Effective protection of grain crops from pests

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Abstract. Plant protection products are currently the main part of crop cultivation technologies not only in the Krasnoyarsk territory, but also around the world. The most promising way to protect plants from pests is an integrated system that involves the use of chemical control agents only in cases where the pest population exceeds the economic threshold, and the effectiveness increase of natural mechanisms for regulating the number is carried out using agro-technical and biological methods of pest suppression. As a result of the conducted research, it was revealed that protective measures allowed to reduce crop losses by 10-15%. During the study period, all pests recorded on grain crops (excluding cereal flies) did not exceed the threshold of harmfulness, but it is necessary to take into account their complex impact on the crop and especially grain pests (aphids, thrips and grain large nutmegs), which revealed themselves massively and spread more widely in grain crops. Pests of ear and grain, cereal aphids and wheat thrips exerted the greatest harmfulness in the experiment especially in the background with zero tillage.

1. Introduction

Crop losses from pests that damage the photosynthetic surface and generative organs of wheat plants are mainly determined by the degree of damage to plants and their resistance to damage [3, 4]. The extent of plant damage depends primarily on the pest ability to populate and damage the plant. It is known that insects damage all the organs of plants of ear crops. Insect species that damage leaves, ears, and grain of these crops are of great economic concern [5, 9]. The photosynthetic surface of plants (leaves, glumes, spikelet awns) is damaged by imago of snapping beetles, stem and striped bread fleas, cereal leaf beetles, wheat and other thrips, caterpillars, etc. Grain, ovaries, and flowers are damaged by caterpillars of cereal leaf beetles, larvae of wheat thrips, Swedish flies, and sharp-headed bugs [6, 10].

It is known that technological methods of crop cultivation have a great influence on the number and harmfulness of insects [7, 8]. In this regard, the development of special agricultural technologies should take into account the complex impact of all natural and anthropogenic factors, since due to the interaction of these factors, biological diversity at the intraspecific and interspecific levels is formed [9].
2. The purpose of the research
Is the effective protection of grain crops from a complex of pests based on phytosanitary monitoring in the forest-steppe zone of the Krasnoyarsk territory.

3. Materials and methods
Monitoring of the number and harmfulness of the complex of grain crops pests was carried out in a multi-factor production experiment in the “Minderlinskoye” agricultural educational farm, in Sukhobuzimsky district. The scheme of the experiment included: control and variants with Dividend Star, Dialen Super, Topic, N (30 active substance/ha) N60P30K30. The listed variants were separately treated with a fungicide (Alto Super, emulsion concentrate 0.5 l/ha) and a tank mixture of it with an insecticide (Tank mixture fungicide +insecticide – Alto super, emulsion concentrate 0.5 l/ha + Tsunami, emulsion concentrate 0.1 l/ha).

This scheme of experiments was superimposed on the background of dump (winter plowing – in autumn, harrowing and sowing – in spring) and zero (sowing – in spring on the stubble of the previous crop) soil treatments.

In the experiments, varieties of spring wheat were sown, and recording was carried out during the entire growing season. The seeding rate was 180 kg of seeds per 1 ha. Sowing was carried out in the third decade of May, using the AGROMASTER seeder (pointed coulter with a 12 cm wide sowing belt) in a unit with the MTZ-1221 tractor.

The prevalence and harmfulness of insects was determined by special surveys of soils and cultivated crops. The quantitative recording of pests was carried out and the degree of damage to grain crops was determined. Using quantitative accounting, the population of soils and plants by pests was determined and the authors considered the number of specimen per plant, per 1 stalk, per 1 m² in points. Records and observations were made during the growing season using generally accepted methods and existing State Standards [1, 2].

4. Research results
Grain crops were populated by adult insects, since insects in the larval stage are unable to migrate over long distances. Imagines of many insect species not only performed the function of dispersal, but also caused significant damage to the grain and leaves of ear crops. Only a few insects (large nutmegs, Swedish flies, Meromyza) did not harm in adulthood.

Before the damage, the plants were populated with larvae or adult insects. In some species of pests (imago and larvae of sharp-headed bugs, grass bugs, cicadas, imago of the striped bread flea, cereal leaf beetle), the pest stage inhabited the plant for a very short period (from a few minutes to several hours), in others (caterpillars of younger ages of large nutmegs, aphids, larvae of barley and wheat miners, cereal leaf beetles) – for a longer period, sometimes until the end of the pest stage development.

