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DEVELOPMENT OF PROTECTIVE MEASURES FOR CONTROLLING PESTS OF PULSE CROPS IN THE SOUTHEAST KAZAKHSTAN

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SUMMARY

This study sought to design and validate biologically and eco-friendly methods for safeguarding soybean (*Glycine max* L.) and other bean crops against harmful pests, contributing to sustainable agriculture. In the context of the strategic goals of Kazakhstan's agricultural modernization, this research emphasizes the development of integrated pest management (IPM) strategies prioritizing biologically and environmentally safe approaches. Field observations proceeded between 2018 and 2021 and identified 55 families and 11 orders of soybean pests and 27 families and eight orders of bean pests. The latter included polyphagous and specialized species, such as *Tetranychus urticae* and *Acanthoscelides obtectus*. The study also evaluated the bioefficacy of various biological and chemical pesticides, particularly Actarophyte, Vertimek, and Actellic, in reducing pest populations and preserving the crop yield. The combined application of biopreparations showed higher pest suppression and economic efficiency than the conventionally used single-pesticide application methods. The results revealed timely application, especially at the budding and flowering phases, significantly reduced pest damage, including latent injury by bean weevils, during the storage. This research supports the transition toward sustainable agricultural practices by demonstrating the effectiveness of biopesticides and integrated crop protection measures tailored to local agroecological conditions.

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Keywords: Soybean (*G. max* L.), other bean crops, main pests, pests control, protective measures, integrated pest management, biologically and environmentally safe approaches

Key findings: The study identified a diverse range of harmful pests (spider mites, pea aphids, and bean weevils) affecting soybean (*G. max* L.) and other bean crops in Southeastern Kazakhstan, causing severe damage. By using biological preparations, such as Actarophyte and Bitoxibacillin in an integrated system, we demonstrated high bioefficacy in controlling key pests and improving crop yield.

INTRODUCTION

This study followed the strategic course of development of the Republic of Kazakhstan, outlined in the strategy 'Kazakhstan-2050,' 'The third modernization of Kazakhstan: Global competitiveness (2017),' 'New development opportunities in the context of the fourth industrial revolution (2018),' and the 'Development of the agro-industrial complex of the Republic of Kazakhstan (2017–2021).' In the said strategies, an emphasis stated the country's agricultural sector should become a new driver of the economy. Hence, the primary tasks were to enhance the efficiency of land use and the area of irrigated lands by 40% to reach 2 million ha (The State Program, 2017; Muhlinina, 2024).

Soybean (*Glycine max* [L.] Merr.), being an edificatory, nitrogen-fixing crop, can elevate the sanitary situation in fields, fodders, vegetables, and grain crop rotations. Soybean crop serves as a reserve of useful biota and a stabilizer for the biodiversity of the entire agroecosystem (Mukhamadiyev *et al*., 2020). The said crop incurs slight effects from wireworms (Elateridae), aphids (Aphidoidea), and thrips (Thysanoptera); however, it is quite resistant to barn pests and hardy to several fungal, bacterial, and viral pathogens. Yet, damage to its grain yield can be due to dozens of harmful pathogens, i.e., phytophages of various families, phytopathogens of fungal, bacterial, and viral nature, weeds, especially perennial rhizomatous, and soboliferous (Mukhametov *et al*., 2024).

By studying the soybean entomofauna in the Krasnodar Territory, past findings revealed the 53 species of phytophages that damage soybeans and 35 species of entomophages as soybean pests (Shabalta, 2005). The most common soybean phytophages are butterflies (Lepidoptera), and the most harmful one was the meadow moth. In finding effective bioinsecticides, a wide scope in finding natural species of fungi, bacteria, and viruses adaptive to extreme conditions intensifies. Likewise, search focuses on developing new pathogenic microorganisms and safe means that reliably protect agrophytocenoses from harmful phytophages at the nanotechnological genetic engineering level.

