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Assessment of Spring Wheat Varieties for Pest Resistance

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Abstract: The article is devoted to the study of spring wheat varieties cultivated in the steppe area of North-Eastern Kazakhstan and their resistance to the main pests. The dynamics of the number and phenology of spring wheat phytophages were investigated in relation to the varietal and climatic characteristics of agricultural production. Modern spring wheat varieties' resistance to the main pests was evaluated in the area of study for the first time. In the course of studying the harmfulness of pest complexes for the studied varieties, three-point mobile scales were used for the first time. They made it possible to identify patterns of varieties damage according to different pest numbers. Reliable differences of nine varieties with respect to the uptake of spring wheat by major pests, as well as their harmfulness, were established. 'Triso', 'Likamero', and 'Kurier' varieties with group resistance to them were identified. An economic evaluation of resistant spring wheat varieties was provided. The study used a three-point evaluation method with moving score limits to identify spring wheat varieties that were settled and damaged by pests. It enables the estimation of varieties with different background densities of insects and the comparison of data from different soil-climatic zones. The analysis of the obtained results confirms the high economic efficiency of pest-resistant varieties cultivation and the role of these varieties in the phytosanitary stabilization of agrobiocenoses and environmental protection. The results of the research could be used in the zoning of spring wheat varieties. Identified cultivars with group-based pest resistance might be used as donors for new breeding varieties.

Keywords: Spring Wheat, Variety, Pests, Harmfulness, Damage, Economic Efficiency

Introduction

The study of crop varieties' resistance to the most important pests is essential for predicting losses from harmful organisms, organizing protective measures in the varieties' cultivation, and reducing pesticide usage. In recent years, the range of spring wheat varieties cultivated in the North-East of Kazakhstan has expanded significantly (Reckling *et al*., 2018; Pelekh, 2022). Intensive type of modern varieties is characterized by increased productivity, high quality, and flavoring properties (Costanzo and Bàrberi, 2014; Bedoussac *et al*., 2015; Shaykhutdinov *et al*., 2023). However, they are often not resistant to pests and this contributes to the accumulation of insects in agrobiocenoses (Hussain *et al*., 2022; Milosavljević *et al*., 2017; Wielkopolan *et al*., 2022). In this regard, it is necessary to search for varieties that combine pathogen and pest resistance with high productivity and grain quality. This requires a long-term assessment of their pest resistance in region-specific soil, climatic, and weather conditions.

As a result of unsustainable land use, an imbalance of beneficial and harmful organisms was observed in crops during the last decade (Ualiyeva *et al*., 2022). New pests, previously observed but not economically significant, tend to emerge. This situation requires the cultivation of resistant varieties and their systematic organization based on integrated group resistance to pests and diseases (Medvid and Havryliuk, 2020; Kauppi *et al*., 2021). According to the modern plant protection strategy, the development of ecosystems that are resistant to biotic stress and characterized by optimal phytosanitary status and varietal resistance to pests is significant today (Keler *et al*., 2023).

Varieties that are characterized by group resistance are the most valuable in terms of plant protection, as they reduce the number of treatments and pollution of the environment by pesticides. In the course of resistance to a sunn pest, they allow almost completely excluding the treatment of crops, limited to cases of mass reproduction of other pests (Grettenberger and Tooker, 2017; Kheirodin *et al*., 2022). This will increase the role of natural entomophages and create conditions for the phytosanitary stabilization of agro landscapes (Crespo-Herrera *et al*., 2013; Saska *et al*., 2021). If the ecological situation of agro-landscapes is stabilized, then the transition to adaptive agriculture based on a significant restriction of pesticide use through the restoration of natural regulatory mechanisms becomes more feasible (Kong, 2014; Lamichhane *et al.*, 2015).

Plant resistance to diseases and pests is an important factor in improving crop yields and stability (Wenda-Piesik *et al*., 2016; Wielkopolan *et al*., 2018; Sharma *et al*., 2020; Kolombar and Maslova, 2020). Developing ways to effectively address this issue is of great economic importance. The development of pest-resistant varieties is the most effective way to protect crops by guaranteeing the environment`s stabilization and allowing a drastic reduction in pesticide use (Hýsek *et al*., 2019; Dam *et al*., 2020; Mustarin *et al*., 2021). According to a strategy of adaptive crop production and phytosanitary stabilization of agricultural landscapes, it is important to study the resistance of varieties to unregulated (weather, soil, and climatic conditions) and regulated environmental factors (agricultural practices in the cultivation process) (Jalli *et al*., 2021; Zholaman *et al*., 2022; Serrão *et al*., 2022; Yang *et al*., 2023; Hamid, 2023). There is no doubt that in order to overcome the influence of unregulated conditions, it is necessary to create varieties with high ecological plasticity and, in relation to regulated conditions, to study and find the best ways of increasing sustainability on the basis of appropriate agricultural techniques (Yang *et al*., 2014; Huang *et al*., 2014; Arif *et al*., 2022; Kosová *et al*., 2022).

The most important methods that eliminate and limit the harmful activity of insects are the selection and introduction of undamaged, slightly damaged, and resistant to damage varieties into production (Yusov *et al*., 2021). The creation and introduction of production varieties that are resistant to damage is a radical and beneficial method of protecting crops from losses caused by pests (Krut, 2022). Therefore, in recent years, great importance has been attached to the resistance of crop varieties, which is considered the most important biological property of plant organisms and plays a major role in plant protection systems (Evseev *et al*., 2021).

The problem of grain crops' resistance to pest damage is becoming increasingly important. The task of providing pest-resistant varieties of agricultural crops is entrusted to breeding centers. These breeding institutions in Kazakhstan are experiencing a clear deficit of sources and donors of resistance to especially dangerous pests and diseases in combination with economically valuable traits (Askhadullin *et al*., 2022). Therefore, the isolation of immunologically valuable source material in the wheat gene pool is one of the most urgent tasks of pest-resistant wheat breeding (Pobereżny *et al*., 2023). In the course of the task's implementation, great responsibility is assigned to entomologists and breeders, who must participate in all stages of the selection process together with specialists of different profiles (Nelis *et al*., 2020).

Thus, the goal is to assess the stability of modern spring wheat varieties against the complex of phytophages in the conditions of North-Eastern Kazakhstan, to identify varieties with group-based resistance to them, and to justify the economic efficiency of their cultivation.

The following tasks were defined for the realization of the goal: To study the degree of spring wheat varieties` colonization by pests; to study the influence of growing seasons` meteorological conditions on the dynamics of pest number and phenology in agrobiocenoses of spring wheat; to assess the harmfulness of the main pests of spring wheat on the studied varieties; to identify varieties that are relatively resistant to damage, including those with group resistance; and to evaluate the economic efficiency of cultivation of pest-resistant spring wheat varieties.

Research studies on the resistance of modern varieties of spring wheat cultivated in the steppe zone conditions of North-Eastern Kazakhstan using three-point mobile scales were conducted for the first time. The research results could be used in the regionalization of spring wheat varieties. The identified varieties with group resistance to pests could be used as donors in the selection of new varieties.

