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Features of spread and harmfulness of wheat thrips (*Haplothrips tritici* Kurd.) on spring wheat crops and protective measures against them in conditions of North Kazakhstan agricultural experimental station

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Abstract

The article presents the results of phytosanitary monitoring and protective measures against thrips pests on spring wheat crops in the conditions of "North Kazakhstan agricultural experiment station" LLP. In 2019-2020, wheat thrips were the most common and main pest on spring wheat agrocenoses (*Haplothrips tritici* Kurd.). Each of the four identified types of wheat thrips were found in more than 80% of the surveyed areas. Also, the article describes the biology of the pest development, its features in the conditions of Northern Kazakhstan. The harmfulness of the main phytophage – wheat thrips on promising varieties of spring

wheat, as well as their resistance to the studied harmful object, was established. The role of biotic factors and nutritional activity of the main entomophages of wheat thrips was studied. The results on the effectiveness of pesticide treatments against the pest are presented and an assessment of the General phytosanitary situation in wheat agrocenoses is given.

Key words: spring wheat, wheat thrips, harmfulness, resistance, entomophages, chemical treatments, yield.

Аннотация

В статье приведены результаты по фитосанитарному мониторингу и проведенным защитным мероприятиям против вредителей-трипсов на посевах яровой пшеницы в условиях ТОО «Северо-Казахстанская ельскохозяйственная опытная станция». В 2019-2020 годы на агроценозах яровой пшеницы наиболее распространенным и основным вредителем был пшеничный трипс (*Haplothrips tritici* Kurd.). Из 4 выявленных видов трипсов пшеничный трипс встречался на более чем 80% обследуемых площадей. Также, в статье дается описание биологии развития вредителя, его особенности в условиях Северного Казахстана. Была установлена вредоносность основного фитофага – пшеничного трипса на перспективных сортах яровой пшеницы, а также их устойчивость к изучаемому вредному объекту. Изучена роль биотических факторов, пищевая активность основных энтомофагов пшеничного трипса. Представлены результаты по эффективности пестицидных обработок против вредителя и дана оценка по общей фитосанитарной ситуации в пшеничных агроценозах.

Ключевые слова: яровая пшеница, пшеничный трипс, вредоносность, устойчивость, энтомофаги, пестицидные обработки, урожайность.

Introduction

Spring wheat is one of the most important grain crops in Northern Kazakhstan. Getting heavy yields of spring wheat grain is associated with a number of difficulties, primarily due to weather conditions, a decrease of farming standards, the influence of weeds, diseases and pests [1].

Currently, the most promising approach to plant protection from diseases and pests is the biocenotic approach, which involves the combined study of the biology and ecology of populations of dominant species, the features of the functioning of agrocenoses in order to increase their stability, and ensuring an equilibrium state through self-regulation processes [2].

In Northern Kazakhstan, wheat thrips is one of the permanent components of the fauna of harmful insect species, number of them especially increasing in the steppe regions. The area of harmfulness of wheat thrips is very wide. The pest has spread almost everywhere and is found wherever spring and winter wheat is cultivated [3].

Thrips are characterized by a peculiar structure of the wings, legs and mouth parts. This is a small insect, whose body length is usually about 0.5-0.7, very few 5 mm. In many species of thrips, the body is elongated-oval, especially in those who live in hidden places, and in those who live in the axils of cereal leaves, the body is flattened, it consists of three well-separated parts: head, chest and abdomen. The body cover consists of relatively dense chitin; adult insects differ from the nymphal stages by a stronger sclerotization of the cover, the segments of the head are fused together. They have opisthognathous head, the upper side of head much shorter than the elongated back lower part. Compound eyes are located on the sides of the front of the head. Between them there is usually an elevation on which located three simple eyes. The antennae are located at the very front edge of the head. They are always one and a half times longer than the head and consist of 6-9 scapes. The antennae, especially in adults, are richly covered with tactile bristles, rows of small hairs, and sensilla [4-5].

External sexual characteristics – sexual dimorphism in the order Thysanoptera is strongly expressed. Males differ from females in their slimmer body and smaller size. The abdomen of males is almost identical, without significantly expanded segments, as in females [6].