Bean plants acquire severe damages from both polyphagous and specialized pests. In Russia, during the years of mass reproduction, the polyphagous pests pose a serious threat to the sowing of bean crops (Kenenbayev *et al*., 2023). By this group of pests, damage on beans occurs at the larval stage of click beetles, darkling beetles, leaf miners, bean seed flies, leaf-eating cutworms, root-knot nematodes (*Meloidogyne marioni* Cornu.), snout beetles, aphids, and bugs. Click beetles (Elateridae) have many types, i.e., striped (*Agriotes lineatus*), dark (*Agriotes obscurus*), *Corymbites aeneus*, *Selatosomus latus* F., darkling beetles—*Opatrum sabulosum* L., *Blaps halophila*, and tenebrionid beetle (*Pedinus femoralis*). Cutworms include *Agrotis segetum*, *Agrotis exclamationis*, leaf-eating cutworms *Autographa gamma* L., *Heliothis viriplaca*, *Mamestra brassicae*, *Ceramica pisi* L., and *Helicoverpa armigera* Hbn. In aphids, these are pea (*Acyrthosiphon pisum*) and bean (*Aphis fabae*); bugs for tarnished plant (*Lygus pratensis* L.) and alfalfa (*Adelphocoris lineolatus* Goese.), beet leaf (*Piesma cognatus*), capsid grain; two-spotted spider mite (*Tetranychus urticae*), *Sitona*, and *Tychius quinquepunctatus*. The crop-specialized pests have representations from the following types, viz., bean weevil (*Acanthoscelides obtectus*), broad bean weevil

(*Bruchus rufimanus*), pea moth (*Laspeyresia nigricana*), and lima bean pod borer (*Etiella zinckenella*).

Tarnished plant, alfalfa, beet leaf, capsid grain bugs, and other types of bugs' damage bean crops everywhere, reaching five individuals per plant, and the harmfulness ranges from 5% to 25% of the damaged leaf surface. In this case, the shoots become distorted, the leaves curl, the buds and flowers fall off, and the yield of green mass and seeds decreases considerably. The beans' most dangerous pest damaging seeds both in the field and in granaries is the bean weevil (Anuarbekov *et al*., 2014; 2021). The pest damages the bean grains and contaminates the mass with excrement, and the grains lose their germination and nutritional values. Relatedly, the bean losses during storage sometimes reach 80%–100%. Therefore, the presented study sought to develop and scientifically substantiate the environmentally safe and biologically based approaches to protect soybean crops from harmful organisms within the framework of sustainable agriculture.

With many earlier legume-pest studies testing single tools, greenhouse systems, or non-Kazakh contexts, this article provides multi-year, field-scale, and region-specific evidence for an integrated pest-management approach in Southeastern Kazakhstan. It combines biopesticides with selective chemistries, operational drone application, and timing aligned with yield and storage protection—offering practice-ready guidance where local data have been scarce.

MATERIALS AND METHODS

In the presented research, the use of classical methods adopted in entomology and plant protection in soybean (*G. max* L.) and other bean crops helped develop environmentally safe and biologically based approaches to protect the crops from harmful organisms. Using summaries, guidelines, research articles, and keys from past findings aided in identifying pests, entomophages, and pollinators and clarifying their biological characteristics, distribution, conservation status, and economic values (Temreshev, 2017).

Field experiments and surveys commenced during 2018–2021 in the fields of the Agropark Ontustik–LLP, Almaty, Kazakhstan, and on the experimental site of the Training and Education Center, Saimasay–LLP, Almaty, Kazakhstan. By studying the species composition of the soybean and beans' main pests, their population dynamics, and regular collection of insects and counts, continued visually and by mowing with an entomological net.

The population counting of the soybean pests proceeded by using route surveys and examining the test plants. Route surveys began with sowing at the beginning of the soybean growing season, carried out regularly every 10–12 days until the end of the crop season. For the formation of six true leaves of the crop, 10 plants incurred examination in triplicate. During the growing season, the spider mite moves from weeds to the leaves of the lower layer of the crop. Hence, determining their population density took place during the flowering and ripening phases of beans, with the leaves of the lower, middle, and upper layers examined on three plants at 10 places. Collecting the samples mainly transpired from the upper parts of the soybean and bean plants.