Materials and Methods

Material

The objects of our research were natural populations of pests of grain crops and nine varieties of spring wheat ('Likamero', 'Triso', 'Uralosibirskaya', 'Omskaya 35', 'Omskaya 36', 'Omskaya 38', 'Kurier', 'Kazakhstanskaya 15' and Pavlodarskaya Yubileinaya'), which were seeded in the crops of environmental variety trials in North-Eastern Kazakhstan. The degree of occupation and damage of studied spring wheat varieties by sunn pests (Eurygaster integriceps), wheat thrips (Haplothrips tritici), wheat aphids (Schizaphis graminum), cereal leaf beetles (Oulema melanopus), and wheat stem sawflies (Cephus pygmaeus) was assessed.

Methods

The studied varieties were cultivated on plots of 100 m^2 in a three-fold repetition during 2021-2022. Laboratory and field methods were used. Phenological observations were made and the following main pests were counted: Sunn pests (*Eurygaster integriceps)*, wheat thrips *(Haplothrips tritici)*, wheat aphids *(Schizaphis graminum)*, cereal leaf beetles *(Oulema melanopus)* and wheat stem sawflies (*Cephus pygmaeus).* Methods recommended for pest-resistance assessments of cereal breeding material were used (Luo *et al*., 2023).

Pests were counted using quantitative methods (Moskvichev *et al*., 2015). We used an aerial insect net to count pests in the upper layer of the grass stand. A standard net (hoop diameter 30 cm, receiving bag depth 60 cm, handle length 1 m) was used. The net was swung 10 times over the upper part of the grass stand without interruption. Then its contents were transferred from the net and the number of insects was counted. Ten series of sweeps were made so that their total number reached 100 in several places in the study area. Relatively large and sedentary pests living on plants and in the soil were enumerated at test sites of 0.25 m^2. A light frame 50 cm in length and 50 cm in width was placed at three plot points (at the beginning, middle, and end). The number of insects was evaluated according to the number of specimens per 1 m^2, assuming that 100 swings of the net are about 40.2 m^2.

The harmfulness of sunn pests (*Eurygaster integriceps*) was determined by the manifestation of ear leucochroism. The percentage of damaged stems in 4 samples was calculated on a 0.5 m row, evenly taken on the plot during the early grain-filling stage. Detecting the number of wheat thrips (*Haplothrips tritici*) was started from the stem elongation stage by opening 30 stems of each variety weekly. After the heading stage, imago and larvae of wheat thrips (*Haplothrips tritici*) on the ears of spring wheat were considered by taking samples of 10 ears in three simultaneous tests from the plots in each repetition. The ears were cut and placed in sealed paper bags. Then they were fixed in the lab in a drying cabinet at 60°C for an hour. Then the number of thrips imago and larvae in the sample was enumerated. Surveys were conducted once a week, from the beginning of the heading stage to the complete ripening of the grain.

The number of wheat aphids (*Schizaphis graminum*) was enumerated by counting the number of species on the stem in the period of stem elongation stage, taking three samples at the same time from 10 stems of extreme and middle rows of each plot. Accounting was conducted once every 5-7 days. According to the size of necrotic spots on the flag leaves (as a percentage of the leaf area), the relative harmfulness of aphids by variety was visually observed.

The number of cereal leaf beetles (*Oulema melanopus*) larvae is determined by frame. The harmfulness of cereal leaf beetles (*Oulema melanopus*) larvae were estimated in the percentage of damaged leaves and surface of the flag leaf at the milky-wax ripeness stage. Binoculars were used to determine the degree of leaves pubescence of different varieties. The percentage of the stems inhabited by wheat stem sawflies (*Cephus pygmaeus*) was determined by opening 100 stems taken at different points of the plot at the milky-wax ripeness or complete ripeness stages.

Laboratory and field assessments of pest severity were supplemented by laboratory analyses of grain damage. The degree of wheat grain damage by sunn pests (*Eurygaster integriceps*) and wheat thrips (*Haplothrips tritici*) was identified. Grain damage by bugs was detected in grain samples after harvester threshing and individual threshing of ears (ISO 950, 1979), simultaneously analyzing two samples each of 50 grains. Grain damage by Sunn pests (*Eurygaster integriceps*) was established in points on a 5-point scale by the method of the All-Russian Research Institute of Plant Protection. In the course of detecting grain damage by wheat thrips, methodical developments of Moskvichev *et al.* (2015) were used, according to which the pest damage is determined by the degree of expanded groove of kernels compared to intact grain.

The content and quality of crude protein in the grains of tested varieties were determined at the Research Laboratory of Phytosanitary Diagnostics and Forecasts of Novosibirsk State Agrarian University (NSAU). The harmfulness of wheat stem sawflies (*Cephus pygmaeus*) in relation to different varieties was assessed by the level of weight reduction of 1000 grains from ears damaged by the pests in comparison with the weight of grains obtained by threshing intact ears (Janusauskaite *et al*., 2022).

The proposed three-point evaluation method of varieties for resistance to pests with moving score limits was used for the comparative estimation of varieties according to settling and damage by pests. This method divides varieties into three groups: Resistant (1 point), moderately resistant (2 points), and non-resistant (3 points) (Table 1). In the group of compared varieties, the points advantage is determined by the average values of the characteristics and $LSD_{0.5}$ (Mukhina, 2007).

In the course of the varieties` evaluation, we rely on indicators of maximum colonization or damage by the respective pest species. Resistant varieties were those with a lower colonization or damage index in relation to the difference between the feature average value (Sx) and $LSD_{0.5}$. Moderately resistant varieties were indicated in the range from (Sx + $LSD_{0.5}$) to (Sx – $LSD_{0.5}$). Non-resistant varieties were classified as cultivars with traits greater than the sum of the average value (Sx) and $LSD_{0.5}$ (Mukhina, 2007).

Table 1: Method of calculation of the point limits for assessing the pest resistance of crop varieties

Varieties group	Resistant	Moderately resistant	Non-resistant
Points	1	2	3
Trait values	< (Sx - $LSD_{0.5}$)	(Sx - $LSD_{0.5}$)-(Sx + $LSD_{0.5}$)	> (Sx + $LSD_{0.5}$)

This method was used to classify varieties into resistant, moderately resistant, and non-resistant, especially when there are a large number of varieties under test and could be used for different crops. Limits between groups vary depending on the data obtained, which demonstrated varieties` mobility. The use of moving limits for resistance characteristics allows the comparison of resistance evaluations of varieties with different pest abundance backgrounds and in different climate zones over the years.

In the course of assessing the harmfulness of the most important pests of the studied varieties, a method of determining the total yield losses of cultivars by comparing the productivity (mass of 1000 grains) of intact and pest-damaged grain was used. The total yield loss was determined by the next formula:

$$L = 1 - \left(1 - L_1\right) \times \left(1 - L_2\right) \times .... \times \left(1 - L_n\right)$$

where,
L = Total loss percentage
$L_1 .....L_n$ = Losses because of harmful objects' impact, expressed in fractions of a unit (Mukhina, 2007)

In our calculations: L_1-loss of grain mass from damage by bugs and larvae of sunn pests (*Eurygaster integriceps*); L_2 - loss of grain mass because of plant damage by wheat thrips (*Haplothrips tritici*); L_3-loss of grain mass because of damage by wheat stem sawflies (*Cephus pygmaeus*).

