UPLC BEH C-18 (100 x 2.1) mm, 1.7 microns (Waters). The temperature of the column is 30 °C. Elution in the acetonitrile – 1% formic acid system in the isocratic mode: 18:82, respectively. The flow rate of the eluent is 200 μl/min. The working wavelength is 252 nm. The volume of the injected sample is 10 μl.

Hygienic standards: (MRL) of thiamethoxam in grain of cereals 0.05 mg/kg. Samples were taken separately from each repetition of the experiment, an average sample was prepared from them (one per variant) and two parallel samples were made in the laboratory for each sample.

The calculation (**toxic load**) was carried out according to the formula proposed by Yu.N. Fadeev (1988): (1988) [242].

$$TL = \frac{\text{Rate of application of the active ingredient (A.I.) in mg / ha}}{\text{LD50 (mg/kg)}}$$

Taking into account the scale of fluctuations in the (TL) indicator, 4 hazard classes of pesticides are distinguished:

I – low-dangerous, when used, (TL) does not exceed 100 semi-annual doses per hectare.

II – moderately dangerous (TL from 100 to 1000 LD_{50}/ha).

III – dangerous (TL 1000 to 10000 LD_{50}/ha).

IV – extremely dangerous, the use of (TL/ha) more than 10,000 semi-annual doses.

Statistical processing of the obtained results was carried out by evaluating the significance of the differences in the sample averages in terms of the least significant difference (LSD).

3 EFFECTIVENESS AND REGULATIONS FOR THE USE OF INSECTICIDES IN THE CONTROL OF THE MAIN PESTS OF WINTER WHEAT

We studied the effectiveness of two insecticides Meadows, OD (200 g/l) and Carnadine, WSC (200 g/l) with the same content of one active ingredient – acetamipride, but in different formulations in pest control on winter wheat for two years.

3.1 Biological effectiveness and regulations for the use of the insecticide Meadows, OD

Field studies of the biological effectiveness of the insecticide Meadows, OD in the control against the sunn pest were conducted in 2021-2022 in the Salsky district of the Rostov region on winter wheat of the Svarog variety (2021) and the Yuka variety (2022).

The phase of development of winter wheat at the time of preparation treatments - grain filling. Insecticide treatment was performed once. Scheme of experience Table 6.

Table 6. **Scheme of experience**

№	Experience variants	Rates of the	Multiplicity

		preparations use	of treatments
1	Meadows, OD (200 g/l)	0.05 l/ha	1
2	Meadows, OD (200 g/l)	0.075 l/ha	1
3	Mospilan, SP (200 g/kg) /standard/	0.075 kg/ha	1
4	Control	–	–

The development of winter wheat took place under moderate conditions. At the experimental site, uniform emergence of seedlings (autumn 2020) and further development of culture (spring-summer 2021) were noted.

The appearance of an adult of a sunn pest on winter wheat crops was noted in the first decade of May with an increase in air temperature to an average of 15 ^{0}C.The intensive settlement of adult was facilitated by optimal air temperature and low rainfall (6.9 mm).

The signal for treatment against larvae is the sum of effective temperatures (SET) equal to 240-280 ^{0}C at a threshold plus 10 ^{0}C from the date of mass egg-laying by the bug.

Mass egg laying in our experience was noted on May 13, at a (SET) of 95 ^{0}C. Spraying of crops was carried out in the first decade of June, when the number of larvae and adult pests averaged 10.5-11.5 individuals/м^2 according to the experimental variants (Economic threshold (ET): 5-10 larvae of 2-3 ages per m^2; at least 2 overwintered adults / m^2) (Table 7).

On the 3rd and 7th days after treatment, the number of sunn pest in the control reached 11.3-15.8 individuals/m2, whereas in plots with the insecticide Meadows, OD (200 g/l), there was a fluctuation in the pest population from 2.8 to 2.3 individuals/m^2 (0.05 and 0.075 l/ha), standard is Mospilan, SP (2.5 individuals/m^2). The biological effectiveness of the studied preparation in two application rates was 77.4-86.8%, acting at the standard level 78.7% and 84.6%.

By the 14th day of the accounting, a slight increase in the number of pests in the accounting plots was noted. In the variants with the insecticide Meadows, OD, the average number of sunn pests was 3.0 and 2.5 individuals/m^2, which was at the level of the standard Mospilan, SP (2.8 individuals/m^2). The biological efficacy of the studied preparation reached 82.6% and 86.2%, similar to the standard (83.2%).

The analysis of the mass of 1000 grains of winter wheat showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

The development of winter wheat in the following year took place under favorable conditions. With an average daily air heating up to 15-17 ^{0}C, the appearance of an adult sunn pest was noted on experimental winter wheat crops. Spraying of crops was carried out in the first decade of June, when the number of larvae and adult pests averaged 8.0-8.8 individuals/m^2 according to the experimental variants (Table 8).

Table 7. **Biological effectiveness of the insecticide Meadows, OD in the control of sunn pest on winter wheat (Rostov region, 2021)**

Experience variants	Dosing used	Average number of larvae (adults) per m^2: Before treatment	After treatment according to the accounting days: 3	7	14	Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %: 3	7	14	Weight of 1000 grains, g
Meadows, OD (200 g/l)	0,05 g/l	11,0	2,8	2,5	3,0	77,4	84,8	82,6	34,3
	0,075 g/l	11,5	2,5	2,3	2,5	79,9	86,8	86,2	34,5
Mospilan, SP (200 g/kg) /standard/	0,075kg/ha	10,8	2,5	2,5	2,8	78,7	84,6	83,2	34,5
Control	–	10,5	11,3	15,8	16,0	–	–	–	31,9
LSD_{05}		2,55	1,51	1,22	1,87	9,37	4,25	7,54	0,80

On the 3rd and 7th days after treatment, the number of sunn pest in the control reached 10.3-12.0 individuals/m^2, whereas in plots with the insecticide Meadows, OD, there was a fluctuation in the pest population from 1.8 to 1.0 individuals/m^2 (0.05 and 0.075 l/ha), and in the variant using the Mospilan standard, SP 1.3 and 1.0 individuals/m^2.

By the 14th day of the accounting, a slight increase in the number of pests in the accounting plots was noted. In the variants with the studied insecticide, the average number of sunn pest was 1.5 and 1.3 individuals/m^2, which was at the standard level (1.3 individuals/m^2).

The analysis of the mass of 1000 grains of winter wheat showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

Table 8. **Biological effectiveness of the insecticide Meadows, OD in the control of sunn pest on winter wheat (Rostov region, 2022)**

Experience variants	Dosing used	Average number of larvae (adults) per m^2				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %			Weight of 1000 grains, g
		Before treatment	After treatment according to the accounting days						
			3	7	14	3	7	14	
Meadows, OD (200 g/l)	0,05 g/l	8,5	1,8	1,3	1,5	83,6	90,0	88,6	38,3
	0,075 g/l	8,8	1,5	1,0	1,3	86,4	92,7	91,2	38,4
Mospilan, SP (200 g/kg) /standard/	0,075kg/ha	8,0	1,3	1,0	1,3	87,6	92,3	90,5	38,4
Control	–	8,3	10,3	12,0	12,5	–	–	–	36,2
LSD_{05}		2,8	1,5	1,5	1,8	5,4	7,6	9,3	1,0

An assessment of the biological effectiveness of the insecticide Meadows, OD (200 g/l), carried out on winter wheat in the Rostov region in 2021, showed that the preparation reduced the number of sunn pest from 77% to 87%, in 2022 from 84% to

93%.

Consequently, in the control of the sunn pest, the insecticide in two application rates of 0.05 and 0.075 l/ha acted at the level of the Mospilan standard, SP (200 g/kg) in the application rate of 0.075 kg/ ha.

3.2 Biological effectiveness and regulations for the use of the insecticide Carnadine, WSC

Field studies of the insecticide against the **sunn pest** were carried out in 2021 on winter wheat of the Svarog variety.

Winter wheat's development phase at the time of preparation treatments (grain filling). Insecticide treatment was performed once. The scheme of the experiment is presented in Table 9

Table 9. **Scheme of experience**

№	Experience variants	Dosing used
1	Carnadine, WSC (200 g/l)	0,05 l/ha
2	Carnadine, WSC (200 g/l)	0,075 l/ha
3	Mospilan, SP (200 g/kg) /standard/	0,075 l/ha
4	Control	–

In the 2021 season, the development of winter wheat took place under moderate conditions. At the experimental site, uniform emergence of seedlings (autumn) and further development of crop wheat (spring-summer) were noted.

As in the experiment with the Meadows, OD insecticide in 2021, the appearance of an adult sunn pest on winter wheat was noted in the first decade of May with an average increase in air temperature to 15 ^{0}C. The intensive settlement of adult was facilitated by optimal air temperature and low rainfall (6.9 mm). The signal for treatment against larvae is the sum of effective temperatures (SET) equal to 240-280 ^{0}C at a threshold plus 10 ^{0}C from the date of mass egg laying by the bug. The mass egg laying in our experience occurred on May 13, with a (SET) equal to 95 ^{0}C. Spraying of crops was carried out in the first decade of June, when the number of larvae and adult pests averaged 10.5-11.5 individuals/m^2 according to the experimental variants (with ET: 5-10 larvae/m^2 of 2-3 adult; at least 2 overwintered individuals/m^2) (Table 10).

On the 3rd and 7th days after treatment, the number of sunn pest in the control reached 12.5-15.3 individuals/m^2, whereas in plots with the insecticide Carnadine, VRK, there was a fluctuation in the pest population from 2.8 to 2.5 individuals/m2 (0.05 and 0.075 l/ha), and in the variant using the Mospilan standard, SP (2.5 and 2.3 individuals/m^2). The biological effectiveness of the studied preparation in two application rates was: 77.6 - 83.7%, acting at the standard level 78.5% - 84.1%.

On the next day of accounting, a slight increase in the number of pests in the accounting plots was noted. In the variants with the insecticide Karandin, WSC, the average number of sunn pests was 3.0 and 2.8 individuals/m^2, which was at the level of the standard Mospilan, SP (2.8 individuals/m^2).

The biological effectiveness of the studied preparation reached 80.5% and 82.8%, similar to the effectiveness of the standard (81.4%).

The analysis of the mass of 1000 grains of winter wheat showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

Table 10. **Biological effectiveness of the insecticide Karandin, WSC in the control of sunn pest on winter wheat (Rostov region, 2021)**

Experience variants	Dosing used	Average number of larvae (adults) per m^2				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %			Weight of 1000 grains, g
		Before treatment	After treatment according to the accounting days						
			3	7	14	3	7	14	
Carnadine, WSC (200	0,05 l/ha	11,0	2,8	2,8	3,0	77,6	81,8	80,5	34,4

g/l)	0,075 l/ha	11,5	2,8	2,5	2,8	78,9	83,7	82,8	34,5
Mospilan, SP (200 g/kg) /standard/	0,075 kg/ha	10,5	2,5	2,3	2,8	78,5	84,1	81,4	34,5
Control	–	11,3	12,5	15,3	15,5	–	–	–	32,0
LSD_{05}		2,30	2,16	1,35	2,46	9,63	7,21	11,86	0,70

Thus, studies have shown that the preparation reduced the number of sun pest from 78% to 84% for 14 days.

Consequently, in the control against the sun pest, the insecticide in the application rates of 0.05 and 0.075 l/ha acted at the level of the standard Mospilan, SP (200 g / kg) in the application rate of 0.075 kg/ha.

3.3 Biological effectiveness and regulations for the use of insecticide Dexter Turbo, SE

Field studies of Dexter Turbo, SE were conducted in 2020-2021. The development of winter wheat took place under moderate conditions. At the experimental site, uniform emergence of seedlings (autumn) and further development of wheat crops (spring) were noted.

The study of the biological effectiveness of the insecticide against **cereal aphids** (*Schizaphis graminum* Rond and *Sitobion avenae* Fabr) was carried out on winter wheat of the Yuka variety (2020) and Svarog variety (2021). according to the scheme: Dexter Turbo, SE in the rates 0.1 and 0.2 l /ha, standard Borey Neo, SC (125 + 100 + 50 g / l) normally 0.2 l / ha, control without treatment.

In the first season, the mass reproduction of aphids began with the onset of average daily air temperatures of 16-18 ^{0}C, as well as sufficient precipitation, which contributed to more intensive colonization of the crop by pest larvae. The sum of the effective temperatures (SET) for the development of one generation of aphids is 75 ^{0}C (at a threshold of 5 ^{0}C), in our experience (SET) = 258-308 ^{0}C reached in the 1st decade of May, the pest by this time had managed to form larvae of the 4th generation.

Spraying of crops was carried out with an average number according to the experimental variants from 12.0 to 12.9 aphids per stem, with an economic threshold (ET) of 10 individuals per stem (Table 11).

On the 3rd day after treatment in variants with Dexter Turbo, SE insecticide in application rates of 0.1 and 0.2 l/ha, the average pest population was at the level of the standard Borei Neo, SC and significantly lower than in the control. The decrease in the pest population in variants with Dexter Turbo, SE was 81.0% and 85.4%, which corresponded to the effectiveness of the reference insecticide 84% (Borey Neo, SC).

On the 7th and 14th days of the accounting, a decrease in the number of aphids was noted in the variants of the experiment with plant treatment. In the variants with the studied insecticide, the average number of aphids ranged from 2.3 to 1.2 aphids per stem, and in the standard variant from 1.8 to 1.5 aphids per stem. Its biological effectiveness was at the level of 83.1 - 90.4%, similar to the standard indicators of 86.2% and 89.0%.

Table 11 – **Biological effectiveness of insecticide Dexter Turbo, SE in the control of cereal aphids on winter wheat (Rostov region, 2020)**

Experience variants	Dosing used	Average number of aphids per stem				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %		
		Before treatment	After treatment according to the accounting days					
			3	7	14	3	7	14
Dexter Turbo, SE (115 + 106 + 70 g/l)	0,1 l/ha	12,9	2,5	2,3	2,0	81,0	83,1	85,3
	0,2 l/ha	12,0	1,8	1,42	1,2	85,4	88,6	90,4
Borey Neo, SC (125 + 100 + 50 g/l) / standard/	0,2 l/ha	12,4	2,0	1,8	1,5	84,0	86,2	89,0
Control	–	12,5	12,8	13,0	13,3	–	–	–
LSD_{05}		0,98	0,45	0,51	0,38	2,31	2,49	1,76

In 2021, the mass reproduction of aphids began with the onset of average daily air temperatures (17-20 ^{0}C), as well as abundant precipitation. These conditions contributed to the intensive colonization of the crop by the pest.

The sum of the effective temperatures (SET) for the development of one generation of aphids is 75 ^{0}C (at a threshold of 5 ^{0}C), in our experience (SET) = 323-357 ^{0}C reached in the 2nd decade of May, the pest by this time had managed to form larvae of the 5th generation. Spraying of crops was carried out with an average number of experimental variants from 13.2 to 14.1 aphids per stem (Table 12).

On days 3 and 7 after treatment in variants with insecticide Dexter Turbo , SE in application rates of 0.1 and 0.2 l / ha, the average pest population was at the level of the standard Borei Neo, SC and significantly lower than in the control.

In the variants with the studied insecticide, the average number of aphids ranged from 2.5 to 1.4 aphids per stem, in the standard variant from 2.1 to 1.4 aphids per stem. The decrease in the pest population in variants with Dexter Turbo, SE was 82.2-91.6%, which corresponded to the effectiveness of the standard insecticide Borei Neo, SC (85.2-91.0%).

On the 14th day of the accounting, an increase in the number of aphids was noted in all variants of the experiment. In the variants with the studied insecticide, the average number of aphids increased to 2.5 aphids per stem (0.1 l/ha) and to 1.6 aphids per stem (0.2 l/ha), in the standard variant to 1.7 aphids per stem. The biological effectiveness of the studied preparation was at the level of 85.6-91.0%, similar to the standard of 90.2%.

Table 12 – **Biological effectiveness of insecticide Dexter Turbo, SE in the control of cereal aphids on winter wheat (Rostov region, 2021)**

Experience variants	Dosing used	Average number of aphids per stem				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %		
		Before treatment	After treatment according to the accounting days					
			3	7	14	3	7	14
Dexter Turbo, SE (115 + 106 + 70 g/l)	0,1 l/ha	13,3	2,5	2,2	2,5	82,2	86,0	85,6
	0,2 l/ha	14,1	2,1	1,4	1,6	86,0	91,6	91,0
Borey Neo,	0,2 l/ha							

SC (125 + 100 + 50 g/l) / standard/		13,9	2,1	1,4	1,7	85,2	91,0	90,2
Control	–	13,2	13,6	15,2	16,8	–	–	–
LSD_{05}		1,33	1,13	1,03	1,19	3,07	3,11	3,17

Therefore, in the first season, the assessment of the biological effectiveness of insecticide Dexter Turbo , SC showed that the preparation reduced the number of aphids to 90% within 14 days, and in the second season to 92%. The effectiveness of the studied insecticide in the application rates of 0.1 and 0.2 l /ha corresponded to the effectiveness of the standard Borei Neo, SC (125 + 100 + 50 g/l) 0.2 l/ha.

The biological effectiveness of the insecticide Dexter Turbo, SE to protect winter wheat from the **sunn pest** was evaluated on the varieties Grom (2020) and Svarog (2021).

The phase of plant development at the time of treatment is grain filling. The stage of the pest is adult and larvae.

Scheme of experience: Dexter Turbo,SE (115 + 106 + 70 g / l) at application rates of 0.1 l/ha and 0.2 l/ha; the standard preparation Grind, SP (200 g/kg acetamipride) at a rate of 0.075 kg/ha and control without treatment.

In the first decade of May 2020, the appearance of an adult sunn pest was noted on winter wheat crops when the air temperature increased to an average of 16.2 ^{0}C.

The optimal air temperature contributed to the rapid settlement of adults. The signal for treatment against larvae is the sum of effective temperatures (SET) equal to 240-280 ^{0}C at a threshold plus 10 ^{0}C from the date of mass egg laying by the sunn pest. The mass egg laying in our experience occurred on May 9, with a (SET) equal to 95 ^{0}C.

Spraying of crops was carried out in the first decade of June (June 1), when the number of larvae and adult pests averaged 10.5-12.8 individuals/m^2 according to the experimental variants (with economic threshold (ET): 5-10 larvae/m^2 of 2-3 adult; at least 2 overwintered individuals/m^2) (Table 13).

On the 3rd and 14th days after treatment, the number of sunn pest in the control reached 13-15 individuals/m^2, whereas in plots with insecticide Dexter Turbo, SE there was a fluctuation in the pest population from 1.8 to 1.3 individuals/m^2 and in the variant using the standard 2 individuals/m^2.

The biological effectiveness of the studied prepation in two application rates (0.1 l /ha and 0.2 l/ ha) ranged from 82.9% to 91.1%, similar to the indicators of the standard Grind, SP 83.0% and 84.7%. On the 7th day of registration, a decrease in the population of sunn pest in experimental plots was noted.

In the variants with the studied insecticide, the average number was 1.3 and 1 individuals/m^2, which was at the standard level (1.5 individuals/m^2). The indicators of biological effectiveness of Dexter Turbo, SE were 88.9% and 92.4%, similar to the indicator of the standard Grind , SP 88.4%.

The analysis of the mass of 1000 grains of winter wheat showed that the data obtained are consistent with the indicators of biological effectiveness: 29.4 g in the control and 32.1 g in the experimental variant.

Table 13 –**Biological effectiveness of insecticide Dexter Turbo, SE in the control sunn pest on winter wheat (Rostov region, 2020)**

Experience variants	Dosing used	Average number of larvae (adults) per m^2				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %			Weight 1000 grains, g
		Before treatment	After treatment according to the accounting days						
			3	7	14	3	7	14	
Dexter Turbo, SE (115 + 106 + 75 g/l)	0,1 л/га	10,5	1,8	1,3	1,8	82,9	88,9	85,3	32,0
	0,2 л/га	11,8	1,3	1,0	1,3	89,8	92,4	91,1	32,1
Grind, SP (200 g/kg) /standard/	0,075 кг/га	11,3	2,0	1,5	2,0	83,0	88,4	84,7	31,1
Control	–	12,8	13,0	14,3	15,0	–	–	–	29,4
LSD_{05}		2,56	1,75	1,3	1,51	11,41	8,27	10,4	0,92

In the 2021 season, the appearance of an adult sunn pest on winter wheat crops was noted in the first decade of May with an average increase in air temperature to 15

^{0}C.The intensive settlement of adult was facilitated by optimal air temperature and low rainfall (6.9 mm).

The mass egg laying in our experience occurred on May 13, with a sum of effective temperatures (SET) equal to 95 ^{0}C. Spraying of crops was carried out in the first decade of June (June 4), when the number of larvae and adult pests averaged 10.5-11.3 individuals/m^2 according to the experimental variants (Table 14).

On the 3rd and 7th days after treatment, the number of sunn pest in the control reached 12.3-15.5 individuals/m^2, whereas in plots with insecticide Dexter Turbo, SE, there was a fluctuation in the pest population from 2.0 to 1.0 individuals/m^2 (0.1 and 0.2 l/ha), and in the variant using the standard Grind, SP 2.0 individuals/m^2.

The biological effectiveness of the studied preparation in two application rates was: 82.7-93.8%, corresponding to the standard 83.4% and 86.9%.

On the next day of accounting, a slight increase in the number of pests in the accounting plots was noted. In variants with insecticide Dexter Turbo, SE the average number of sunn pest was: 1.8 and 1.5 individuals/m^2.

The biological effectiveness of the studied preparation reached 87.3% and 90.5%.The analysis of the mass of 1000 grains of winter wheat showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

Table 14 –**Biological effectiveness of insecticide Dexter Turbo, SE in the control of sunn pest on winter wheat (Rostov region, 2021)**

Experience variants	Dosing used	Average number of larvae (adults) per m^2				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %			Weight 1000 grains, g
		Before treatment	After treatment according to the accounting days						
			3	7	14	3	7	14	
Dexter Turbo, SE (115 + 106 + 75 g/l)	0,1 л/га	10,5	2,0	1,8	1,8	82,7	87,7	87,3	34,8
	0,2 л/га	11,3	1,5	1,0	1,5	88,4	93,8	90,5	35,0
Grind, SP (200 g/kg) /standard/	0,075 кг/га	11,0	2,0	2,0	2,3	83,4	86,9	85,3	34,7

Control	–	11,3	12,3	15,5	15,8	–	–	–	32,0
LSD_{05}		2,9	1,77	1,39	1,62	9,10	7,03	8,93	0,66

Thus, the assessment of the biological effectiveness of the insecticide Dexter Turbo, SE showed that the preparation in the first season (2020) reduced the number of sunn pests to 92% for 14 days, and in the second season (2021) to 94% for 14 days, not inferior to the standard of Grind, SP (200 g/kg).

Field studies of the insecticide in the control **cereal leaf beetle** were carried out on winter wheat of the Grom variety (2020) and Svarog variety (2021). The phase of development of winter wheat at the time of preparation treatments is the exit into the tube. A single insecticide treatment was performed to control larvae of 2-3 ages.

The scheme of the experiment: Dexter Turbo, SE in the application rates of 0.1 l/ha and 0.2 l /ha, the standard preparation Karachar, EC (50 g/l) in the rate of 0.15 l/ha, control without treatment. In the 2020 season, the appearance of cereal leaf beetles on experimental winter wheat crops was noted in the second decade of April, with an average daily air heating up to 10-15 ^{0}C. After additional feeding and mating, the females laid eggs in the form of a chain on the underside of the leaf blade of cereals, along the veins. After 10 days, the hatching of larvae from laid eggs was observed. Spraying of crops was carried out with an average number of larvae according to the pre-treatment options from 92.0 to 97.3 larvae/100 stems, with an economic threshold (ET) of 0.5-1 larvae/stem (Table 15).

Table 15 –**Biological effectiveness of insecticide Dexter Turbo, SE in the control of cereal leaf beetle on winter wheat (Rostov region, 2020)**

Experience variants	Dosing used	Average (larvae in 100 stems)				Decrease in the number of larvae relative to the initial one, adjusted for control after treatment according to the accounting days, %			Biological grain yield, c/ha
		Before treatment	After treatment according to the accounting days						
			3	7	10	3	7	10	
Dexter Turbo, SE	0,1 l/ha	92,0	16,5	15,0	14,0	83,1	85,3	86,5	27,0

(115 + 106 + 70 g/l)	0,2 l/ha	96,8	12,0	7,8	7,0	88,3	92,8	93,6	27,2
Karachar, EC (50 g/l) /standard/	0,15 l/ha	95,5	14,3	10,8	9,8	86,0	89,8	91,0	27,0
Control	–	97,3	102,5	107,8	110,0	–	–	–	25,1
LSD_{05}		6,57	5,39	4,41	5,88	4,51	3,86	4,16	0,29

On the 3rd day after treatment in the variants with insecticides, the number of cereal leaf beetle decreased from 16.5 to 12.0 larvae/100 stems. The biological effectiveness of the studied preparation Dexter Turbo, SE in two application rates (0.1 l/ha and 0.2 l/ha) was 83.1 and 88.3% and was not inferior to the effectiveness of the standard Karachar, EC (86%) in the application rate of 0.15 l/ha.

On the 7th and 10th days after treatment, in the variants with the studied preparation, the tendency to decrease the number of pest larvae remained. The biological effectiveness of the insecticide was 85.3-93.6% and was at the standard level (89.8-91.0%).

In the control during the accounting period, a gradual increase in the average number of larvae of the cereal leaf beetle was noted, respectively: 97,3-102,5-107,8-110,0 larvae/100 stems. The analysis of the winter wheat harvest showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

In the 2021 season, the appearance of cereal leaf beetles on experimental winter wheat crops was noted in the third decade of April, with an average daily air heating up to 10-15 ^{0}C. The females laid eggs after additional feeding and mating. After 12 days, the hatching of larvae from laid eggs was observed. Spraying of crops was carried out with an average number of larvae according to the experimental variants before treatment from 96.8 to 98.8 larvae/100 stems (Table 16).

On the 3rd day after treatment in the variants with insecticides, the number of cereal leaf beetle decreased to 10.5-15.3 larvae/100 stems. The biological effectiveness of the studied preparation Dexter Turbo, SE in two application rates (0.1 l/ha and 0.2 l/ha) was: 84.3% and 89.4% and was not inferior to the effectiveness of the standard

(87.9%), at a rate of application 0.15 l/ha.

On the 7th and 10th days after treatment, in the variants with the studied preparation, the tendency to decrease the number of pest larvae remained. The biological effectiveness of the insecticide was 87.1-93.9%, the effect of which was at the standard level (90.6% and 91.1%).

In the control during the accounting period, a gradual increase in the average number of larvae of the cereal leaf beetle was noted, respectively: 98,8-99,3-108,5-111,8 larvae/100 stems.

The analysis of the winter wheat harvest showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

Table 16 –**Biological effectiveness of insecticide Dexter Turbo, SE in the control of cereal leaf beetle on winter wheat (Rostov region, 2021)**

Experience variants	Dosing used	Average (larvae in 100 stems)				Decrease in the number of larvae relative to the initial one, adjusted for control after treatment according to the accounting days, %			Biological grain yield,c/ha
		Before treatment	After treatment according to the accounting days						
			3	7	10	3	7	10	
Dexter Turbo, SE (115 + 106 + 70 g/l)	0,1 l/ha	97,3	15,3	13,8	13,5	84,3	87,1	87,7	39,3
	0,2 l/ha	98,0	10,5	7,3	6,8	89,4	93,3	93,9	39,6
Karachar, EC (50 g/l) /standard/	0,15 l/ha	96,8	11,8	10,0	9,8	87,9	90,6	91,1	39,4
Control	–	98,8	99,3	108,5	111,8	–	–	–	35,5
LSD_{05}		5,04	3,70	3,22	4,01	4,16	2,82	3,88	0,98

Therefore, it was proved that the new combined insecticide we studied, containing 115 g/l acetamipride, 106 g/l lambda-cyhalothrin and 70 g/l clothianidin at application rates of 0.1 l/ha and 0.2 l/ha, can effectively protect winter wheat from cereal leaf beetle.