A lot is known about the biology of this pest from the literature [6, 7, 8]. So it is established that in the development cycle of wheat thrips after leaving the egg before fledging, there are five stages – two larval, pronymph and two nymphal. Wheat thrips, like other representatives of the order Thysanoptera, in their biology in the world of living creatures – a unique and inimitable phenomenon. It is a narrow oligophagous. It lives only on winter and spring wheat. This species overwinters as an adult-larva in the soil at a depth of 10-20 cm or in the basal parts of stubble close to the surface. In spring, when the arable layer is warmed up to 10 °C, the larvae rise to the upper layers of the soil, where they turn successively into a pronymph, a nymph, and then into an adult insect. The pronymph is less mobile than the larva. They do not feed, develop latently, morphologically combine the specific features of the dormant stage with adult insects, and do not resemble larvae. The duration of the nymphal phases at a temperature of 20-25 °C in the first pronymph and nymph 2-3 days, the second nymph – from 4 to 6 days.

The age structure of the thrips population at the beginning of the growing season is extremely heterogeneous, so the adult emergence is very long. Some of them fly out at the end of May and populate winter cultures (in the areas of cultivation) and wild cereals. Mass emergence of adults occurs at the beginning of wheat ear formation. During this period, adults account for more than 90% of the total pest population [7].

Soon after settling the crops, the females' mate and lay eggs on the inner side of the spikelet scales in groups of 4-5, in rare cases one at a time. The color of eggs is white or pale orange, oblong in shape, 0.4-0.6 mm long. Egg development takes 6-8 days. Female fertility is 20-25 eggs. Thrips breed more intensively in dry years. In the steppe zone, thrips on wheat crops are significantly more than in the forest-steppe zone. One of the limiting factors of thrips reproduction in the forest-steppe zone is an unfavorable combination of temperature and humidity in the summer-autumn period, which causes fungal diseases of larvae. The color of hatched larvae are greenish-yellow, after a few hours they become reddish, and after the first molt become bright red. By the time of harvest, the larvae descend to the soil and prepare for wintering. During the year, thrips develops in one generation [6, 8].

Plant damage caused by thrips can reduce the yield of spring wheat by 2.0-2.5 c/ha or more. Especially great is the damage in dry years or on bogharic lands, when damage leads to the formation of feeble grain up to 40-50%. Such grain has reduced seed quality and regenerative capacity [6].

Materials and methods of research

The aim of the research was to study the biological characteristics and harmfulness of wheat thrips, as well as to test the most effective and safe methods for controlling it for humans and the environment.

The main biological features of wheat thrips were studied by using the methods of V.I.Tansky (1970), Ju.B. Shurovenkova (1962), V.I.Krivokhizhina, V.A.Korobova (1987), N.I.Kulikova (1999).

The number of adult wheat thrips was taken into account by mowing with a standard entomological net once every 2-3 weeks for the phases of crop development from the third decade of May to mid-September. On each plot were made 10 strokes of the skimming net. In total, during the research period (2019-2020), 20 mowings were sorted and analyzed on 20 plots of spring wheat, where counted about 3 thousand thrips. To obtain data on the absolute number of adult thrips in the phase of stem elongation, it was directly counted on ears in the field. In total, were reviewed about 1000 ears.

The degree of population of the ears of adults, larvae and eggs of thrips, as well as their distribution in the field, was determined by analyzing the ears that were cut in the field

and studied in the laboratory. The ears were taken in the phase of stem elongation, earing, flowering and milk ripeness of the grain. When analyzing the ears, the total number of adults, eggs and larvae of wheat thrips in the sample was calculated and their average number per 1 ear and per 1 m². At the same time, the age composition of thrips populations was determined during this accounting period (the ratio of the number of adults, eggs, and larvae of ages 1 and 2). The live biomass of thrips was determined based on data on their absolute abundance and the average live weight of eggs, adults, and larvae of ages 1 and 2. In 2019-2020, more than 1000 ears were viewed, about 500 adult specimens, 1000 egg specimens, and 700 larvae specimens of 1st and 2nd instars taken from spring wheat fields were weighed.

In this regard, it is necessary to improve methods of dealing with harmful objects and develop new ones that are most effective and safe for humans and the environment.