Decreases in grain quality due to damage by sun pests (*Eurygaster integritsps*) were determined by the amount and quality of crude protein in grain samples at the research laboratory for phytosanitary diagnostics and prognosis of Novosibirsk State Agrarian University (NSAU). The economic evaluation of the efficiency of the cultivation of resistant spring wheat varieties was carried out using a common methodology (Titkov and Baykasenov, 2014). Research results were processed by methods of dispersion and correlation-regression analyses.

Characteristics of the Studied Varieties

Spring wheat varieties of Kazakh breeding (‘Kazakhstanskaya 15’, ‘Pavlodarskaya Yubileinaya’) and foreign breeding (‘Likamero’, ‘Triso’, ‘Uralosibirskaya’, ‘Omskaya 35’, ‘Omskaya 36’, ‘Omskaya 38’, ‘Kurier’) were used for the research.

'Likamero' variety breeder is Secobra Recherches (France); its parentage is (Hanno × Devon) × (STRU689 × Quattro). The variety is lutescens. This variety is characterized by rapid development in the early phases, good resistance to lodging, very high resistance to spikelet fusariosis, root rot, powdery mildew, and brown rust is affected poorly, and high protein content in the grain. This is a compensatory type, which forms its harvest by having a high ear and 1000 grains weight, the vegetation period is 72-97 days, and it is moderately drought-resistant. Baking qualities are good, can be sown in early terms, and not afraid of early spring frosts.

The breeder of the 'Triso' variety is Deutsche Saatveredelung AG (Germany); its parentage is Kadett × Weihenstephan Stamm. Variety is lutescens. This variety is characterized by good lodging resistance, the period of vegetation is about 85-90 days, baking quality is good, moderately susceptible to brown rust, powdery mildew, and strongly susceptible to smut. It is an intensive type of variety, double-root, that is, when sown in the fall, develops as a winter form, when sown in spring as spring, which provides the variety with high adaptive properties. It can be sown as early as possible to achieve high tillering, the variety is not afraid of frost.

The breeders of the 'Uralosibirskaya' variety are the Federal State Budgetary Scientific Institution "Siberian Research Institute of Agriculture" and LLC "Agrocomplex 'Kurgan Semena'" (Russia). Variety is lutescens. The vegetation period is 78-93 days, and drought resistance is good. It is moderately susceptible to leaf rust, susceptible to smut, and powdery mildew, and strongly susceptible to root rot. In field conditions, it is strongly affected by smut and *septoriosis*. 'Uralosibirskaya' variety is resistant to adverse environmental factors, thanks to the thick straw, has a high tolerance to lodging, and a high percentage of preservation of the stem.

The breeder of the 'Omskaya 35' variety is the Federal State Budgetary Scientific Institution "Omsk agricultural research Centre" (Russia). The variety is *lutescens*. Its vegetation period is about 87-90 days. Tolerant to lodging, moderately drought resistant. Moderately susceptible to brown rust, susceptible to dusty mildew, strongly susceptible to hard smut, stem rust, powdery mildew, and root rot. The 'Omskaya 35' variety has a high potential yield and forms high-quality heavy grains. Because of the high productivity in combination with resistance to diseases and lodging, this variety can successfully compete with varieties of similar ripeness groups.

The breeders of the 'Omskaya 36' variety are the federal state budgetary scientific institution "Siberian research institute of agriculture" and LLC "Agrocomplex 'Kurgan Semena'" (Russia). Variety is *lutescens*. The vegetation period is 75-86 days. A high-yielding, plastic variety of the steppe ecotype, coarse-grained, drought and heat-resistant, tolerant to diseases, lodging, and shedding. It is responsive to the increased agricultural background, retains quality when overgrows, forms grain with excellent baking qualities

The breeders of the 'Omskaya 36' variety are the federal state budgetary scientific institution "Siberian research institute of agriculture" and LLC "Agrocomplex 'Kurgan Semena'" (Russia). Variety is *lutescens*. The vegetation period is 76-99 days, ripens 2-3 days after standards. Resistance to diseases and pests: Moderately susceptible to brown rust, susceptible to powdery mildew, *septoriosis*, root rot, common bunt, strongly susceptible to dust bunt. It is resistant to adverse abiotic environmental factors. The variety forms high-quality grain because it has a high yield potential.

The breeders of the ‘Kurier’ variety are Federal State Budgetary Scientific Institution “P.P. Lukyanenko national grain centre” and federal state budgetary scientific institution "Ershov Experimental Station of Irrigated Agriculture, Research Institute of Agriculture of the Southeast" (Russia). Variety is *lutescens*. The vegetation period is 76-88 days, with middle ripening. Against the background of artificial infection, it is resistant to stem rust and powdery mildew. Moderately resistant to brown rust and head blight. Moderately susceptible to yellow rust and *septoriosis*. The main advantage of the 'Kurier spring wheat variety is a high and stable yield in both favourable and extreme weather conditions.

The breeders of the 'Kazakhstans kaya 15' varieties are LLP "Kazakh Research Institute of Agriculture and crop production” and LLP “Pavlodar Research Institute of Agriculture” (Kazakhstan). Variety is *lutescens*. The vegetation period is 85-90 days. It is resistant to lodging, preharvest germination of grain. The variety is tolerant to drought and brown rust.

The breeder of the ‘Pavlodarskaya Yubileinaya’ variety is LLP “pavlodar research institute of Agriculture” (Kazakhstan). Variety is *lutescens*. It is a medium maturing type, resistant to lodging and pre-treatment germination of grain. The variety is drought-tolerant.

Agroclimatic Features of the Research Area

The main feature of the region's climate is extreme continentality: Long and cold winter (5-5.5 months), and hot and short summer (3 months). Adverse weather factors include late spring and early autumn frosts, insufficient and unstable rainfall, strong winds, dust and sand storms, and severe frosts in winter (ACGPR, 1958).

The area is characterized by a lack of rainfall and low relative humidity in spring and the first half of summer, maximum precipitation in the middle of summer, high summer and winter temperatures, late spring and early autumn frosts, and high wind activity during the year. The minimum temperature is in January-February, where the average temperature in January is minus 18-19°C. The maximum temperature is identified in June-July, whereas the average temperature in July is 19-20°C. The average annual rainfall is 275.5 mm, sometimes more than 300 mm.

Vegetation is represented by forb-feather associations; there are some aspen and birch forest outliers. Soil covering is represented by southern black soil; more often, they are solonetzic and solodised, forming complexes and combinations with solonetz and meadow-chernozemic solonetzic soils, occurring in depressions. The presence of complexes with solonetzic soils creates heterogeneity and spotting in the fields, which leads to the uneven appearance of seedlings and thinning of crops.

