ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Harmful Of Wheat Trips (Haplothrips Tritici Kurd) And Its Food Preferences.

Bakaeva NP[1]*, Nasyrova YG[1], Saltykova OL[2], Korzhavina NY[2], and Mamay OV[3].

[1]Dept of Biological Sciences, Federal State Budget Educational Institution of Higher Education "Samara State Agricultural Academy"
[2]Dept of Agricultural Sciences, Federal State Budget Educational Institution of Higher Education "Samara State Agricultural Academy"
[3]Dept of economical sciences, Federal State Budget Educational Institution of Higher Education "Samara State Agricultural Academy"

ANNOTATION

Investigations of biochemical indicators of wheat grain quality depending on the severity of wheat thrips Haplothrips tritici Kurd. were conducted on the wheat of the species Triticum aestivum of five varieties of soft spring wheat Kinelskaya 61, Kinelskaya 59, Grekum 3152, Kinelskaya 60 and Tulaykovskaya 5, as well as four species of wheat Triticum dicoccum, Triticum spelta, Triticum persicum, Triticum sphaerococcum. Comprehensive biochemical studies were carried out to determine the effect of damage caused by wheat thrips on the protein content and its fractional composition, the content of starch and sugars, the enzymatic activity of proteases and amylases in the grain of varieties and wheat species studied. The damage caused by wheat thrips was determined and evaluated for the biochemical composition of the grain. Based on a comparison of the values of the studied parameters, a carbohydrate orientation in the nutrition of wheat thrips is established. The study of the activity of proteo-, amylolytic enzymes of grain and various degrees of grain damage by wheat thrips suggests that there is an extraintestinal digestion in this pest.

Keywords: grain of five species and five varieties of spring wheat; protein, protein fractions, sugars, starch, proteases, amylases, damage to wheat thrips.

Corresponding author

ISSN: 0975-8585

INTRODUCTION

The real value of wheat grain is largely determined by its quality indicators: technological and baking, which are primarily associated with enzymatic, protein and carbohydrate compounds. Enzymes of grain whose activity affects the transformation of proteins and carbohydrates play an important role. The quality of wheat grain is of great importance in the food industry, and it is important to clarify the physiological and biochemical changes occurring under the influence of the harmfulness of wheat thrips to reveal the mechanisms of biochemical stability of grain and the possibility of its use for bakery [1,2,3,4].

Effective means of improving the quality characteristics of grain is the control of pests and plant diseases. The numerous and widely studied wheat phytophagus - wheat thrips (Haplothrips tritici Kurd.) Has a small size and latent lifestyle at all stages of its development, which are the causes of interest in the study of its biology and ecology [6,7,8]. The conducted studies, as a rule, were aimed at studying the prevalence, seasonal and long-term dynamics of populations of wheat thrips, food relations, relationships with fodder plants and the influence of agrotechnical methods of cultivation on crops [4,5,7]. The issue of changing the biochemical quality of grain varieties, as well as various types of wheat, has not been studied, depending on the varying degree of grain damage by wheat thrips.

MATERIALS AND METHODS

Investigations of biochemical indicators of wheat grain quality depending on the severity of wheat thrips Haplothrips tritici Kurd. were carried out with the help of analytical methods in the Laboratory of Biochemistry of the Department of Chemistry and Biochemistry of the Samara State Agricultural Academy and in the fields of the Povolzhskiy Research Institute of Selection and Seed Growing named after P.N. Konstantinov.

The work was carried out on wheat grains of the species Triticum aestivum - varieties of spring soft wheat Kinelskaya 61, Kinelskaya 59, Grekum 3152, Kinelskaya 60 and Tulaykovskaya 5, as well as wheat Triticum dicoccum, Triticum spelta, Triticum persicum, Triticum sphaerococcum, differing in the morphological structure of the ear, biochemical composition of grain and baking properties, and, consequently, possessing different resistance to pest damage.

The following methods were used for biochemical studies: protein analysis of wheat grain was carried out by two methods, the fractionation of protein substances was carried out according to the method proposed by H.N. Pochinok [9, 10], and for the allocation of total proteins, the method proposed by B.P. Pleshkov was taken [11]. The method of determining the quantitative protein content was the Biuret method (microdefinition). Analysis of carbohydrate complex included colorimetric methods for determination of starch according to H.N. Pochinok [9] and sugars according to A.I. Ermakov [12]. The enzymatic activity of proteases was studied by the method of N.N. Tretyakov [13], and the activity of amylases was determined by the BP method. Pleshkova [10].