Among non-chemical methods of protection against pests, the use of varieties resistant to diseases and pests is distinguished by its economic and economic efficiency, reliability and long-term effect. It is generally recognized that the sowing of such varieties serves as the basis for complex methods of plant protection. Non-susceptible varieties limit the spread of pests, which contributes to improving the phytosanitary situation in the fields. As a result, crop losses from harmful organisms are sharply reduced [9-10].

Currently, new varieties of spring wheat such as Astana 2, Omsk 31, Omsk 36, Svetlanka, etc., which are resistant to lodging, drought resistance, tolerance to brown rust, and also have high grain quality, have been introduced in Akmola and North Kazakhstan regions. However, the use of selection and genetic methods in plant protection is still not enough. Taking into consideration that one of the main factors in reducing the quality of the crop is harmful organisms, it is impossible to exclude the possibility of using chemical control over them.

Among the harmful entomofauna of grain crops, the most common and harmful species in the region is wheat thrips.

According to research by B.G. Shurovenkov [7], damage to thrips can reduce the yield by 2.0-2.5 c/ha or more. Especially great is the damage in dry years, when damage leads to the formation of feeble grain up to 40-45%. Such grain has reduced seed quality and regenerative capacity. According to research by V.I. Tansky [8], the decrease in grain mass with weak damage was equal 5.6-7.0%, and with strong damage up to 15.9-31.6%.

Four-year studies of the harmfulness of wheat thrips in southern Ukraine allowed N. P. Dyadechko [11] to establish a certain relationship between the number of thrips per ear at the beginning of the wheat earing phase and the subsequent loss of grain mass. Thus, with an average number of adult thrips per ear of 3-6 pieces, the loss of grain weight was 3.4-6.7%; at 7.2-12.6 pieces – 7.2-9.4%; 13.1-19.7 pieces – 9.8-14.3%; 20.2-29.8 pieces – 14.5-24.5%; and at 30.6-41 pieces – 25.1-30.7%.

Results and discussion

Analysis of the phytosanitary situation of wheat agrobiocenoses conducted in 2019-2020 in the "North Kazakhstan agricultural experiment station" LLP in the North Kazakhstan region shows that grain flea beetle, corn-flies, apamea anceps, and wheat thrips were of economic importance. The last one showed significant damage to spring wheat crops, having a significant impact on reducing the productivity and quality of grain. In General, the species composition of thrips that damage cereals in the Akmola region is represented by a small number of species compared to other regions. In the Kurgan region by B.G.Shurovenkov [7] were founded 22 species of thrips, in Ukraine N. P. in Ukraine, by N.P.Dyadechko [9] were noted 22 species on perennial grasses and 5 species on cereals, in the Saratov region, by L.I.Chekmareva were identified 20 species of thrips from 9 genus and 3 families. It is also known that according to V.I. Tansky's research [8], 23 species of thrips were registered on cultivated cereals in Northern Kazakhstan.

As a result of studying a large number of thrips collected for 2019-2020 on grain crops in the conditions of "North Kazakhstan agricultural experiment station" LLP, we identified 4

types of thrips. The dominant wheat thrips (*Haplothrips tritici* Kurd.) inhabits from 70 to 87% of the surveyed areas of cereals. As one of the main pests of grain crops, including spring wheat in this region, this harmful object is indicated in our previous studies [9-10].

Adults of wheat thrips appeared on the crop of spring wheat in the tillering period. Their average number was 14.6 spec. per 1 plant. The maximum number of adult wheat thrips was observed during the earing phase and was 18.5 spec./plant. Wheat thrips larvae appeared in the flowering phase, numbering 15.6 spec./ear. By middle dough stage, it reached 27.7 spec./ear.

Table 1.
Number of adults and larvae of wheat thrips in spring wheat crops, on average for 2019-2020.