Research Period

The studies were conducted on an experimental field of spring wheat («Zhumabek Agro» seed farming-steppe zone of North-Eastern Kazakhstan) during the growing seasons of 2021 and 2022.

Results

Meteorological Conditions of the Growing Seasons

The region of North-East Kazakhstan during the spring wheat growing season in 2021 was characterized by the following climate indicators. The average temperature in May was 14.5°C and thus 1.3°C above the long-term average temperature. The rainfall amount per month was about 28.8 mm, which is 18% above the standard. Precipitation was characterized by uneven rainfall during the month and relative humidity of about 47%.

June was characterized by moderate temperatures; the monthly average temperature was 19.5°C, which was 0.2°C below the long-term average. During the month, the amount of precipitation increased to 51.3 mm, which is 30% above the norm. Rainfall was characterized by an uneven pattern of precipitation during the month and 52% relative humidity. In July, the monthly average temperature was at the level of 21°C, the amount of precipitation was only slightly higher than the total precipitation in June by 1.3-52.6 mm, and the monthly average relative humidity was 60%. In July, sharp fluctuations in temperature indicators were clearly visible, especially in the second decade. The rest of the time the temperature regime was relatively stable. In August, temperature indicators were close to the average (monthly temperature 19.4°C), which exceed the long-term average by 1.6°C. Rainfall for the month -34.1 mm, which is 9% less than normal. Precipitation was unevenly distributed.

The 2022 growing season was characterized by the following meteorological conditions. In May 2022, the temperature regime was quite moderate. So, that daily average temperature was about 17.5°C, which is 4.3°C higher than the long-term average temperature. The first and third ten days of the month were characterized by relative stability in the temperature regime, while the second decade was accompanied by fluctuations in temperature indicators. The whole month was characterized by a lack of precipitation, while the average amount of it was 12 mm with a relative humidity of 38%.

June was marked by a gradual increase in temperature with an average degree of 18.5°C. The first and second decades of June were characterized by temperature drops, while the third decade showed a relatively stabilized temperature regime. The amount of precipitation increased by up to 30 mm, which also led to a 50% increase in relative humidity. July was characterized by a moderate temperature regime, while the monthly average temperature was 21.5°C and thus 0.8°C above the long-term average. Monthly rainfall dipped to 30 mm, which is 39% less than normal. Rainfall was inadequate and uneven in some areas and relative humidity was indicated at around 55%. In August, there were no sharp changes in temperature: Average temperature -20°C, relative humidity -61%. The amount of precipitation increased in comparison to the previous months and amounted to 52.1 mm.

Meteorological data for the 2021 and 2022 growing seasons are presented in Table 2.

Degree of Spring Wheat Varieties Infestation by Pests

Pest counts were conducted during the growing season, starting from the stage of complete shoots and spring wheat colonization by pests until the full-ripe stage.

In the third decade of May, spring wheat crops started to be colonized by Sunn pests (*Eurygaster integriceps*) (daytime temperature +18°- +19°C). In the first days after the bug's flight to agrocenoses, they were localized in the lower layer of herbage, later in tillering nodes. The bugs became active and began to feed at a temperature of +18°C. At the same time, they damaged plants in the tillering and stem elongation stages by piercing their probosci's plant stems below the ear`s base and sucking out their juices. After settling the crops in 5-12 days, the beetles mated and their eggs were collected in two rows on the leaves of spring wheat. The process of embryonic development lasted on average 6-12 days and larval development 20-60 days. The mass pest fledging coincides with the end of two stages: Milky ripeness and complete ripeness of grain.

The most intensive colonization of cultivated plants by wheat thrips (*Haplothrips tritici*) coincides with the beginning of the heading stage, where the main mass of adults is concentrated. Most commonly, adults fed behind the sheath of the penultimate leaf, sucking the juices from the most tender part of the ear sheath. Oviposition took place in groups of 48, rarely individually, mostly on the inner side of the glumes and on the ear peduncle. The duration of the laying period was 25-35 days. The larvae of *Haplothrips tritici* first fed on the juice of glumes and perianth, then on kernel juice. *Haplothrips tritici* left the ears when wax ripeness began.

Colonization of agrocenoses by wheat aphids (*Schizaphis graminum*) took place during the vegetation period of spring wheat (stem elongation stage) and lasted until the phase of full ripeness. Phytophages were identified in two forms: Wingless parthenogenetic females and winged parthenogenetic females. The insect was found in large colonies, localized on the underside and top of leaves, stems, and behind the leaf sheath. In infected plants, the number of empty spikelets per spike increased, straw weight decreased and grain became puny. In the feeding areas of the aphids, plants became discoloured, leaf tips turned yellow or reddened and leaf edges sometimes bent in. Damaged plants withered and died from severe damage.

Cereal leaf beetles (*Oulema melanopus*) began colonizing wheat crops from the beginning of tillering until the grain ripening stages. The greatest amount of pest infestation occurs in two stages heading flowering and milky ripening of the grain. The main damage to plants` vegetative parts was caused by larvae. Females laid eggs in several pieces in a chain on the leaves' surface. Hatching larvae fed on leaves for 2-2.6 weeks and then pupated.

The main colonization of spring wheat by wheat stem sawflies (*Cephus pygmaeus*) occurred in the course of the stem elongation stage. With the help of a serrated ovipositor, the female made a small incision in the stem under the ear and laid eggs through it. There was one egg per stem. The process of embryonic development lasted 5-10 days, after which the larva, feeding on the inner part of the stem, moved from top to bottom towards the root part. In July, the adult larva reached the level of lower internode, where it pupated and formed a transparent cocoon. In the case of pests, there is a clear correlation of development with certain stages of spring wheat organogenesis. Summer peaks and periods of damage from specialized pests fall mainly on the VII-XI stages of -2022 is organogenesis. Varieties infestation by pests at the most dangerous stages of spring wheat development in 2021presented in Table 3.

‘Likamero’ and ‘Triso’ varieties showed the lowest selectivity towards sunn pests (*Eurygaster integriceps*). The most attractive varieties for sunn pests (*Eurygaster integriceps*) were 'Uralosibirskaya', 'Kurier', 'Kazakhstanskaya 15', and 'Pavlodarskaya Yubileinaya'. 'Omskaya 35', 'Omskaya 36', and 'Omskaya 38' varieties were identified as moderately resistant to colonization by sunn pests (*Eurygaster integriceps*).

Differences between the varieties in terms of attractiveness for the process of wheat thrips (*Haplothrips tritici*) development were most evident in the different numbers of larvae during milky ripeness. It was found that ‘Likamero’, ‘Triso’ and ‘Kurier’ varieties were resistant to colonization by thrips (*Haplothrips tritici*); ‘Uralosibirskaya’, ‘Omskaya 35’, ‘Omskaya 36’, ‘Omskaya 38’ - moderately resistant; ‘Kazakhstanskaya 15’, ‘Pavlodarskaya Yubileinaya’ - non-resistant.