The degree of grain damage was determined by the accepted method of V.I. Tanskoy [14].

The obtained data were subjected to statistical processing by the method of dispersion and correlation analysis according to B.A. Dospekhov [15]. Mathematical processing of data was carried out using the Excel software package and the "Statistics Package".

RESULTS AND ITS DISCUSSION

There were comparative studies of biochemical qualitative indicators of the protein content and its fractional composition, starch and mono-, disaccharides, as well as enzymatic activity of proteases and amylases in the grain of the studied species and varieties of wheat, and their changes resulting from malicious damage by wheat thrips

It is considered [16] that in certain years, in a narrower range of conditions, there can be instances of a different correlation between the protein and starch content in the grain. Therefore, the special studies of the protein and starch content in the grain, and for this purpose, the biochemical features of grain quality

were studied: the content of protein and its fractions, starch and sugars, the enzymatic activity of proteases and amylases differing in developmental biology and the quality of the grain of five botanical wheat species and for the species Triticum aestivum - five varieties of soft spring wheat (Table 1).

Table 1: The content of protein and its fractions, starch and sugars in the grain of species and varieties of wheat studied, on average over the study period

Species, varieties of wheat*	Protein, %					Carbohydrates, %		
	albumins	globulins	gliadins	glute-nins	total protein	mono- and disaccha-rides	reducing sugars	starch
Triticum aestivum Varieties								
Kinelskaya 61	2,98	2,88	4,60	3,35	13,8	2,68	0,472	67,1
Kinelskaya 59	2,64	2,30	4,58	3,15	12,7	3,00	0,455	69,7
Grekum 3152	2,88	2,73	4,59	3,10	13,3	3,00	0,453	68,9
Kinelskaya 60	2,89	2,70	4,67	3,41	13,7	2,68	0,474	67,0
Tulaykovskaya 5	2,77	2,73	4,63	3,33	13,5	2,85	0,462	68,0
Average for species	**2,83**	**2,67**	**4,61**	**3,27**	**13,4**	**2,84**	**0,463**	**68,1**
LSD_{05} for wheat species	0,10	0,10	0,08	0,09	0,11	0,15	0,04	0,86
Triticum dicoccum	2,88	2,33	4,89	3,98	14,1	2,68	0,476	66,4
Triticum spelta	2,87	2,84	4,70	3,80	14,2	2,50	0,512	66,2
Triticum persicum	2,73	2,72	4,41	3,47	13,3	2,85	0,464	68,6
Triticum sphaerococcum	2,76	2,72	4,40	3,30	13,2	2,85	0,463	69,6
Average for varieties	**2,81**	**2,65**	**4,60**	**3,64**	**13,7**	**2,72**	**0,479**	**67,7**
LSD05 for wheat varieties	0,10	0,09	0,08	0,10	0,14	0,13	0,04	0,97

As for the protein content the varieties Kinelskaya 61, Kinelskaya 60 and Tulaykovskaya 5, the species Triticum dicoccum and Triticum spelta were the high-protein, they contained it up to 14%. Varieties Kinelskaya 59 and Grekum 3152, species of T. persicum and T. Sphaerococcum accumulated protein less by almost 8%. Over the years of investigation, the starch content was up to 68% for the varieties and types of wheat studied and did not reveal a difference in species and varietal specificity. Kinelskaya 59 and the species T. persicum and T. sphaerococcum were distinguished by the greatest content of starch for the years of research. Against the high protein content, grains of varieties Kinelskaya 61 and Kinelskaya 60, species of T. spelta and T. dicoccum contained less starch, up to 64%,. On the content of protein and starch in the grain of the studied species and wheat varieties, inverse relationships were obtained.

Fractional composition of protein, mono-, disaccharides and reducing sugars were also studied.

All protein fractions can be divided into low-molecular albumins, globulins and high-molecular gliadins, glutenins regarding their molecular weight. In the study of individual protein grain fractions, a higher protein content in the gliadin fractions to 4.6% and glutenins to 3.3% was observed in all the species and varieties of wheat studied. High molecular weight fractions are called gluten proteins, since they form a gluten during dough kneading. During the years of research, the high content of gluten proteins was in Kinelskaya 61, Kinelskaya 60 and Tulaykovskaya 5 and species Triticum spelta and Triticum dicoccum.