Field studies to evaluate the effectiveness of Dexter Turbo, SE to control **wheat beetles** were conducted on winter wheat of the Grom variety (2020) and Svarog variety (2021). The phase of development of winter wheat at the time of preparation treatments is grain filling.

In 2020, wheat beetles were introduced: *Anisoplia austriaca* Hrbst. (80%), *Anisoplia agricola* Poda. (10%) and *Anisoplia segetum* Herbst. (10%), in 2021 (90%, 5% and 5%) respectively. A single insecticide treatment was performed control adults.

The scheme of the experiment: the studied insecticide Dexter Turbo, SE at application rates of 0.1 l/ha and 0.2 l/ha, the standard preparation Espero, SC (200 + 120 g/l) at a rate of 0.1 l/ha, control without treatment. The populating of winter wheat crops by wheat beetles was observed at the end of the first and beginning of the second decade of June 2020.

The main mass of pests was located on the edge strips. The beetles actively fed during the day, in warm sunny weather at temperatures above 20 ^{0}C, gnawing out grains or eating grooves and narrow depressions in them. At the same time, some of the grains were on the soil (it was knocked out by beetles).

Spraying of crops in 2020 was carried out when the number of wheat beetles averaged 8-9 adults per m^2 according to the experimental variants (with an economic threshold (ET) 3-5 adults per m^2) (Figure 19) (Appendix 5).

During the accounting period on days 3, 7 and 14 after treatment, the number of wheat beetles in the control reached 9.8-10.8 adult per m^2, whereas in plots with the studied insecticide, there was a fluctuation in the pest population from 1.8 to 0.5 adult per m^2, similar to the variant using the standard Espero, SC (1.5-1.0 adult per m^2).

The biological effectiveness of the studied preparation ranged from 82.2% (0.1 l/ha) to 95.3% (0.2 l/ha), which was at or above the standard: 83.5-89.3% (Figure 20) (Appendix 5). The analysis of the winter wheat harvest showed that the data obtained, in general, are consistent with the results of the assessment of biological effectiveness: the biological yield in the experiment was 26.2-26.4 c/ha, in the control 24.6 c/ha, LSD_{05} = 0.61.

Spraying of crops in 2021 was carried out when the number of wheat beetles averaged 7.5-8.0 adults per m^2 according to the experimental variants (Figure 21) (Appendix 6). During the accounting period on days 3 and 7 after treatment, the number of wheat beetles in the control reached 9.5-12.0 adults per m^2, whereas in plots with the studied insecticide, there was a fluctuation in the pest population from 1.8 to 1.0 adults per m^2, similar to the variant using the standard Espero ,SC (1.5 and 1.3 adults per m^2).

The biological effectiveness of the studied preparation in two application rates (0.1 and 0.2 l/ha) was: 81.6-92.1%, which was at the level of the standard indicators: 84.8% and 89.4% (Figure 22) (Appendix 6).

On the 14th day of accounting, in all variants of the insecticide experiment, a decrease in the average pest population was noted, including in the control. In the variants with the studied insecticide, the average number of wheat beetles was 1.0 and 0.8 adults per m^2, which was at the level of the standard Espero, SC (0.8 adults per m^2).

The biological effectiveness of the studied preparation reached 89.1% and 92.4%, similar to the indicator of the standard (90.9%). The analysis of the winter wheat harvest showed that the data obtained are also generally consistent with the results of the assessment of biological effectiveness: the biological yield in the experiment was 39.2-39.4 c/ha, in the control 35.4 c/ha, LSD_{05} = 1.03.

Therefore, it was proved that the new combined insecticide Dexter Turbo, SE studied by us in application rates of 0.1 l/ha and 0.2 l/ha, can effectively protect winter wheat from dangerous phytophages wheat beetles.In 2020, the maximum effectiveness was 95.3 %, in 2021 92.4%.

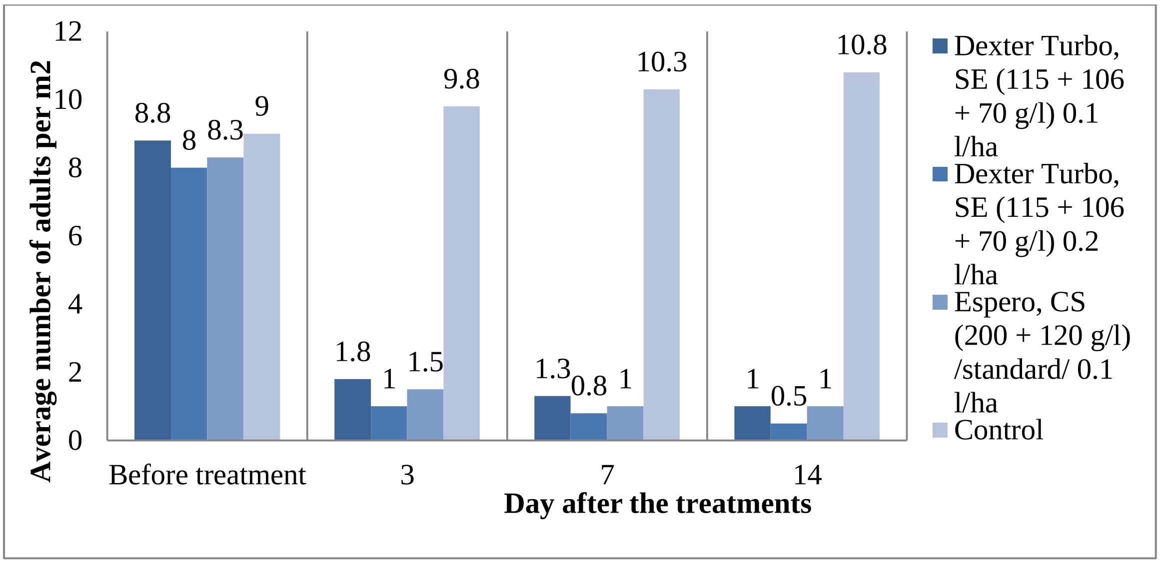


Figure 19. **The change in the number of wheat beetles under the effect of insecticides (Rostov region, 2020).**

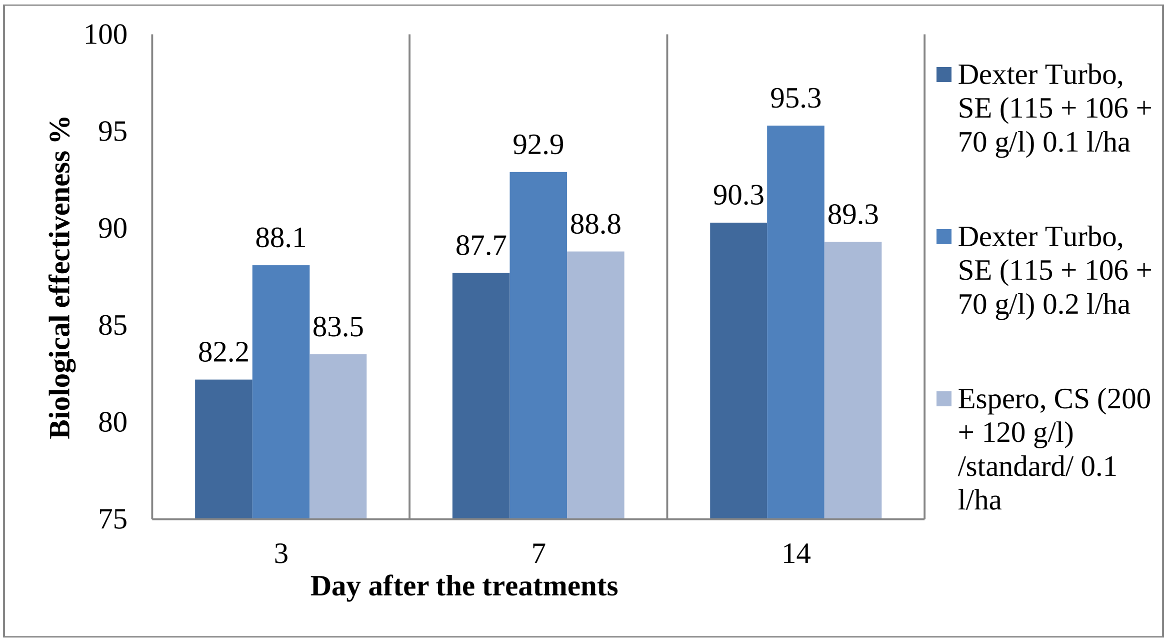


Figure 20. **Biological effectiveness of Dexter Turbo , SE insecticide in the control of wheat beetles on winter wheat (Rostov region, 2020)**

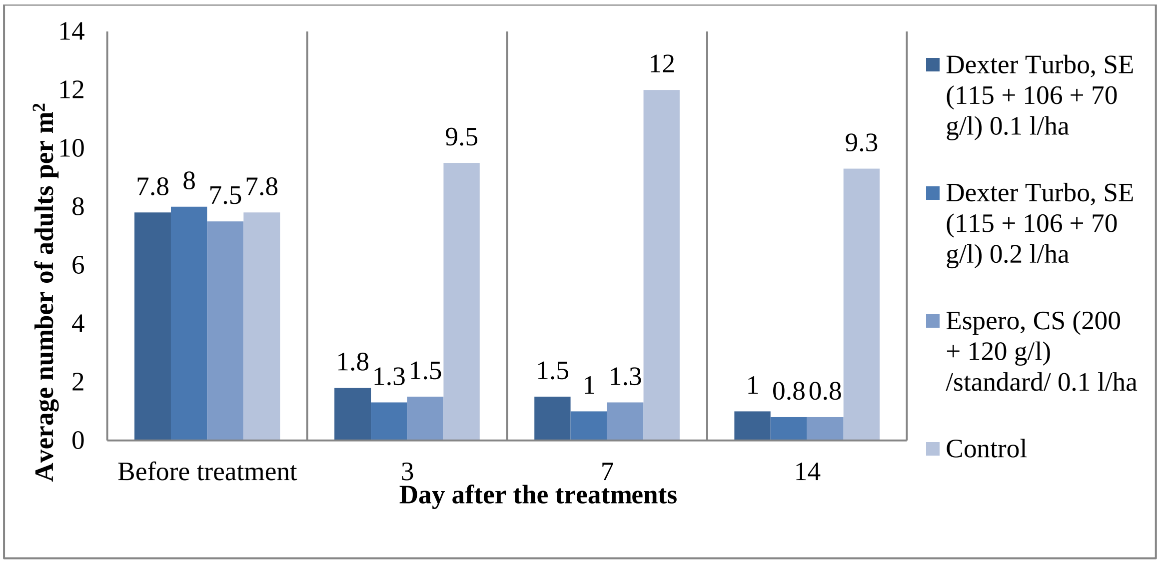


Figure 21. **The change in the number of wheat beetles under the effect of insecticides (Rostov region, 2021)**

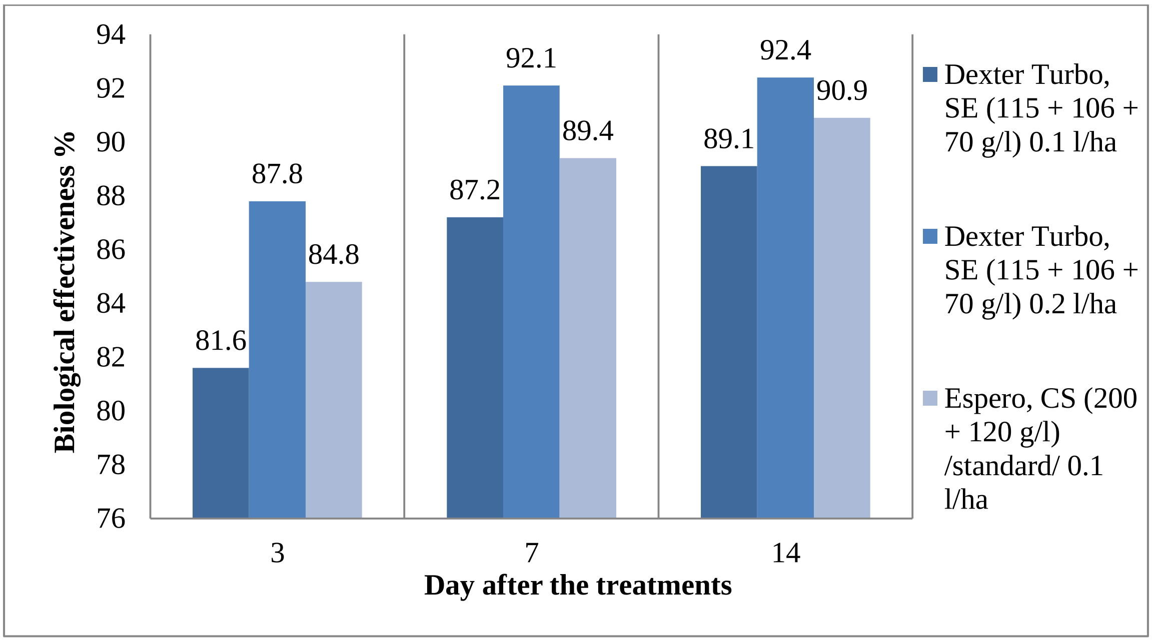


Figure 22. **Biological effectiveness of Dexter Turbo , SE insecticide in the control of wheat beetles on winter wheat (Rostov region, 2021)**

3.4 Biological effectiveness and regulations for the use of insecticide Factoria, MCS

The study of the biological effectiveness of the combined insecticide Factoria, MCS, containing 141 g/l thiamethoxam + 106 g/l lambda-cyhalothrin for the control of **cereal aphids** was carried out in 2019-2020 on winter wheat of the Yuca variety.

The phase of development of winter wheat at the time of preparation treatments is the exit into the tube. Insecticide treatment is a single treatment.The scheme of the experience is presented in Table 17.

Table 17 – **Scheme of experience**

№	Experience variants	Dosing used
1	Factoria, MCS (141 + 106 g/l)	0,1 l/ha
2	Factoria, MCS (141 + 106 g/l)	0,2 l/ha
3	Eforia, CS (141 + 106 g/l) /standard/	0,2 l/ha
4	Control	–

The development of winter wheat in 2019 took place under favorable conditions. Uniform emergence of seedlings (autumn 2018) and further development of crops (spring 2019) were noted at the experimental site.

The mass reproduction of aphids began with the onset of optimal average daily air temperatures (16-20 ^{0}C), as well as sufficient precipitation.

The prevailing favorable conditions contributed to the intensive colonization of the crops by the pest. The sum of the effective temperatures for the development of one generation of aphids is 75 ^{0}C (at a threshold of 5 ^{0}C), in our experience a sum of effective temperatures (SET) = 375-450 ^{0}C reached in the 2nd decade of May, the pest by this time had managed to form larvae of the 5th-6th generation.

Spraying of crops was carried out with an average number according to the experimental variants from 12.8 to 15.1 aphids per stem, with an economic threshold (ET) of 10 individuals per stem (Table 18).

Table 18 –**Biological effectiveness of the insecticide Factoria, MCS in the control of cereal aphids on winter wheat (Rostov region, 2019)**

Experience variants	Dosing used	Average number of aphids per stem				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %		
		Before treatment	After treatment according to the accounting days					
			3	7	14	3	7	14
Factoria, MCS (141 + 106 g/l)	0,1 l/ha	14,3	3,2	3,0	2,6	78,9	81,6	84,9
	0,2 l/ha	15,1	2,7	2,5	2,2	83,1	85,8	88,0
Eforia, CS (141 + 106 g/l) /standard/	0,2 l/ha	12,8	2,6	2,4	2,2	81,4	83,9	86,2
Control	–	14,6	15,5	16,6	17,6	–	–	–
LSD_{05}		1,7	1,2	1,1	1,0	5,2	4,8	4,2

On the 3rd day after treatment in the variant with the insecticide Factoria, MCS in the application rates of 0.1 and 0.2 l /ha, the average pest population was close to the level of the standard Ephoria, CS and significantly lower than in the control. The decrease in the pest population in the variants with the insecticide Factoria, MCS amounted to 78.9 and 83.1%, corresponding to the effectiveness of the standard preparation of 81.4% (Eforia, CS).

On the 7th and 14th days of the accounting, a decrease in the number of aphids was noted in the variants of the experiment with plant treatment. In the variants with the studied insecticide, the average number of aphids was 3.0-2.2 aphids per stem, in the standard variant 2.4 and 2.2 aphids per stem. Its biological effectiveness was 81.6-88.0%, similar to the standard indicators of 83.9% and 86.2%.

The development of winter wheat in 2020 took place under moderate conditions. At the experimental site, the uniform appearance of seedlings (autumn 2019) and further development of crops (spring 2020) were noted.

The mass reproduction of aphids began with the onset of average daily air temperatures (16-18 ^{0}C), as well as a sufficient amount of precipitation. This contributed to a more intensive colonization of the crop by pest larvae. The sum of the effective temperatures (SET) for the development of one generation of aphids is 75 0C (at a threshold of 5 0C), in our experience (SET) = 258-308 0C reached in the 1st decade of May, the pest by this time had managed to form larvae of the 4th generation. Spraying of crops was carried out with an average number according to the experimental variants from 11.7 to 12.4 aphids per stem, with an economic threshold (ET) of 10 individuals per stem (Table 19).

On the 3rd day after treatment in the variants with the insecticide Factoria, MCS in the application rates of 0.1 and 0.2 l/ha, the average pest population was close to the standard level and significantly lower than in the control. The decrease in the pest population in the variants with the studied preparation amounted to 80.1% and 84.9%, which corresponded to the effectiveness of the standard variant of the experiment at 85.6%.

On the 7th and 14th days of the accounting, a decrease in the number of aphids was noted in the variants of the experiment with plant treatment. In the variants with the studied insecticide, the average number of aphids ranged from 2.3 to 1.7 aphids per stem, in the standard variant from 1.9 to 1.8 aphids per stem. Its biological effectiveness was at the level of 82.8-87.6%, similar to the standard indicators of 86.1% and 87.0%.

Table 19 –**Biological effectiveness of the insecticide Factoria, MCS in the control of cereal aphids on winter wheat (Rostov region, 2020)**

Experience variants	Dosing used	Average number of aphids per stem				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %		
		Before treatment	After treatment according to the accounting days					
			3	7	14	3	7	14
Factoria, MCS (141 + 106 g/l)	0,1 l/ha	11,7	2,5	2,3	2,2	80,1	82,8	83,7
	0,2 l/ha	12,4	2,0	1,9	1,7	84,9	86,6	87,6

Eforia, CS (141 + 106 g/l) /standard/	0,2 l/ha	12,2	1,9	1,9	1,8	85,6	86,1	87,0
Control	–	11,7	12,5	12,9	13,2	–	–	–
LSD_{05}		0,88	0,70	0,64	0,54	3,91	3,85	3,01

So, an assessment of the biological effectiveness of Factoria insecticide, MCS (141 + 106 g/l), carried out on wheat in the Rostov region, showed that the preparation reduced the number of cereal aphids by up to 88%. The effectiveness of the studied preparation in the application rates of 0.1 and 0.2 l/ha was not inferior to the effectiveness of the standard Eforia, CS (141 + 106 g / l) 0.2 l /ha.

Field studies on the biological effectiveness of the insecticide Factoria, MCS to control **sunn pests** were conducted in 2010-2020 in the Salsky district of the Rostov region on winter wheat of the Yuka variety (2019) and the Grom variety (2020).

The phase of development of winter wheat at the time of preparation treatments is milk maturity. Insecticide treatment was performed once. The scheme of the experience is presented in Table 20.

Table 20 –**Scheme of experience**

№	Experience variants	Dosing used
1	Factoria, MCS (141 + 106 g/l)	0,1 l/ha
2	Factoria, MCS (141 + 106 g/l)	0,2 l/ha
3	Eforia, CS (141 + 106 g/l) / standard – 2019/ Kungfu Super, CS (106 + 141 g/l) /standard – 2020/	0,2 l/ha
4	Control	–

In the 2019 season, the development of winter wheat took place under favorable conditions. At the experimental site, uniform emergence of seedlings (autumn 2018) and further development of crops (spring-summer 2019) were noted. The signal for treatment is the sum of effective temperatures (SET) equal to 240-280 ^{0}C at a threshold plus 10 ^{0}C from the date of mass egg laying by the sunn pests.

The mass egg laying in our treatment occurred on May 4, with a (SET) equal to 95 ^{0}C. Spraying of crops was carried out in the first decade of June, when the number of larvae and adult pests averaged 9.5-11.3 individuals/m^2 according to the experimental variants (Table 21).

Table 21 –**Biological effectiveness of the insecticide Factoria, MCS in the control of sunn pest on winter wheat (Rostov region, 2019)**

Experience variants	Dosing used	Average number of larvae (adults) per m^2				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %			Weight of 1000 grains, g
		Before treatment	After treatment according to the accounting days						
			3	7	14	3	7	14	
Factoria, MCS (141 + 106 g/l)	0,1 l/ha	10,8	2,3	1,8	2,3	81,5	87,3	84,1	50,6
	0,2 l/ha	9,8	1,5	0,8	1,3	86,4	94,1	90,4	51,5
Eforia, CS (141 + 106 g/l)/standard/	0,2 l/ha	9,5	2,0	1,3	1,5	81,3	89,5	88,1	51,0
Control	–	11,3	12,5	14,0	14,8	–	–	–	46,6
LSD_{05}		2,49	1,93	2,19	1,62	9,68	7,43	4,65	0,71

On the 3rd and 14th days after treatment, the number of sunn pest in the control reached 12.5-14.8 individuals/m^2, whereas in plots with insecticide Factoria, MCS, there was a fluctuation in the pest population from 2.3 to 1.3 individuals/m^2, and in the variant using the standard Eforia, CS 2.0 -1.5 individuals/m^2.

The biological effectiveness of the studied preparation ranged from 81.5% to 90.4%, depending on the rate of application of the pesticide and was not inferior to the effectiveness of the standard.

On the 7th day of the accounting, a decrease in the population of the experimental plots with a sunn pest was noted. In the variants with the studied insecticide, the average number was 1.8 and 0.8 individuals/m^2, which was at the standard level. The indicators of the biological effectiveness of the preparation Factoria, MCS amounted to 87.3-94.1%, similar to the indicator of the standard Eforia, CS 89.5%.

The analysis of the mass of 1000 grains of winter wheat showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

In the 2020 season, the development of winter wheat took place under moderate conditions. At the experimental site, the uniform appearance of seedlings (autumn 2019) and further development of crops (spring 2020) were noted.

In the first decade of May, the appearance of an adult sunn pest was noted on winter wheat crops when the air temperature increased to an average of 16.2 ^{0}C. The optimal air temperature contributed to the rapid settlement of adults. The signal for treatment against larvae is the sum of effective temperatures (SET) equal to 240-280 ^{0}C at a threshold plus 10 ^{0}C from the date of mass egg laying by the sunn pest.

The mass egg laying in our experience occurred on May 9, at a (SET) of 95 ^{0}C. Spraying of crops was carried out in the first decade of June, when the number of larvae and adult pests averaged 10.8-12.5 individuals/m^2 according to the experimental variants (Table 22).

On the 3rd and 7th days after treatment, the number of sunn pest in the control reached 13.3-15.5 individuals/m^2, whereas in plots with insecticide Factoria, MCS, there was a fluctuation in the pest population from 2.3 to 1.3 individuals/m^2 (0.1 l/ha and 0.2 l/ha), and in the variant using the standard 1.8-1.5 individuals/m^2. The biological effectiveness of the studied preparation in two application rates was: 80.2-91.8%, acting at the standard level 86.1% and 89.9%.

On the next day of accounting, a slight increase in the number of pests in the accounting plots was noted. In the variants with the insecticide Factoria, MCS, the average number of sunn pest was 2.0 and 1.5 individuals/m^2, which was at the standard level (1.8 individuals/m^2). The biological effectiveness of the studied preparation reached 90.6%, similar to the indicator of the standard (88.8%).

The analysis of the mass of 1000 grains of winter wheat showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

Table 22 –**Biological effectiveness of the insecticide Factoria, MCS in the control of sunn pest on winter wheat (Rostov region, 2020)**

Experience	Dosing used	Average number of larvae (adults) per m^2	Decrease in the number relative to the	Weight of 1000

variants		Before treatment	After treatment according to the accounting days			initial one, adjusted for control after treatment according to the accounting days, %			grains, g
			3	7	14	3	7	14	
Factoria, MCS (141 + 106 g/l)	0,1 l/ha	10,8	2,3	2,0	2,0	80,2	85,4	85,3	31,7
	0,2 l/ha	12,3	2,0	1,3	1,5	85,1	91,8	90,6	32,0
Kungfu Super, CS (106 + 141 g/l) /standard/	0,2 l/ha	11,8	1,8	1,5	1,8	86,1	89,9	88,8	31,8
Control	–	12,5	13,3	15,5	16,0	–	–	–	29,5
LSD_{05}		3,31	2,6	2,21	2,51	9,43	4,72	7,16	0,52

Therefore, the assessment of the biological effectiveness of the insecticide Factoria, MCS showed that the preparation reduced the number of sunn pest to 94%.Consequently, in the control of the sunn pest, the insecticide in the application rates of 0.1 l/ha and 0.2 l/ha acted at the standard level.

A field assessment of the biological effectiveness of the insecticide Factoria, MCS in the control of **cereal leaf beetle** was carried out in 2019-2020 on winter wheat of the Yuka variety (2019) and the Grom variety (2020). The phase of development of winter wheat at the time of preparation treatments is the exit into the tube. A single insecticide treatment was performed against larvae of 2 and 3 ages. The scheme of the experience is shown in Table 23.

Table 23 –**Scheme of experience**

№	Experience variants	Dosing used
1	Factoria, MCS (141 + 106 g/l)	0,1 l/ha
2	Factoria, MCS (141 + 106 g/l)	0,2 l/ha
3	Kung Fu Super, CS (106 + 141 g/l) /standard/	0,2 l/ha
4	Control	–

In the 2019 season, the development of winter wheat took place under favorable conditions. At the experimental site, uniform emergence of seedlings (autumn 2018) and further development of crops (spring 2019) were noted.

On experimental plots of winter wheat, adults of the pest appeared in the second decade of April. After 7-9 days, the hatching of larvae from laid eggs was observed. Spraying of crops was carried out with an average number of larvae according to the pre-treatment options from 89.3 to 99.3 larvae/ 100 stems, with an economic threshold (ET) of 0.5-1 larvae/stem (Table 24).

Table 24 –**Biological effectiveness of the insecticide Factoria, MSC in the control of cereal leaf beetle on winter wheat (Rostov region, 2019)**

Experience variants	Dosing used	Average (larvae in 100 stems)				Decrease in the number of larvae relative to the initial one, adjusted for control after treatment according to the accounting days, %			Biological grain yield,c/ha
		Before treatment	After treatment according to the accounting days						
			3	7	10	3	7	10	
Factoria, MCS (141 + 106 g/l)	0,1 l/ha	99,3	14,3	13,3	15,0	82,1	84,8	84,1	36,9
	0,2 l/ha	89,3	7,8	7,0	7,8	89,2	91,1	90,9	37,0
Kung Fu Super, CS (106 + 141 g/l) /standard/	0,2 l/ha	94,0	8,8	8,5	8,3	88,4	89,7	90,8	37,0
Control	–	89,8	71,8	78,5	85,3	–	–	–	34,5
LSD_{05}		15,5	10,0	11,0	8,3	2,9	2,9	2,7	0,3

On the 3rd day after treatment in the variants with insecticide, the number of cereal leaf beetle decreased from 14.3 to 7.8 larvae/100 stems. The biological effectiveness of the studied preparation Factoria, MCS in two application rates (0.1 l/ha and 0.2 l/ha) was 82.1-89.2% and was not inferior to the effectiveness of the standard Kung Fu Super, CS (88.4%) in the application rate of 0.2 l/ha.