Table 2: Meteorological conditions 2021 and 2022 growing seasons

Month	Average temperature, °C				
	Long-time average	2021	Deviation	2022	Deviation
May	13,2	14,5	+1,3	17,5	+4,3
June	19,7	19,5	-0,2	18,5	-1,2
July	20,7	21	+0,3	21,5	+0,8
August	17,8	19,4	+1,6	20	+2,2
Month	Precipitation, mm				
	Long-time average	2021	Deviation	2022	Deviation
May	24,4	28,8	+4,4	12	-12,4
June	39,3	51,3	+12	30	-9,3
July	54	52,6	-1,4	33	-21
August	37,4	34,1	-3,3	52,1	+14,7

Table 3: Varieties infestation by pests at the most dangerous stages of spring wheat development in 2021-2022

	Sunn pests, sp./m^2		Wheat thrips, sp./ear		Wheat aphids, sp./stem		Cereal leaf beetles, sp./m^2		Wheat stem sawflies, sp./m	
Varieties	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
'Likamero'	0,1	4,3	9,3	15,6	5,2	5,5	0,9	0,9	13,1	13,4
'Triso'	0,5	4,2	8,5	8,5	5,5	8,5	0,9	0,9	8,4	9,0
'Uralosibirskaya'	1,0	6,7	20,7	28,3	8,5	10,7	1,2	1,2	12,0	12,2
'Omskaya 35'	1,2	5,8	25,6	32,3	8,5	12,8	2,8	1,8	13,1	14,2
'Omskaya 36'	1,1	5,4	24,2	30,1	8,7	10,6	2,7	2,2	12,9	13,4
'Omskaya 38'	0,7	5,3	21,4	27,4	7,5	15,5	1,1	1,1	12,5	12,9
'Kurier'	0,9	7,3	8,7	15,5	5,5	6,7	0,9	0,9	8,4	9,9
'Kazakhstanskaya 15'	1,8	6,0	35,6	45,3	13,5	18,3	1,5	1,5	12,0	13,1
'Pavlodarskaya Yubileinaya'	1,7	5,6	36,4	52,7	10,2	20,2	1,7	1,7	11,5	12,2
Sx	1,0	5,6	21,2	28,4	8,1	12,1	1,5	1,4	11,5	12,3
$LSD_{0.5}$	0,38	0,71	7,6	10,1	3,1	3,6	0,86	0,54	2,7	1,64

In the case of mass reproduction of wheat aphids (*Schizaphis graminum*) during the milky-wax ripeness, pest infestation levels ranged from 5.2-20.2 species on stems of different varieties (Table 3). The resistant varieties were 'Likamero' and 'Kurier', which showed the lowest cultivars infestation in 2022, but these varieties showed moderate resistance to this type of phytophage in 2021. 'Triso', 'Uralosibirskaya', 'Omskaya 35', 'Omskaya 36', and 'Omskaya 38' varieties were classified as moderately resistant. 'Kazakhstanskaya 15' and 'Pavlodarskaya Yubileinaya' varieties were identified as not resistant, because of the maximum settlement and reproduction of wheat aphids (*Schizaphis graminum*). 'Pavlodarskaya Yubileinaya' variety showed moderate resistance to wheat aphids (*Schizaphis graminum*) colonization in 2021.

In the course of the milky ripeness stage, cereal leaf beetles (*Oulema melanopus*) larvae of older age (2-3 years old) were found, which completed the diet before going into the soil to pupate. 'Omskaya 36' and 'Omskaya 35' varieties were non-resistant to cereal leaf beetles (*Oulema melanopus*) settlement. 'Likamero', 'Triso', 'Uralosibirskaya', 'Omskaya 38', 'Kurier', 'Kazakhstanskaya 15' and 'Pavlodarskaya Yubileinaya' varieties were moderately colonized by cereal leaf beetles (*Oulema melanopus*). Varieties sparsely occupied by cereal leaf beetles (*Oulema melanopus*) were not identified.

Depending on the degree of damage by wheat sawflies (*Cephus pygmaeus*), studied varieties were also divided into 3 groups: 'Triso', 'Kurier' resistant varieties; 'Likamero', 'Uralosibirskaya', 'Omskaya 36', 'Omskaya 38', 'Kazakhstanskaya 15', 'Pavlodarskaya Yubileinaya' - moderately resistant; 'Omskaya 35' non-resistant, but this variety showed moderate resistance in 2021.

Two varieties ('Likamero' and 'Triso') were the most resistant to all studied pest species. 'Kurier' was relatively resistant to three pests. There was a tendency for similarity in cultivar selectivity between wheat thrips (*Haplothrips tritici*) and wheat sawflies (*Cephus pygmaeus*). 'Omskaya 38' and 'Uralosibirskaya' varieties showed moderate resistance to all investigated spring wheat phytophages. Based on all cultivars, 'Omskaya 35' and 'Omskaya 36' varieties showed resistance to cereal leaf beetles (*Oulema melanopus*) and 'Omskaya 35' to wheat sawflies (*Cephus pygmaeus*) in 2022. Some varieties ('Kazakhstanskaya 15' and 'Pavlodarskaya Yubileinaya') showed a lack of resistance to complexes of pest species. However, these cultivars showed moderate resistance to cereal leaf beetles (*Oulema melanopus*) and wheat sawflies (*Cephus pygmaeus*) (Table 4).

Assessment of spring wheat varieties' resistance to pest infestation (2021-2022 annual average) is presented in points in Fig. 1.

Table 4: Comparative pest infestation of spring wheat varieties in 2021-2022

Varieties	Plant infestation in points									
	Eurygaster integriceps		*Haplothrips tritici*		*Schizaphis graminum*		*Oulema melanopus*		*Cephus pygmaeus*	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
'Likamero'	1	1	1	1	2	1	2	2	2	2
'Triso'	1	1	1	1	2	2	2	2	1	1
'Uralosibirskaya'	2	3	2	2	2	2	2	2	2	2
'Omskaya 35'	2	2	2	2	2	2	3	2	2	3
'Omskaya 36'	2	2	2	2	2	2	3	3	2	2
'Omskaya 38'	2	2	2	2	2	2	2	2	2	2
'Kurier'	2	3	1	1	2	1	2	2	1	1
'Kazakhstanskaya 15'	3	2	3	3	3	3	2	2	2	2
'Pavlodarskaya Yubileinaya'	3	2	3	3	2	3	2	2	2	2

Note: Symbols: Resistant varieties - 1; moderately resistant varieties - 2; non-resistant varieties - 3