Many types of pests (bread bugs, adult caterpillars of large nutmegs, cereal leaf beetle imago, bread striped flea, ground beetles, bread beetles) inhabited the area of sowing for a long period of time, not the plant itself. In this case, the connection with a particular plant was short-term. The size of this area was determined by the migration abilities of the pest stage, the presence of suitable plant organs for population, temperature, humidity and light in the stem density.

In different types of insects, damage to plants largely depends on the structure of the oral apparatus and the age of the pest. Species with a gnawing mouth (cereal leaf beetles, bread striped fleas, gray large nutmegs), damaged the plant (or organ) more than species with a sucking mouth (thrips, aphids, cicadas, bread bugs). At the same time, the age of the harmful stage was of great importance. Older larvae caused more damage to the plant or organ than younger larvae, and adults usually caused more damage than larvae.

The degree of pest exposure to the plant depended on the characteristics of the damaged organs and the phase of plant development. The death of plants when the leaves were destroyed by insects was observed during the period of germination – tillering. Within the booting stage of the plant, even with
severe damage to the leaves by cereal leaf beetles, aphids, cicadas, striped bread flea, plant death was rarely noted.

Acceleration in the development of plants and reduction of damage has a clear relationship with the fertilizing. Nitrogen fertilizers (especially in high doses) slowed down the passage of plant development phases, lengthened their vegetation, and increased the damage rate of aphids, cereal leaf beetles, gray large nutmegs, and other pests. With increased doses of full fertilizer (N, P, K), damage by some pests, such as thrips, was reduced. And in this case, the break in the conjugate phases of the plant development and the insect adapted to feeding on it is one of the ways to reduce the level of plant damage.

The degree of plant resistance to damage depends on: the phase of plant development during their damage; the role of damaged organs in crop formation; the intensity of damage and the nature of their distribution in the crop; the duration of the damage period; the growing conditions of crops (moisture, temperature, nutrients, stem density, crop contamination).

The reaction of plants depends on the intensity of damage. In weak damage, the photosynthesis and growth processes of damaged organs increase in comparison with intact ones; in strong damage, these processes are inhibited and plants are oppressed. The earlier damage to plants occurs, the more structural elements of the crop it affects.

When determining ETH (economic thresholds of harmfulness), it is necessary to take into account crop losses, the costs of organizing and conducting control, as well as the environmental consequences of using pesticides. Experiment has shown that the introduction of economically justified thresholds of harmfulness has reduced the volume of chemical treatments by 1/3, while the number of species of phytophagous insects against which extermination measures were recommended has decreased several times.

According to the results of studies conducted during the study period, 18 main insect species that are trophically associated with spring wheat crops belonging to 7 families of 4 orders of the Insecta class were identified.

The collected material identifies a complex of insects that damage spring wheat during the entire growing season. It includes 5 species, among which the following ecological groups were distinguished: leaf-eating, intra-stem, sucking and grain pests.

Colonization of spring wheat crops began in mid-June and lasted until the end of August.

After the emergence of seedlings (the first decade of June) and before the beginning of tillering (the third decade of June), the growth in the number of pests was relatively low. During this period, representatives of the families: Chrysomelidae, Chloropidae, and Anthomyidae were recorded in seeding. The striped bread flea was one of the first from leaf-eating insects to appear, but in the case when sowing was rather late, the damage caused by it was insignificant. Later, spring flies and stem fleas appeared in the crops.

In late sowings, these pests rarely significantly damaged the crop, since the flight of the spring fly occurred at the beginning of the third decade of May and it usually flew to earlier crops. Stem fleas also preferred to have additional feeding and produced egg laying on earlier spring wheat seedlings.

During the full tillering phase (the third decade of June), the first Swedish flies were found on the crops. These were the latest of the intra-stem pests in the Krasnoyarsk forest-steppe. They damaged the main stem, but mostly settled in the secondary stems, and if by the time they appeared the plant had passed the “vulnerable phase”, they willingly colonized wild cereals: oatmeal, meadow grass, cock’s-foot grass, and others.