On the 7th and 10th days after treatment in the variants with the studied preparation, the biological effectiveness of the insecticide was 84.8-90.9%, the effect of which was at the standard level (89.7-90.8%).

The fluctuation in the number of larvae of the cereal leaf beetle in the control (on 3-7-10 days of registration) was as follows: 71,8-78,5-85,3 larvae/100 stems, respectively.The analysis of the winter wheat harvest showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness: 37 c/ha in the experimental and standard variants and 34.5 c/ha in the control.

In the 2020 season, the development of winter wheat took place under moderate conditions. At the experimental site, the uniform appearance of seedlings (autumn 2019) and further development of crops (spring 2020) were noted.

The appearance of cereal leaf beetle beetles in experimental plots in winter wheat crops was noted in the second decade of April, with an average daily air heating up to 10-15 ^{0}C. After additional feeding and mating, the females laid eggs in the form of a chain on the underside of the leaf blade of cereals, along the veins. After 10 days, the hatching of larvae from laid eggs was observed. Spraying of crops was carried out with an average number of larvae according to the pre-treatment options from 90.8 to 96.3 larvae/100 stems (Table 25).

Table 25 – **Biological effectiveness of the insecticide Factoria, MSC in the control of cereal leaf beetle on winter wheat (Rostov region, 2020)**

Experience variants	Dosing used	Average (larvae in 100 stems)		Decrease in the number of larvae relative to the initial one, adjusted for control after treatment according to the accounting	Biological grain yield,c/ha
		Before treatment	After treatment according to the accounting days		

						days, %			
			3	7	10	3	7	10	
Factoria, MCS (141 + 106 g/l)	0,1 l/ha	90,8	18,0	16,5	16,3	81,1	84,0	85,3	26,9
	0,2 l/ha	95,3	13,3	10,3	9,5	86,8	90,6	91,8	27,0
Kung Fu Super, CS (106 + 141 g/l) /standard/	0,2 l/ha	96,3	13,0	9,8	9,8	87,2	91,1	91,6	27,0
Control	–	92,3	96,5	104,8	112,5	–	–	–	25,3
LSD_{05}		5,28	4,57	3,81	3,97	4,31	2,70	3,75	0,20

On the 3rd day after treatment in the variants with insecticides, the number of cereal leaf beetle decreased from 18.0 to 13.0 larvae/100 stems. The biological effectiveness of the studied preparation Factoria, MCS in two application rates (0.1 l/ha and 0.2 l/ha) was 81.1-86.8% and was not inferior to the effectiveness of the standard Kung Fu Super, CS (87.2%) in the application rate of 0.2 l/ha.

On the 7th and 10th days after treatment, in the variants with the studied preparation, the tendency to decrease the number of pest larvae remained. The biological effectiveness of the insecticide was 84.0-91.8% and was at the standard level (91.1-91.6%). In the control during the accounting period, a gradual increase in the average number of larvae of the cereal leaf beetle was noted, respectively: 92,3-96,5-104,8-112,5 larvae/100 stems.The analysis of the winter wheat harvest showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

Therefore, an assessment of the biological effectiveness of insecticide Factoria , MCS showed that the preparation reduced the number of cereal leaf beetle larvae by up to 92% within 10 days.Consequently, in the control of the cereal leaf beetle , the insecticide in two application rates (0.1 and 0.2 l/ha) acted at the level of the Kung Fu Super, CS

The biological effectiveness of the insecticide Factoria, MCS in the control of **wheat beetles** was studied on winter wheat varieties Yuka (2019) and Grom (2020).

The phase of development of winter wheat at the time of preparation treatments is grain filling. The scheme of the experience is shown in table 26.

Table 26 –**Scheme of experience**

№	Experience variants	Dosing used
1	Factoria, MCS (141 + 106 g/l)	0,1 l/ha
2	Factoria, MCS (141 + 106 g/l)	0,2 l/ha
3	Eforia, CS (141 + 106 g/l) / standard – 2019/ Kungfu Super, CS (106 + 141 g/l) /standard – 2020/	0,2 l/ha
4	Control	–

In the 2019 season, the development of winter wheat took place under favorable conditions. At the experimental site, uniform emergence of seedlings (autumn 2018) and further development of crops (spring-summer 2019) were noted.

Beetles began to colonize wheat crops in June mainly around the edges and ate soft unripe grains, lived openly on spikes. The beetles were active, feeding only during the day, especially in hot sunny weather. Spraying of crops was carried out when the number of wheat beetles averaged 8.8-10 imagos per m^2 according to the experimental variants (economic threshold (ET) 3-5 adults per m^2) (Table 27).

Table 27 –**Biological effectiveness of the Factoria, MCS in the control of wheat beetles on winter wheat, Rostov region, 2019)**

<table>
<tr><th rowspan="3">Experience variants</th><th rowspan="3">Dosing used</th><th colspan="4">Average number of adults per m²</th><th colspan="3" rowspan="2">Decrease in the number of larvaerelative to the initial one,adjusted for controlafter treatment according to the accounting days, %</th><th rowspan="3">Biological grain yield, c/ha</th></tr>
<tr><th rowspan="2">Before treatment</th><th colspan="3">After treatment according to the accounting days</th></tr>
<tr><th>3</th><th>7</th><th>14</th><th>3</th><th>7</th><th>14</th></tr>
</table>

Factoria, MCS (141 + 106 g/l))	0,1 l/ha	9,8	1,3	1,0	1,0	88,0	90,4	91,2	37,0
	0,2 l/ha	8,8	0,8	0,5	0,5	92,0	95,1	95,5	37,2
Eforia, CS (141 + 106 g/l) /standard/	0,2 l/ha	9,8	1,0	0,5	0,5	91,0	95,7	96,1	37,1
Control	–	10,0	10,5	10,8	11,8	–	–	–	34,5
LSD_{05}		2,36	1,57	1,16	1,46	8,56	7,01	6,43	0,38

Throughout the entire accounting period: 3, 7 and 14 days after treatment, the number of wheat beetles in the control reached 10.5-11.8 adults per m^2, whereas in plots with insecticide Factoria, MCS (141 + 106 g/l), a fluctuation in the pest population from 1.3 to 0.5 adults per m^2 was observed. The biological effectiveness of the studied preparation ranged from 88% (0.1 l/ ha) to 95.5% (0.2 l/ha), which was at the level of the standard Eforia, CS 91-96.1%.

The analysis of the winter wheat harvest showed that the data obtained, in general, are consistent with the results of the assessment of biological effectiveness: 37.0-37.2 c/ha in the experiment, 34.5 c/ha in the control.

In the 2020 season, the development of winter wheat took place under moderate conditions. At the experimental site, uniform emergence of seedlings (autumn 2019) and further development of crops (spring-summer 2020) were noted.

The colonization of winter wheat crops by wheat beetles was observed in the second decade of June. The main mass was on the edge bands. The beetles actively fed during the day, in warm sunny weather at temperatures above 20 ^{0}C, gnawing out grains or eating grooves and narrow depressions in them. At the same time, some of the grains were on the soil (knocked out by beetles). Spraying of crops was carried out when the number of wheat beetles averaged 8.3-9.8 adults per m2 according to the experimental variants (Table 28). During the accounting period on days 3, 7 and 14 after treatment, the number of wheat beetles in the control reached 9.8-11.8 adults per m^2, whereas in plots with insecticide Factoria, MCS, there was a fluctuation in the pest population from

1.5 to 0.5 adults per m^2, similar to the option using the standard. The biological effectiveness of the studied preparation in the application rates of 0.1 l/ha and 0.2 l/ha ranged from 87.6% to 96.6% and was not inferior to the effectiveness of the standard 89.2-96.1%.

The analysis of the winter wheat harvest showed that the data obtained, in general, are consistent with the results of the assessment of biological effectiveness.

Table 28 – **Biological effectiveness of the Factoria, MCS in the control of wheat beetles on winter wheat, Rostov region, 2020)**

<table>
<tr><th rowspan="3">Experience variants</th><th rowspan="3">Dosing used</th><th colspan="4">Average number of adults per m^2</th><th colspan="3" rowspan="2">Decrease in the number of larvaerelative to the initial one,adjusted for controlafter treatment according to the accounting days, %</th><th rowspan="3">Biological grain yield, c/ha</th></tr>
<tr><th rowspan="2">Before treatment</th><th colspan="3">After treatment according to the accounting days</th></tr>
<tr><th>3</th><th>7</th><th>14</th><th>3</th><th>7</th><th>14</th></tr>
<tr><td rowspan="2">Factoria, MCS (141 + 106 g/l)</td><td>0,1 l/ha</td><td>9,8</td><td>1,5</td><td>1,5</td><td>1,0</td><td>87,6</td><td>89,2</td><td>92,1</td><td>26,1</td></tr>
<tr><td>0,2 l/ha</td><td>9,0</td><td>0,8</td><td>0,8</td><td>0,5</td><td>93,5</td><td>94,3</td><td>96,6</td><td>26,3</td></tr>
<tr><td>Kungfu Super, CS (106 + 141 g/l) /standard/</td><td>0,2 l/ha</td><td>9,3</td><td>1,3</td><td>1,0</td><td>0,5</td><td>89,2</td><td>92,6</td><td>96,1</td><td>26,2</td></tr>
<tr><td>Control</td><td>–</td><td>8,3</td><td>9,8</td><td>11,5</td><td>11,8</td><td>–</td><td>–</td><td>–</td><td>24,5</td></tr>
<tr><td colspan="2">LSD_{05}</td><td>2,36</td><td>1,62</td><td>1,32</td><td>1,59</td><td>13,29</td><td>7,05</td><td>8,13</td><td>0,68</td></tr>
</table>

Therefore, an assessment of the biological effectiveness of insecticide Factoria, MCS showed that the preparation reduced the number of wheat beetles by up to 97%. Consequently, in the control of wheat beetles, the studied insecticide in the application rates of 0.1 l /ha and 0.2 l/ha acted at the standard level.

3.5 Biological effectiveness and regulations for the use of insecticide Mainstay, SE

Field studies of the Mainstay, SE preparation were carried out in 2021-2022 on winter wheat of the Svarog variety (2021) and the Yuka variety (2022). The development of winter wheat in 2021 took place under moderate conditions. At the experimental site, uniform emergence of seedlings (autumn 2020) and further development of the crops (spring 2021) were noted. The development of winter wheat in 2022 took place under favorable conditions.

The study of the biological effectiveness of insecticide control **cereal aphids** was carried out according to the scheme shown in Table 29.

Table 29 –**Scheme of experience**

№	Experience variants	Dosing used	Multiplicity of treatments
1	Mainstay, SE (112+37 g/l)	0,2 l/ha	1
2	Mainstay, SE (112+37 g/l)	0,3 l/ha	1
3	Mainstay, SE (112+37 g/l)	0,4 l/ha	1
4	Clonrin, CE (150+100 g/l) /standard/	0,2 l/ha	1
5	Control	–	–

The mass reproduction of aphids in 2021 began with the onset of average daily air temperatures (17-20 ^{0}C), as well as abundant precipitation. These conditions contributed to the intensive colonization of the crops by pest larvae. The sum of the effective temperatures (SET) for the development of one generation of aphids is 75 ^{0}C (at a threshold of 5 ^{0}C), in our experience (SET) = 323-357 0C reached in the 2nd decade of May, the pest by this time had managed to form larvae of the 5th generation. During the laying of the experiment, winter wheat was in the phase of entering the tube. Spraying of crops was carried out with an average number of experimental variants from 14.0 to 14.7 aphids per stem, with an economic threshold (ET) of 10 individuals per stem (Table 30). On the 3rd and 7th days after treatment in the variants with the insecticide

Mainstay, SE in the application rates of 0.2, 0.3 and 0.4 l/ha, the average pest population was close to the level of the Clonrin, CE standard and significantly lower than in the control. In the variants with the studied insecticide, the average number of aphids ranged from 2.0 to 0.7 aphids per stem, in the standar variant from 1.8 to 1.5 aphids per stem. The decrease in the pest population in variants with the Mainstay, SE preparation amounted to 86.9-95.9 %, which corresponded to the effectiveness of the standar insecticide Clonrin, CE (88.1-91.0%).

On the 14th day of the accounting, an increase in the number of aphids was noted in all variants of the experiment, including in the control. In the variants with the studied insecticide, the average number of aphids increased to 1.9 aphids per stem (0.2 l/ha), to 1.3 aphids per stem (0.3 l/ha) and to 0.9 aphids per stem (0.4 l/ha), in the standar variant to 1.7 aphids per stem. The biological effectiveness of the studied preparation was 89.5-95.0 % and was at or above the effectiveness of the standard 90.2%.

Table 30–**Biological effectiveness of the insecticide Mainstay, SE in the control of cereal aphids on winter wheat (Rostov region, 2021)**

Experience variants	Dosing used	Average number of aphids per stem: Before treatment	After treatment according to the accounting days: 3	7	14	Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %: 3	7	14
Mainstay, SE (112+37 g/l)	0,2 l/ha	14,6	2,0	1,6	1,9	86,9	90,2	89,5
	0,3 l/ha	14,0	1,6	1,1	1,3	89,2	93,1	92,7
	0,4 l/ha	14,7	1,4	0,7	0,9	91,3	95,9	95,0
Clonrin, CE (150+100 g/l) /standard/	0,2 l/ha	14,1	1,8	1,5	1,7	88,1	91,0	90,2
Control	–	14,0	14,8	16,1	17,0	–	–	–
LSD_{05}		0,98	0,71	0,95	0,72	2,08	2,51	1,82

In the 2022 season, the mass reproduction of aphids began with the onset of optimal average daily air temperatures (16-20 ^{0}C), as well as sufficient precipitation. The prevailing favorable conditions contributed to the intensive colonization of the crop by the pest. During the laying of the experiment, winter wheat was in the phase of entering the tube. Spraying of crops was carried out with an average number of experimental variants from 14.4 to 16.0 aphids per stem, with an economic threshold (ET) of 10 individuals per stem (Table 31). On the 3rd and 7th days after treatment in variants with the insecticide Mainstay , SE in all application standards, the average pest population was close to the level of the Clonrin, CE standard and significantly lower than in the control. In the variants with the studied insecticide, the average number of aphids ranged from 2.1 to 0.9 aphids per stem, in the standard variant from 1.6 to 1.5 aphids per stem.

On the 14th day of the accounting, an increase in the number of aphids was noted in all variants of the experiment, including in the control. In the variants with the studied insecticide, the average number of aphids increased to 1.9 aphids per stem (0.2 l/ha), to 1.2 aphids per stem (0.3 l/ha) and to 1.1 aphids per stem (0.4 l/ha), in the standard variant to 1.7 aphids per stem. The biological effectiveness of the studied preparation was 87.4-95.0 % and was at or above the effectiveness of the standard 90.9%.

Table 31 – **Biological effectiveness of the insecticide Mainstay, SE in the control of cereal aphids on winter wheat (Rostov region, 2022)**

Experience variants	Dosing used	Average number of aphids per stem				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %		
		Before treatment	After treatment according to the accounting days					
			3	7	14	3	7	14
Mainstay, SE (112+37 g/l)	0,2 l/ha	16,0	2,1	1,6	1,9	87,4	91,4	90,3
	0,3 l/ha	15,0	1,6	1,0	1,2	89,5	94,0	93,2

	0,4 l/ha	15,8	1,5	0,9	1,1	90,6	95,0	94,4
Clonrin, CE (150+100 g/l) /standard/	0,2 l/ha	14,4	1,6	1,5	1,7	88,9	90,9	90,0
Control	–	15,3	15,5	17,3	18,2	–	–	–
LSD_{05}			0,6	0,9	0,7	2,7	2,5	2,2

An assessment of the biological effectiveness of the insecticide Mainstay , SE conducted on winter wheat, showed that the preparation reduced the number of cereal aphids by up to 95%. The studied preparation in three application rates (0.2, 0.3 and 0.4 l/ha) was at and above the effectiveness of the standard Clonrin, CE is normally used 0.2 l/ha.

The study of the biological effectiveness of the insecticide control the **sunn pest** was carried out according to the scheme presented in Table 32.

Table 32 –**Scheme of experience**

№	Experience variants	Dosing used	Multiplicity of treatments
1	Mainstay, SE (112+37 g/l)	0,3 l/ha	1
2	Mainstay, SE (112+37 g/l)	0,4 l/ha	1
3	Mainstay, SE (112+37 g/l)	0,5 l/ha	1
4	Clonrin, CE (150+100 g/l) /standard/	0,2 l/ha	1
5	Control	–	–

The appearance of an adult sunn pest on winter wheat crops was noted in the first decade of May, with an average increase in air temperature to 15 ^{0}C. The intensive colonization of adults was facilitated by the optimal air temperature and a low amount of precipitation (6.9 mm). The signal for treatment against larvae is the sum of effective temperatures (SET) equal to 240-280 ^{0}C at a threshold plus 10 ^{0}C from the date of mass egg laying by the sun pest. The mass egg laying in our experience occurred on May 13, with a (SET) equal to 95 ^{0}C.

Spraying of crops was carried out in the first decade of June, when the number of larvae and adult pests averaged 10.3-11.0 individuals /m^2 according to the experimental variants (with economic threshold (ET): 5-10 larvae/m^2 of 2-3 ages; at least 2 overwintered adults/m^2) (Table 33).

On the 3rd and 7th days after treatment, the number of sunn pest in the control reached 11.8-14.3 individuals/m^2, whereas in plots with the insecticide Mainstay, SE, there was a fluctuation in the pest population from 1.5 to 0.5 individuals/m^2 (0,3-0,4-0,5 l/ha), and in the variant using the standard Clonrin, CE 1.5 and 1.3 individuals/m^2. The biological effectiveness of the studied preparation in three application rates was: 87.8-96.9%, not inferior to and exceeding the standard 86.8-90.7%. By the 14th day of accounting, the indicators of the biological effectiveness of the studied preparation Mainstay, SE amounted to 90.1-96.5%, which was not inferior to the effectiveness of the standard Clonrin, CE (89.2%).

The analysis of the mass of 1000 grains of winter wheat showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

Table 33 –**Biological effectiveness of the insecticide Mainstay, SE in the control of sunn pest on winter wheat (Rostov region, 2021)**

Experience variants	Dosing used	Average number of larvae (adults) per m^2				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %			Weight of 1000 grains, g
		Before treatment	After treatment according to the accounting days						
			3	7	14	3	7	14	
Mainstay, SE (112+37 g/l)	0,3 l/ha	11,0	1,5	1,3	1,5	87,8	91,5	90,1	34,9
	0,4 l/ha	10,5	1,3	0,8	1,0	89,3	94,8	93,5	35,1
	0,5 l/ha	10,8	1,0	0,5	0,5	91,1	96,9	96,5	35,2
Clonrin, CE (150+100 g/l) /standard/	0,2 l/ha	10,3	1,5	1,3	1,5	86,8	90,7	89,2	34,9

Control	–	10,8	11,8	14,3	15,0	–	–	–	32,3
LSD_{05}		2,67	1,32	1,35	1,03	4,94	5,21	7,23	0,60

In the 2022 season, with an average daily air heating up to 15-17 ^{0}C, the appearance of an adults sunn pest was noted on experimental winter wheat crops. Spraying of crops was carried out in the first decade of June, when the number of larvae and adult pests averaged 7.3-8.8 individuals/m^2 according to the experimental variants (Table 34).

On the 3rd and 7th days after treatment, the number of sunn pest in the control reached 10.8-12.8 individuals/m^2, whereas in plots with the insecticide Mainstay, SE, there was a fluctuation in the pest population from 1.0 to 0.3 individuals/m^2 (0,3-0,4-0,5 l/ha), and in the variant using the standard Clonrin, CE 1.3 and 0.8 individuals/m^2.

The biological effectiveness of the studied preparation in three application rates was: 89.7-98.4%, not inferior to the standard. By the 14th day of registration in the variants with the studied insecticide, the average number of sunn pests increased to 0.8 individuals/m^2 (0.3 l/ha), 0.5 individuals/m^2 (0.4 l/ha), 0.3 individuals/m^2 (0.5 l/ha), which was lower than the standard 1.0 individuals/m^2.

The biological effectiveness of the studied preparation was 93.9-98.3%. The analysis of the mass of 1000 grains of winter wheat showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

Table 34 – **Biological effectiveness of the insecticide Mainstay, SE in the control of sunn pest on winter wheat (Rostov region, 2022)**

Experience variants	Dosing used	Average number of larvae (adults) per m^2				Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %			Weight of 1000 grains, g
		Before treatment	After treatment according to the accounting days						
			3	7	14	3	7	14	
Mainstay, SE (112+37 g/l)	0,3 l/ha	7,3	1,0	0,5	0,8	89,7	95,6	93,9	39,2
	0,4 l/ha	8,8	1,0	0,3	0,5	91,0	97,9	96,4	39,3

	0,5 l/ha	8,5	0,8	0,3	0,3	94,3	98,4	98,3	39,5
Clonrin, CE (150+100 g/l) /standard/	0,2 l/ha	7,8	1,3	0,8	1,0	87,1	93,7	92,1	39,0
Control	–	8,8	10,8	12,8	13,0	–	–	–	36,0
LSD_{05}		3,0	1,6	1,1	1,8	10,5	6,6	8,3	1,0

Therefore, the assessment of the biological effectiveness of the insecticide Mainstay, SE, carried out on winter wheat, showed that the preparation reduced the number of sunn pests to 98.4% (0.5 l/ha).

Consequently, in the control of the sunn pest, the insecticide in three application rates (0.3, 0.4, and 0.5 l/ha) was not inferior to the standard Clonrin, CE, and in the application rate 0.2 l /ha.

The study of the biological effectiveness of the insecticide control **cereal leaf beetle** was carried out according to the scheme shown in Table 35.

Table 35 –**Scheme of experience**

№	Experience variants	Dosing used	Multiplicity of treatments
1	Mainstay, SE (112+37 g/l)	0,2 l/ha	1
2	Mainstay, SE (112+37 g/l)	0,3 l/ha	1
3	Mainstay, SE (112+37 g/l)	0,4 l/ha	1
4	Clonrin, CE (150+100 g/l) /standard/	0,2 l/ha	1
5	Control	–	–

The appearance of cereal leaf beetles on experimental winter wheat crops was noted in the third decade of April, with an average daily air heating up to 10-15 ^{0}C. After additional feeding and mating, the females laid eggs in the form of a chain on the underside of the leaf blade of cereals, along the veins. After 12 days, the hatching of larvae from laid eggs was observed. Spraying of crops was carried out with an average number of larvae according to the experimental variants before treatment from 95.8 to

98.5 larvae/100 stems, with an economic threshold (ET) of 0.5-1 larvae/stem (Table 36).

On the 3rd day after treatment in the variants with insecticides, the number of cereal leaf beetle decreased from 14.5 to 9.0 larvae/100 stems. The biological effectiveness of the studied preparation Mainstay, SE in three application rates (0.2, 0.3 and 0.4 l/ha) was: 85.4-91.0% and was not inferior to the effectiveness of the standard Clonrin, CE (88.9%), at a rate 0.2 l/ ha.

On the 7th and 10th days after treatment, in the variants with the studied preparation, the tendency to decrease the number of pest larvae remained. The biological effectiveness of the insecticide was: 88.0-95.6%, the effect of which was at the standard level (90.8% and 92.9%).

In the control during the accounting period, a gradual increase in the average number of larvae of the cereal leaf beetle was noted, respectively: 97,0-97,8-107,0-111,3 larvae/100 stems. The analysis of the winter wheat harvest showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

Table 36 –**Biological effectiveness of the insecticide Mainstay, SE in the control of larvae of the cereal leaf beetle on winter wheat (Rostov region, 2021)**

Experience variants	Dosing used	Average (larvae in 100 stems)				Decrease in the number of larvae relative to the initial one, adjusted for control after treatment according to the accounting days, %			Biological grain yield, c/ha
		Before treatment	After treatment according to the accounting days						
			3	7	10	3	7	10	
Mainstay, SE (112+37 g/l))	0,2 l/ha	97,8	14,5	13,0	11,8	85,4	88,0	89,6	39,4
	0,3 l/ha	95,8	11,5	8,0	7,5	88,1	92,4	93,2	39,6
	0,4 l/ha	98,5	9,0	6,3	5,0	91,0	94,3	95,6	39,8

Clonrin, CE (150+100 g/l) /standard/	0,2 l/ha	98,0	11,0	10,0	8,0	88,9	90,8	92,9	39,5
Control	–	97,0	97,8	107,0	111,3	–	–	–	35,7
LSD_{05}		5,14	3,98	3,71	3,53	3,90	3,44	3,00	0,92

In the 2022 season, with an average daily air heating up to 10-15 ^{0}C, beetles of the cereal leaf beetle were noted on experimental winter wheat crops. 15 days after hatching of larvae from laid eggs, spraying of crops was carried out, with an average number of larvae according to the experimental variants of 100.8-102.3 larvae/100 stems (Table 37).

The at 3 and 7 days after treatment in the variants with the studied insecticide, the average number of cereal leaf beetle decreased to 14.5-4.5 larvae/100 stems and was lower than in the control. In the standard variant, the decrease was 11.5-8.3 larvae/100 stems.

The biological effectiveness of the studied preparation Mainstay, SE in three application rates (0.2, 0.3 and 0.4 l/ha) was: 85.9-95.8% and was not inferior to the effectiveness of the standard Clonrin, CE (88.7 – 92.1%), at a rate 0.2 l/ha.

On the 10th day after treatment, in the variants with the studied preparation, the number of pest larvae changed to 5.3-11.5 larvae/100 stems, and in the standard to 10.5 larvae/100 stems. The biological effectiveness of the insecticide was 89.8-95.4%, the effect of which was at the standard level (90.6%).

In the control during the accounting period, a gradual increase in the average number of larvae of the cereal leaf beetle was noted, respectively: 102,0-103,8-105,5-113,5 larvae/100 stems.

The analysis of the winter wheat harvest showed that the data obtained are generally consistent with the results of the assessment of biological effectiveness.

Table 37 – **Biological effectiveness of the insecticide Mainstay, SE in the control of larvae of the cereal leaf beetle on winter wheat (Rostov region, 2022)**

Experience variants	Dosing used	Average (larvae in 100 stems)		Decrease in the number of larvae relative to the	Biological grain
		Before	After treatment		

		treatment	according to the accounting days			initial one, adjusted for control after treatment according to the accounting days, %			yield, c/ha
			3	7	10	3	7	10	
Mainstay, SE (112+37 g/l))	0,2 l/ha	101,3	14,5	10,3	11,5	85,9	90,3	89,8	40,3
	0,3 l/ha	100,8	11,5	6,8	8,0	88,8	93,5	92,9	40,6
	0,4 l/ha	102,3	9,0	4,5	5,3	91,4	95,8	95,4	40,8
Clonrin, CE (150+100 g/l) /standard/	0,2 l/ha	100,0	11,5	8,3	10,5	88,7	92,1	90,6	40,5
Control	–	102,0	103,8	105,5	113,5	–	–	–	37,4
LSD_{05}		4,5	3,7	3,7	3,8	3,0	2,8	2,7	0,5

Therefore, an assessment of the biological effectiveness of the insecticide Mainstay, SE, showed that the preparation reduced the number of cereal leaf beetle larvae to 95.8%. The studied preparation in three application rates (0.2, 0.3 and 0.4 l/ha) corresponded to the effectiveness of the standard Clanrin, CE in the application rate of 0.2 l/ha and even exceeded it.

3.6 Study of the effectiveness of acetamipride in different preparation forms (Iraq)

The experiments were conducted based on the National Center for Pesticide Control in the Ministry of Agriculture of Iraq (Abu Ghraib Baghdad).

The preparation of nanocapsules from suspension and acetamipride powder, coated with chitosan and polyethylene glycol (PEG), as well as nanoemulsions was carried out according to the method described by Sugumar and others with some modifications [243,244].