Table 5: Pest damage of spring wheat varieties in 2021-2022

Variety	*Eurygaster integriceps*		*Haplothrips tritici*	*Schizaphis graminum*	*Oulema melanopus*	*Cephus pygmaeus*
	Stem damage, %	Grain damage, %	Grain damage, %	Leaves damage /leaf area, %	Leaves damage, %	Stem damage, %
'Likamero'	2,95	5,0	29,7	13,5/0,09	21	13,6
'Triso'	2,88	4,9	26,7	13,5/0,10	17	11,4
'Uralosibirskaya'	5,11	9,0	31,5	24,3/0,31	24	10,9
'Omskaya 35'	3,52	8,0	31,7	25,5/0,30	35	13,9
'Omskaya 36'	3,46	7,0	30,4	24,6/0,29	34	13,4
'Omskaya 38'	3,42	7,0	31,6	18,7/0,25	25	12,8
'Kurier'	3,02	7,75	27,6	12,5/0,08	18	9,0
'Kazakhstanskaya 15'	5,23	9,75	33,1	25,5/0,31	21	12,1
'Pavlodarskaya Yubileinaya'	3,31	5,5	35,6	17,5/0,28	22	11,8
S_x	3,7	7,1	30,9	19,5	24,1	12,1
$LSD_{0.5}$	0,63	1,4	1,9	6,4	6,13	1,5

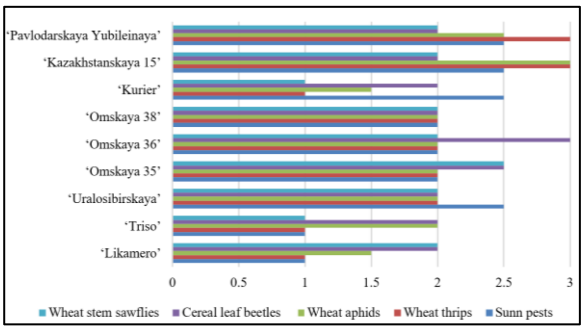

Fig. 1: Assessment of spring wheat varieties' resistance to pest infestation (2021-2022 annual average)

Harmfulness of Spring Wheat Phytophages

In the course of studying varieties for resistance to pests, a number of anatomical and morphological characteristics of the studied varieties, as well as their nature and degree of damage by phytophages, were analyzed.

The average degree of damage to the examined varieties stems by the sunn pests (*Eurygaster integriceps*) for 2 years varied in grades from 2.88% to 5.23% (Table 5). Varieties differed significantly in the degree of grain damage, although second-class damage generally predominated. Some varieties showed low grain damage and others were high. The average grain damage over 2 years was 7.1% (Table 5). Varieties slightly damaged by sunn pests (*Eurygaster integriceps*) may be varieties whose grain was not mostly damaged (1 point). Heavily damaged varieties were treated preferentially with grain damage (3 points). These are such varieties as 'Uralosibirskaya' and 'Kazakhstanskaya 15'. The moderately damaged varieties were 'Omskaya 35', 'Omskaya 36', 'Omskaya 38', 'Kurier', and 'Pavlodarskaya Yubileinaya' (Fig. 2).

'Triso' and 'Kurier' varieties were the most resistant to wheat thrips (*Haplothrips tritici*) damage. 'Likamero', 'Uralosibirskaya', 'Omskaya 35', 'Omskaya 36', 'Omskaya 38' varieties were moderately damaged. In the case of 'Kazakhstanskaya 15' and 'Pavlodarskaya Yubileinaya' varieties, the grain was strongly damaged by thrips (*Haplothrips tritici*).

Table 5 shows flag leaf damage by wheat aphids (*Schizaphis graminum*) in 2021-2022 (in % and by size of necrotic spots on them). 'Kurier' variety differed in the least leaf damage (up to 13.1%). Leaves of the other examined varieties ('Likamero', 'Triso', 'Uralosibirskaya', 'Omskaya 35', 'Omskaya 36', 'Omskaya 38', 'Kazakhstanskaya 15' and 'Pavlodarskaya Yubileinaya') had moderate damage and strong leaf damage was not detected.

Table 6: Calculation of economic efficiency of spring wheat varieties with different resistance to pests

	Variety		
Indicators	Non-resistant 'Pavlodarskaya Yubileinaya'	Moderately resistant 'Uralosibirskaya'	Group-based resistance 'Triso'
Productivity per 1 ha, c	31,6	37,4	41,2
Yield increase per 1 ha, c	-5,5	-	3,7
The income per 1 ha, USD	155,1	183,4	201,7
Labor costs per 1 ha, man/h	12,9	14,2	15,3
Cost of funds per 1 ha, USD	59	61,7	64,5
Cost of 1 c, USD	1,83	1,62	1,54
Profit per 1 ha, USD	96,1	121,7	137,2
Profitability, %	51,6	73,7	87,5

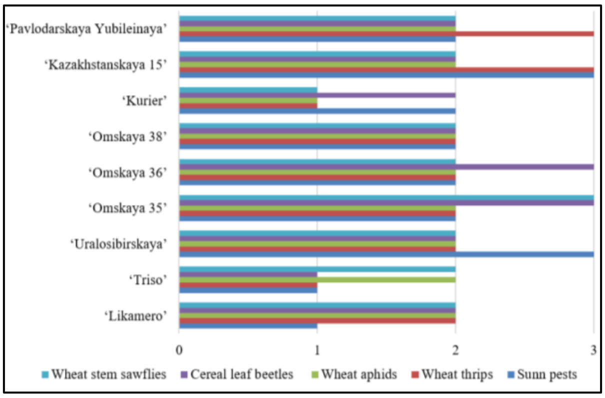

Fig. 2: Assessment of damage to spring wheat varieties by pests (2021-2022 annual average)

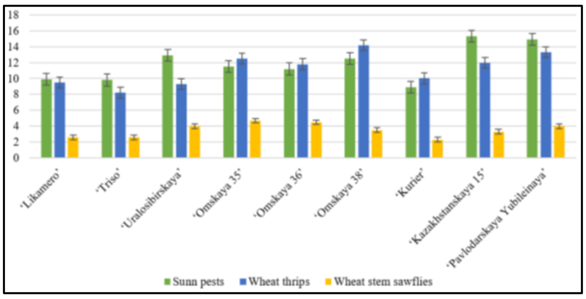

Fig. 3: Harvest losses of spring wheat due to main pests in 2021-2022

Varieties damaged by the larvae of cereal leaf beetles (*Oulema melanopus*) are shown in Table 5, where the percentage of damaged leaves is given. 'Omskaya 35', and 'Omskaya 36' varieties (3 points) were the most damaged by cereal leaf beetles (*Oulema melanopus*). Their larvae moderately damaged leaves of 'Likamero', 'Uralosibirskaya', 'Omskaya 38', 'Kurier', 'Kazakhstanskaya 15' and 'Pavlodarskaya Yubileinaya' varieties (2 points). The highest resistance to damage from this pest was shown by the 'Triso' variety (1 point) (Fig. 2).

'Kurier' variety was the most resistant to wheat sawflies (*Cephus pygmaeus*). 'Likamero', 'Triso', 'Uralosibirskaya', 'Omskaya 36', 'Omskaya 38', 'Kazakhstanskaya 15' and 'Pavlodarskaya Yubileinaya' varieties were moderately damaged. These varieties possessed a high degree of performance in terms of straw parenchyma, strength, and thickness of the straw walls. The most damaged variety was the 'Omskaya 35'.

Assessment of damage to spring wheat varieties by pests (2021-2022 annual average) is presented in points in Fig. 2.