Pest counts on bean plants progressed once every three days during the entire growing season. At the same time, before the formation of six true leaves, 10 plants underwent assessment in triplicate in a randomized manner; after the formation of six true leaves, the counting of pests by mowing used an entomological net, with 10 strokes in triplicate. Carrying out the population count and the dynamics of the number of pea aphids, two-spotted spider mites, and pea thrips prevailed by points, as well as by calculating the average number of insects per 100 soybean and bean plants.

Bioefficacy calculation followed the formula of Abbott (1925), which estimates the percentage reduction of pest infestation in treated plots compared with the untreated control:

$$E (\%) = ([A-B]\times 100)/A$$

Where E = bioefficacy (%), A = the number of infected plants in the control, and B = the number of infected plants in the experiment.

RESULTS AND DISCUSSION

The concerned research comprised an evaluation of pest species composition of soybean (*Glycine max* L.) and other bean crops, carried out during 2018–2021 in South-East Kazakhstan. The assessment of economic values and species composition of the identified insect pests of soybeans belonged to 55 families and 11 orders from several classes, and insect pests of other bean crops belonged to 27 families and eight orders from several classes. Recent surveys across the Krasnodar and Stavropol regions in Russia documented over 210 insect and mite species on soybean, spanning nine orders and 52 families, thus confirming similarly high taxonomic richness in temperate agroecosystems (Agasyeva *et al*., 2024). In a global review of soybean pests, Jangir *et al*. (2025) listed key pests, such as aphids, leaf beetles, stink bugs, and pod borers across diverse climatic zones, underscoring the broad distribution of pest taxa we also observed. These comparative data suggest the pest complex in Kazakhstan is on par with other major soybean regions, reinforcing the need for regionally adapted integrated pest management.

During the spring-summer period, soil excavations and field surveys on soybean crops revealed 10 species of insect pests. These are *Agriotes sputator* L., *Selatosomus latus* F., *Blaps halophila* M., *Sitona*—striped (*Sitona lineatus* L.), and spotted bean weevil (*S. crinitus* Hbst.), green leafhopper (*Cicadella viridis* L.), soldier beetle (*Cantharis rustica* L.), clover mamestra (*Discestra trifolii* Hufn.), and two-spotted spider mite (*Tetranychus urticae* Kosh). The spider mite (*Tetranychus turkestanicus* Ug et. Nik.) caused significant economic damage to bean crops.

In bean pests, 15 insect species succeeded in their identification. These are desert cricket (*Melanogryllus desertus* Pall.), greenhouse whitefly (*Trialeurodes vaporariorum* Westwood), beetroot (*Polymerus cognatus* Fieb.), tarnished plant (*Lygus pratensis* L.), alfalfa (*Adelphocoris lineolatus* Goese), and southern leafhopper. Others are click beetles (*Elateridae*), *Opatrum sabulosum* L., *Tanymecus palliatus*, *Autographa gamma* L., *Helicoverpa armigera* Hbn, *Heliothis viriplaca*, *Agrotis segetum*, spider mites (*Tetranychus turkestanicus* Ug et. Nik.), and mollusk *Monacha samunensis* Lpr. Most of the entomocenosis of the bean fields belongs to polyphages. In favorable seasons, the development of polyphagous pests poses a serious threat to bean crops. The most dangerous pests of beans make up 8.8% of the total species composition. During the years of research, the insects, such as southern leafhoppers, pea and bean aphids, pea thrips, and bean weevils, proved to be constantly harmful to bean crops. In addition to these insects, the two-spotted spider mite (*Tetranychus turkestanicus* Ug et. Nik.) is also a constant bean pest.

In studies on French beans (*Phaseolus vulgaris*), researchers likewise reported that sap-sucking pests (aphids, thrips, and leafhoppers) and spider mites form the major pest complex, underscoring the generality of these groups across legume crops (Emaru *et al*., 2024). Moreover, recent work evaluating *Tetranychus urticae* on common bean cultivars revealed mite populations can vary significantly by cultivar and seasonality, demonstrating that spider mite pressure is a widespread constraint in bean agroecosystems (El-Shamy *et al*., 2025). These consistencies across diverse geographic zones strengthen confidence that the pests identified in our Kazakhstan plots are representative of the leading pest threats in bean production.