The next increase in the number of phytophagous insects was observed during the spring wheat booting phase. At this time, representatives of the orders Homoptera and Thysanoptera, as well as the family Chrysomelidae were recorded on crops. Thrips imagos were registered on the crops during the culture booting phase (the second – the third decades of June). They fed on the vegetative parts of plants, sucking the sap from the stems and leaves of plants. The thrips imago stage harmed plants until the earing phase, and then during the grain filling phase, thrips larvae colonized the ear. They fed by sucking out the growing grain of spring wheat.
Individual species of cereal leaf beetle were detected on crops. This pest is characterized by a pronounced cyclical increase in numbers and this usually occurred four years later on the fifth. The rest of the time, its population is small.

During the period of flowering and filling of grain on spring wheat, representatives of the families Cicadelidae and Delphacidae were noted, most often it was a six-point cicada, less often a dark cicada. Their number in the Krasnoyarsk territory has never exceeded the critical level, and the harmfulness is not expressed. There is an increase in the number of representatives of the Aphididae family – grass aphids.

The last pest from the group of phytophagous insects, a representative of the Noctuidae family, the gray large nutmeg, was registered on spring wheat. Its caterpillars fed on grain, starting from the doughy phase and ending with almost complete ripeness of the grain. The pest appeared more often in years with a limited amount of precipitation during the grain filling period.

The striped bread flea (Phyllotreta vittula) was found in crops at an insignificant level of abundance, the reason for this was, first of all, the late sowing of spring wheat (the third decade of May) and the striped bread flea had its main feeding on wild cereal plants.

Stem bread fleas (Chaetocnema hortensis and Ch. aridula) are among the earliest hidden-stem pests in the Krasnoyarsk territory. Their mass output began in the second decade of May. That is, they had additional nutrition on wild grasses and seeded grasses, partially populated the early crops held at the “Minderlinskoe” agricultural educational farm, and then after laying eggs, they concentrated on seeded grasses and field borders. Some of the insects moved to later crops, where the adults after laying eggs fed on the parenchyma of the young plants leaves.

During the recording of stem fleas, their presence was registered on the variants of the experiment with the use of nitrogen fertilizers. Plants were with more tender covers, not rough, which allowed the pest to get the necessary food quite easily.

In the variants of the experiment without the use of nitrogen fertilizers, the plants had coarser covers and did not attract the pest as a food source. Based on the above, the number of this pest was below the economic threshold of harmfulness (ETH).

The following hidden-stem pests registered on spring wheat crops belong to the Diptera order: grass flies (Phorbia genitalis and Oscinella pusilla). The first of them, the spring fly, began flying from the third decade of May, when the average daily temperatures exceeded +14 °C, a favorable temperature mode contributed to the pest development. Its population in spring wheat crops was focal in nature. Pests populated early seedlings with a well-developed coleoptile. During the beginning of tillering, the plants inhabited by the pest were clearly visible (there was no mass growth of weeds), according to the characteristic signs of the damage pattern, namely, the drying of the central leaf. Despite the focal spread over the crop, in the variants where the pest was detected, the damage to plants was quite significant from 2 to 10%.

Swedish flies, in the conditions of the Krasnoyarsk territory, this is Swedish barley fly (Oscinella pusilla) developed in two generations. The first developed on cultivated cereals, and the second – on wild plants. The pest overwintered in the larval stage and pupated in spring. It appeared to the tillering phase of spring wheat on crops of cultivated plants. The mass death of the pest occurred at the beginning of the third decade of June. This was facilitated by the high average daily temperature and sufficient precipitation, which provided the necessary humidity of the atmospheric air.

Among the variants of the experiment, the pest populated the areas where fertilizers were used. The percentage of infested plants ranged from 3 to 18%; for the most part it was the secondary stems. Most of the damaged plants were marked by a non-soil background. In the analysis of damaged plants the development of an inferior ear (sometimes 5-6 grains), as well as a hollow ear was established. Complete death of stems was also noted.