The prepared formulations of the experimental variants were evaluated according to the methodology proposed by Drais and Hussein with additions [245–247].

The size and polydispersity index (i.e., size distribution) of the particles were determined using dynamic light scattering (DLS) technology [248–250] using the HORIBA SZ-100 model to determine the particle size. The samples were tested at the Faculty of Biology of the University of Tehran (Tehran, Iran). The following results were found:

Acetamipride suspension nanocapsules coated with chitosan had a size of 178.4 nm; acetamipride powder nanocapsules coated with chitosan were 274.4 nm; acetamipride suspension nanocapsules coated with PEG had a size of 290.2 nm; acetamipride powder nanocapsules coated with PEG had a nanoparticle size of 268.5 nm, and the particle size of acetamipride standard had a size of 643.5 nm (appendix 1); the particle size of acetamipride powder nanoemulsion was 278.0 nm; acetamipride suspension nanoemulsions was 300.6 nm (appendix 2).

The shape and size of the nanoparticles of the preparation samples were studied using an autoemission scanning electron microscope (FE-SEM).

Appendix 3 presents images obtained using an electron microscope (FE-SEM), which showed the formation of particles (nanocapsules) of various shapes and sizes depending on the preparation method.

The particle size of the nanoemulsion of the preparation samples was studied using transmission electron microscopy (TEM).

Appendix 4 images were obtained using an electron microscope (TEM), which showed that the diameter of the nanoemulsion particles of the studied compositions corresponds to the nanometric scale.

Field experiments to evaluate the effectiveness of experimental samples of acetamiprid formulations were conducted in Abu Ghraib (Iraq) in an area of 2500 m^2 in the winter of 2020-2021. (Figure 23). Winter wheat variety IPA - 99. The repetition of each option is threefold. Spraying was carried out using a knapsack sprayer Matabi Super (Figure 24).

The effectiveness of the experimental samples was studied on the greenbug aphid *Schizaphis graminum* Rond.

The treatment was carried out on February 22, 2021, according to the protocols applied to this insect species. The number of aphids in the field reached economic threshold (ET). There was a low temperature of 25.4°C and a high temperature of 29.5°C, along with 48–51% relative humidity and 5.8–7.9 km/h winds. Henderson and Tilton (1955) methodology was used to determine the samples' biological effectiveness.. The results are presented in table 38.

Figure – 23. **Experimental winter wheat crops (Abu Ghraib) (orig.)**

Figure – 24. **The spraying process using the knapsack spraye Matabi super (orig.)**

The maximum effectiveness in all variants of the experiment was obtained on the third day after treatment. The effectiveness of acetamipride in experimental preparation forms was inferior to the standard preparation (84.2%). The highest effect was achieved in the following variants: acetamipride suspension nanocapsules coated with PEG (78.7%) and acetamipride powder nanocapsules coated with chitosan (80.0%).

Therefore, since our experimental samples of new preparation forms were less effective than the standard preparation, further research is needed to develop new preparation nanoforms based on acetamipride.

Table 38. **The biological effectiveness of acetamiprid in different preparation forms controls Schizaphis graminum Rond on winter wheat (Abu Ghraib, 2021)**

Experience variants	Dosing used	Average number of aphids per stem (before treatment)	Decrease in the number relative to the initial one, adjusted for control after treatment according to the accounting days, %		
			3	7	10
Nanocapsules of acetamipride Powder Coated with PEG	60 ml /10 l	89,0	60,2	35,8	12,5
Nanocapsules of acetamipride suspension coated with PEG	16 ml /10 l	91,7	78,7	33,7	17,0
Nanocapsules of acetamipride Powder Coated with chitosan	220 ml /10 l	98,3	80,0	43,4	23,8
Nanocapsules of acetamipride suspension coated with chitosan	220 ml /10 l	134,7	65,9	49,6	45,2
Nanoemulsion of acetamipride powder	90 ml /10 l	124,3	65,4	49,1	48,3
Nanoemulsion of acetamipride suspension	16 ml /10 l	115,3	56,7	34,0	32,4
Acetamiprid standard	5 ml /10 l	110,3	84,2	58,2	50,3
Control* (water)	–	138,3	168,7	180,3	162,3
LSD_{05}		11,7	4,20	3,13	3,31

*- Number of aphids (individuals per stem) according to the accounting dates.

4 ECOTOXICOLOGICAL SAFETY OF INSECTICIDES

4.1 Residual amounts of insecticides in plant material of winter wheat

It is crucial to research the dynamics of a pesticide's active ingredient degradation in plants since it can influence the regulations for the use of the preparation in specific conditions and therefore prevent possible contamination of agricultural products [251].

In this regard, as part of our research, we studied the dynamics of degradation of residual amounts of preparations in the green mass, grain and straw of winter wheat.

The results of studies on the degradation and transformation of the preparation **Meadows, OD** (200 g/l) at a rate of 0.075 l/ha in 2021 showed that residual amounts of the active ingredient **acetamipride** (15.0 g/ha) were detected in the winter wheat crop in levels of 0.49 mg/kg on the day of treatment, 0.12 mg/kg after 10 days, and none of these values above the maximum residues level (MRL) of 0.5 mg/kg for acetamipride after 20 days of treatment (Table 39).

The findings of a study conducted in 2021 on the dynamics of acetamipride degradation enable us to conclude that this substance's presence in the green mass of plants helps to maintain the preparation's protective effect. Simultaneously, the presence of acetamipride below the maximum residue level (MRL) even on the initial post-treatment day enables us to discuss not only the length of the protective effect but also the ecological safety of the final product and its adherence to GN 1.2.2701-10 sanitary requirements.

Table 39 – **The content of residual amounts of acetamiprid in winter wheat using the insecticide Meadows, OD (200 g/l) in the Rostov region (2021)**

Preparation. The rate of use for the preparation and A.I. Multiplicity, date of treatment	**Timing of sampling**	**Date of sampling**	**The analyzed object**	**The content of the detected substance in the analyzed object, mg/kg**
Meadows, OD (200 g/l) 0.075 l/ha ; 15.0 g/ha -	Treatment day	31.05.21	green mass	0,49
	10	10.06.21	green mass	0,12

acetamipride; 1-multiple: 31/05/2021	20	20.06.21	green mass	not detected
	30	30.06.21	grains	not detected
	30	30.06.21	straw	not detected
	harvest	10.07.21	grains	not detected
	harvest	10.07.21	straw	not detected

The study of the dynamics of degradation of the active ingredients of the combined insecticide Dexter Turbo, SE at a rate of 0.2 l/ha in 2020 and 2021 showed that the residual amounts of the active ingredient acetamiprid at a rate of 23.0 g/ha per day of treatment in 2020. they were detected in an amount of 0.05 mg/kg, after 14 days 0.03 mg/kg, which did not exceed the maximum residue level (MRL) (0.5 mg/kg), after 28 days, no residual amounts of acetamipride were found in the samples (Table 40); in 2021, on the day of treatment 0.96 mg/kg, and after 14 days, no residual amounts of acetamipride were found (Table 41).

Table 40 – **The content of residual amounts of acetamiprid in winter wheat using the insecticide Dexter Turbo, SE in the Rostov region (2020)**

Preparation. The rate of use for the preparation and A.I. Multiplicity, date of treatment	**Timing of sampling**	**Date of sampling**	**The analyzed object**	**The content of the detected substance in the analyzed object, mg/kg**
Dexter Turbo, SE (115 + 106 + 70) g/l 0.2 l/ha; 23.0 g/ha - acetamipride; 1-multiple: 22/05/2020	Treatment day	22.05.20	green mass	0,05
	14	05.06.20	green mass	0,03
	28	19.06.20	spikes	under 0,01
	40	01.07.20	grains	not detected
	40	01.07.20	straw	not detected
	harvest	11.07.20	grains	not detected
	harvest	11.07.20	straw	not detected

Table 41 – **The content of residual amounts of acetamiprid in winter wheat using an insecticide Dexter Turbo, SE in the Rostov region (2021)**

Preparation. The rate of use for the preparation and A.I. Multiplicity, date of treatment	**Timing of sampling**	**Date of sampling**	**The analyzed object**	**The content of the detected substance in the analyzed object, mg/kg**
Dexter Turbo, SE (115 + 106 + 70) g/l 0.2 l/ha; 23.0 g/ha - acetamipride; 1-multiple: 21/05/2021	Treatment day	21.05.21	green mass	0,96
	14	04.06.21	green mass	not detected
	28	18.06.21	green mass	not detected
	40	30.06.21	grains	not detected
	40	30.06.21	straw	not detected
	harvest	10.07.21	grains	not detected
	harvest	10.07.21	straw	not detected

The results of studies of preparation Dexter Turbo, SE at a rate 0.2 l/ha in 2020 and 2021 on the degradation of the active ingredient **lambda-cyhalothrin** at a rate 21.2 g/ha are shown in Tables 42 and 43.

Table 42 – **The content of residual amounts of lambda-cyhalothrin in winter wheat using insecticide Dexter Turbo, SE in the Rostov region (2020)**

The rate of use for the preparation and A.I. Multiplicity, date of treatment	**Timing of sampling**	**Date of sampling**	**The analyzed object**	**The content of the detected substance in the analyzed object, mg/kg**
Dexter Turbo, SE (115 + 106 + 70) g/l 0.2 l/ha; 21.2 g/ha - lambda cyhalothrin; 1-multiple: 22/05/2020	Treatment day	22.05.20	green mass	0,366
	14	05.06.20	spikes	0,075
	28	19.06.20	spikes	0,024
	40	01.07.20	grains	under 0,005
	40	01.07.20	straw	not detected
	harvest	11.07.20	grains	not detected
	harvest	11.07.20	straw	not detected

On the day of treatment in 2020, residual amounts of lambda-cyhalothrin were found in the green mass 0.366 mg/kg, after 14 days in the spikes 0.075 mg/kg, and after 28 days 0.024 mg/kg. After 40 days, the content of lambda-cyhalothrin in grain samples was under 0.005 mg/kg, which did not exceed the maximum residue level (MRL) equal to 0.01 mg/kg for lambda-cyhalothrin. During the harvest period, no residual amounts of lambda-cyhalothrin were found in grain and straw samples.

Table 43 – **The content of residual amounts of lambda-cyhalothrin in winter wheat using insecticide Dexter Turbo, SE in the Rostov region (2021)**

The rate of use for the preparation and A.I. Multiplicity, date of treatment	Timing of sampling	Date of sampling	The analyzed object	The content of the detected substance in the analyzed object, mg/kg
Dexter Turbo, SE (115 + 106 + 70) g/l 0.2 l/ha; 21.2 g/ha - lambda cyhalothrin; 1-multiple: 21/05/2021	Treatment day	21.05.21	green mass	0,376
	14	04.06.21	green mass	0,06
	28	18.06.21	green mass	0,02
	40	30.06.21	grains	not detected
	40	30.06.21	straw	not detected
	harvest	10.07.21	grains	not detected
	harvest	10.07.21	straw	not detected

On the day of treatment in 2021, residual amounts of lambda-cyhalothrin were found in the green mass 0.376 mg/kg, after 14 days in the green mass 0.06 mg/kg, after 28 days 0.02 mg/kg. After 40 days, no residual amounts of lambda-cyhalothrin were found in grain and straw samples.

The results of studies of Dexter Turbo, SE at a rate of 0.2 l/ha in 2020, 2021 on the degradation of the active ingredient **clothianidin** at a rate of 14.0 g/ha are shown in Tables 44 and 45.

On the day of treatment in 2020, residual amounts of clothianidine in the amount of 0.26 mg/kg were found in the green mass. On day 14, under 0.05 mg/kg was found in winter wheat ears, which was already below the (MRL) level (0.2 mg/kg). Starting from 28 days, clothianidin was absent in wheat spikes, grain and straw.

Table 44 – **The content of residual amounts of clothianidin in winter wheat using insecticide Dexter Turbo, SE in the Rostov region (2020)**

The rate of use for the preparation and A.I. Multiplicity, date of treatment	Timing of sampling	Date of sampling	The analyzed object	The content of the detected substance in the analyzed object, mg/kg
Dexter Turbo, SE (115 + 106 + 70) g/l 0.2 l/ha; 14.0 g/ha - clothianidin; 1-multiple: 22/05/2020	Treatment day	22.05.20	green mass	0,26
	14	05.06.20	spikes	under 0,05
	28	19.06.20	spikes	not detected
	40	01.07.20	grains	not detected
	40	01.07.20	straw	not detected
	harvest	11.07.20	grains	not detected
	harvest	11.07.20	straw	not detected

On the day of treatment in 2021, residual amounts of clothianidine in the amount of 0.47 mg/kg were found in the green mass. Starting from day 14, clothianidin was absent in the green mass, grain and straw of wheat.

Table 45 – **The content of residual amounts of clothianidin in winter wheat using insecticide Dexter Turbo, SE in the Rostov region (2021)**

The rate of use for the preparation and A.I. Multiplicity, date of treatment	Timing of sampling	Date of sampling	The analyzed object	The content of the detected substance in the analyzed object, mg/kg
Dexter Turbo, SE (115 + 106 + 70) g/l 0.2 l/ha; 14.0 g/ha - clothianidin; 1-multiple: 21/05/2021	Treatment day	21.05.21	green mass	0,47
	14	04.06.21	green mass	not detected
	28	18.06.21	green mass	not detected
	40	30.06.21	grains	not detected
	40	30.06.21	straw	not detected
	harvest	10.07.21	grains	not detected
	harvest	10.07.21	straw	not detected

As a result of our research to determine the residual amounts of active ingredients of Dexter Turbo, SE in 2020-2021. It was found that acetamiprid, lambda-cyhalothrin, and clothianidin were not found in the crop. These results indicate that the final product complies with (sanitary) hygienic standards.

while studying the degradation of the active ingredients of the combined preparation Factoria, MCS in 2020, at a rate of 0.2 l/ha, the preparation's component thiamethoxam was discovered to have degraded to undetectable levels as early as the fourteenth day following treatment (remaining thiamethoxam levels were only recorded on the day of therapy at 0.05 mg/kg, which matched MRL)(table 46).

The active ingredient lambda-cyhalothrin of the same preparation degraded to (MRL) on the 40th day after treatment (Table 47). The content of thiamethoxam and lambda-cyhalothrin did not exceed (MRL) (equal to 0.05 mg/kg and 0.01 mg/kg, respectively) in the crop.

Table 46 – **The content of residual amounts of thiamethoxam in winter wheat using the insecticide Factoria, MCS in the Rostov region (2020)**

Preparation. The rate of use for the preparation and A.I. Multiplicity, date of treatment	Timing of sampling	Date of sampling	The analyzed object	The content of the detected substance in the analyzed object, mg/kg
Factoria, MCS (141 g/l + 106 g/l) 0.2 l/ha; 28.2 g/ha - thiamethoxam 1-multiple: 22/05/2020	Treatment day	22.05.20	green mass	0,05
	14	05.06.20	green mass	not detected
	28	19.06.20	spikes	not detected
	40	01.07.20	grains	not detected
	40	01.07.20	straw	not detected
	harvest	11.07.20	grains	not detected
	harvest	11.07.20	straw	not detected

Table 47 – **The content of residual amounts of lambda-cyhalothrin in winter wheat using the insecticide Factoria, MCS in the Rostov region (2020)**

Preparation. The rate of use for the preparation and A.I. Multiplicity, date of treatment	Timing of sampling	Date of sampling	The analyzed object	The content of the detected substance in the analyzed object, mg/kg
Factoria, MCS (141 g/l + 106 g/l) 0.2 l/ha; 21.2 g/ha - lambda cyhalothrin 1-multiple: 22/05/2020	Treatment day	22.05.20	green mass	0,43
	14	05.06.20	green mass	0,16
	28	19.06.20	spikes	0,05
	40	01.07.20	grains	not detected
	40	01.07.20	straw	not detected
	harvest	11.07.20	grains	not detected
	harvest	11.07.20	straw	not detected

Summarizing the data on the degradation of active ingredients of insecticides Meadows, OD (200 g/l); Dexter Turbo, SE (115 g/l + 106 g/l + 70 g/l); Factoria, MCS (141 g/l + 106 g/l) we can say that the active ingredients of these preparations they were not found in the winter wheat crop, which indicates that the products obtained fully comply with the (sanitary) hygienic standards GN 1.2.2701-10.

4.2 Study of the toxic load of insecticides

To assess the risk of the studied preparations, we calculated the indicator–toxic load (Table 48). The results obtained allowed us to classify the insecticides Meadows, OD, and Canadian, WSC as low-dangerous preparations, and Dexter Turbo, SE; Mainstay, SE and Factoria, MCS as moderately dangerous.

Table 48 – **Toxic load of the studied insecticides**

Name of the preparation	**Rate of use, l/ha**	**LD_{50} mg/kg**	**Toxic load, the amount of semi-lethal doses per 1 ha**	**Characteristic**
Meadows, OD (200 g/l acetamiprid)	0,075	acetamiprid = 217	69	low-dangerous
Carnadine, WSC (200 г/л acetamiprid)	0,075	acetamiprid = 217	69	low-dangerous
Dexter Turbo, SE (115 g/l acetamiprid + 106 g/L lambda-cyhalothrin + 70 g/L clothianidin)	0,2	acetamiprid = 217 lambda-cyhalothrin = 79 clothianidin = 5000	377	moderate-dangerous
Mainstay, SE (112 g/l of Bifenthrin + 37 g/l sulfoxaflor)	0,4	Bifenthrin = 54.5 sulfoxaflor = 1000	837	moderate-dangerous
Factoria, MCS (141 g/l thiamethoxam + 106 lambda-cyhalothrin g/l)	0,2	thiamethoxam = 1563 lambda-cyhalothrin = 79	286	moderate-dangerous

CONCLUSION

1. As a result of the study of new insecticides, an assortment of preparations for the protection of winter wheat has been developed: Meadows, OD (200 g/l acetamiprid), Carnadin, WSC (200 g/l acetamiprid), Dexter Turbo, SE (115 g/l acetamiprid +106 g/L lambda-cyhalothrin + 70 g/L clothianidin), Factoria, MCS (141 g/L thiamethoxam + 106 g/l lambda-cyhalothrin), Mainstay, SE (112 g/l Bifenthrin + 37 g/l sulfoxaflor).

2. In the conditions of the steppe zone of Ciscaucasia, the following insecticides provided high biological efficiency on winter wheat against the main phytophages:

Against the sunn pest: Meadows, OD 93%, Carnadine, WSC 84%, Dexter Turbo, SE 94%, Factoria, MCS 94%, mainstay, SE 98 %.

Against wheat beetles: Dexter Turbo, SE 95%, Factoria, MCS 97 %.

Against cereal leaf beetle : Dexter Turbo, SE 94%, Factoria, MCS 92%, Mainstay, SE 96 %.

Against cereal aphids: Dexter Turbo, SE 92%, Factoria, MCS 88%, mainstay, SE 95 %.

3. Regulations have been developed for the effective and safe use of insecticides to protect winter wheat from the main phytophages in the steppe zone of the Caucasus:

Meadows, OD 0.05 - 0.075 l/ha against the sunn pest.

Carnadin, WSC 0.05 - 0.075 l/ha against the sunn pest.

Dexter Turbo, SE 0.1 - 0.2 l/ha against the sunn pest, cereal aphids, wheat beetles and cereal leaf beetle.

Factoria, MCS 0.1 - 0.2 l/ha against the sunn pest, cereal aphids, wheat beetles and cereal leaf beetle.

Mainstay, SE 0.2 - 0.4 l/ha against cereal aphids and cereal leaf beetle; 0.3 - 0.5 l /ha against the sunn pest.

4. The ecological safety of the final product and its compliance with hygienic standards GN 1.2.2890-11 is guaranteed by the fact that the developed application regulations ensure the absence of active ingredients in the winter wheat crop. The results of studying the degradation of active ingredients of insecticides Meadows, OD

(200 g/l); Dexter Turbo, SE (115 g/l + 106 g/l + 70 g/l); Factoria, MCS (141 g/l + 106 g/l) proved that the residual amounts of these preparations in the yield it was not found.

5. According to the indicator of toxic load, the studied preparations can be attributed to:

- low- dangerous: Meadows, OD; Karnadin, WSC.
- Moderate-dangerous: Dexter Turbo, SE ; Factoria, MCS; Mainstay, SE.

PRACTICAL RECOMMENDATIONS

1. New insecticides Meadows, OD (200 g/l acetamiprid), Dexter Turbo, SE (115 g/L acetamiprid +106 g/L lambda-cyhalothrin + 70 g/L clothianidin), Factoria, MCS (141 g/L thiamethoxam + 106 g/L lambda-cyhalothrin) that are included in the State Catalog of Pesticides (2023) can be used to protect winter wheat.
2. The results of the study of new insecticides Carnadin, WSC (200 g/l acetamiprid), Mainstay, SE (112 g/l Bifenthrin + 37 g/l sulfoxaflor) in terms of assessing biological effectiveness can be used in the State registration process as promising insecticides for winter wheat.

REFERENCES

1. FAO Cereal Supply and Demand Brief | World Food Situation | Food and Agriculture Organization of the United Nations. – URL: https://www.fao.org/worldfoodsituation/csdb/en/ (date accessed: 07.11.2021). – Text: electronic.
2. Mittal S. Wheat and Barley Production Trends and Research Priorities: A Global Perspective //New Horizons in Wheat and Barley Research: Global Trends, Breeding and Quality Enhancement. – Singapore: Springer Singapore, 2022. – P. 3-18.
3. Еськов, И. Д., Бузина Н. А. Распространение хлебных жуков в посевах озимой пшеницы в Приволжском федеральном округе в 2015-2019 гг //Агрофорсайт. – 2020. – №. 5. – С. 51-55.
4. Соколов, М. С., Санин, С. С., Долженко, В. И., Спиридонов, Ю. Я., Глинушкин, А. П., Каракотов, С. Д., & Надыкта, В. Д. Концепция фундаментально-прикладных исследований защиты растений и урожая // Агрохимия. – 2017. – №. 4. – С. 3-9.
5. Глазунова, Н. Н., Безгина, Ю. А., Мазницына, Л. В., & Хомутова, А. В. Биологическая эффективность защиты озимой пшеницы от фитофагов биопестицидами в весенне-летний период вегетации //Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета. – 2020. – №. 155. – С. 220-229.
6. Павлюшин, В. А., Долженко, В. И., Шпанев, А. М., Лаптиев, А. Б., Гончаров, Н. Р., Лысов, А. К., Филоненко, В. А. Интегрированная защита озимой пшеницы //Защита и карантин растений. – 2015. – №. 5. – С. 38-71.
7. Хилевский В. А. Основные составляющие системы защиты пшеницы озимой в фазу конец колошения-начало формирования зерна в условиях Ростовской области //Новая наука: Теоретический и практический взгляд. – 2016. – 9 с.
8. Глазунова, Н. Н., Романенко, Е. С., Шипуля, А. Н., Дергунова, Е. В. Способы обработки почвы и комплекс патогенных микромицетов в агроценозе озимой пшеницы //Земледелие. – 2012. – №. 4. – С. 31-33.
9. Хилевский В. А. Современные средства защиты озимой пшеницы от черной

пшеничной мухи *Phorbia fumigata* Mg. (Diptera: Anthomyiidae) // XV congress of the Russian Entomological Society. – 2017. – С. 515-516.

10. Долженко В. И., Сухорученко Г. И., Лаптиев А. Б. Развитие химического метода защиты растений в России // Защита и карантин растений. – 2021. – №. 4. – С. 3-13.
11. Stephenson G. R., Coats J. R., Yamamoto H. Pesticide use and world food production: risks and benefits // Expert Committee on Weeds Comité d'experts en malherbologie. Proceedings of the 2000 National Meeting. – Citeseer, 2001. – P. 9-15.
12. Chen, X., Qiu, L., Liu, Q., He, Y. Preparation of an Environmentally Friendly Nano-Insecticide through Encapsulation in Polymeric Liposomes and Its Insecticidal Activities against the Fall Armyworm, Spodoptera frugiperda // Insects. – 2022. – V. 13. – №. 7. – P. 625.
13. Станкевич С. В., Барышников Н. А. Вредители зерновых колосовых культур в Украине //Agricultural sciences trends of modern science and practice. – 2022. – 36 с.
14. Павлюшин В.А. Карты распространения и зон вредоносности вредителей зерновых культур // Приложения к журналу Вестник защиты растений. – 2018. – Т. 27. – 85 с.
15. Хилевский В. А. Эффективные инсектициды для защиты пшеницы озимой от обыкновенной хлебной жужелицы (*Zabrus tenebrioides* Goeze) и черной пшеничной мухи (*Phorbia fumigata* Meigen) в степной зоне Предкавказья: дис. – СПб.: Всероссийский научно-исследовательский институт защиты растений Российской академии сельскохозяйственных наук, 2014. – 22 с.
16. Долженко В. И., Сухорученко Г. И., Лаптиев А. Б. Развитие химического метода защиты растений в России // Защита и карантин растений. – 2021. – №. 4. – С. 3 - 13.
17. Хилевский В. А. Основные составляющие системы защиты пшеницы озимой в фазу конец колошения - начало формирования зерна в условиях Ростовской области // Новая наука: Теоретический и практический взгляд. – 2016. – 9 с.
18. Капусткина А. В., Хилевский В. А. Динамика численности и вредоносности вредной черепашки *Eurygaster integriceps* Put. (Heteroptera, Scutelleridae) в посевах зерновых культур степной зоны Предкавказья // Энтомологическое обозрение. –

2020. – Т. 99. – №. 1. – С. 71-78.

19. Бойко С.В., Немкевич М.Г., М. Ю. И. опасный вредитель зерновых культур // Наше сельское хозяйство. Серия Агрономия. – 2022. – № 9. – С.15-30.
20. Бойко С. В. Опасны ли вредители зерновых культур в условиях этого года? // Наше сельское хозяйство. – 2020. – №. 7. – С. 12-21.
21. Шорохов М. Н., Петрова Н. Г., Долженко В. И. Совершенствование ассортимента инсектофунгицидов // Российская сельскохозяйственная наука. – 2020. – №. 3. – С. 28-31.
22. Лосева М. П. Остаточные количества ацетамиприда в сельскохозяйственных растениях // Защита растений. – 2022. – №. 44. – С. 260-265.
23. Маркарова Ж. Р. Эффективность инсектицидов против вредной черепашки в зависимости от сроков их применения // Международный журнал гуманитарных и естественных наук. – 2018. – №. 9. – С. 99-103.
24. Маркарова Ж. Р. Эффективность осеннего применения инсектицидов на озимой пшенице в условиях Ростовской области // Международный журнал гуманитарных и естественных наук. – 2019. – №. 11-2. – С. 125-129.
25. Хилевский В. А. Инсектициды для защиты озимой пшеницы от вредной черепашки (*Eurygaster integriceps* Put.) в условиях Ростовской области // Сельскохозяйственные науки и агропромышленный комплекс на рубеже веков. – 2015. – №. 11. – С. 101-109.
26. Fanger G. O. Microencapsulation: a brief history and introduction //Microencapsulation: Processes and Applications. – 1974. – P. 1-20.
27. Li, X., Chen, Y., Xu, J., Lynch, I., Guo, Z., Xie, C., Zhang. Advanced nanopesticides: Advantage and action mechanisms //Plant Physiology and Biochemistry. – 2023. – 108051 p.
28. Wang, D., Saleh, N. B., Byro, A., Zepp, R., Sahle-Demessie, E., Luxton, T. P., Su, C. Nano-enabled pesticides for sustainable agriculture and global food security //Nature nanotechnology. – 2022. – V. 17. – №. 4. – P. 347-360.
29. Yan, S., Gu, N., Peng, M., Jiang, Q., Liu, E., Li, Z., ... & Dong, M. A preparation method of nano-pesticide improves the selective toxicity toward natural enemies

//Nanomaterials. – 2022. – V. 12. – №. 14. – 2419 p.