Also, on average, over the years of research, the content of mono- and disaccharides in the grain of the wheat varieties studied was up to 2.8%, the content of reducing sugars was 0,46%, and the content of sucrose alone was 1,91%. In the wheat species studied, the content of mono- and disaccharides averaged at the level of the content of these sugars in wheat grains and was 2,7%; reducing sugars were at the level of 0,48%, and the content of individual sucrose was 1,85%, which is almost the same as the results of the varietal analysis. This is a good indication of the quality of these wheat, since in baking, when kneading the dough, when enzymes that break down starch to maltose are inactive, the yeast feed exclusively on the natural sugars of flour [17].

ISSN: 0975-8585

Variability of activity of proteolytic and amylolytic enzymes.

Proteolytic enzymes (proteases) cleave peptide bonds in protein molecules with the formation of peptides and individual aminoacids, which in turn affects the speed of the proteolysis in the bread preparation process, and also facilitates the digestion process during nutrition. Among all wheat varieties studied, the maximum activity of proteases was observed in the grains of varieties Kinelskaya 59 and species T. persicum and T. Sphaerococcum, the minimum value of this index was 1.1 times less in the grain of varieties Kinelskaya 61 and Kinelskaya 60 and in the grain of T. spelta u T. dicoccum, throughout the years of research (Table 2).

Table 2: The activity of proteolytic (E) and amylolytic (mg hydrolyzed starch per 1 g of flour) enzymes in the grain of species and varieties of wheat, on average over the study period

Species, varieties of wheat	Enzymatic activity			
	proteolytic	α-amylase	β-amylase	α-+ β-amylase
Triticum aestivum				
Varieties				
Kinelskaya 61	1,37	20,8	173,2	194,0
Kinelskaya 59	1,54	23,1	153,0	175,9
Grekum 3152	1,47	21,7	157,5	179,3
Kinelskaya 60	1,37	20,8	173,2	194,0
Tulaykovskaya 5	1,48	21,1	169,7	190,8
Average for varieties	**1,45**	**21,5**	**165,3**	**186,8**
Triticum dicoccum	1,36	20,42	179,7	189,1
Triticum spelta	1,38	20,42	179,7	189,1
Triticum persicum	1,48	21,23	166,8	188,1
Triticum sphaerococcum	1,46	21,23	155,1	176,4
Average for species	**1,42**	**20,8**	**170,3**	**186,6**

Dispersion analysis of the data obtained in the experiment with the calculations of the LSD – the least significant difference (05) showed that all the results of the experiments are reliable.

Thus, the variability of the activity of proteolytic enzymes in varieties and species of wheat depends on the genotype and is an indicator of the biochemical quality of the grain.

The relationship between the protein content and proteolytic activity correlates well in varieties and species of wheat, when the greater content of protein substances in the grain corresponds to a lower proteolytic activity and vice versa. This regularity is possible due to an increase in the intensity of grain accumulation of protein substances, which results in a greater compaction of the protein, which is manifested in another property of the grain-vitreousity and proteolytic enzymes that show less activity. In the grain with a high protein structure, a large protease activity is observed.

Amylolytic enzymes (amylases) break down starch into disaccharides and monosaccharides. The amylolytic activity of the grain depends on the accumulation of starch, and if the process is rather intensive, then the grain contains a lot of starch, and its amylolytic activity is low. Under conditions where the grain forms an endosperm with a high degree of vitreousity, it is known to promote the formation of large starch particles. In this case, varieties and species of wheat characterized by high vitreousity and a denser structure of the endosperm (Kinelskaya 60) had higher amylolytic activity values up to 194 mg/g than the Kinelskaya 59 with a loose endosperm structure up to 176 mg/g.

This dependence is expressed by the correlation coefficient r = -0,14 for wheat varieties and r = -0,727 for species.

The amount of activity of enzymes depends on the content of substrates. Proteolytic activity depends on content of protein, amylolytic activity depends on content of starch. Substrates in the grain are structured, this is

indicated by the physical property of the grain - vitreousness. In the high-glassy grain, the stacking density is achieved by binding the starch with a protein, so in a structured endosperm a relatively large protein content, but in an associated state, and therefore the proteolytic activity is low. The relative content of starch is low and it is also difficult to access, so the high activity of amylolytic enzymes develops. With less structured endosperm, the protein content is small, but it is available and the proteolytic activity is high, there is a lot of starch and it is easily accessible from here and amylolytic activity is low therefore. Changes in the activity of enzymes correspond to the demand for products of hydrolysis of protein or starchy substances. First and foremost, obviously, glucose, as an energy component in the course of those or other processes, both during the germination of the seed, and the baking that occurs during doughing [18].