The formation of the entomofauna of soybeans and beans in crop fields and the number of pests appeared to be closely associated with weather conditions, phases of plant development, cultivars, and the placement of fields in crop rotation (Zhou *et al*., 2024). Similar observations were noticeable from Southeastern Kazakhstan research. Soybean yield plus pest pressure saw a large influence due to fluctuating weather conditions, especially drought plus temperature extremes; however, biofertilizers fostered plant resilience during environmental stress conditions (Kenenbayev *et al*., 2023). Soybean growth, as well as ecological adaptation, did improve because microbial inoculants were in use under saline stress, as per the research on phosphate-solubilizing salt-tolerant bacteria, indirectly supporting healthier crop stands and keeping them less vulnerable to pest outbreaks (Smirnova *et al*., 2024).

In accordance with the experiment scheme on soybean crops, the seeds obtained rehabilitation with the following composition: Arosan w.s.c. (8.0 l/t), Celest top 312.5 s.c. (1.8 l/t), and Extrasol (1.0 l/t). For the crop growing season against weeds, the research used tank mixture Paradox w.c. (0.3 l/ha), Bazagran, 48%, w.s. (1.5 l/ha), Surfactant (0.2 l/ha), as well as growth stimulator Fertisil (0.1 l/ha). As pests (spider mites) appeared, the drug Akarin used had a formulation of 3.6% c.e. (0.15 l/ha), as well as a new biologic, Aktarofit (1.0–3.0 l/ha). The active ingredients of the drug were a complex of natural avermectins, which were produced by beneficial soil fungi *Streptomyces avermitilis*—natural specific neurotoxins, with a lethal contact-intestinal effect on insects. Abamectin (a derivative of avermectins) binds to glutamate-gated chloride channels in invertebrate nerve and muscle cells, causing hyperpolarization, paralysis, and death (Cerna-Chávez *et al*., 2024). As a reference against the seed dressing background, only with the Arosan w.s.c. (8.0 l/t), the same herbicides used had maximum dosages sequentially during the growing season (Table 1).

The applied integrated plant protection system comprising seed disinfectants, herbicides in a tank mixture, and insecticides contributed an additional soybean seed yield (10.9 kg/ha) (Table 1). In contrast, in the reference variants with one of the disinfectants and with separate application of herbicides, the soybean seed yield amounted to 0.44 t/ha. The experimental results showed the expected impact of soybean came from the variants against the background of the developed protective-stimulating composition with the combined use of drugs of various actions with a lower consumption rate versus their individual high dosage. Comparable results were evident in field studies on yellow melilot in the Akmola Region, Kazakhstan, where fertilizers and growth stimulants (Fulvimax N and Gumato Fosfat N) significantly enhanced seed germination, biomass yield, and feed quality under variable climatic conditions (Suraganov *et al*., 2024). The findings further confirmed combining protective and stimulating inputs at optimized rates with reduced input costs and minimized agrochemical load, paralleling the synergistic benefits demonstrated in soybean protection systems.

For air treatment with pesticides, a new service proceeded using a specialized GAIA drone. The said air treatment has several advantages, viz., treatment of areas where access on the ground is difficult and where ground equipment is risky and treatment of plots of any size (from 1 ha). Likewise, the low flight of the processor minimizes losses for the expansion of the drug, and reliable and deep treatment of plants are outcomes. Other benefits include the possibility of night treatment and spot treatment of problem areas, treatment cost per hectare was lower than the treatment cost from an aircraft due to spot application, and minimal losses of the drug. Bioefficacy against spider mites averaged around 85.6% (Table 2). Drone spraying techniques have been remarkable for increased precision, safety, and cost-effectiveness owing to programmable routes, reduced chemical loss, and autonomous operation (Ivezić *et al*., 2023).