30. Bhattacharyya, A., Bhaumik, A., Rani, P. U., Mandal, S., Epidi, T. T. Nano-particles-A recent approach to insect pest control //African Journal of Biotechnology. – 2010. – V. 9. – №. 24. – P. 3489-3493.
31. Hassan, S. M., Ibrahim, A., Hassan, S. K., Majeed, A., Siddiqi, S. A., & Naeem, N. Importance of Nanotechnology: A Review //Lahore Garrison University Journal of Life Sciences. – 2018. – V. 2. – №. 1. – P. 1-6.
32. Banerjee, S., Mazumder, S., Chatterjee, D., Bose, S., Majee, S. B. Nanotechnology for cargo delivery with a special emphasis on pesticide, herbicide, and fertilizer / /Nano-enabled Agrochemicals in Agriculture. – Academic Press, 2022. – P. 105-144.
33. Zhao, M., Chen, Z., Hao, L., Chen, H., Zhou, X., Zhou, H. CMC based microcapsules for smart delivery of pesticides with reduced risks to the environment //Carbohydrate polymers. – 2023. – V. 300. – 120260 p.
34. Margulis-Goshen K., Magdassi S. Nanotechnology: an advanced approach to the development of potent insecticides //Advanced technologies for managing insect pests. – 2013. – P. 295-314.
35. Ragaei M., Sabry A. H. Nanotechnology for insect pest control //International journal of science, environment and technology. – 2014. – V. 3. – №. 2. – P. 528-545.
36. Deng, S., Gigliobianco, M. R., Censi, R., Di Martino, P. Polymeric nanocapsules as nanotechnological alternative for drug delivery system: current status, challenges and opportunities // Nanomaterials. – 2020. – V. 10. – №. 5. – 847 p.
37. Журавлева, Е. В., Милащенко, Н. З., Сапожников, С. Н., Трушкин, С. В. Система увеличения производства высококачественного зерна пшеницы //Достижения науки и техники АПК. – 2020. – Т. 34. – №. 3. – С. 7-10.
38. Санин, С. С., Карлова, Л. В., Кащеев, А. В., Корнева, Л. Г. Экономические и агроэкологические аспекты химической защиты зерновых культур от вредных организмов // Защита и карантин растений. – 2021. – №. 5. – С. 3-13.
39. Злотников, А. К., Подварко, А. Т., Рябчинская, Т. А., Кудрявцев, Н. А., Злотников, К. М., & Ханиева, И. М. Оценка эффективности использования биопрепарата альбит в системе защиты полевых культур против насекомых-вредителей

//Земледелие. – 2017. – №. 4. – С. 37-42.

40. Оберцейзер А. В., Стожко Н. Ю. Экологические последствия применения пестицидов // Экологическая безопасность в техносферном пространстве. – 2023. – С. 239-242.
41. Neimorovets V. Review of the genus Eurygaster (Hemiptera: Heteroptera: Scutelleridae) of Russia // Zootaxa. – 2020. – V. 4722. – №. 6. – 47 p.
42. Шорохов М. Н., Долженко В. И., Силаев А. И. Совершенствование ассортимента средств химической защиты озимой пшеницы от клопа вредной черепашки (*Eurygaster integriceps* Put.) //Агрохимия. – 2019. – №. 11. – С. 38-47.
43. Шорохов М. Н. Совершенствование средств химической защиты пшеницы озимой от вредной черепашки (*Eurygaster integriceps* Put.) //Вестник аграрной науки. – 2015. – Т. 57. – №. 6. – С. 48-54.
44. Привалов Ф. И., Шантыр В. А., Сорочинский Л. В. Фитосанитарные риски при возделывании зерновых культур в Беларуси // Земледелие и растениеводство. – 2022. – №. 4. – С. 43-46.
45. Павлюшин, В. А., Волкова, Н. А., Сухорученко, Г. И., Нефедова, Л. И. Вредная черепашка: распространение, вредоносность, методы контроля //Защита и карантин растений. – 2010. – №. 1. – С. 53-84.
46. Фролов А. Н. Закономерности динамики численности вредителей и фитосанитарный прогноз // Вестник защиты растений. – 2019. – №. 3 (101). – С. 4-33.
47. Станкевич С. В., Барышников Н. А. Вредители зерновых колосовых культур в Украине // Editorial board. – 2022. – 36 с.
48. Kapustkina A. V., Khilevskiy V. A. Population and Harmfulness Dynamics of The Sunn Pest *Eurygaster integriceps* Put. (Heteroptera, Scutelleridae) in Wheat Crops of The Ciscaucasia Steppe Zone // Entomological Review. – 2020. – V. 100. – P. 173-178.
49. Маркарова Ж. Р. Эффективность инсектицидов против вредной черепашки в зависимости от сроков их применения // Международный журнал гуманитарных и естественных наук. – 2018. – №. 9. – С. 99-103.
50. Капусткина А. В., Хилевский В. А. Реакция ростовской популяции вредной

черепашки на высеваемые сорта озимой пшеницы и применяемые инсектициды // Зерновое хозяйство России. – 2022. – Т. 14. – №. 3. – С. 95-101.DOI: 10.31367/2079-8725-2022-81-3-95-101

51. Капусткина А. В., Хилевский В. А. Динамика численности и вредоносности вредной черепашки *Eurygaster integriceps* Put. (Heteroptera, Scutelleridae) в посевах зерновых культур степной зоны Предкавказья //Энтомологическое обозрение. – 2020. – Т. 99. – №. 1. – С. 71-78.
52. Хилевский В. А. Динамика численности и инсектициды в борьбе с вредной черепашкой на озимой пшенице // Научная дискуссия: инновации в современном мире. – 2015. – №. 7. – С. 66-72.
53. Юсупова С. К., Ганджаева Л. А. Поврежденность зерна пшеницы вредной черепашкой (*Eurygaster integriceps* Put.) //Инновационные технологии современной научной деятельности: стратегия, задачи, внедрение. – 2023. – С. 5-9.
54. Павлюшин, В. А., Долженко, В. И., Шпанев, А. М., Лаптиев, А. Б., Гончаров, Н. Р., Лысов, А. К., Филоненко, В. А. Интегрированная защита озимой пшеницы // Защита и карантин растений. – 2015. – №. 5. – С. 38-71.
55. Ториков В. Е., Вершило Е. Н. Динамика развития бурой ржавчины и клопа вредной черепашки на посевах озимой пшеницы // Современные тенденции развития аграрной науки. – 2022. – С. 129-135.
56. Дмитренко Н. Н., Почуйко А. С., Довлятко А. А. Видовой состав и вредоносность основных вредителей в посевах озимой пшеницы // Концепции устойчивого развития науки в современных условиях. – 2017. – С. 176-179.
57. Исави М. Б. А., Хилевский В. А., Долженко Т. В. Комбинированный инсектицид для защиты пшеницы озимой от хлебных жуков // Известия Санкт-Петербургского государственного аграрного университета. – 2023. – №. 2 (71). – С. 38-46.
58. Козич И. А. Эффективность защиты яровых зерновых культур от комплекса доминантных вредителей // Защита растений. – 2022. – №. 41. – С. 245-254.
59. Еськов, И. Д., Теняева, О. Л., Лихацкая, С. Г. Эффективность предпосевной защиты озимой мягкой пшеницы в лесостепной зоне Правобережья Саратовской области // Вавиловские чтения. – 2022 . – С. 313-317.

60. Еськов, И. Д., Бузина Н. А. Динамика численности хлебных жуков в посевах озимой пшеницы в Поволжье // Вавиловские чтения-2020. – 2020. – С. 126-128.

61. Говоров Д. Н., Живых А. В., Луговой И. Ю. Распространение хлебных жуков в посевах зерновых в Российской Федерации в 2013-2017 гг // Вестник защиты растений. – 2018. – №. 2 (96). – С. 50-54.

62. Ахмедов А. Д., Гахраманова Г. Е. Биоэкологические особенности пластинчатоусых (Scarabaeidae) хлебного жука кузьки (*Anisoplia austriaca* (Herbst, 1783)) в Азербайджане // Известия Нижневолжского агроуниверситетского комплекса: наука и высшее профессиональное образование. – 2017. – №. 2 (46). – С. 73-78.

63. Трибель С. А., Федоренко А. В. Хлебные жуки: особенности биологии и система контроля численности // Защита и карантин растений. – 2011. – №. 5. – С. 57-60.

64. Трепашко Л. И., Бойко С. В. Защита тритикале озимого от доминантных видов насекомых с учетом комплексных экономических порогов вредоносности // Защита растений. – 2022. – №. 42. – С. 259-273.

65. Логинова М. В. Использование инсектицидов при возделывании яровой пшеницы // Молодой исследователь: от идеи к проекту. – 2022. – С. 74-75.

66. Станкевич С. В., Барышников Н. А. Вредители зерновых колосовых культур в Украине //Editorial board. – 2022. – 36 с.

67. Глазунова, Н. Н., Безгина, Ю. А., Шипуля, А. Н., Волосова, Е. В., Пашкова, Е. В.. Роль погодных условий в регуляции численности популяций пьявицы красногрудой (*Oulema melanopus* L.) в агробиоценозе озимой пшеницы// Земледелие. – 2021. – №. 3. – С. 36-39.

68. Трепашко Л. И., Бойко С. В., Слабожанкина О. Ф. Энтомофаги вредителей зерновых культур // Защита и карантин растений. – 2014. – №. 6. – С. 21-23.

69. Császár O., Tóth F., Lajos K. Estimation of the expected maximal defoliation and yield loss caused by cereal leaf beetle (*Oulema melanopus* L.) larvae in winter wheat (*Triticum aestivum* L.) // Crop Protection. – 2021. – V. 145. – 105644 p.

70. Jasrotia P., Singh B., Nagpal M. Biology and Management Strategies of Major Insect-Pests of Wheat //New Horizons in Wheat and Barley Research: Crop Protection and

Resource Management. – Singapore: Springer Nature Singapore, 2022. – P. 283-307.

71. Глазунова Н. Н., Хомутова А. В., Безгина Ю. А. Мониторинг численности фитофагов в посевах разных сортов озимой пшеницы //Аграрный вестник Северного Кавказа. – 2023. – №. 2 (50). – С. 58-64.
72. Хомутова А. В. Биологический цикл развития пьявицы красногрудой (*Lema melanopus* l.) в Ставропольском крае / /Вестник АПК Ставрополья. – 2022. – №. 2 (46). – С. 46-50.
73. Манукян, И. Р., Абиева, Т. С., Хохоева, Н. Т., Догузова, Н. Н. Характеристика устойчивости селекционных образцов озимой пшеницы к пьявице красногрудой (*Oulema melanopus* l.) в условиях Предгорной зоны центрального Кавказа // Нива Поволжья. – 2022. – №. 2 (62). – 1001с.
74. Бойко С. В., Василевская Л. П., Хотынюк Ю. И. Двухкомпонентные инсектициды– эффективность на зерновых колосовых культурах в период вегетации // Защита растений. – 2022. – №. 44. – С. 124-137.
75. Бойко С. В. Опасны ли вредители зерновых культур в условиях этого года? // Наше сельское хозяйство. – 2020. – №. 7. – С. 12-21.
76. Бойко С. В., Немкевич М. Г. Усовершенствование химической системы защиты семенных посевов пшеницы яровой от вредителей в Беларуси // Защита растений. – 2023. – Т. 1. – №. 47. – С. 169-184.
77. Хилевский В. А., Шорохов М. Н., Долженко В. И. Эффективные средства защиты озимой пшеницы от основных вредителей в условиях степной зоны Предкавказья //Российская сельскохозяйственная наука. – 2016. – №. 4. – С. 34-40.
78. Гринько А. В. Видовой состав основных фитофагов озимой пшеницы в приазовской зоне Ростовской области // Международный журнал гуманитарных и естественных наук. – 2018. – №. 3. – С. 124-127.
79. Гринько А. В. Эффективность осеннего применения инсектицидов на озимой пшенице в условиях Ростовской области //Аллея науки. – 2018. – Т. 4. – №. 3. – С. 446-451.
80. Shorokhov M. N., Khilevsky V. A., Dolzhenko V. I. Insectofungicides on Winter Wheat in Rostov Oblast // Russian Agricultural Sciences. – 2022. – V. 48. – №. 6. – P. 459-

466.

81. Khilevsky V. A., Shorokhov M. N., Dolzhenko V. I. Effective preparations of protection of winter wheat against main pests in conditions of the Precaucasian steppe zone // Russian agricultural sciences. – 2016. – V. 42. – №. 5. – P. 332-338.
82. Арзуманян, К. Э., Березуцкая, М. В., Зеленская, О. М., Орлов, В. Н., Замотайлов, А. С. Использование протравителей для контроля численности двукрылых вредителей всходов на озимой пшенице // Вестник научно-технического творчества молодежи Кубанского ГАУ. – Т. – 2018. – С. 12-14.
83. Гандрабур Е. С., Верещагина А. Б. Развитие весенних поколений розанно-злаковой тли *Metopolophium dirhodum* Walk. на различных видах шиповника // Биологическая защита растений-основа стабилизации агроэкосистем. – 2022. – С. 131-138.
84. Zhang, N., Liu, D., Zhai, Y., Li, X., & Simon, J. C. Functional divergence of three glutathione transferases in two biotypes of the English grain aphid, *Sitobion avenae* // Entomologia Experimentalis et Applicata. – 2022. – V. 170. – №. 1. – P. 79-87.
85. Шпанев А. М. Комплексная вредоносность вредных организмов на яровой пшенице в Ленинградской области // Вестник защиты растений. – 2015. – Т. 85. – №. 3. – С. 41-45.
86. Трепашко Л. И., Козич И. А., Василевская Л. П. Экономическое обоснование применения препаратов разного направленного действия для защиты ячменя ярового от вредителей // Защита растений. – 2022. – №. 42. – С. 274-286.
87. Kozulina, N. S., Vasilenko, A. V., Vasilenko, A. A., Shmeleva, Z. N. Effective protection of grain crops from pests // IOP Conference Series: Earth and Environmental Science. – IOP Publishing, 2021. – V. 677. – №. 4. – 042014 p.
88. Мелюхина Г. В. Динамика численности злаковых цикадок (Homoptera, Auhenorrhyncha) в зависимости от срока посева и нормы высева пшеницы озимой на протяжении всей вегетации в условиях лесостепи Украины //Защита растений. – 2022. – №. 42. – С. 238-248.
89. Ualiyeva, R. M., Kukusheva, A. N., Insebaeva, M. K., Zhumabekova, D. K., Kazakova, O. A., Kaverina, M. M. Phytophages in the agrocenosis of spring wheat in the pavlodar

region // Herald of science of s seifullin kazakh agro technical research university. – 2022. – №. 2 (113). – P.46-55.

90. Хилевский В. А. Видовой состав членистоногих пшеничного агробиоценоза в Ростовской области //Новая наука: от идеи к результату. – 2015. – №. 7-2. – С. 16-19.
91. Шорохов М. Н. Биологическое и экотоксикологическое обоснование использования современных инсектицидов для защиты пшеницы озимой от вредной черепашки (Eurygaster integriceps Put.) в условиях Сальских степей Предкавказья: дис. – Всерос. науч.-исслед. ин-т защиты растений РАСХН, 2014.
92. Нейморовец, В. В., Гричанов, И. Я., Овсянникова, Е. И., Саулич, М. И. Ареал и зоны вредоносности вредной черепашки *Eurygaster integriceps* Puton (Heteroptera, Scutelleridae) // Вестник защиты растений. – 2006. – №. 4. – С. 27-31.
93. Павлюшин, В. А., Долженко, В. И., Шпанев, А. М., Лаптиев, А. Б., Гончаров, Н. Р., Лысов, А. К., Филоненко,В. А. Интегрированная защита озимой пшеницы // Защита и карантин растений. – 2015. – №. 5. – С. 38-71.
94. Азизов З. М., Архипов В. В., Имашев И. Г. Ресурсосберегающие системы основной обработки почвы в 4-польном зернопаровом севообороте засушливой чернозёмной степи Поволжья // Земледелие. – 2022. – №. 4. – С. 12-17.
95. Jafarpour, A. A., Carjan, A. S., Imani, S., Mahjoub, S. M., Mahmoudvand, M. Toxic effects of neonicotinoid insecticides on nymphs and adults of the sunn pest, *Eurygaster integriceps* Puton (Hemiptera: Scutelleridae) // Acta Entomologica Sinica. – 2011. – V. 54. – №. 8. – P. 938-942.
96. Alizadeh, M., Sheikhi Garjan, A., Ma'mani, L., Bandehhagh, A., Hosseini Salekdeh, G. Control of Sunn-Pest, *Eurygaster integriceps* Puton, using Deltamethrin Nanopesticide // Applied Entomology and Phytopathology. – 2022. – V. 89. – №. 2. – P. 213-223.
97. Фролов А. Н. Закономерности динамики численности вредителей и фитосанитарный прогноз // Вестник защиты растений. – 2019. – №. 3 (101). – С. 4-33.
98. Грибуст И. Р. Экологические аспекты стабильности лесомелиоративных комплексов: принцип усложнения фитоценоза // Научно-агрономический журнал.

– 2018. – №. 2 (103). – С. 63-65.

99. Павлюшин В. А., Новикова И. И., Бойкова И. В. Микробиологическая защита растений в технологиях фитосанитарной оптимизации агроэкосистем: теория и практика (обзор) // Сельскохозяйственная биология. – 2020. – Т. 55. – №. 3. – С. 421-438.

100. Islamoglu M. Effect of Some Abiotic Factors on Migration of Sunn Pest (*Eurygaster integriceps* Put.) (Hemiptera: Scutelleridae) from Aestivation Sites to Overwinteing Sites // Pakistan Journal of Zoology. – 2023. – V. 55. – №. 1. – 379 p.

101. Motie J. B., Saeidirad M. H., Jafarian M. Identification of Sunn-pest affected (*Eurygaster Integriceps* Put.) wheat plants and their distribution in wheat fields using aerial imaging // Ecological Informatics. – 2023. – V. 76. – P. 102146.

102. Ghanbari S., Farshbaf Pourabad R., Ashouri S. Influence of wheat cultivars on digestive enzyme activity and protein content of the Sunn pest, *Eurygaster integriceps* (Hem.: Scutelleridae) // Journal of Crop Protection. – 2022. – V. 11. – №. 1. – P. 107-119.

103. Kapustkina A. V., Frolov A. N. Wheat Grain Damage by *Eurygaster integriceps* Puton (Hemiptera, Scutelleridae): Diagnostics and Detection Methods // Entomological Review. – 2022. – V. 102. – №. 1. – P. 50-62.

104. Капусткина А. В. Фенотипический мониторинг внутривидовой структуры популяций клопов Eurygaster spp. в различных агробиоценозах // Вестник защиты растений. – 2018. – №. 3 (97). – С. 55-61.

105. Капусткина А. В. Внутривидовая структура популяций вредной черепашки в агробиоценозах // Научное обеспечение развития АПК в условиях импортозамещения. – 2018. – С. 106-111.

106. Kang, C., Zhang, Z., Kudashev, S., Liu, M., ZhanG, Q., Pan, J. Bulletin of Science and Practice //Bulletin of science and practice. – 2022. – V. 8. – №. 8. – P. 245-262.

107. Borzykh, O., Chaika, V., Schevchuk, O., Borysenko, V., Janse, L. Long-term (2005-2020) winter wheat pest population dynamics in Ukraine in response to effects of acreage treated with insecticides and climate change // AgroLife Scientific Journal. – 2023. – V. 12. – №. 2. – P. 35-45.

108. Макарова, Т. Н., Чернышова, Л. В., Баженова, И. А., Мошкина, Ю. С., Калюжина, Е. Л. Динамика численности хлебной полосатой блошки на зерновых культурах в условиях лесостепной зоны южного урала //Вестник ИрГСХА. – 2022. – №. 112. – С. 111-120.

109. Еськов, И. Д., Бузина, Н. А. Факторы влияющие на снижение численности хлебных жуков в среднем поволжье // Международной научно-практической конференции, посвященной 134-летию со дня рождения академика Н.И. Вавилова. – Саратов: Амирит, . – 2021. – С. 79 – 82.

110. Васильев В. П. Вредители сельскохозяйственных культур и лесных насаждений. – Рипол Классик, 1973. – Т. 1.– 437 с.

111. Гулиев Д. А. Вредоносность хлебного жука-кузьки // Защита и карантин растений. – 2008. – №. 12. –35 с.

112. Шорохов М. Н., Долженко В. И. Эффективность современных инсектицидов в борьбе с хлебными жуками на пшенице // Вестник аграрной науки. – 2017. – №. 2 (65). – С. 15-19.

113. Говоров Д. Н., Живых А. В., Луговой И. Ю. Распространение хлебных жуков в посевах зерновых в Российской Федерации в 2013-2017 гг. // Вестник защиты растений. – 2018. – №. 2 (96). – С. 50-54.

114. Еськов, И. Д., Гусарова, И. С. Агробиологические приемы борьбы с хлебными жуками на яровой пшенице //Защита и карантин растений. – 2008. – №. 2. – С. 61-62.

115. Трибель С. А., Федоренко А. В. Хлебные жуки: особенности биологии и система контроля численности // Защита и карантин растений. – 2011. – №. 5. – С. 57-60.

116. Илларионов А. И., Женчук А. В. Тактика защиты озимой пшеницы от вредных организмов // 100-летие кафедры растениеводства, кормопроизводства и агротехнологий: итоги и перспективы инновационного развития. – 2019. – С. 228-235.

117. Шорохов, М. Н., Долженко, В. И. Совершенствование ассортимента инсектицидов для защиты зерновых культур // Вестник российской сельскохозяйственной науки. – 2017. – №. 2. – С. 32-34.

118. Романов Н. Г., Илларионов А. И. Эффективность инсектицидов при ограничении численности хлебных жуков //инновационные решения молодых ученых в аграрной науке. – 2019. – С. 86-90.

119. Козич И. А. Эффективность защиты яровых зерновых культур от комплекса доминантных вредителей //Защита растений. – 2022. – №. 41. – С. 245-254.

120. Родионова Е. Ю., Пушня М. В., Снесарева Е. Г. Разработка биологических методов борьбы с пьявицей красногрудой Oulema (Lema) melanopus L. // Плодоводство и ягодоводство России. – 2018. – Т. 55. – С. 279-283.

121. Webster J. A., Smith Jr D. H. Cereal leaf beetle (*Oulema melanopus* (L.)) population densities and winter wheat yields //Crop Protection. – 1983. – V. 2. – №. 4. – P. 431-436.

122. Балахнина, И. В., Кремнева, О. Ю., & Снесарева, Е. Г. Севооборот как способ увеличения биоразнообразия в агроэкосистемах, регулирования численности вредных фитофагов //Юг России: экология, развитие. – 2023. – Т. 18. – №. 2 (67). – С. 113-126.

123. Гринько А. В. Видовой состав основных фитофагов озимой пшеницы в приазовской зоне Ростовской области //Международный журнал гуманитарных и естественных наук. – 2018. – №. 3. – С. 124-127.

124. Хилевский В.А. Современные средства защиты озимой пшеницы от черной пшеничной мухи Phorbia fumigata Mg.(Diptera: Anthomyiidae) // XV congress of the Russian Entomological Society. – 2017. – С. 515–516.

125. Krusteva H. et al. Impacts of triticale crop sowing date on the insect pest species composition and damage caused //Bulgarian Journal of Agricultural Science. – 2011. – V. 17. – №. 4. – P. 411-416.

126. Shorokhov M. N., Petrova N. G., Dolzhenko V. I. Advances in the Assortment of Insecto-Fungicides //Russian Agricultural Sciences. – 2020. – Т. 46. – С. 354-358.

127. Шорохов М. Н., Хилевский В. А., Долженко В. И. Инсектофунгициды на пшенице озимой в Ростовской области // Российская сельскохозяйственная наука. – 2022. – №. 5. – С. 23-29. DOI: 10.31857/S2500262722050052.

128. Rabbinge, R., Drees, E. M., Van der Graaf, M., Verberne, F. C. M., Wesselo, A.

Damage effects of cereal aphids in wheat //Netherlands Journal of Plant Pathology. – 1981. – V. 87. – P. 217-232.

129. Mornhinweg D. W. Biotic stress in barley: Insect problems and solutions // Barley. – 2010. – P. 355-390.

130. Быковская А. В., Бойко С. В. О вредителях просяных культур (литературный обзор) // Защита растений. – 2022. – Т. 1. – №. 46. – С. 193-205.

131. Мелюхина Г. В. Видовое и количественное биоразнообразие межвидовых природных популяций наездников: афидиид, афелинид (Hymenoptera: Aphelinidae, Aphidiidae) полезных насекомых-энтомофагов вредных насекомых-хозяев (жертв) злаковых тлей (Homoptera, Aphididae) на протяжении всей вегетации пшеницы озимой в условиях лесостепи Украины //Биологическая защита растений-основа стабилизации агроэкосистем. – 2018. – С. 120-123.

132. Берим М. Н. Виды тлей в Ленинградской области / /Вестник защиты растений. – 2014. – №. 2. – С. 77-78.

133. Лысов А. К., Павлюшин В. А. Фитосанитарное проектирование агроэкосистем и дистанционное зондирование // Современные проблемы дистанционного зондирования Земли из космоса. – 2022. – Т. 19. – №. 5. – С. 101-112.

134. Amin, M., Mahmood, K., Nazir, N., Kassi, A. K., Ahmed, S. Population dynamics of wheat aphid on different landraces of wheat under field conditions // Plant Protection. – 2019. – V. 3. – 2 p.

135. Singh B., Jasrotia P., Crespo-Herreraa L. Breeding for aphid resistance in wheat: status and future prospects // New Horizons in Wheat and Barley Research: Global Trends, Breeding and Quality Enhancement. – 2022. – P. 381-399.

136. Khanal, D., Maharjan, S., Lamichhane, J., Neupane, P., Sharma, S., Pandey, P. Efficacy of biorational compounds against mustard aphid (*Lipaphis erysimi* Kalt.) and english grain aphid (*Sitobion avenae* Fab.) under laboratory conditions in Nepal // Advances in agriculture. – 2020. – V. 2020. – P. 1-7.

137. Amer S. A. Ecological Studies on Aphid Species Infesting Maincereal Crops //Annals of Agricultural Science, Moshtohor. – 2016. – V. 54. – №. 1. – P. 129-138.

138. Ступин А. С. Опасные вредители зерновых культур // Современные энерго-и

ресурсосберегающие, экологически устойчивые технологии и системы сельскохозяйственного производства. – 2014. – С. 215-218.

139. Евдакова М. В., Дедюлина И. А. Вредители зерновых колосовых культур с колюще-сосущим ротовым аппаратом в осенний период в условиях орловской области (Обзорная статья) //Научно-практические аспекты развития АПК. – 2023. – С. 59-61.

140. Kyrychenko A. M. et al. Weeds as reservoirs of viruses in agrobiocenoses of cereal crops in Ukraine // Microbiological journal. – 2022. – №. 84. – P. 72-86.

141. Кожевникова А. Г. и др. Цикадовые и биология наиболее вредоносных видов // Вестник науки. – 2019. – Т. 1. – №. 12 (21). – С. 248-251.

142. Yuan F., Wei C. Gene expression profiles in Malpighian tubules of the vector leafhopper Psammotettix striatus (L.) revealed regional functional diversity and heterogeneity // BMC genomics. – 2022. – V. 23. – №. 1. –67 p.

143. Ding L. et al. Immunodominant membrane protein (Imp) promotes the transmission of wheat blue dwarf (WBD) phytoplasma by directly interacting with α-tubulin in leafhoppers //European Journal of Plant Pathology. – 2022. – P. 1-11.

144. Жуковский, А. Г., Бойко, С. В., Трепашко, Л. И., Крупенько, Н. А., Сорока, Л. И., & Сорока, С. В. Современное фитосанитарное состояние агроценозов пшеницы озимой в Республике Беларусь //Земледелие и растениеводство. – 2022. – №. 3. – С. 16-26.