Harvest losses of spring wheat due to the main pests in 2021-2022, shown in Fig. 3. Grain mass loss from sunn pests damage (*Eurygaster integriceps*) ranged from 8.9-15.3%, indicating varying degrees of damage and resistance of cultivars. Calculation of 1,000-grain mass loss data for wheat thrips damage showed that the average grain mass loss from wheat thrips (*Haplothrips tritici*) damage was 3.7-6.5 grams per 1,000 grains. In percentage terms, it was between 8.2 and 14.2%. The mass loss of damaged grain by wheat sawflies (*Cephus pygmaeus*) was 1.2-2.16 g per 1000 grains, or 2.3-4%, depending on the variety.

According to the average yield of the tested varieties, 44 c/ha would mean a loss of 0.15-0.23 c/ha or 15-23 kg of grain per ha. A field size of 100 hectares results in a grain yield loss of 15-23 c. In these calculations, we did not take into account the yield reduction due to the harmful activity of cereal leaf beetles (*Oulema melanopus*), wheat aphids (*Schizaphis graminum*), and other spring wheat pests.

Economic Efficiency of Resistant Spring Wheat Varieties Growing

Calculation of the profitability of growing varieties according to their yield without the use of special measures to protect against pests and diseases is presented in Table 6. Moderately resistant and pest-resistant varieties were compared to non-resistant varieties.

The level of resistant varieties' profitability to spring wheat pests according to the example of the 'Pavlodarskaya Yubileinaya' variety was 51.6%. The profitability of the 'Uralosibirskaya' variety (moderately resistant variety) was 73.7%, while the same characteristics of varieties with high resistance, for example, the 'Triso' variety showed a high result of 87.5%.

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Discussion

Dynamics of the number of sunn pests (*Eurygaster integriceps*) during two years of research was characterized by a slight increase. The maximum density of bugs was up to 6.7 sp. per m^2, on average 5.6 sp. per m^2. The relatively high background count of sunn pests (*Eurygaster integriceps*) in 2021-2022 contributes to the reliable identification of resistant spring wheat varieties. The dynamics of the number of sunn pests in different years was determined by an expression of stability. Adverse hydrothermal conditions for the population appear in spring, in the course of bug flow, and massive laying of eggs in summer when the larvae hatch and feed. In general, hot and dry weather in the steppe zone of North-Eastern Kazakhstan contributed to the growth of the sunn pests (*Eurygaster integriceps*) population.

Wheat thrips (*Haplothrips tritici*) had close ontogenetic synchrony with the development of crop plants. We noted the most intense pest reproduction in 2022. The number of thrips larvae (*Haplothrips tritici*) in one ear ranged from 8.5 to 52.7 species.

In general, weather conditions during the research period did not contribute to the development of wheat aphids (*Schizaphis graminum*). Their numbers of wheat were low, reaching 8.1 species per year in 2021 and 12.1 species per year in 2022. Grain leaf beetle (*Oulema melanopus*) overwinters in soil and under plant residues and activates quite late in May (in our research area). However, the maximum infestation of spring wheat crops was identified in some vegetation phases (heading-flowering and milky ripeness stages). During the years of research (high temperatures), a decrease in the number of larvae of grain leaf beetle (*Oulema melanopus*) and, at the same time, an increase in their harmfulness were observed.

The trend toward numerical superiority of grain sawflies (*Cephus pygmaeus*) continued in the research area. The average population of stalks was 11.5% in 2021 and 12.3% in 2022. Thus, there were no significant differences in the larvae number of grain sawflies (*Cephus pygmaeus*) in these years, although an increasing trend can be observed.

The resistance of spring wheat varieties to pest infestation showed the following results on average in 2021-2022: Two varieties (‘Likamero’ and ‘Triso’) were identified as resistant to sunn pests (*Eurygaster integriceps*), three varieties (‘Likamero’, ‘Triso’, ‘Kurier’) to wheat thrips (*Haplothrips tritici*) and two varieties (‘Likamero’ and ‘Kurier’) to wheat aphids (*Schizaphis graminum*). The varieties were found to be resistant to cereal leaf beetles (*Oulema melanopus*), but at the same time, two of the varieties ('Triso', 'Kurier') were identified as resistant to grain sawflies (*Cephus pygmaeus*).

In the course of selecting varieties for a particular climatic zone and managing them, the species composition of the dominant pests and the attractiveness of the varieties to them should be taken into account. In areas, where sucking pests, such as wheat thrips (*Haplothrips tritici*) and wheat aphids (*Schizaphis graminum*) are the most dangerous, it is not necessary to plant ‘Kazakhstanskaya 15’ and ‘Pavlodarskaya Yubileinaya’ varieties.

Most of the examined varieties were at risk of being damaged by wheat aphids (*Schizaphis graminum*). In those years when the number of aphids (*Schizaphis graminum*) is expected to increase, it can be recommended to plant varieties that are less colonized by aphids (‘Likamero’ and ‘Kurier’). According to the estimation of the relative occupancy of the cultivars, this provides an indirect indication of the nutritional benefit for the studied pests. This makes it possible to create targeted varieties with group resistance to colonization by wheat thrips and aphids.

The most important pest among all phytophages that damage crops is a sunn pest (*Eurygaster integriceps*), which is characterized by the highest harmfulness among other bugs (Nawaz *et al*., 2019). The productivity of spring wheat plants damaged by Sunn pests is greatly affected by the timing of the onset of heading and damage to the plants. It is known that during the stem-elongation stage, a high number of bugs can reduce the amount of yield to 75% (Li *et al*., 2021).

There is no clear correlation between varieties damaged by Sunn pests (*Eurygaster integriceps*) and their ripeness, height, colour, and other habitual and ontogenetic traits. The average degree of stem damage ranged from 2.88 to 5.23% for 2 years. The grain damage varied in the range of 4.9-9.75%. Damage of 'Uralosibirskaya' and 'Kazakhstanskaya 15' was significantly strong (3 points). Slight grain damage (1 point) was observed for the 'Likamero' and 'Triso' varieties. Moderate damage (2 points) was identified for 'Omskaya 35', 'Omskaya 36', 'Omskaya 38', 'Kurier', and 'Pavlodarskaya Yubileinaya'. Thus, 7 of the 9 cultivars showed relative resistance to damage by sunn pests (*Eurygaster integriceps*).

Wheat thrips (*Haplothrips thrtici* Kurd.) is a widespread wheat pest, particularly numerous in the steppe zone of North-Eastern Kazakhstan. Wheat was damaged by both adult thrips and their larvae (Ivanchenko and Shevyakhova, 2022; Zhichkina *et al*., 2021; 2023). Adult insects cause damage during the period of wheat stem elongation-heading. However, the main damage to wheat crops was caused by larvae of wheat thrips (*Haplothrips tritici*) (Ualiyeva *et al*., 2022). Larvae damage grains during their development, so some compensation for losses by plants is possible at the organism level (Li *et al*., 2021).