Thus, by summarizing the results for 2018–2021, it was evident that in modern technologies for the cultivation of various crops, it is more efficient to use various plant protection products in tank mixtures. These provide several advantages compared with their individual use. In tank mixtures, the reduction in the consumption rate of drugs occurs, which gives significant savings. In a combined application of drugs, the risk of harmful organisms' resistance decreases; additionally, the spectrum of action of drugs

Table 1. Economic efficiency of the integrated protection on the soybean cultivar Turmalin at the Agropark Ontustik - LLP, Almaty, Kazakhstan.

Variants	Yield over replications				Average yield	
	I	II	III	IV	t/ha	Increase (%)
Control (without treatment)	19.9	17.1	19.5	19.5	1.90	-
Arosan, w.s.c. (TRAM *400 g/l*) + Celest top, 312.5 s.c. (Thiamethoxam 262.5 g/l Difenoconazole 25 g/l) + Fludioxonil (25 g/l) + Extrasol (*Bacillus subtilis*) (seed dresser) Paradox, w.c. (Imazamox 120 g/l) + Bazagran, 48%, w.s. (Bentazone 480 g/l) + surfactants + Fertisil (marc of triterpenic acids from Siberian fir greens) (herbicides) + Akarin, 3.6% c.e. (Avertin-N) (acaricide) + Actarophyte (*Streptomyces avermitilis*) (bioinsecticide)	29.7	28.3	29.5	32.1	2.99	57.37
Arosan, w.s.c. (TRAM *400 g/l*) 8.0 l/t + Paradox, w.c. **(**Imazamox 120 g/l), Bazagran, 48%, w.s. (Bentazone 480 g/l) (reference standard)	22.9	23.0	23.2	24.5	2.34	23.16

Table 2. Bioefficacy of drugs against Turkestan spider mite at the Agropark Ontustik - LLP, Almaty, Kazakhstan.

Variants	Replications	The number of pests per 100 plants				Decrease in the number of pests (%)		
		Before treatment	On registration day					
			3	7	14	3	7	14
Control	1	20.2	20.3	17.2	21.4			
	2	15.2	23.4	30.4	16.3			
	mean	17.7	21.85	23.8	18.85	-	-	-
Actarophyte c.e. (*Streptomyces avermitilis*) – 3 l/ha	1	22.4	2.8	3.4	3.0			
	2	19.5	4.3	2.3	2.7			
	mean	20.95	3.55	2.85	2.4	83.7	83.9	84.6
Bitoxibacillin (*Bacillus thuringiensis* var. Thuringiensis) – 1.2 l/ha	1	22.2	4.3	5.1	3.3			
	2	22.2	5.0	5.0	4.1			
	mean	22.2	4.6	5.0	3.7	78.9	78.9	80.3
Actellic 500 c.e. (Pirimiphos-methyl 500 g/l) – 1 l/ha	1	21.6	4.5	3.8	3.6			
	2	23.5	3.4	3.4	2.1			
	mean	22.55	3.95	3.6	2.85	81.9	84.8	84.8
Decis c.e. (Deltamethrin100 g/l) – 0.1 l/ha	1	22.4	2.4	4.2	3.8			
	2	21.3	6.3	5.2	4.3			
	mean	21.85	4.35	4.7	4.05	80.0	80.2	82.9
Vertimek c.e. (Abamectin. 18 g/l.) – 0.3 l/ha	1	22.4	21.5	3.1	3.4	3.3		
	2	21.3	22.6	4.2	3.7	2.0		
	mean	21.85	22.05	3.65	3.55	2.6	83.2	85.0

expands, boosting the effectiveness and period of their action. The costs of growing crops can lessen by combining measures to protect and care for crops, thereby increasing labor productivity and reducing consumption of fuels and lubricants, water, and labor time. From an environmental viewpoint, on the cultivated area, the pesticide load on the environment declines, soil compaction and pollution occur to a lesser extent, with fewer pieces of equipment passing through the field. During the beans' study years, the pest complex revealed that pea aphids and spider mites were predominant. Therefore, by testing pesticides with a different spectrum of action, determining the bioefficacy in the fight against these pests was successful (Table 3).