Stage of plant development	Replication				Average number
	1	2	3	4	
Number of adults, spec./plant					
Tillering	17.1	14.7	14.3	13.5	14.6
Stem elongation	21.1	15.8	22.1	26.2	21.0
Ear formation	36.2	14.4	32.0	28.5	27.7
Flowering	4.0	3.1	3.6	3.7	3.6
Least Significant Difference ₀₅					3.9
Number of larvae, spec./ear					
Flowering	14.6	13.7	18.6	15.7	15.6
Early formation of grain	18.0	10.9	14.8	15.9	14.9
Milky stage	23.4	23.1	21.5	23.4	22.8
Middle dough stage	25.5	29.1	26.4	28.3	27.7
Least Significant Difference ₀₅					3.6

The total number of pests on spring wheat crops in the fields of the farm was formed in such a way that led to the need for chemical treatment, that means that the Economic threshold of harmfulness was exceeded. The treatment was carried out in the earing phase with the preparation Engio 247 SC (Thiamethoxam, 141 g/l + lambda-cyhalothrin, 106 g/l), with a norm of 0.15 l/ha.

After the treatment, the number of pests was minimal during the flowering phase, which is understandable, since the maximum effect of the drug lasts 2 weeks.

From the flowering phase to the milky stage of spring wheat, the pest population began to increase. In the phase of middle dough stage of wheat, the number of wheat thrips larvae reached 18.5 spec./ear. However, this situation did not give rise to repeated insecticide treatment.

The count of the number of surviving pests carried out by us two weeks after treatment showed a high biological efficiency of 92.3%. However, taking into account the fact that at the time of accounting after chemical treatment, i.e. during the flowering phase, wheat thrips had already hatched larvae and their number in total with imago increased, in this case, the biological effectiveness of the drug against this species became lower and amounted to 87.5%.

Both adult insects and wheat thrips larvae cause damage to white straw crops. The degree of damage to grain crops is determined by the phase of their development during the fledging period [12].

As mentioned above, thrips prefer to populate crops before plowing. The first thrips feed on wild cereals, perennial grasses, and the bulk of them feed on spring wheat. The harmfulness of thrips in the period of booting and earing of wheat was established. Before earing, they are concentrated at the base of 5-6 leaves, where they feed. As a result, yellow spots appear on the ear wrapper and at the base of the leaf blade. With the formation of a crack in the wrapper, thrips penetrate to the young ear and suck the sap this plants. Their

pricks cause discoloration of the spikelet scales, curvature of the awns, and deformation of the ear.

The effect of thrips on the crop largely depends on the intensity of damage and the number of damaged plants. To assess the intensity of damage plant adult thrips were used: a 3-point scale: one point – slight damage, awns are curled, without white-spiked; two points – the average intensity of damage, awns are curled, partial white-leaved at the very top of the ear; three points – severe damage, awns are curled, white-leaved up to 1/3 or 1/2 of the ear.

In our studies, the implementation of protective measures by a single spraying of spring wheat crops against thrips in the earing phase with Decis Expert, EC with a norm of 0.12 l/ha, with a working fluid flow rate of 200 l/ha had a positive effect on crop yield (table 2).

Table 2.

Effect of treatment with Engio 247, SC on the yield of spring wheat, grade Astana 2, on average for 2019-2020.

Variant	Yield, t/ha				Average yields, t/ha
	Replication				
	1	2	3	4	
Monitoring (without treatment)	1.70	1.60	1.54	1.62	1.65
Engio 247 SC	1.87	1.83	1.84	1.85	1.86
Addition yield, t/ha					0.21
Least Significant Difference₀₅					0.11

From the data in table 2, it follows that in the control, where chemical treatment with insecticide was not carried out, the yield of spring wheat grain was 1.65 t/ha, while the variation in repetitions was from 1.62 to 1.70 t/ha.

In the variant with the use of Decis Expert, EC, the yield increased to 1.86 t/ha, thereby exceeding the control by 0.21 t/ha.

To assess the stability of wheat varieties, used a 5-point scale: 1 point – single specimens, 1-2% of ears; 2 points – 5-15 thrips per ear, 5% of ears; 3 points – 15-40 thrips per ear, 30% of ears; 4 points – 40-50 thrips per ear, 50% of ears; 5 points – over 50 thrips per ear.

Great harm to wheat crops is caused by thrips larvae. After hatching, they feed on the sap of spikelets and flower films, causing their discoloration. Then, as the tissues of these parts of the ear are buried, the larvae move to the forming grain. As a result of injections and sucking, yellow-brown spots of different sizes and shapes appear on it. On the grain damaged by thrips, formed wrinkles and depressions, then the furrow expands and deepens, the back of the grain becomes saddle-shaped.