145. Иванов, А. Л., Кулинцев, В. В., Дридигер, В. К., Белобров, В. П. Освоение технологии прямого посева на черноземах России // Сельскохозяйственный журнал. – 2021. – №. 2 (14). – С. 18-36.

146. Иванов, А. Л., Кулинцев, В. В., Дридигер, В. К., Белобров, В. П. О целесообразности освоения системы прямого посева на черноземах России // Достижения науки и техники АПК. – 2021. – Т. 35. – №. 4. – С. 8-16.

147. Скребцова Т. И. Биоэкологические особенности вредной черепашки (*Eurygaster integriceps* Put.) и совершенствование мер борьбы с ней в Центральном Предкавказье //Автореф. канд. дисс. М. – 2009. – 188 с.

148. Горбачев, И. В., Гриценко, В. В., Захваткин, Ю. А., Исаичев, В. В., Кручина, С.

Н., Попов, С. Я., Третьяков, Н. Н. Защита растений от вредителей // Москва, Колос. – 2002. – 472 с.

149. Лысенко Н. Н., Лысенко С. Н., Наумкин В. П. Экологические предпосылки формирования вредной энтомофауны соевого агроценоза в Орловской области // Вестник аграрной науки. – 2012. – Т. 35. – №. 2. – С. 2-10.

150. Бойко С. В. Защита тритикале озимого от доминантных вредителей в условиях Беларуси // Защита растений. – 2022. – №. 41. – С. 196-210.

151. Касаточкина М. Ю., Сорокина М. В. Основные элементы ресурсосберегающих технологий в сельском хозяйстве // Научный журнал молодых ученых. – 2022. – №. 5 (30). – С. 27-31.

152. Грязнов А. А. Нудум 95 - высокобелковый сорт голозерного ячменя //АПК России. – 2016. – Т. 75. – №. 1. – С. 175-180.

153. Павлюшин, В. А., Вилкова, Н. А., Сухорученко, Г. И., Нефедова, Л. И., Капусткина, А. В. Вредная черепашка и другие хлебные клопы //СПб.: ВИЗР. – 2015. – Т. 170. – 280 с.

154. Маркарова Ж. Р. Вредитель клоп–вредная черепашка на хлебных посевах и сорта устойчивые к их повреждению / /Международный журнал гуманитарных и естественных наук. – 2019. – №. 3-1. – С. 118-120.

155. Maurya, R. P., Koranga, R., Samal, I., Chaudhary, D., Paschapur, A. U., Sreedhar, M., Manimala, R. N. Biological control: A global perspective //International Journal of Tropical Insect Science. – 2022. – V. 42. – №. 5. – P. 3203-3220.

156. Shavanov M. V., Shigapov I. I., Niaz A. Biological methods for pests and diseases control in agricultural plants //AIP Conference Proceedings. – AIP Publishing, 2022. – V. 2390. – №. 1. – P. 320

157. Jasrotia P., Singh B., Nagpal M. Biology and Management Strategies of Major Insect-Pests of Wheat //New Horizons in Wheat and Barley Research: Crop Protection and Resource Management. – Singapore: Springer Nature Singapore, 2022. – P. 283-307.

158. Bažok R. Integrated pest management of field crops //Agriculture. – 2022. – V. 12. – №. 3. – 425 p.

159. Mansion-Vaquié, A., Ferrante, M., Cook, S. M., Pell, J. K., Lövei, G. L. Manipulating

field margins to increase predation intensity in fields of winter wheat (Triticum aestivum) //Journal of Applied Entomology. – 2017. – V. 141. – №. 8. – P. 600-611.

160. Tortosa, A., Duflot, R., Rivers-Moore, J., Ladet, S., Esquerré, D., Vialatte, A. Natural enemies emerging in cereal fields in spring may contribute to biological control //Agricultural and Forest Entomology. – 2022. – V. 24. – №. 3. – P. 267-278.

161. Пушня, М. В., Родионова, Е. Ю., Снесарева, Е. Г., Исмаилов, В. Я. Регулирующая роль энтомофагов доминантных вредителей озимой пшеницы в системах органического земледелия // Достижения науки и техники АПК. – 2020. – Т. 34. – №. 7. – С. 49-55.

162. Голубцов Д. Н., Жижина Е. Ю., Климкин А. Ф. Способы повышения численности энтомофагов *Coccinella septempunctata* L. (Coleoptera, Coccinellidae) и *Sphaerophoria scripta* L. (Diptera, Syrphidae) // Биологизация земледелия: перспективы и реальные возможности. – 2019. – С. 303-304.

163. Helmy, S. M., El-Sahn, O., El-Razek, A., Maha, I. Predation Efficacy of Chrysoperla carnea (Steph.) on Parlatoria proteus (Curtis) and Fiorinia phoenicis (Balachowsky) under Semi Field Conditions at Giza Governorate //Journal of Plant Protection and Pathology. – 2020. – V. 11. – №. 12. – P. 663-666.

164. Tomanović, Ž., Kavallieratos, N. G., Ye, Z., Nika, E. P., Petrović, A., Vollhardt, I. M., Vorburger, C. Cereal Aphid Parasitoids in Europe (Hymenoptera: Braconidae: Aphidiinae): Taxonomy, Biodiversity, and Ecology //Insects. – 2022. – V. 13. – №. 12. – 1142 p.

165. Масленников В. А. К познанию фауны мух-ктырей (Diptera: Asilidae) Ульяновской области //Природа Симбирского Поволжья. – 2012. – С. 145-150.

166. Захаренко В. А. Экономическая целесообразность системы защиты зерновых культур в России //Достижения науки и техники АПК. – 2018. – Т. 32. – №. 7. – С. 5-8.

167. Orr D. B. Scelionid wasps as biological control agents: a review //Florida Entomologist. – 1988. – P. 506-528.

168. Austin A. D., Johnson N. F., Dowton M. Systematics, evolution, and biology of scelionid and platygastrid wasps //Annu. Rev. Entomol. – 2005. – V. 50. – P. 553-582.

169. Kivan M., Kilic N. Age-specific fecundity and life table of Trissolcus semistriatus, an egg parasitoid of the sunn pest Eurygaster integriceps //Entomological Science. – 2006. – V. 9. – №. 1. – P. 39-46.

170. Tarla G., Poinar G., Tarla Ş. Hexamermis eurygasteri n. sp. (Nematoda: Mermithidae) parasitising the sunn pest Eurygaster integriceps Puton (Hemiptera: Scutelleridae) in Turkey //Systematic Parasitology. – 2011. – V. 79. – P. 195-200.

171. Tarla G., Tarla S., İslamoğlu M. First report of Hexamermis sp. (Nematoda: Mermithidae) parasitizing Eurygaster maura (Heteroptera: Scutelleridae) in an overwintering area //Florida Entomologist. – 2015. – P. 974-978.

172. Kafi-Farashah, F., Farazmand, H., Vafaei-Shoushtari, R., Golmohammadi, G., Sanatgar, E. Effects of anti-juvenile hormone, precocene-I, on egg development of sunn pest, Eurygaster integriceps, and its progenies // Journal of Agricultural Science and Technology. – 2018. – V. 20. – №. 5. – P. 979-986.

173. Скребцова Т. И. Современные меры борьбы с вредной черепашкой Eurygaster integriceps Put // Материалы IX Международной научно-практической интернет-конференции «Актуальные вопросы энтомологии» (г. Ставрополь). – 2016. – С. 87–89.

174. Попов Ю. В., Хрюкина Е. И., Рукин В. Ф. Интеграция методов защиты зерновых культур // Защита и карантин растений. – 2012. – №. 7. – С. 45-48.

175. Devi P. I., Manjula M., Bhavani R. V. Agrochemicals, environment, and human health // Annual Review of Environment and Resources. – 2022. – V. 47. – P. 399-421.

176. Jacquet, F., Jeuffroy, M. H., Jouan, J., Le Cadre, E., Litrico, I., Malausa, T., Huyghe, C. Pesticide-free agriculture as a new paradigm for research // Agronomy for Sustainable Development. – 2022. – V. 42. – №. 1. –. 8 p.

177. Scorza, F. A., Bombardi, L. M., de Almeida, A. C. G., Beltramim, L., Finsterer, J. Pesticide residues in vegetables and fruits: watching diet while pregnant'is safe' // American Journal of Obstetrics and Gynecology. – 2023. – P. 22-93.

178. Davari A., Parker B. L. A review of research on Sunn Pest {Eurygaster integriceps Puton (Hemiptera: Scutelleridae)} management published 2004–2016 //Journal of Asia-Pacific Entomology. – 2018. – V. 21. – №. 1. – P. 352-360.

179. Alizadeh, M., Sheikhi Garjan, A., Ma'mani, L., Bandehhagh, A., Hosseini Salekdeh, G. Control of Sunn-Pest, Eurygaster integriceps Puton, using Deltamethrin Nanopesticide //Applied Entomology and Phytopathology. – 2022. – V. 89. – №. 2. – P. 213-223.

180. Можарова И. П., Мухина М. Т. Аналитический обзор о конференции «проблемы и пути их решения при проведении испытаний агрохимикатов и регуляторов роста растений для государственной регистрации на территории российской федерации» // Плодородие. – 2021. – №. 4 (121). – С. 73-77.

181. Воронов С. И., Плескачёв Ю. Н., Ильяшенко П. В. Основы производства высококачественного зерна озимой пшеницы // Плодородие. – 2020. – №. 2 (113). – С. 64-66.

182. Ториков, В. Е., Мельникова, О. В., Мамеев, В. В., Осипов, А. А., Локтев, А. Н., Кулинкович, С. Н. Урожайность и качество сортов нового поколения хлебопекарной озимой пшеницы // Вестник Брянской государственной сельскохозяйственной академии. – 2017. – №. 3 (61). – С. 9-14.

183. Ториков В. Е., Мельникова О. В., Богомаз Р. А. Урожайность и качество зерна новых сортов озимой пшеницы //Вестник Алтайского государственного аграрного университета. – 2015. – №. 8 (130). – С. 10-14.

184. Shorohov M. N., Dolzhenko V. I. The efficacy of new insecticides to protect wheat from sunn pest (Eurygaster integriceps put.) // Вестник аграрной науки. – 2015. – V. 53. – №. 2. – P. 3-7.

185. Шорохов М. Н., Долженко В. И. Экотоксикологическая оценка фосфорорганических, пиретроидных и комбинированных инсектицидов, используемых против клопа вредной черепашки // Известия Санкт-Петербургского государственного аграрного университета. – 2013. – №. 33. – С. 49-53.

186. Токарев Е. В., Хилевский В. А., Маханькова Т. А. Изучение комбинированных гербицидов на посевах пшеницы озимой в условиях степной зоны северного Кавказа //Приоритетные направления развития науки и образования. – 2015. – №. 3. – С. 152-155.

187. Хилевский В. А. Фитоэкспертиза и протравливание семян озимой пшеницы в Ростовской области // Наука и образование. – 2015. – С. 102-107.

188. Глазунова Н. Н. Оптимизированная система защиты озимой пшеницы // Защита и карантин растений. – 2019. – №. 12. – С. 16-19.

189. Хилевский В. А. Современные средства защиты озимой пшеницы от черной пшеничной мухи Phorbia fumigata Mg. (Diptera: Anthomyiidae) //XV congress of the Russian Entomological Society. – 2017. – С. 515-516.

190. Хилевский В. А., Шорохов М. Н., Мартынушкин А. Н. Инсектициды для интегрированных систем защиты зерновых культур // Бюллетень ВПРС МОББ. – 2017. – 303 с.

191. Николаева З. О., Тимофеева Н. Ю. Тли - вредители зерновых культур в псковской области // Наукосфера. – 2021. – №. 1. – С. 123-128.

192. Бойко С. В. Опасны ли вредители зерновых культур в условиях этого года? //Наше сельское хозяйство. – 2020. – №. 7. – С. 12-21.

193. Бойко С. В., Слабожанкина О. Ф. Инсектициды с д. в. дельтаметрин против основных вредителей зерновых культур //Земледелие и растениеводство. – 2022. – №. 3. – С. 52-56.

194. Glazunova, N. N., Bezgina, Y. A., Maznitsyna, L. V., Tuturzhans, L. V., Mikhno, L. A. Computer program for forecasting and calculating the number of winter wheat phytophages // IOP Conference Series: Earth and Environmental Science. – IOP Publishing, 2020. – V. 548. – №. 3. – 318 p.

195. Ivantsova, E. A., Novochadov, V. V., OnistratenkO, N. V., Postnova, M. V. Ecological aspects of phytosanitary optimization of arid agrobiocenoses of the South of Russia //Bulgarian Journal of Agricultural Science. – 2017. – V. 23. – №. 5. – P. 834-842.

196. Марченко Д. М., Филенко Г. А., Некрасов Е. И. Семеноводство озимой пшеницы в Ростовской области //Достижения науки и техники АПК. – 2016. – Т. 30. – №. 11. – С. 57-59.

197. Филенко Г. А., Фирсова Т. И., Марченко Д. М. Состояние семеноводства и сортовой состав озимой пшеницы в Ростовской области //Зерновое хозяйство России. – 2015. – №. 3. – С. 40-44.

198. Ибрагимов, А. А., Голосная, Е. Л., Дрёпа, Е. Б., Вольтерс, И. А., Голубь, А. С. Анализ производства озимой пшеницы юга России и влияние сортосмены на

урожайность и качество зерна // Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета. – 2021. – №. 174. – С. 130-142.

199. Афанасенко О. С., Аблова И. Б. Выдающиеся ученые России. Академик РАН Л.А. Беспалова // Письма в Вавиловский журнал генетики и селекции. – 2022. – Т. 8. – №. 1. – С. 98-105.

200. Рябцева Н. А. Урожайность озимой пшеницы в зависимости от предшественников и сортов в условиях Ростовской области //Аграрная наука. – 2023. – №. 1. – С. 65-69.

201. Мельников Н. Н. Пестициды. Химия, технология и применение //М.: Химия. – 1987. – Т. 712. – 2 с.

202. Долженко В. И. Эффективные средства защиты озимой пшеницы от основных вредителей в условиях степной зоны Предкавказья// Агрохимия. – 2009. – №. 4. – С. 43-54.

203. Долженко, В. И., Новожилов, К. В., Сухорученко, Г. И., Тютерев, С. Л. Химическая защита растений в фитосанитарном оздоровлении агроэкосистем // Вестник защиты растений. – 2011. – №. 3. – С. 3-12.

204. Долженко В. И., Новожилов К. В. Становление и развитие НИР в системе биологической регламентации и государственной регистрации новых средств защиты растений // Вестник защиты растений. – 2010. – №. 3. – С. 16-29.

205. Долженко В. И., Новожилов К. В. Химический метод защиты растений: состояние и перспективы повышения экологической безопасности // Защита и карантин растений. – 2005. – №. 3. – С. 80-84.

206. Ракитский В. Н., Синицкая Т. А., Батищев И. С. Комбинированное действие пестицида и антидота производственного назначения // Токсикологический вестник. – 2011. – №. 2 (107). – С. 2-4.

207. Ran, X., Hadiatullah, H., Yuchi, Z., Yang, X., Zhu, X. Sustainable Use of Pesticides //Agriculture. – 2023. – V. 13. – №. 7. – 1393 p.

208. Хилевский В. А., Шорохов М. Н., Долженко В. И. Эффективные инсектициды для защиты зерновых от злаковых мух // Агротехнический метод защиты растений

от вредных организмов. – 2017. – С. 476-480.

209. Мельников Н. Н. Пестициды. Химия, технология и применение // М.: Химия. – 1987. – Т. 712. – С. 2.

210. Buszewski, B., Bukowska, M., Ligor, M., & Staneczko-Baranowska, I. A holistic study of neonicotinoids neuroactive insecticides properties, applications, occurrence, and analysis // Environmental Science and Pollution Research. – 2019. – V. 26. – P. 34723-34740.

211. Zuščíková, L., Bažány, D., Greifová, H., Knížatová, N., Kováčik, A., Lukáč, N., Jambor, T. Screening of toxic effects of neonicotinoid insecticides with a focus on acetamiprid: a review // Toxics. – 2023. – V. 11. – №. 7. – 598 p.

212. Zapol'skii, V. A., Fischer, R., Namyslo, J. C., Kaufmann, D. E. Chemistry of polyhalogenated nitrobutadienes, 8: Nitropolychlorobutadienes—Precursors for insecticidal neonicotinoids // Bioorganic & medicinal chemistry. – 2009. – V. 17. – №. 12. – P. 4206-4215.

213. Лосева М. П. Остаточные количества ацетамиприда в сельскохозяйственных растениях // Защита растений. – 2022. – №. 44. – С. 260-265.

214. Phogat, A., Singh, J., Kumar, V., Malik, V. Toxicity of the acetamiprid insecticide for mammals: A review // Environmental Chemistry Letters. – 2022. – P. 1-26.

215. Illarionov, R. A., Alekseev, E. Y., Peskova, A. I., Petrova, M. O. Determination of residual amounts of acetamiprid in crops by high-performance liquid chromatography //10° Encontro National de Cromatografia. – 2017. – P. 147-147.

216. Carbonell-Rozas, L., Lara, F. J., del Olmo Iruela, M., Garcia-Campana, A. M. A novel approach based on capillary liquid chromatography for the simultaneous determination of neonicotinoid residues in cereal samples / /Microchemical Journal. – 2021. – V. 161. – 105756 p.

217. Alsafran, M., Rizwan, M., Usman, K., Saleem, M. H., Al Jabri, H. Neonicotinoid insecticides in the environment: A critical review of their distribution, transport, fate, and toxic effects // Journal of Environmental Chemical Engineering. – 2022. – 108485 p.

218. Hodoșan, C., Gîrd, C. E., Ghica, M. V., Dinu-Pîrvu, C. E., Nistor, L., Bărbuică, I. S., Popa, L. Pyrethrins and Pyrethroids: A Comprehensive Review of Natural Occurring

Compounds and Their Synthetic Derivatives // Plants. – 2023. – V. 12. – №. 23. – 4022 p.

219. Ahamad A., Kumar J. Pyrethroid pesticides: An overview on classification, toxicological assessment and monitoring //Journal of Hazardous Materials Advances. – 2023. – 100284 p.
220. Zacharia J. T. Identity, physical and chemical properties of pesticides //Pesticides in the modern world-trends in pesticides analysis. – 2011. – P. 1-18.
221. Laskowski D. A. Physical and chemical properties of pyrethroids //Reviews of Environmental Contamination and Toxicology: Continuation of Residue Reviews. – 2002. – P. 49-170.
222. El-Shewy, A., Mohamed, G., Elbath, M. Efficiency of Insecticides Imidacloprid and Lambada-Cyhalothrin on Two Public Health Pests Musca domestica and Rattus norvegicus under Laboratory Conditions / /Egyptian Academic Journal of Biological Sciences, F. Toxicology & Pest Control. – 2023. – V. 15. – №. 2. – P. 79-97.
223. Ahamad A., Kumar J. Pyrethroid pesticides: An overview on classification, toxicological assessment and monitoring // Journal of Hazardous Materials Advances. – 2023. – 100284 p.
224. Zhorov B. S., Dong K. Pyrethroids in an AlphaFold2 model of the insect sodium channel // Insects. – 2022. – V. 13. – №. 8. – 745 p.
225. Ravula A. R., Yenugu S. Pyrethroid based pesticides–chemical and biological aspects // Critical Reviews in Toxicology. – 2021. – V. 51. – №. 2. – P. 117-140.
226. Khanday A. A. Phytotoxicity of common pesticides to physiological and biochemical makeup of Triticumaestivumvar. Lok-1 // GSC Biological and Pharmaceutical Sciences. – 2022. – V. 18. – №. 3. – P. 092-099.
227. Uneme H. Chemistry of clothianidin and related compounds // Journal of Agricultural and Food Chemistry. – 2011. – V. 59. – №. 7. – P. 2932-2937.
228. Alsafran, M., Saleem, M. H., Al Jabri, H., Rizwan, M.,Usman, K. Principles and applicability of integrated remediation strategies for heavy metal Removal/Recovery from contaminated environments //Journal of Plant Growth Regulation. – 2023. – V. 42. – №. 6. – P. 3419-3440.

229. Buszewski, B., Bukowska, M., Ligor, M., Staneczko-Baranowska, I. A holistic study of neonicotinoids neuroactive insecticides—properties, applications, occurrence, and analysis //Environmental Science and Pollution Research. – 2019. – V. 26. – P. 34723-34740.
230. Zhang, X., Huang, Y., Chen, W. J., Wu, S., Lei, Q., Zhou, Z., Chen, S. Environmental occurrence, toxicity concerns, and biodegradation of neonicotinoid insecticides //Environmental Research. – 2023. – V. 218. – 114953 p.
231. Xu, X., Wang, X., Yang, Y., Ares, I., Martínez, M., Lopez-Torres, B., Martinez, M. A. Neonicotinoids: Mechanisms of systemic toxicity based on oxidative stress-mitochondrial damage //Archives of Toxicology. – 2022. – V. 96. – №. 6. – P. 1493-1520.
232. Khanday A. A. Phytotoxicity of common pesticides to physiological and biochemical makeup of Triticumaestivumvar. Lok-1 //GSC Biological and Pharmaceutical Sciences. – 2022. – V. 18. – №. 3. – P. 092-099.
233. Грузнов, Д. В., Грузнова, О. А., Лобанов, А. В., Сохликов, А. Б. Химическая безопасность // Химическая безопасность. Федеральный исследовательский центр химической физики им. НН Семенова РАН. – 2022. – Т. 6. – №. 2. – С. 81-116.
234. Thany S. H. Molecular Mechanism of Action of Neonicotinoid Insecticides //International Journal of Molecular Sciences. – 2023. – V. 24. – №. 6. – 5484 p.
235. Hodoșan, C., Gîrd, C. E., Ghica, M. V., Dinu-Pîrvu, C. E., Nistor, L., Bărbuică, I. S., Popa, L. Pyrethrins and Pyrethroids: A Comprehensive Review of Natural Occurring Compounds and Their Synthetic Derivatives //Plants. – 2023. – V. 12. – №. 23. – 4022 p.
236. Zhu, Y., Loso, M. R., Watson, G. B., Sparks, T. C., Rogers, R. B., Huang, J. X., Thomas, J. D. Discovery and characterization of sulfoxaflor, a novel insecticide targeting sap-feeding pests //Journal of Agricultural and Food chemistry. – 2011. – V. 59. – №. 7. – P. 2950-2957.
237. Babcock, J. M., Gerwick, C. B., Huang, J. X., Loso, M. R., Nakamura, G., Nolting, S. P., Zhu, Y. Biological characterization of sulfoxaflor, a novel insecticide //Pest management science. – 2011. – V. 67. – №. 3. – P. 328-334.

238. Bacci L., Convertini S., Rossaro B. A review of sulfoxaflor, a derivative of biological acting substances as a class of insecticides with a broad range of action against many insect pests //Journal of Entomological and Acarological Research. – 2018. – V. 50. – №. 7836. – 36 p.
239. Cutler, P., Slater, R., Edmunds, A. J., Maienfisch, P., Hall, R. G., Earley, F. G., Crossthwaite, A. J. Investigating the mode of action of sulfoxaflor: a fourth‐generation neonicotinoid //Pest management science. – 2013. – V. 69. – №. 5. – P. 607-619.
240. Долженко, В.И. Методические указания по регистрационным испытаниям инсектицидов, акарицидов, моллюскоцидов и родентицидов в сельском хозяйстве / В.И. Долженко. – СПб., 2009. – С. 321.
241. Долженко О. В., Коковихина А. И. Эффективность новых комбинированных инсектицидов для защиты картофеля от тлей-переносчиков вирусов в Ленинградской области // Известия Санкт-Петербургского государственного аграрного университета. – 2018. – №. 3 (52). – С. 33-37.
242. Фадеев Ю. Н. Оценка санитарной и экологической безопасности пестицидов // Защита растений. – 1988. – Т. 7. – С. 20-21.
243. Sugumar, S., Clarke, S. K., Nirmala, M. J., Tyagi, B. K., Mukherjee, A., Chandrasekaran, N. Nanoemulsion of eucalyptus oil and its larvicidal activity against Culex quinquefasciatus // Bulletin of entomological research. – 2014. – V. 104. – №. 3. – P. 393-402.
244. Badawy, M. E., Saad, A. F. S., Tayeb, E. S. H., Mohammed, S. A., Abd-Elnabi, A. D. Development and characterization of nanoemulsions of some insecticides by high energy technique for targeting delivery // J. Agric. Res. – 2019. – V. 57. – №. 1. – P. 15-23.
245. Drais H. K., Hussein A. A. Formulation and characterization of carvedilol nanoemulsion oral liquid dosage form // Int J Pharm Pharm Sci. – 2015. – V. 7. – №. 12. – P. 209-216.
246. de Mattos, C. B., Argenta, D. F., Melchiades, G. D. L., Sechini Cordeiro, M. N., Tonini, M. L., Moraes, M. H., Koester, L. S. Nanoemulsions containing a synthetic chalcone as an alternative for treating cutaneous leshmaniasis: optimization using a full

factorial design // International journal of nanomedicine. – 2015. – P. 5529-5542.

247. Silvander, M., Hellström, A., Wärnheim, T., Claesson, P. Rheological properties of phospholipid-stabilized parenteral oil-in-water emulsions—effects of electrolyte concentration and presence of heparin //International journal of pharmaceutics. – 2003. – V. 252. – №. 1-2. – P. 123-132.

248. Hallett F. R. Particle size analysis by dynamic light scattering // Food research international. – 1994. – V. 27. – №. 2. – P. 195-198.

249. Silva, A. M., Alvarado, H. L., Abrego, G., Martins-Gomes, C., Garduño-Ramirez, M. L., García, M. L., Souto, E. B. In vitro cytotoxicity of oleanolic/ursolic acids-loaded in PLGA nanoparticles in different cell lines //Pharmaceutics. – 2019. – V. 11. – №. 8. – P. 362.

250. Carbone, C., Martins-Gomes, C., Pepe, V., Silva, A. M., Musumeci, T., Puglisi, G., Souto, E. B. Repurposing itraconazole to the benefit of skin cancer treatment: A combined azole-DDAB nanoencapsulation strategy //Colloids and Surfaces B: Biointerfaces. – 2018. – V. 167. – P. 337-344.

251. Ракитский В. Н., Синицкая Т. А., Громова И. П. Потенцирование токсичности при комбинированном действии пестицидов и тяжелых металлов // Сборник материалов международной научно-практической конференции" Здоровье и окружающая среда". – 2019. – С. 299-301.