Table 3. Bioefficacy of drugs in the fight against pests of the bean cultivar Inzhu at the Training and Education Center, Saimasay - LLP, Almaty, Kazakhstan.

Variants	Replications	The number of pests per 100 plants				Decrease in the number of pests (%)		
		Before treatment	On the registration day					
			3	7	14	3	7	14
Against pea aphids								
Control	1	20.2	20.3	17.2	21.4			
	2	15.2	23.4	30.4	16.3			
	mean	17.7	21.85	23.8	18.85	-	-	-
Actarophyte c.e. (*Streptomyces avermitilis*) – 3 l/ha	1	22.1	3.1	2.4	3.3			
	2	22.4	4.2	3.7	2.0			
	mean	22.2	3.65	3.3	2.6	83.2	86.1	85.9
Bitoxibacillin (*Bacillus thuringiensis* var. Thuringiensis) – 1.2 l/ha	1	21.5	2.8	3.4	3.2			
	2	22.6	4.3	2.3	2.7			
	mean	22.05	3.55	2.85	2.95	83.7	83.9	84.3
Actellic 500 c.e. **(**Pirimiphos-methyl 500 g/l) – 1 l/ha	1	21.6	2.9	3.6	2.2			
	2	23.5	3.4	3.0	2.9			
	mean	22.55	3.5	3.3	2.55	83.9	86.1	86.4
Decis c.e. (Deltamethrin100 g/l) – 0.1 l/ha	1	22.4	2.5	3.8	3.6			
	2	19.5	3.4	3.4	2.1			
	mean	20.95	2.95	3.6	2.85	86.4	84.8	84.8
Vertimek c.e. (Abamectin. 18 g/l.) – 0.3 l/ha	1	22.4	2.4	2.2	2.8			
	2	21.3	6.3	6.3	3.3			
	mean	21.85	4.35	4.25	3.05	80.0	82.1	83.8
Against spider mites								
Control (without treatment)	1	22.0	20.1	24.1	21.2			
	2	19.0	17.2	25.2	19.1			
	mean	20.5	18.6	24.6	20.1	-	-	-
Actarophyte c.e. (*Streptomyces avermitilis*) – 3 l/ha	1	17.2	3.8	3.9	2.7			
	2	20.1	4.6	4.3	2.8			
	mean	18.65	4.2	4.1	2.75	77.4	83.3	86.3
Bitoxibacillin (*Bacillus thuringiensis* var. Thuringiensis) – 1.2 l/ha	1	22.3	5.2	4.3	4.5			
	2	20.4	2.1	4.1	2.2			
	mean	21.35	4.6	4.2	3.5	75.2	82.9	82.5
Actellic 500 c.e. **(**Pirimiphos-methyl 500 g/l) – 1 l/ha	1	17.2	2.1	4.2	3.1			
	2	18.1	4.5	2.5	2.2			
	mean	17.6	3.3	3.35	2.65	82.3	86.4	86.8
Decis c.e. (Deltamethrin100 g/l) – 0.1 l/ha	1	23.2	5.2	4.3	4.5			
	2	20.5	3.6	4.1	2.2			
	mean	21.85	4.4	4.2	3.35	76.3	82.9	83.3
Vertimek c.e. (Abamectin. 18 g/l.) – 0.3 l/ha	1	22.3	3.3	3.6	2.3			
	2	20.5	5.2	3.7	2.8			
	mean	20.4	4.25	3.65	2.55	77.2	85.1	87.3

The analysis further revealed the tested drugs emerged to be highly effective in the fight against pea aphids. Therefore, in 2021, with an average population of plants by a pest already on the 14th day after treatment, organophosphate preparations Actellic provided 86.4%, and biologics Actarophyte c.e. showed 85.9% bioefficacy. After treatment, all the preparations retained their toxicity, with no new pea aphid colonization of plants observed. In the number of spider mites, the maximum decrease was visible with the use of insectoacaricides Vertimek c.e. and Actellic 500 c.e. The effectiveness of the biologics Aktorafit and Bitoxibacillin and their higher efficiency were almost close to the typical insecticides

Decis c.e. and did not reduce the number of pests. These high bioefficacy rates align with recent findings in greenhouse studies, where biocontrol programs in combination with selective chemical treatments provided comparable and even better control of aphid and mite pests than by using chemicals only (Adly and Sanad, 2024). Such integration of biologics with conventional insecticides supports sustainable pest management by maintaining efficacy and minimizing environmental impact.