The damage caused by larvae on ripe grain is clearly visible by the lighter color and roughness in the sucking areas. In the depth of the furrow, the damage retains a white color and on ripe grain. The degree of change in the shape and color of the furrow depends on the degree of damage to the grain.

To determine the stability of spring wheat varieties, grain losses from the harmfulness of thrips were calculated by using the following formula:

$$n = N k_1 k_2 k_3 (m_1 - m_2) / 1000 \quad (1),$$

where n – grain loss, kg/ha; N – plant density per 1 ha; k_1 – productive tilling capacity; k_2 – the number of grains in the ear, pcs. k_3 – the proportion of damaged grains; m_1 – the mass of 1000 intact grains; m_2 – the mass of 1000 damaged grains, g.

As shown by calculations to determine the yield losses of various varieties of spring wheat, the most resistant to damage by thrips should be considered the Astana 2 variety,

which has an ear water content of 35.2 pcs. of grains, as well as the largest grain weight in the ear – 1.315 g. On other subjects the grades Omsk 31, Svetlanka, the figures were respectively 34,0 pieces and 1,211 g, 32,3 pcs and 1,160 g. At the same time, in the Astana 2 variety, the grain was damaged by 18.3%, despite the high number of phytophages during the formation and filling of grain (over 30 copies/ear). The weight of 1000 grains in affected grains decreased by 7.5% (in other varieties – 10.2-11.5%) and grain losses were less-2.1% of the grain yield. Grain losses due to thrips damage in the Astana 2 variety were 1.5-2 times less than in the Omsk 31 and Svetlanka varieties.

The need to protect the environment from pollution requires a comprehensive reduction in the use of pesticides, the conservation and use of beneficial organisms that live in agroecosystems.

Currently, a fairly large complex of predatory parasitic insects is known, contributing to the reduction of the number of phytophages in general and insects with a piercing-sucking mouth apparatus in particular. To them in the first place should include ground beetles, coccinellidae, lacewings, predatory thrips, the aphidius etc. [12].

During all the years of research, beetles of the coccinellidae family appeared on spring wheat when the crop was in the tillering phase. During this period, the number of beetles was small and varied in different years from 0.5 to 1.2 spec./m². Their small number during this period is due to the fact that the number of its main victims (thrips and aphids) on spring wheat at this time is negligible.

In the subsequent phases of wheat development, a gradual increase in the number of coccinellidae was observed on its crops. By the period of earing, the number of coccinellidae increased in and reached up to 3-5 spec./m². The number of thrips also grew. And by the flowering period, the number of coccinellidae increased even more and reached a maximum. This is due to the beginning of hatching of a new generation of larvae.

The calculated correlation coefficients showed that the relationship between the number of thrips and the number of coccinellids was closer than in the case of aphids. Therefore, it can be assumed that thrips are the most preferred feed component for coccinellids than aphids. In addition to aphids and thrips, cicadas can also be a food component for coccinellids, but judging by the close relationship, coccinellids least preferred to eat them.

For other entomophages, a close direct correlation was observed between the number of lacewings and the number of thrips as a food component. A similar pattern was observed for the development phases of spring wheat, in which the largest number of Golden eyes occurred during the flowering period of wheat.

Conclusion

Thus, as a result of studying the distribution and harmfulness of wheat thrips (*Haplothrips tritici* Kurd.) on spring wheat crops in the conditions of "North Kazakhstan agricultural experiment station" LLP on agroecosystems of spring wheat crops, it was established that:

- The dominant wheat thrips inhabits from 70 to 87% of the surveyed areas of cereals.
- thrips prefer to populate spring wheat crops before plowing out. In the years of research, their number was higher than the Economic Threshold of Harmfulness;
- treatment of spring wheat crops in the earing phase with Decis Expert, EC with a norm of 0.12 l/ha reduces the negative impact of wheat thrips on crop productivity and provides a significant increase in yield compared to the control at the level of 0.23 t/ha;
- among the studied varieties of spring wheat, the most resistant to damage by thrips was the Astana 2 variety, in which grain losses were 1.5-2 times lower than in the Omsk 31 and Svetlanka varieties;

- the density of coccinellids and lacewings is a powerful factor limiting the development and reproduction of sucking harmful insects in spring wheat crops.

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