APPENDIX

Appendix 1. **Particle Size Analysis (DLS)**

2021.04.26 09:38:26

HORIBA Scientific

HORIBA SZ-100 for Windows [Z Type] Ver2.20

SZ-100

G-Size_03.nsz

Measurement Results

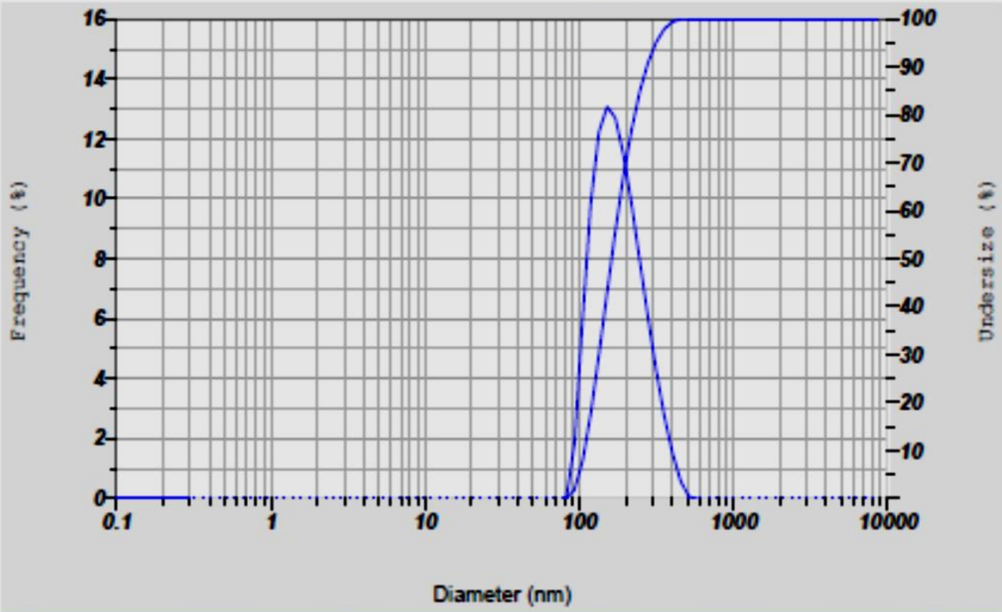
Date	:	Monday, April 26, 2021 9:33:55 AM
Measurement Type	:	Particle Size
Sample Name	:	14000206-Noroozi-G-Size
Scattering Angle	:	90
Temperature of the Holder	:	25.2 °C
Dispersion Medium Viscosity	:	0.892 mPa·s
Transmission Intensity before Meas.	:	27754
Distribution Form	:	Standard
Distribution Form(Dispersity)	:	Polydisperse
Representation of Result	:	Scattering Light Intensity
Count Rate	:	1195 kCPS

Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	1.00	178.4 nm	67.1 nm	142.9 nm
2	---	--- nm	--- nm	--- nm
3	---	--- nm	--- nm	--- nm
Total	1.00	178.4 nm	67.1 nm	142.9 nm

Cumulant Operations

Z-Average	:	175.2 nm
PI	:	0.300



Explore the future HORIBA

1/1

a - **Nanocapsules of acetamipride suspension coated with chitosan, size 178.4 nm**

2021.04.26 09:44:13

HORIBA Scientific

HORIBA SZ-100 for Windows [Z Type] Ver2.20

SZ-100

F-Size_03.nsz

Measurement Results

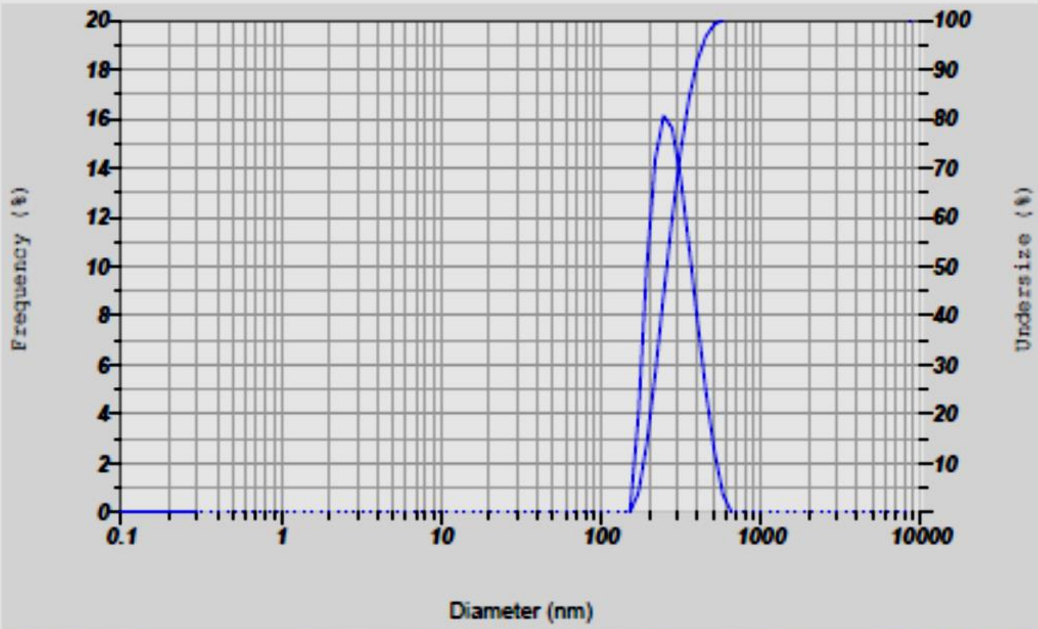
Date	: Monday, April 26, 2021 9:43:12 AM
Measurement Type	: Particle Size
Sample Name	: 14000206-Noroozi-F-Size
Scattering Angle	: 90
Temperature of the Holder	: 25.2 °C
Dispersion Medium Viscosity	: 0.892 mPa·s
Transmission Intensity before Meas.	: 23722
Distribution Form	: Standard
Distribution Form(Dispersity)	: Polydisperse
Representation of Result	: Scattering Light Intensity
Count Rate	: 739 kCPS

Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	1.00	274.4 nm	79.7 nm	233.4 nm
2	---	--- nm	--- nm	--- nm
3	---	--- nm	--- nm	--- nm
Total	1.00	274.4 nm	79.7 nm	233.4 nm

Cumulant Operations

Z-Average	: 296.5 nm
PI	: 0.356



Explore the future HORIBA

1/1

b - **Nanocapsules of acetamipride powder coated with chitosan, nanoparticles size 274.4 nm**

2021.04.26 09:59:44

HORIBA Scientific

HORIBA SZ-100 for Windows [Z Type] Ver2.20

SZ-100

D-Size_02.nsz
Measurement Results

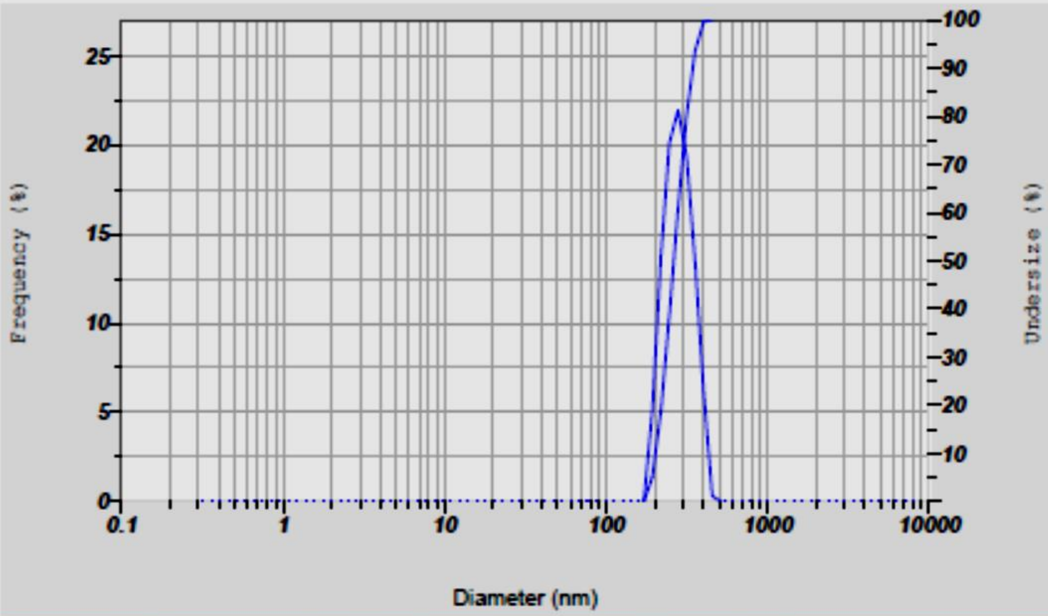
Date	: Monday, April 26, 2021 9:55:36 AM
Measurement Type	: Particle Size
Sample Name	: 14000206-Noroozi-D-Size
Scattering Angle	: 90
Temperature of the Holder	: 25.1 °C
Dispersion Medium Viscosity	: 0.892 mPa·s
Transmission Intensity before Meas.	: 36880
Distribution Form	: Standard
Distribution Form(Dispersity)	: Polydisperse
Representation of Result	: Scattering Light Intensity
Count Rate	: 23 kCPS

Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	1.00	268.5 nm	52.5 nm	262.0 nm
2	---	--- nm	--- nm	--- nm
3	---	--- nm	--- nm	--- nm
Total	1.00	268.5 nm	52.5 nm	262.0 nm

Cumulant Operations

Z-Average	: 171.9 nm
PI	: 1.239



HORIBA

1/1

c - **Nanocapsules of acetamipride suspension coated with PEG, nanoparticle size 290.2 nm**

2021.04.26 09:44:04

HORIBA SZ-100 for Windows [Z Type] Ver2.20

HORIBA
Scientific

SZ-100

F-Size_01.nsz

Measurement Results

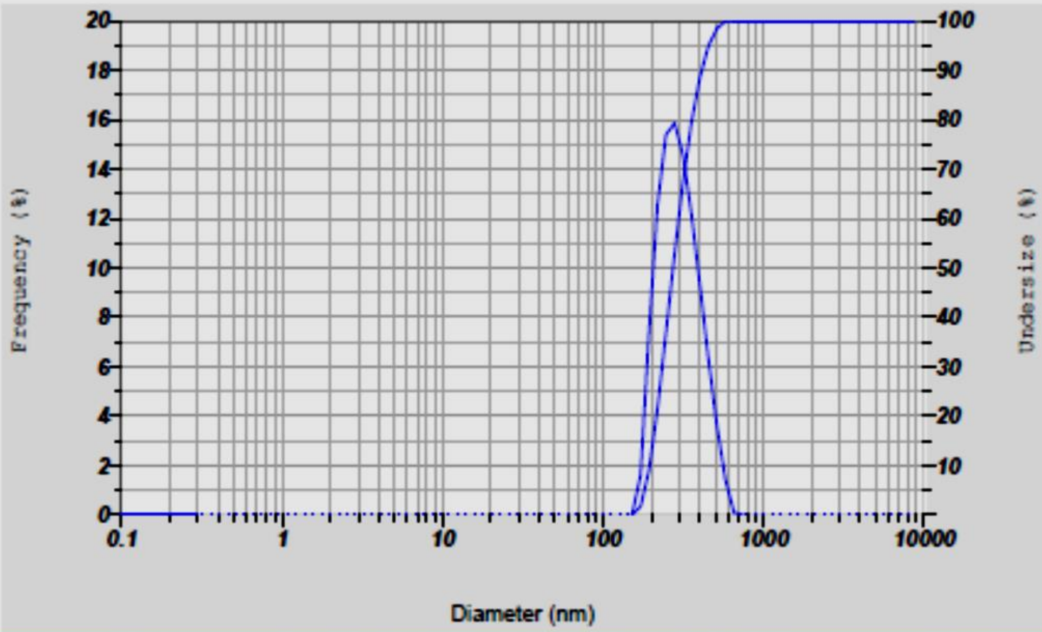
Date	:	Monday, April 26, 2021 9:41:52 AM
Measurement Type	:	Particle Size
Sample Name	:	14000206-Noroozi-F-Size
Scattering Angle	:	90
Temperature of the Holder	:	25.1 °C
Dispersion Medium Viscosity	:	0.893 mPa·s
Transmission Intensity before Meas.	:	23722
Distribution Form	:	Standard
Distribution Form(Dispersity)	:	Polydisperse
Representation of Result	:	Scattering Light Intensity
Count Rate	:	814 kCPS

Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	1.00	290.2 nm	84.5 nm	261.7 nm
2	---	--- nm	--- nm	--- nm
3	---	--- nm	--- nm	--- nm
Total	1.00	290.2 nm	84.5 nm	261.7 nm

Cumulant Operations

Z-Average	:	316.1 nm
PI	:	0.352



Explore the future HORIBA

1/1

d- **Nanocapsules of acetamipride powder coated with PEG, nanoparticle size 268.5 nm**

2021.04.26 09:10:58

HORIBA Scientific

HORIBA SZ-100 for Windows [Z Type] Ver2.20

SZ-100

C-Size_03.nsz

Measurement Results

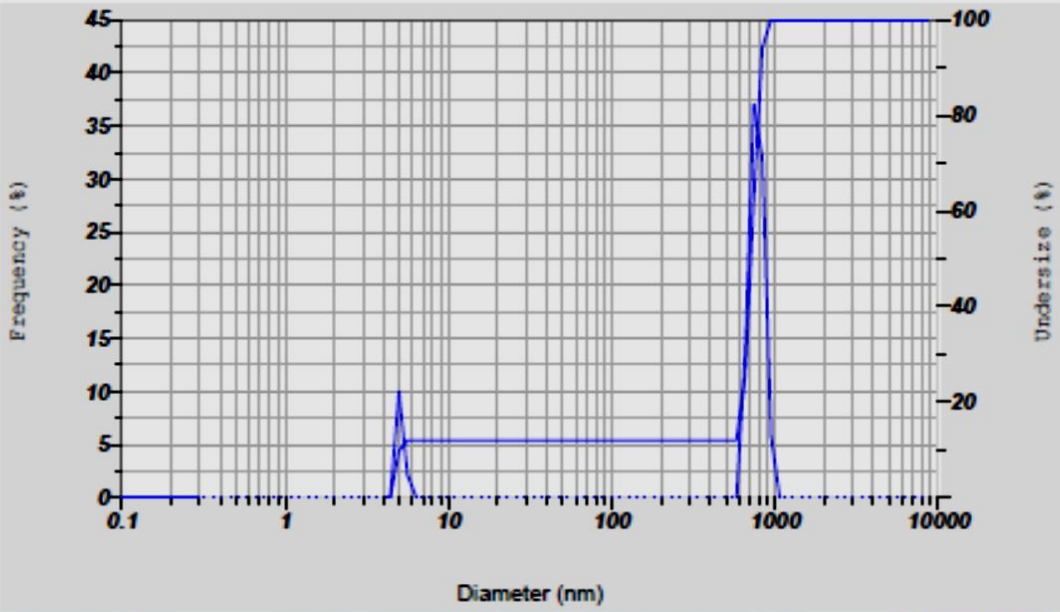
Date	:	Monday, April 26, 2021 9:09:47 AM
Measurement Type	:	Particle Size
Sample Name	:	14000206-Noroozi-C-Size
Scattering Angle	:	90
Temperature of the Holder	:	25.2 °C
Dispersion Medium Viscosity	:	0.891 mPa·s
Transmission Intensity before Meas.	:	31218
Distribution Form	:	Standard
Distribution Form(Dispersity)	:	Polydisperse
Representation of Result	:	Scattering Light Intensity
Count Rate	:	41 kCPS

Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	0.12	4.8 nm	0.2 nm	4.7 nm
2	0.88	730.3 nm	72.5 nm	718.7 nm
3	---	--- nm	--- nm	--- nm
Total	1.00	643.3 nm	245.2 nm	718.7 nm

Cumulant Operations

Z-Average	:	1949.0 nm
PI	:	1.055



Explore the future HORIBA

1/1

e - **Acetamipride is standard, the nanoparticle size is 643.5 nm**

Appendix 2. **Particle Size Analysis (DLS)**

2021.04.26 09:27:41

HORIBA Scientific

HORIBA SZ-100 for Windows [Z Type] Ver2.20

SZ-100

A-Size_02.nsz

Measurement Results

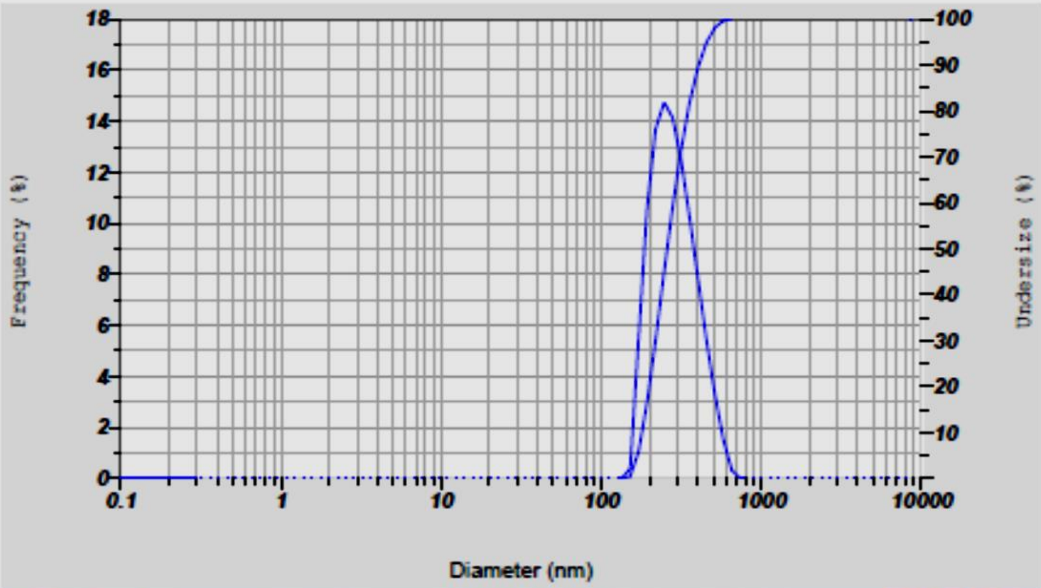
Date	: Monday, April 26, 2021 9:26:12 AM
Measurement Type	: Particle Size
Sample Name	: 14000206-Noroozi-A-Size
Scattering Angle	: 90
Temperature of the Holder	: 25.2 °C
Dispersion Medium Viscosity	: 0.892 mPa·s
Transmission Intensity before Meas.	: 24771
Distribution Form	: Standard
Distribution Form(Dispersity)	: Polydisperse
Representation of Result	: Scattering Light Intensity
Count Rate	: 674 kCPS

Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	1.00	278.0 nm	89.6 nm	232.8 nm
2	---	--- nm	--- nm	--- nm
3	---	--- nm	--- nm	--- nm
Total	1.00	278.0 nm	89.6 nm	232.8 nm

Cumulant Operations

Z-Average	: 250.2 nm
PI	: 0.233



Explore the future HORIBA

1/1

a - **Nanoemulsion of acetamipride powder, nanoparticles size 278.0 nm**

2021.04.26 09:27:45

HORIBA Scientific

HORIBA SZ-100 for Windows [Z Type] Ver2.20

SZ-100

A-Size_03.nsz

Measurement Results

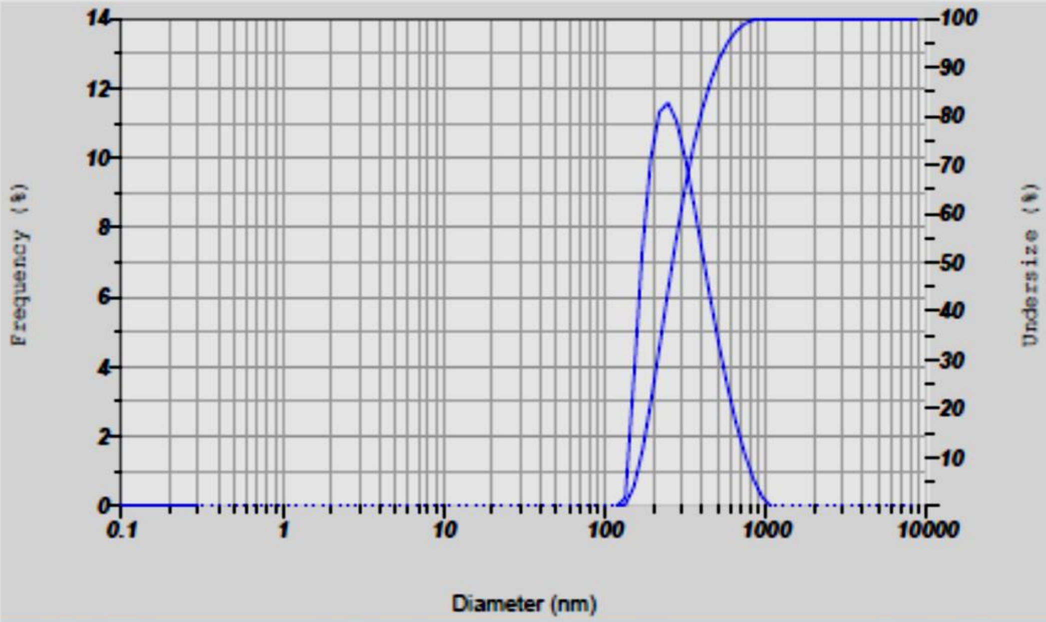
Date	: Monday, April 26, 2021 9:26:46 AM
Measurement Type	: Particle Size
Sample Name	: 14000206-Noroozi-A-Size
Scattering Angle	: 90
Temperature of the Holder	: 25.2 °C
Dispersion Medium Viscosity	: 0.891 mPa·s
Transmission Intensity before Meas.	: 24771
Distribution Form	: Standard
Distribution Form(Dispersity)	: Polydisperse
Representation of Result	: Scattering Light Intensity
Count Rate	: 723 kCPS

Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	1.00	300.6 nm	134.4 nm	232.0 nm
2	---	--- nm	--- nm	--- nm
3	---	--- nm	--- nm	--- nm
Total	1.00	300.6 nm	134.4 nm	232.0 nm

Cumulant Operations

Z-Average	: 267.4 nm
PI	: 0.028



Explore the future

HORIBA

1/1

b - **Nanoemulsion of acetamipride suspension, nanoparticles size 300.6 nm**

2021.04.26 09:10:58

HORIBA Scientific

HORIBA SZ-100 for Windows [Z Type] Ver2.20

SZ-100

C-Size_03.nsz

Measurement Results

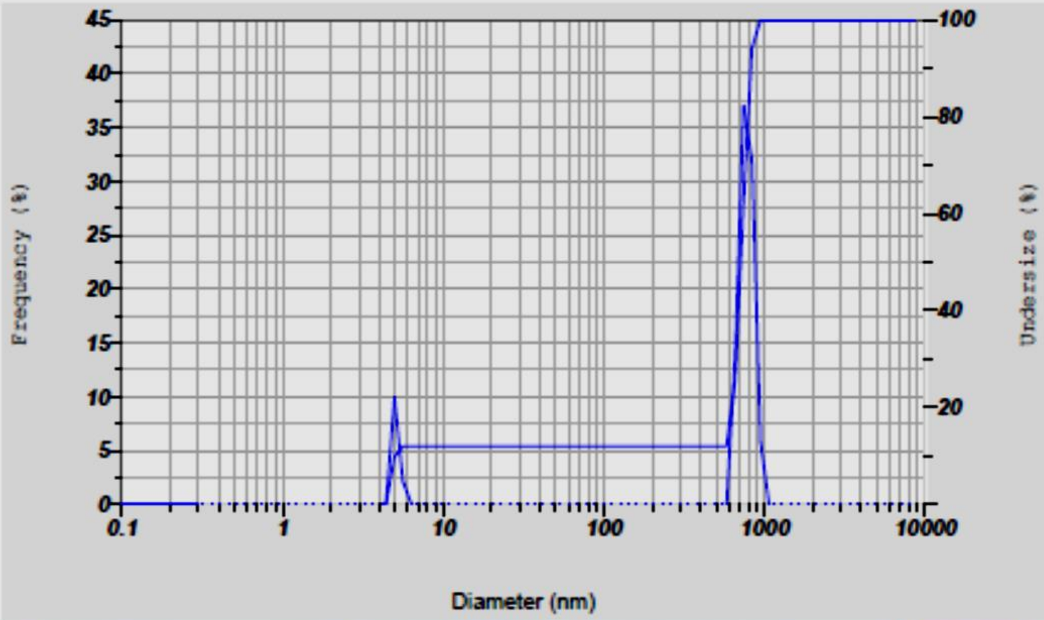
Date	:	Monday, April 26, 2021 9:09:47 AM
Measurement Type	:	Particle Size
Sample Name	:	14000206-Noroozi-C-Size
Scattering Angle	:	90
Temperature of the Holder	:	25.2 °C
Dispersion Medium Viscosity	:	0.891 mPa·s
Transmission Intensity before Meas.	:	31218
Distribution Form	:	Standard
Distribution Form(Dispersity)	:	Polydisperse
Representation of Result	:	Scattering Light Intensity
Count Rate	:	41 kCPS

Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	0.12	4.8 nm	0.2 nm	4.7 nm
2	0.88	730.3 nm	72.5 nm	718.7 nm
3	---	--- nm	--- nm	--- nm
Total	1.00	643.3 nm	245.2 nm	718.7 nm