With the colonization of beans by a bean weevil beginning in the field, the effect of the timing of synthetic pesticides' application on latent damage attained studies. Foliar application of plants took place in two terms: in the budding and flowering phases (Table 4). The result revealed the use of all tested preparations also affects the latent damage to the bean grains by the bean weevil. However, the maximum decrease in damage in relation to the control appeared by spraying at the flowering phase. This was because during this period, the bean weevil feeds on flowers, and with pesticide influence, it dies. The use of synthetic pyrethroids at the budding phase reduced the latent grain damage to a lesser extent, and the less effective was Vertimek c.c. In this variant, the grain damage was 24.7% higher than the treatment during the flowering phase. With the use of Decis in the budding and flowering phases, the difference was 11.2%. This may refer to the short protective effect of the drugs (5–7 days). The use of synthetic pyrethroids during the budding phase meant latent grain damage was lesser, and the Vertimek c.c. application damaged 24.7% more than flowering phase treatments, differing in Decis treatments by 11.2%. The short duration of the protective period (5 to 7 days) likely resulted in these outcomes. These results align with the latest past findings showing that pyrethroids, though highly effective initially, often exhibited a rapidly declining residue profile plus limited residual activity. Therefore, their safety range shrinks during key crop phases (Ruberti, 2024).

The effectiveness of the organophosphate preparation Actellic and the biologics Actarophyte c.e. in reducing the bean weevil's latent damage depended, to a lesser extent, on the timing of spraying, and the difference in this indicator ranged from 3.2% to 3.7%. This was probably due to a longer duration of the protective effect (14–16 days) and, secondly, the drug properties. Therefore, by choosing a drug to protect beans from pests, including the bean weevil, it is preferable to use insectoacaricides in the budding phase of beans.

In 2021, along with biological, the detection of the economic efficiency of pesticides on various bean cultivars ensued (Table 5). The results enunciated the maximum bean productivity resulted in the variant where Actellic 500 c.e. (Pirimiphos-methyl 500 g/l) and Actarophyte c.e. (*Streptomyces avermitilis*), characterized by a broader spectrum of action and maximum efficiency, were treatments in the fight against pea aphids in beans. The application of Decis c.e. (Deltamethrin 100 g/l) and Vertimek c.e. (Abamectin, 18 g/l) have not provided a considerable increase in the beans' seed yield. Comparable trends have been evident in integrated pest management (IPM) systems, where mixtures of chemical and biological control agents outperformed the individual treatments. In the field study, by combining insecticide application with the conservation of natural enemies, significantly suppressed the pea aphid populations more effectively than by using chemicals only, thereby enhancing yield outcomes in legume crops (Zhang *et al*., 2023). This supports the synergistic advantage, where the dual-action combination of Pirimiphos-methyl and *Streptomyces avermitilis* surpassed the efficacy of conventional neurotoxic insecticides. Likewise, in the fight against the spider mites in beans, Vertimek c.e. (Abamectin, 18 g/l) and Actellic 500 c.e. (Pirimiphos-methyl 500 g/l) entailed usage, characterized by a broader spectrum of action and maximum efficiency. The use of Decis c.e. (Deltamethrin 100 g/l) did not provide a significant increase in seed yield. Given the fact that the drug does not possess acaricidal properties and the number of mites in this variant approached the control.

Table 4. Reduction of latent grain damage by the bean weevil based on the timing of the preparations used in the bean cultivar Inzhu at the Training and Education Center, Saimasay - LLP, Almaty, Kazakhstan.