Changes in protein content and its composition, starch and sugars content, as well as proteo- and amylolytic activities of enzymes in grain of different wheat varieties and species, depending on the degree of damage by thrips.

Grain of investigated varieties and species of wheat in the period 2001-2003 was divided into fractions, depending on the degree of damage by the thrips on: weak, medium and strong. For control, intact grain was taken, and the protein content, in which it was assumed to be 100%.

The greatest losses of total protein to 6,7% were observed in heavily damaged grains of varieties Kinelskaya 61 and in the species Triticum spelta. A similar loss of protein was found in the Kinelskaya 60 and Triticum dicoccum species. A smaller decrease in the amount of total protein had a highly damaged grain of Kinelskaya 59 up to 4,8% protein loss and Grekum 3152 up to 5,3% protein loss and species of T. persicum, T. sphaerococcum up to 4,5 ... 4,9% protein loss. In a weakly damaged wheat grain, protein losses averaged 1,3 ... 1,8%, in species – 1,6 ... 2,1% and were the highest in the same varieties and types of wheat. In general, over the years of research, the protein loss by variety of wheat was 1.1 times less than the loss of total protein in the studied varieties.

The correlation coefficient of the total protein content and grain damage was r = 0,710 in wheat varieties and r = 0,667 in wheat species.

In the proteins of the damaged grain, a consistent decrease in all protein fractions was observed, but on average, over the years of research, the decrease in the content of albumins and gliadins in grains with a high degree of damage was higher to 6,5, 6,8%, respectively, in varieties and types of wheat, and globulins and glutenins are less than 4,2% and 4,7%, respectively. The largest losses of gluten protein fractions on average during the years of research were observed in heavily damaged grains of varieties Kinelskaya 61 and Kinelskaya 60 up to 8,6% of losses and species of T. spelta and T. dicoccum up to 8,1% of losses (Fig. 1). During the studying of wheat damaged by thripses, it turned out that the share of protein losses in the fractions decreased so high relative to the percentage of this fraction in intact grain, which may be due to their intensive absorption during feeding of wheat thrips, and speaks about less losses and less preferability of these groups of proteins for thrips nutrition.

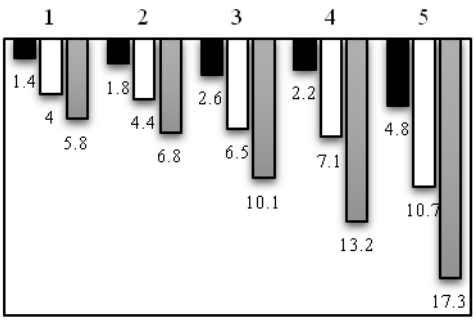
As for the percentage ratio of the fractions gliadin/glutenin, gluten of the severely damaged grain of most of the species and varieties studied can be classified as "highly extensible", i.e. of poor quality. However, a grain with such a gluten is still suitable for bakery, since it does not cause disaggregation of protein molecules, so the deterioration in the quality of the wheat grain damaged by thrips is probably due to a change in the carbohydrate complex of substances [19].

The lowest losses of starch in grain with a strong degree of damage in comparison with other wheat forms studied were observed in the Kinelskaya 61 and Kinelskaya 60 varieties and in the T. spelta and T. dicoccum species (on average 10%), and the largest ones were noted in the variety Kinelskaya 59 and in the species T. sphaerococcum (on average 16%), as against the background of other wheat, these forms differed by a more mealy endosperm. The minimum decrease in the starch content in grain with a low degree of damage was recorded in the Kinelskaya 61 and in the T. spelta species (on average, at 2,5%), and the largest losses of starch in the grain with a low degree of damage were Kinelskaya 59 and Grekum 3152 and species T. sphaerococcum, an average of 4.8%.