The results of our study showed that ‘Triso’ and ‘Kurier’ varieties were the most resistant to wheat thrips (*Haplothrips tritici*) damage, while 'Likamero', 'Uralosibirskaya', 'Omskaya 35', 'Omskaya 36', 'Omskaya

38' varieties were moderately damaged. The grain of 'Kazakhstanskaya 15' and 'Pavlodarskaya Yubileinaya' varieties were mainly damaged by thrips.

The morphological barrier expressed in the ear structure is the main resistance barrier for spring wheat. A high spike density maintains a more resistant grain to aphids (Pucherelli *et al*., 2012). We assessed the resistance of varieties to aphids (*Schizaphis graminum*) by the number of inhabited varieties, as well as by the number and size of necrotic spots on the flag leaf of plants. According to our studies, leaves of 'Kurier' were the least damaged (up to 12.5%). The leaves of other varieties were moderately damaged. Strong leaf damage in the studied varieties was not detected.

Among the varieties we examined, cultivars with strong resistance to grain leaf beetle (*Oulema melanopus*) were not found, apparently due to the low expression of their anatomical-morphological characteristics of resistance. Field, or actual damage and resistance of variety, is the result of the influence not only of the variety properties but also many environmental factors, starting with the number of pests in agro biocenosis, the presence of their entomophages, the ontogenetic coupling between variety and pest in a given year and others (Ualiyeva *et al*., 2022). It can be concluded that anatomical-morphological resistance traits of the investigated varieties in combination with other environmental factors led to an average (2 points) damage of the plants by larvae of cereal leaf beetles (*Oulema melanopus*). This suggests that breeders should consider these plant traits when breeding cereal leaf beetles (*Oulema melanopus*) resistant varieties.

Our investigations showed that the studied varieties differed significantly in the degree of plant damage, although overall damage predominated in the second point. Some varieties showed low, others high grain and leaf damage.

In general, calculations of cumulative harmfulness from thrips, sunn pests, and grain sawflies, fluctuations in grain yield losses ranged from 20.6-32.2% of their mass by variety. Grain damage caused by Sunn pests (*Eurygaster integriceps*), wheat thrips (*Haplothrips tritici*), and grain sawflies (*Cephus pygmaeus*), which leads to a significant deficit even without regard to the quality of production. The smallest losses from the complex of three pests were identified for 'Triso', 'Likamero', and 'Kurier' varieties, while the largest for 'Kazakhstanskaya 15' and 'Pavlodarskaya Yubileinaya'.

Thus, 'Likamero', 'Triso', and 'Kurier' varieties can be recommended for introduction as they are the most resistant to spring wheat pests damage. Predicting the damage of the studied varieties, we can conclude that 'Kazakhstanskaya 15' and 'Pavlodarskaya Yubileinaya' varieties were the most attractive and favorable for the development of pests in the steppe zone of North-East Kazakhstan. They were actively settled by the three main pests (Sunn pests (*Eurygaster integriceps*), wheat thrips (*Haplothrips tritici*), and wheat aphids (*Schizaphis graminum*)) in 2021-2022.

It makes economic sense to cultivate resistant spring wheat varieties that do not require pesticides in order to achieve sufficiently high yields. The profitability of grain production is 87.5%. According to the profitability indicators, in the area of our research, cultivating resistant varieties because of their high productivity is more cost-effective.

In the course of the need to protect crops of non-resistant varieties from pests, cultivation costs will increase significantly, which will reduce profitability without a significant yield increase from pest control. Thus, the cultivation of resistant spring wheat varieties that do not require the use of pesticides to produce high grain yields is economically feasible. According to the ecological point of view, widespread cultivation of resistant varieties makes sense and is effective, as it contributes to stabilizing the phytosanitary situation in the agrobiocenoses. When pesticide use is reduced, beneficial entomofauna in agrobiocenoses of wheat and adjacent crops reduce pest abundance. Establishing a controlled phytosanitary environment in the agricultural landscape will facilitate the transition to agrarian landscape farming based on the sustainability of agroecosystems.

The studies were conducted in natural conditions without creating a provocative background. These studies are the basis for the breeding of spring wheat varieties with group resistance to pests, where we plan to create an infectious background in the future, which will allow us to determine the degree of the wheat breeding material`s susceptibility.

Conclusion

Nine spring wheat varieties were studied, two of which were resistant to colonization by Sunn pests (*Eurygaster integriceps*), three varieties of wheat thrips (*Haplothrips tritici*), two varieties of wheat aphids (*Schizaphis graminum*) and two varieties to grain sawflies (*Cephus pygmaeus*). Seven of the tested varieties showed moderate resistance to cereal leaf beetles (*Oulema melanopus*). These varieties were resistant to cereal leaf beetles, so the latter were not found in agrocenoses.

'Triso' variety was characterized by group resistance to colonization by Sunn pests (*Eurygaster integriceps*), wheat thrips (*Haplothrips tritici*), and grain sawflies (C*ephus pygmaeus*) in 2021-2022. ‘Likamero’ variety possessed group resistance to Sunn pests (*Eurygaster integriceps*) and wheat aphids (*Schizaphis graminum*). ‘Kurier’ variety was resistant to colonization by wheat thrips (*Haplothrips tritici*) and grain sawflies (*Cephus pygmaeus*).

Sunn pests (*Eurygaster integriceps*) and wheat aphids (*Schizaphis graminum*) affecting ‘Triso’ and ‘Likamero’ varieties were found to cause the least damage. The most resistant to damage from wheat thrips (*Haplothrips tritici*) were 'Triso', 'Kurier', and 'Likamero' cultivars. 'Triso' and 'Kurier' varieties were identified as resistant to damage by cereal leaf beetles (*Oulema melanopus*). 'Kurier', 'Uralosibirskaya', and 'Triso' varieties were resistant to grain sawflies (*Cephus pygmaeus*).

Minimal crop losses due to damage from sunn pests (*Eurygaster integriceps*), wheat thrips (*Haplothrips tritici*), and wheat sawflies (*Cephus pygmaeus*) indicated for 'Triso', 'Kurier', 'Likamero' varieties. The grain production profitability of resistant varieties is 87.5% due to the additional cost savings by pest control.

The cultivation of resistant spring wheat varieties that do not require the use of pesticides in order to stabilize the phytosanitary situation in agrobiocenoses is ecologically justified and contributes to the preservation of useful entomofauna and environmental cleanliness.

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Author’s Contributions

Rimma Meyramovna Ualiyeva: Participated in all experiments, coordinated the data analysis and contributed to the writing of the manuscript.

Mariya Mikhailovna Kaverina: Determined the degree of spring wheat varieties occupation by pests, analyzed the resistance to main pests in the conditions of the study area and contributed to the technical editing of the manuscript.

Lyubov Nikolaevna Ivanko: Determined the damage of grain and vegetative parts of wheat and evaluated the harmfulness of the most important pests on the examined spring wheat varieties during the research years.

Sayan Berikovich Zhangazin: Determined total crop losses for each variety; conducted an economic evaluation of the efficiency of cultivation of resistant spring wheat varieties.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all other authors have read and approved the manuscript and no ethical issues have been involved.

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