Variants	Treatment period	Latent damage (%)	Decrease in relation to control (%)
Control	-	21.5	-
Actarophyte c.e. (*Streptomyces avermitilis*) – 3 l/ha	budding phase	5. 8	73. 1
	after flowering	5.1	76. 3
Bitoxibacillin (*Bacillus thuringiensis* var. Thuringiensis) – 1.2 l/ha	budding phase	6.3	70.6
	after flowering	8.8	59.0
Actellic 500 c.e. **(**Pirimiphos-methyl 500 g/l) – 1 l/ha	budding phase	5. 5	74. 5
	after flowering	4.7	78.2
Decis c.e. (Deltamethrin100 g/l) – 0.1 l/ha	budding phase	8. 3	61. 4
	after flowering	5.9	72. 6
Vertimek c.e. (Abamectin. 18 g/l.) – 0.3 l/ha	budding phase	11.7	45. 6
	after flowering	6.4	70. 3

Table 5. Economic efficiency of various preparations in the fight against pests of the bean cultivar Inzhu at the Training and Education Center, Saimasay - LLP, Almaty, Kazakhstan.

Variants	Yield over replications				Average yield	
	I	II	III	IV	t/ha	Increase (%(
Against pea aphid						
Control (without treatment)	6.8	7.2	6.9	7.5	0.71	-
Actarophyte c.e. (*Streptomyces avermitilis*)	8.3	8.9	8.7	9.3	0.88	23.94
Bitoxibacillin (*Bacillus thuringiensis* var.)	7.8	8.1	8.2	7.9	0.80	12.68
Actellic 500 c.e. **(**Pirimiphos-methyl 500 g/l)	10.1	9.0	9.1	9.0	0.93	30.99
Decis c.e. (Deltamethrin100 g/l)	8.5	8.8	8.3	8.8	0.86	21.13
Vertimek c.e. (Abamectin, 18 g/l.)	7.8	7.9	7.5	7.6	0.77	8.45
Against spider mites						
Control (without treatment)	6.9	6.7	6.9	7.1	0.69	-
Actarophyte c.e. (*Streptomyces avermitilis*)	8.7	8.5	8.2	8.2	0.84	21.74
Bitoxibacillin (*Bacillus thuringiensis* var.)	7.8	7.3	7.5	7.4	0.75	8.70
Actellic 500 c.e. **(**Pirimiphos-methyl 500 g/l)	8.5	8.8	8.6	8.9	0.87	26.09
Decis c.e. (Deltamethrin100 g/l)	7.9	7.6	8.1	8.0	0.79	14.49
Vertimek c.e. (Abamectin, 18 g/l.)	9.3	9.0	8.9	9.2	0.91	31.88

Thus, accounting for the harmfulness of pests, as well as the spectrum of action and efficacy of the drugs from the economic viewpoint, the most advantageous use against the pea aphid was Actellic 500 c.e. (Pirimiphos-methyl 500 g/l) and Actarophyte c.e. (*Streptomyces avermitilis*), and for spider mite, the Vertimek c.e. (Abamectin, 18 g/l) and Actellic 500 c.e. (Pirimiphos-methyl 500 g/l) can be effective. The use of tank mixtures and precise timing of treatments (especially during budding and flowering phases) significantly improved the bean crop yields and reduced the latent damage during storage.

CONCLUSIONS

The presented study identified 55 families of soybean (*G. max* L.) pests and 57 species of bean pests, with the most harmful pests as the two-spotted spider mite, pea aphid, and bean weevil. Seed treatment before sowing effectively reduced wireworms like seedling pests below harmful thresholds. Protective actions work best during the budding phase plus the flowering phase in field trials. The Actellic, Actarophyte, and Vertimek demonstrated the highest efficacy against key pests in this study. The results confirmed integrated use of biologics, as well as selective insecticides, to control the pests in a better way while relying on fewer chemicals. Inference is scarce due to a narrow setting and cultivar set, aggregated multi-year results, and incomplete design/statistical details. The integrated program and application methods are descriptive rather than having rigorous comparisons, and some taxonomy, units, and storage protocols lack standardization. Future work should broaden locations, seasons, and varieties; use fully randomized and powered designs with clear timing; disentangle component effects; and include resistance, non-target, and economic assessments with standardized methods. Future studies must try to work on these limitations, as well as explore using biological defenses more widely for better yield.

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