Cumulant Operations

Z-Average	:	1949.0 nm
PI	:	1.055



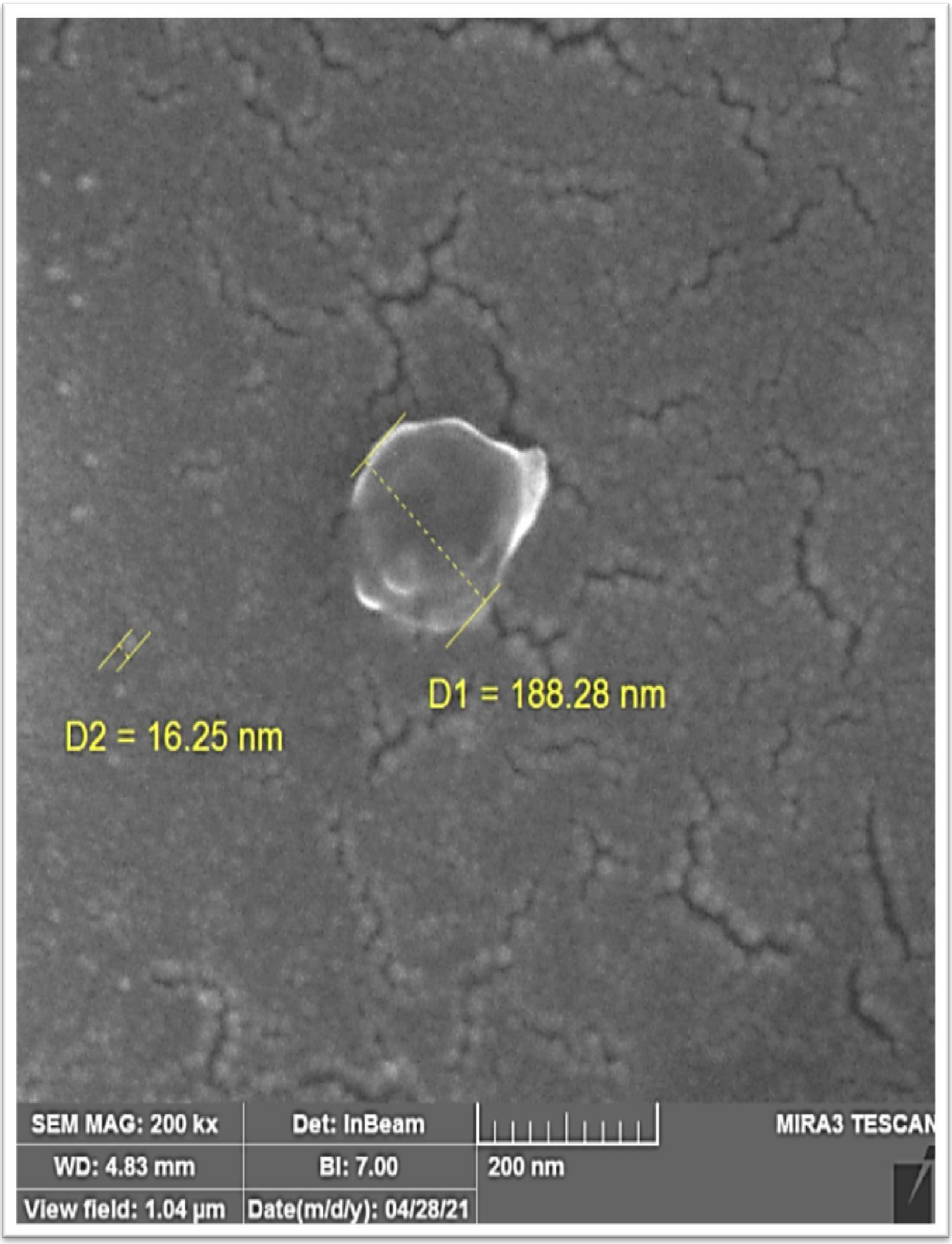
Explore the future

HORIBA

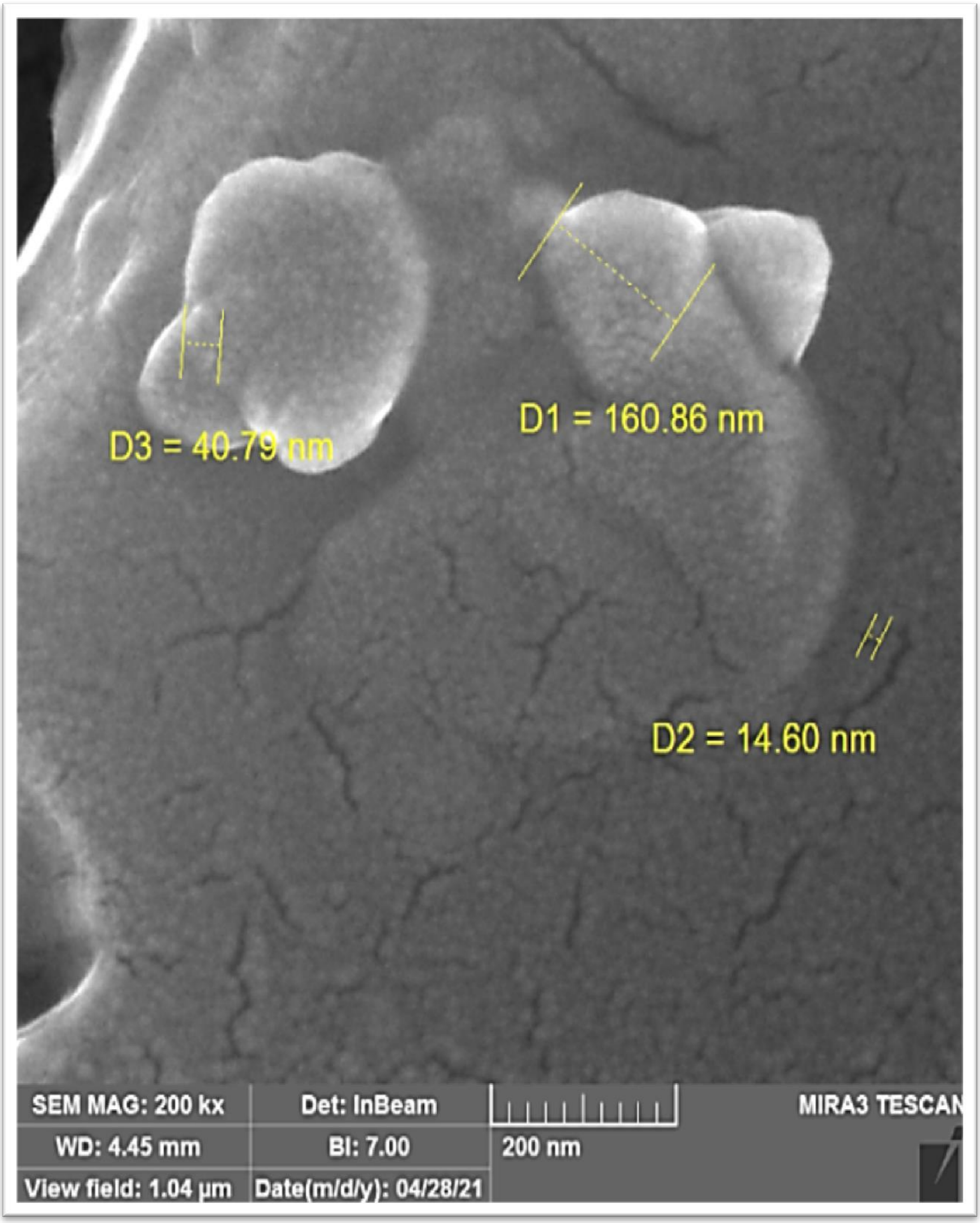
1/1

c - **Acetamipride is standard, the nanoparticle size is 730.3 nm**

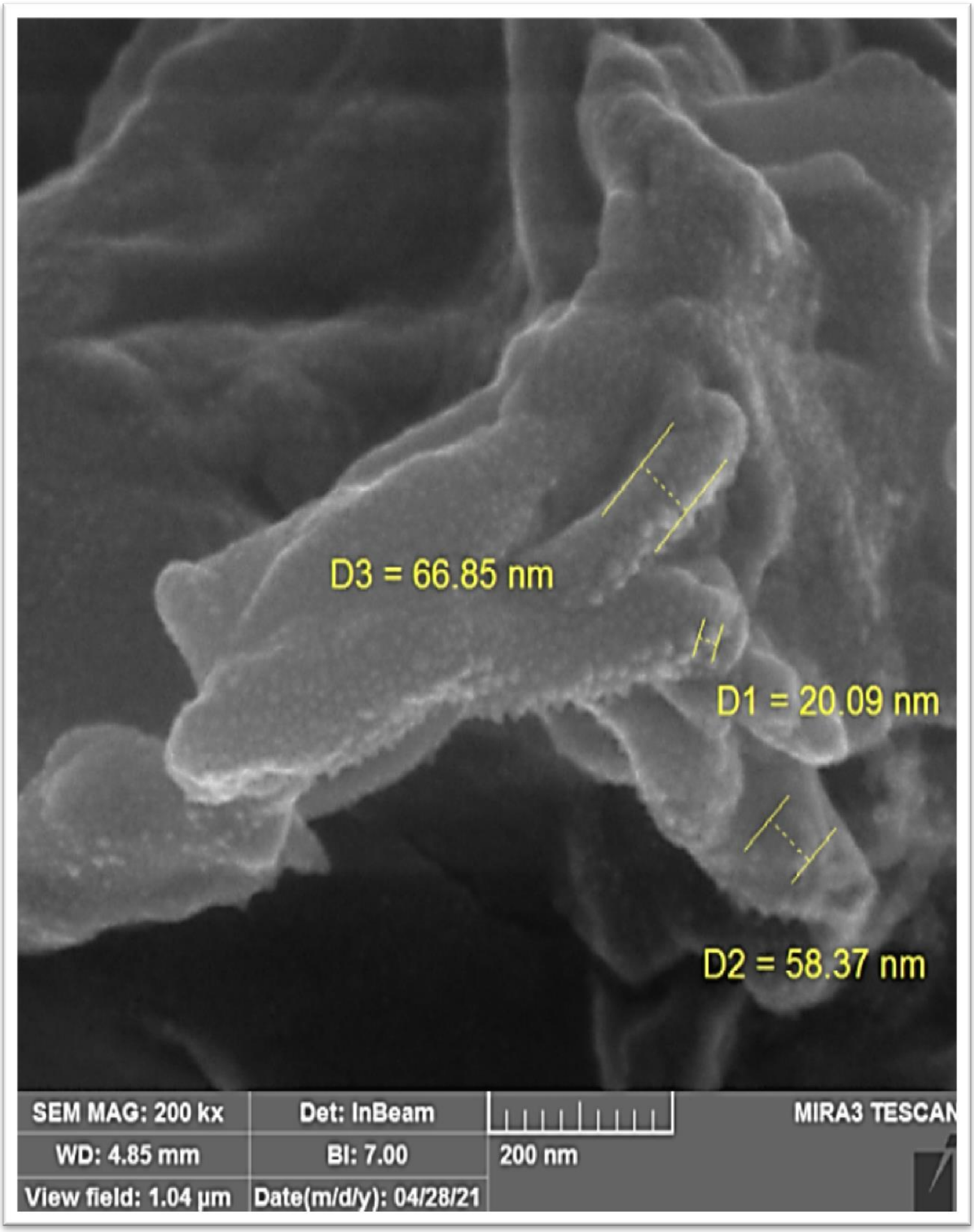
Appendix 3**. Particle shape and size analysis (FE-SEM)**



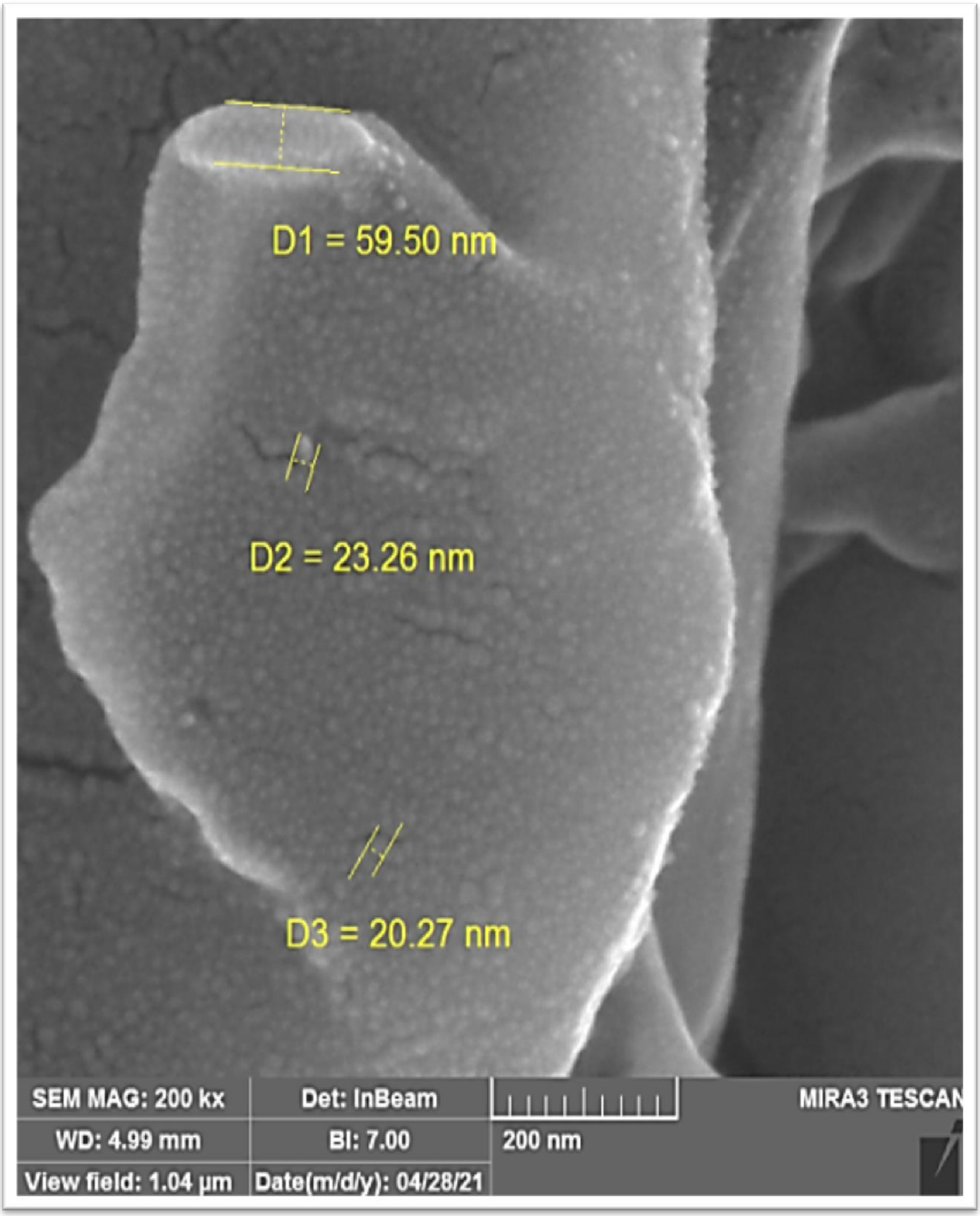
a - **Nanocapsules of acetamipride suspension coated with chitosan, nanoparticles size 102.265 nm. Spherical and oval shapes**



b- **Nanocapsules of acetamipride powder coated with chitosan, nanoparticles size 72.083 nm. shapes range from spherical, square and rectangular**

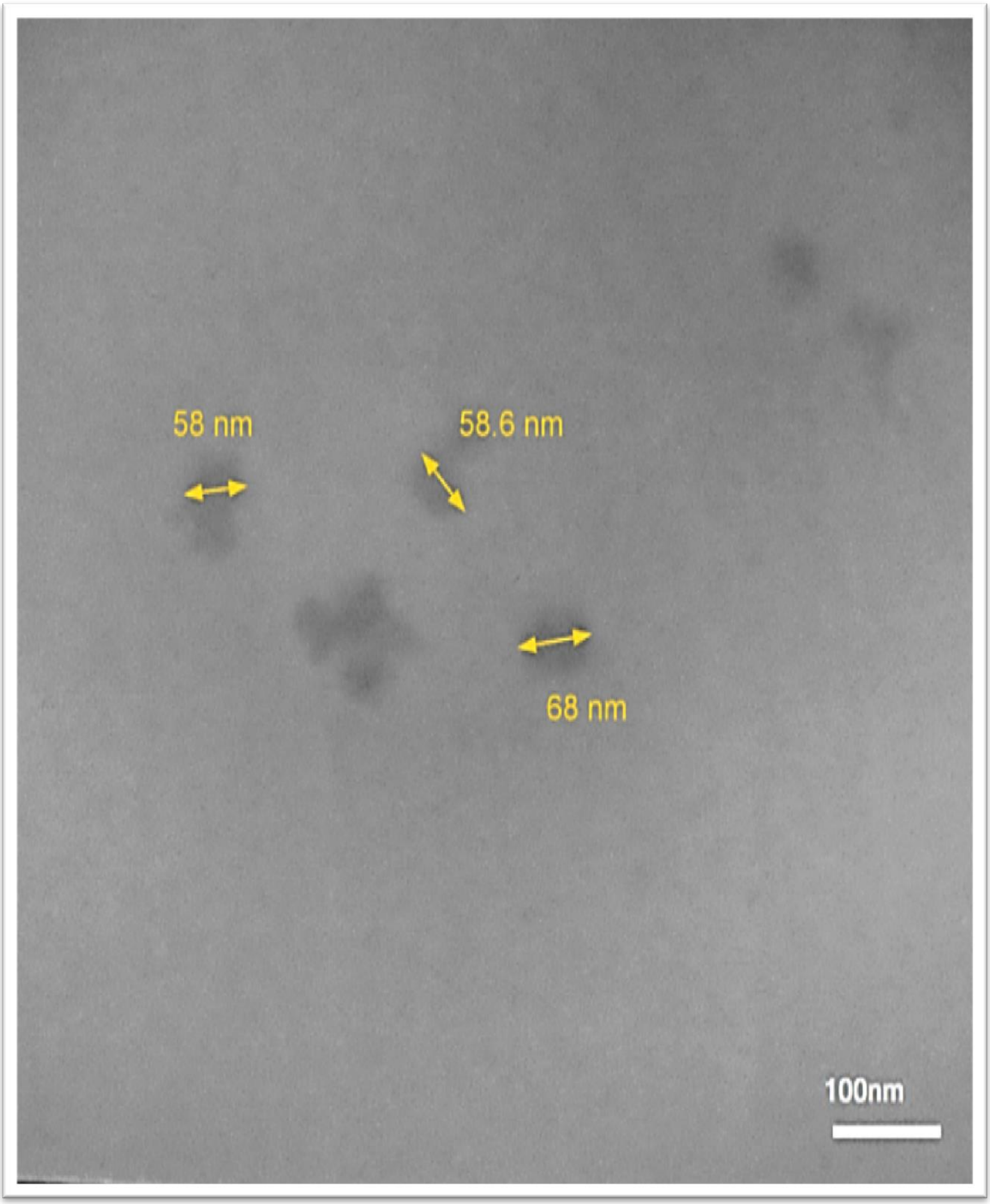


c - **Nanocapsules of acetamipride suspension coated with PEG, nanoparticle size 34.343nm. Mostly spherical**

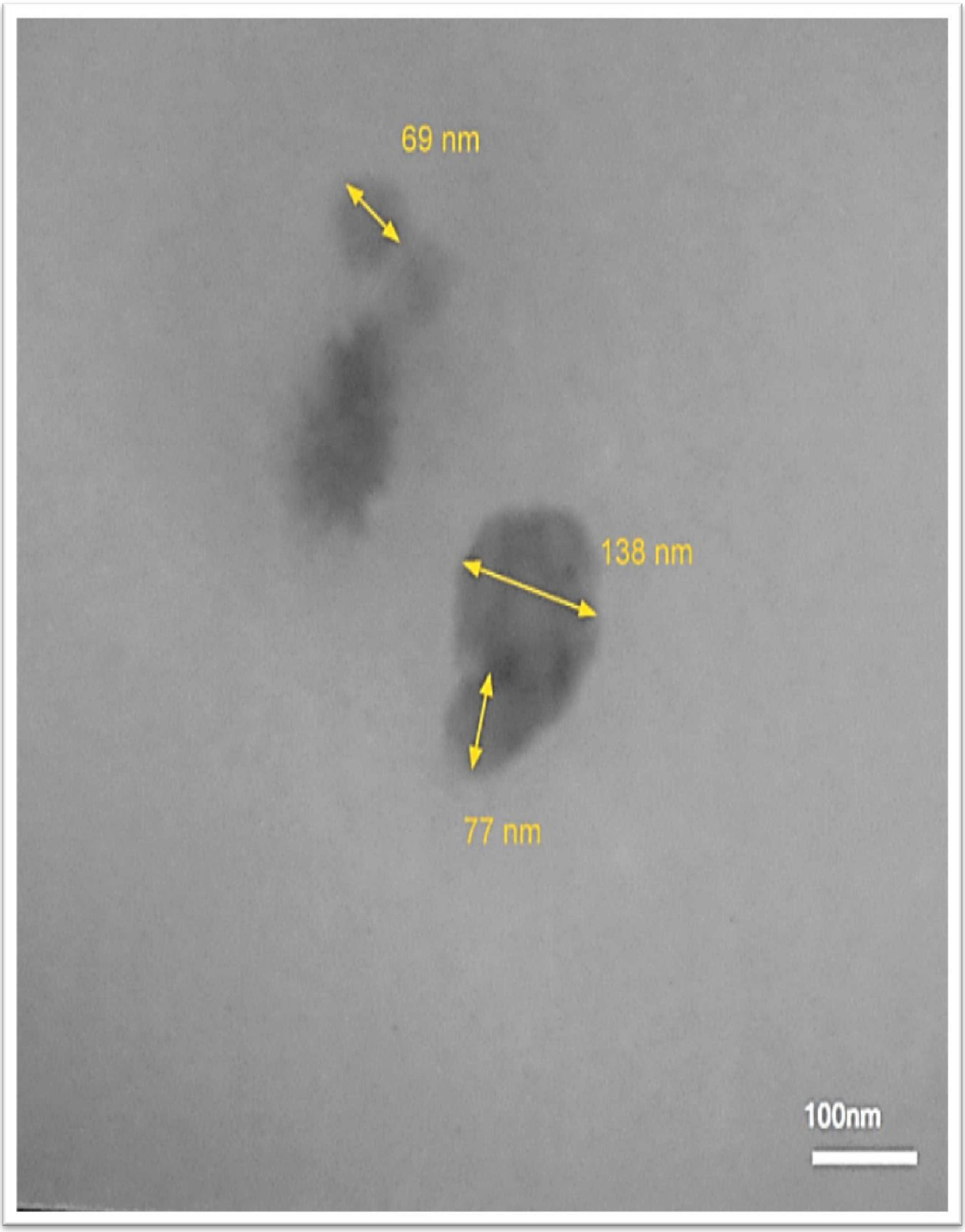


d - **Nanocapsules of acetamipride powder coated with PEG, nanoparticle size 48.436 nm. In shapes ranging from spherical, square and rectangular**

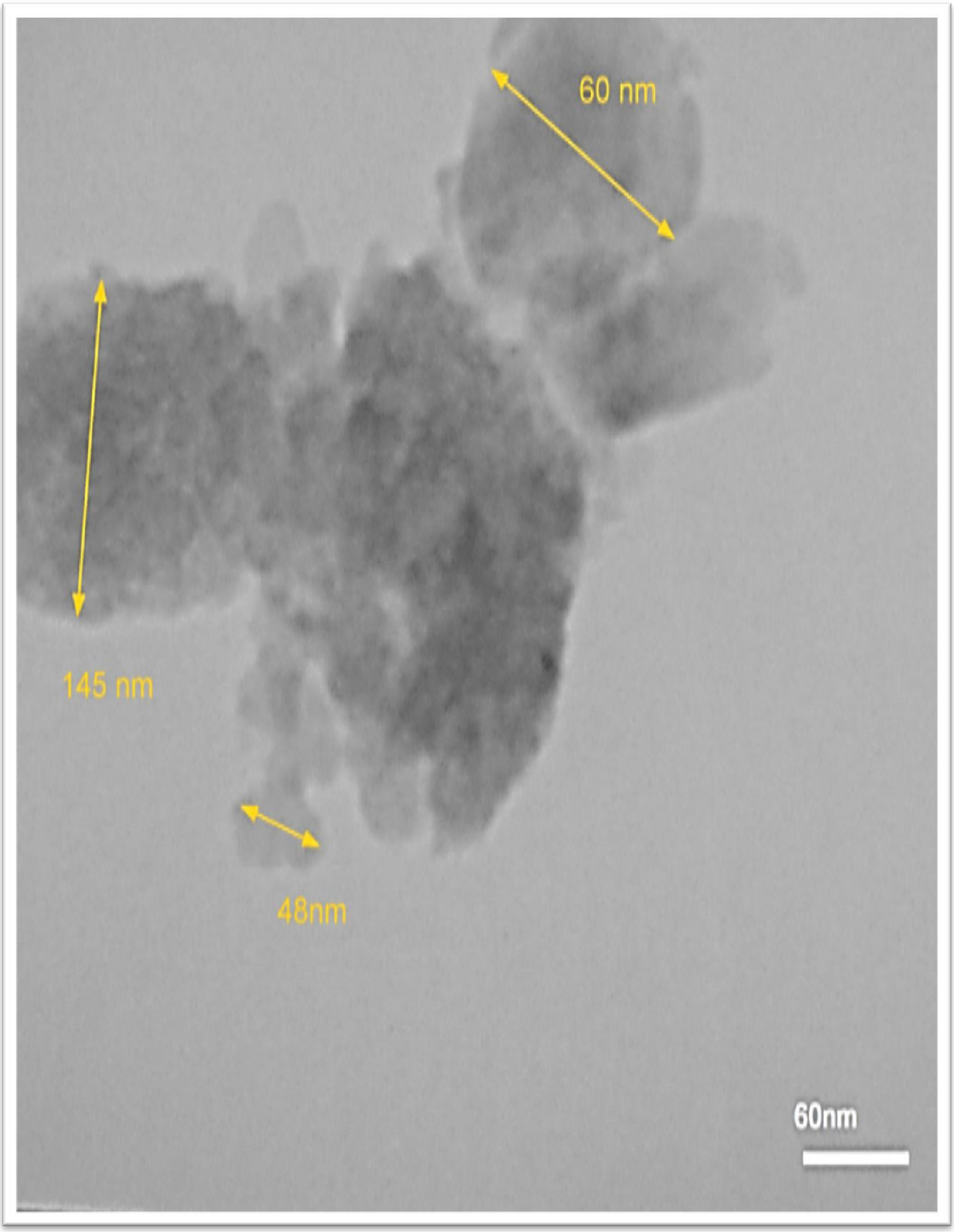
Appendix 4. **Particle shape and size analysis (FE-SEM)**



a - Nanoemulsion of acetamipride suspension, nanoparticles size 61.5 nm



b - **Nanoemulsion of acetamipride powder, nanoparticles size 94.66 nm**



c - **Aetamipride standard, the nanoparticle size is 84.3 nm**

Appendix 5. **Biological effectiveness of Dexter Turbo , SE insecticide in the control of wheat beetles on winter wheat (Rostov region, 2020)**

Experience variants	Dosing used l/ha	Repeat	Average number of adults per m²				Decrease in the number of larvaerelative to the initial one,adjusted for controlafter treatment according to the accounting days, %			Biological grain yield, c/ha
			Before treatment	After treatment according to the accounting days						
				3	7	14	3	7	14	
Dexter Turbo, SE (115 + 106 + 70 g/l)	0,1	1	10	3	2	1	72,3	82,4	91,6	25,6
		2	8	1	1	1	88,5	89,0	89,5	26,4
		3	8	1	1	1	88,5	89,0	89,5	26,5
		4	9	2	1	1	79,5	90,2	90,7	26,3
		ср.	**8,8**	**1,8**	**1,3**	**1,0**	**82,2**	**87,7**	**90,3**	**26,2**
	0,2	1	8	1	1	0	88,5	89,0	100,0	26,6
		2	6	1	0	0	84,6	100,0	100,0	26,8
		3	8	1	0	1	88,5	100,0	89,5	26,4
		4	10	1	2	1	90,8	82,4	91,6	25,8
		ср.	**8,0**	**1,0**	**0,8**	**0,5**	**88,1**	**92,9**	**95,3**	**26,4**
Espero, SC (200 + 120 g/l) /standard/	0,1	1	9	2	1	1	79,5	90,2	90,7	26,3
		2	7	1	1	1	86,8	87,5	88,0	26,4
		3	6	1	1	1	84,6	85,4	86,0	26,6
		4	11	2	1	1	83,2	92,0	92,4	25,7
		ср.	**8,3**	**1,5**	**1,0**	**1,0**	**83,5**	**88,8**	**89,3**	**26,3**
Control	–	1	10	8	9	11	–	–	–	24,9
		2	9	10	9	10	–	–	–	24,8
		3	8	10	11	9	–	–	–	24,7
		4	9	11	12	13	–	–	–	24,1
		ср.	**9,0**	**9,8**	**10,3**	**10,8**	**–**	**–**	**–**	**24,6**
LSD_{05}			2,33	1,30	1,42	1,39	8,11	9,06	5,78	0,61

Appendix 6. **Biological effectiveness of Dexter Turbo , SE insecticide in the control of wheat beetles on winter wheat (Rostov region, 2021)**

Experience variants	Dosing used l/ha	Repeat	Average number of adults per m^2				Decrease in the number of larvaerelative to the initial one,adjusted for controlafter treatment according to the accounting days, %			Biological grain yield, c/ha
			Before treatment	After treatment according to the accounting days						
				3	7	14	3	7	14	
Dexter Turbo, SE (115 + 106 + 70 g/l)	0,1	1	7	1	2	1	88,3	81,5	88,0	39,7
		2	9	2	1	1	81,9	92,8	90,7	38,7
		3	8	2	2	1	79,6	83,9	89,5	38,6
		4	7	2	1	1	76,7	90,8	88,0	39,9
		cp.	**7,8**	**1,8**	**1,5**	**1,0**	**81,6**	**87,2**	**89,1**	**39,2**
	0,2	1	8	2	1	1	79,6	91,9	89,5	38,9
		2	7	0	1	0	100	90,8	100	40,2
		3	9	2	2	1	81,9	85,6	90,7	38,5
		4	8	1	0	1	89,8	100	89,5	40,0
		cp.	**8,0**	**1,3**	**1,0**	**0,8**	**87,8**	**92,1**	**92,4**	**39,4**
Espero, SC (200 + 120 g/l) /standard/	0,1	1	6	0	1	1	100	89,2	86,0	40,0
		2	9	3	2	0	72,8	85,6	100	38,3
		3	7	2	1	1	76,7	90,8	88,0	39,6
		4	8	1	1	1	89,8	91,9	89,5	39,4
		cp.	**7,5**	**1,5**	**1,3**	**0,8**	**84,8**	**89,4**	**90,9**	**39,3**
Control	–	1	9	11	14	10	–	–	–	35,0
		2	7	8	12	9	–	–	–	35,6
		3	8	10	9	7	–	–	–	35,8
		4	7	9	13	11	–	–	–	35,3
		cp.	**7,8**	**9,5**	**12,0**	**9,3**	**–**	**–**	**–**	**35,4**
LSD_{05}			1,57	1,63	1,87	1,42	15,03	7,83	7,52	1,03