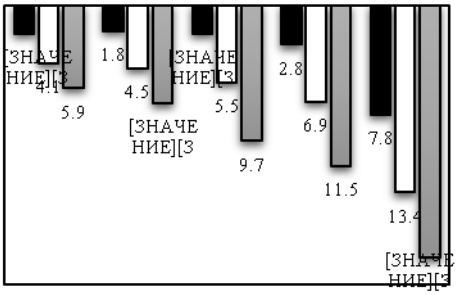
ISSN: 0975-8585

Wheat varieties

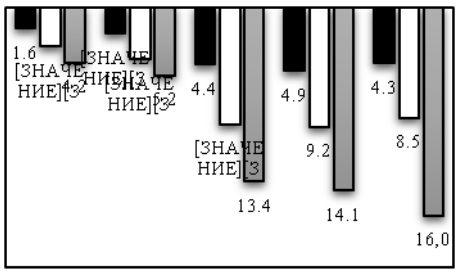
Triticum dicoccum



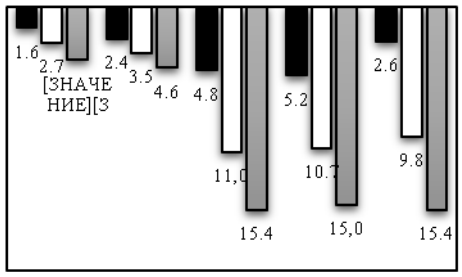
Triticum spelta



Triticum persicum



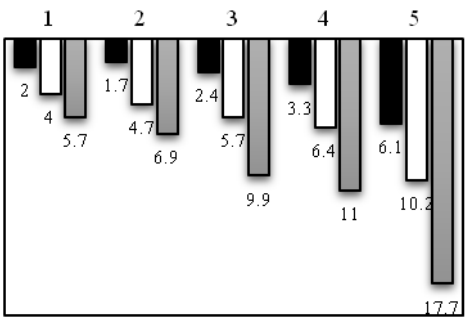
Triticum sphaerococcum



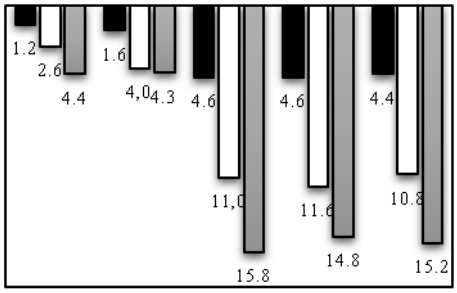
Substance loss, %

1 - low molecular weight proteins;
2 - high molecular weight proteins;
3 - starch;
4 - mono- and disaccharides;
5 - reducing sugars

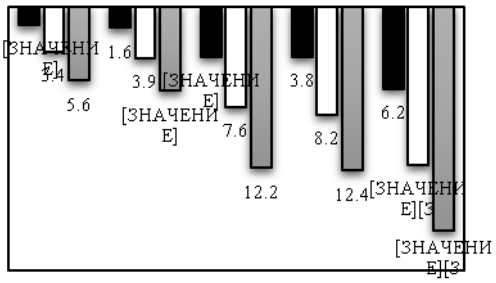
Wheat species Triticum aetstivum
Wheat varieties
Kinelskaya 61



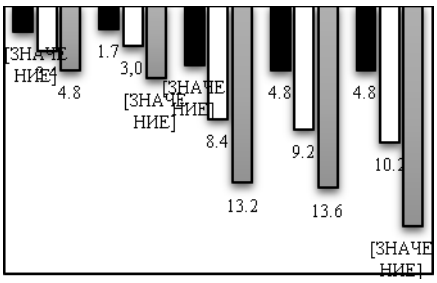
Kinelskaya 59



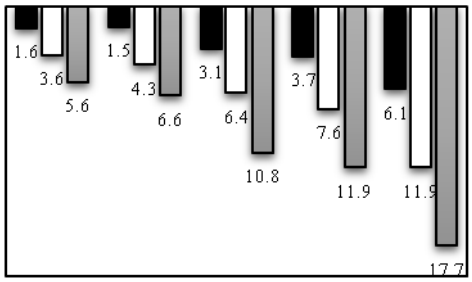
Greku
m 3152



Kinelskaya 60



Tulaykovskaya 5



ISSN: 0975-8585

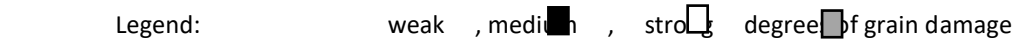


Fig 1: Comparative losses of proteins and carbohydrates in damaged grain of different wheat varieties and species

The maximum losses of mono- and disaccharides were observed in the damaged grains of Grekum 3152 and Kinelskaya 59 varieties and species T. sphaerococcum (on average up to 15%). The minimum reduction of this group of sugars was in damaged grains of the Kinelskaya 61, Kinelskaya 60 and T. spelta varieties (on average up to 11%). Reducing sugars were minimally reduced in the damaged grain varieties Kinelskaya 59, Grekum 3152 and the species T. sphaerococcum (on average up to 16%), and maximally in highly damaged grain varieties Kinelskaya 61, Kinelskaya 60 and T. spelta (on average up to 18%). In the grain with a low degree of damage, the minimum losses of mono- and disaccharides were in Kinelskaya 61 and Kinelskaya 60 (on average up to 3,5%) and in the species T. spelta and T. dicoccum (average 2,0%), and the maximum losses of these sugars were observed in Grekum 3152 and T. sphaerococcum (on average up to 5,3%).