There was a mass population of crops by grass aphids (Schizaphis graminum) during the period of grain filling. Aphids had colonized the plants of spring wheat, both in the variants with fertilizers and without them. The most numerous colonies were marked against the background of soil-free main tillage. The variety “Novosibirskaya-15” was colonized a slightly smaller. At this time, high average
daily air temperatures and moderate precipitation were observed, which are necessary for the initial period of population. The number of aphids per ear in different experiment variants ranged from 2 to 23 individuals. But the long-term presence of this pest on spring wheat crops was not recorded. So, aphids appeared in the third decade of July, and in the first decade of August the pest practically disappeared. A significant role in this was played by the precipitation of this period, which did not allow the pest to cause significant damage to plants and growing grain. Nevertheless, on plants where the population density was higher, there were external signs of insect feeding, namely, a change in the color of the glumes (from individual spots in the feeding area to whiteness of the glumes from $\frac{1}{4}$ to $\frac{1}{2}$).

The wheat thrip (Haplothrips tritici) was a permanent resident of spring wheat agrocenoses in the Krasnoyarsk territory. It colonized the crops annually, while its number varied within quite significant limits. In the experiment, it ranged from 1 to 29 larvae per ear. However, there was no clear pattern in its distribution. However, the preferred distribution of thrips in the variants of the experiment with fertilization was noted. And for the backgrounds of the main processing, a slightly higher number was noted for plowing.

As noted earlier, plants on backgrounds with nitrogen fertilizers were physiologically more attractive to pests. The flight of adult thrips occurred from the third decade of July to the second decade of August; the temperature and humidity mode of this period was quite favorable for it.

The large nutmeg (Apamea anceps) was also a permanent pest of spring wheat, damaging the grain of plants during the filling period from doughy ripeness to the beginning of full ripeness. Its number was not high, but it caused significant damage to the commercial quality of grain. The first caterpillars were found on spring wheat crops of the "Novosibirskaya-15" variety. The damage to the grains themselves was not as obvious as in the years of mass reproduction; only small parts of the endosperm were gnawed out.

The conducted research indicates that the "Novosibirskaya-15" spring wheat variety has a complex index for variants higher than 1.0. At the same time, the background of the main dump tillage was highlighted; here the complex index had a higher numerical value in almost all variants. It was found that the nature of the damage caused was influenced by the phase of plant development during the period of harmful insect activity. Moreover, in addition to the terms of damage, their multiplicity is important. If one-time damage to plants was largely compensated, the repeated ones, even weak, had a significant negative impact of each damage separately, which led to a decrease in yield.

5. Conclusions

As a result of the conducted research, it was established:

- The following main pests were registered in the experiment crops: striped bread flea (Phyllotreta vittula), stem fleas (Chaetocnema aridula, Ch. hortensis), grass flies (Phorbia genitalis, Oscinella pusilla), grass aphid (Schizaphis graminum), wheat thrips (Haplothrips tritici) and a large nutmeg (Apamea anceps). In small numbers cereal leaf beetles (Cereal leaf beetle melanopus) and cicadas (Macrostelus laevis, Psammotettix striatus) were common. Individual specimens of sharp-headed bedbugs (Aelia acuminate) were also noted.
- The colonization starting time in the spring wheat crops in the experiment was recorded in the period of full shoots – tillering – beginning of booting culture stage (07 June–06 July). Due to earlier shoots, pests first appeared on variants placed on zero tillage.
- The spread of pests on plants (with fixing on them) was recorded during earing – flowering – wax ripeness of the crop (July 05 – August 27).
- The degree of insect pests’ impact on plants was characterized by leaf-eating as insignificant, hidden-stem pests (in some variants) and pests of ear and grain from moderate to severe.
- When colonizing plants and causing them harm, insect pests preferred options for the experiment with the introduction of nitrogen fertilizers and full mineral fertilizer, on all backgrounds of soil cultivation.
Compensatory abilities of plants inhabited by pests were characterized as moderate for the “Novosibirskaya-15” variety.

The pests of ear and grain: cereal aphids and wheat thrips were characterized in the experiment by the greatest harmfulness, especially in the background with zero tillage.

In general, the indicators of the insect population for the experiment variants and varieties of spring wheat for different backgrounds of tillage indicate to the fact that the pests did not exceed the established economic thresholds of harmfulness. Phytosanitary monitoring of grain crops allows to make a forecast of harmfulness and, if necessary, to effectively protect plants from pests, taking into account the economic thresholds of harmfulness and at the same time meeting environmental and economic requirements.

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