The correlation analysis revealed a reverse correlation between the degree of grain damage and the content of starch and sugar for varietal ($r = -0,707$ for starch content and $r = -0,759$ for sugar content) and species ($r = -0,696$ for starch content and $r = -0,682$ for sugar content) analysis of grain.

Thus, against the background of a higher content of one or another group of sugars in the original intact wheat grain, more significant losses of the saccharides considered here were also observed. Initially, the lower content of reducing sugars (in 1,1 times) in the grains Kinelskaya 59 and Grekum 3152 indicates that they are used for the synthesis of starch and other complex substances, and therefore more carbohydrates are synthesized in their flower shells (in particular, starch), which are easily hydrolyzed and assimilated by the pest insect, as a result, against the background of the highly proteinaceous varieties Kinelskaya 61, Kinelskaya 60 and Tulaykovskaya 5 they are more damaged by wheat thrips. Among the wheat species studied, a similar situation can be traced also to the more mealy species of T. sphaerococcum and T. persicum.

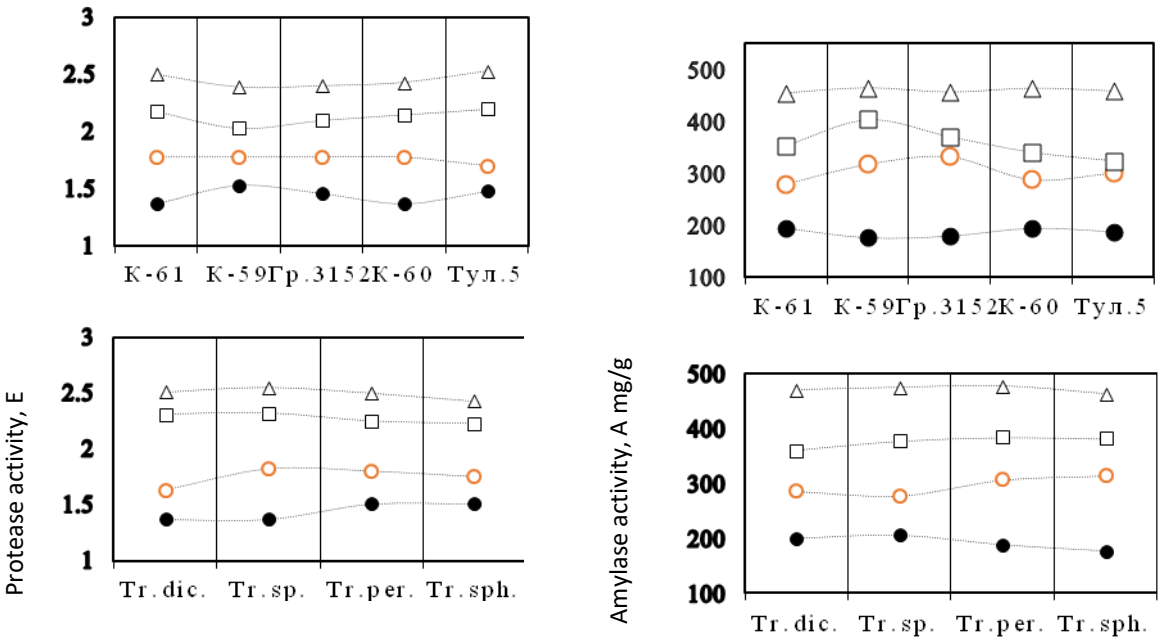
Analyzing the general biochemical state of grain damaged by wheat thrips, in all studied wheat varieties and species it was found that the ratio in the losses for proteins, starch and sugars, prevailed towards the carbohydrate complex (Fig. 1). And since wheat thrips more consume carbohydrates, this indicates the carbohydrate diet of the pest. To confirm this point of view, studies were conducted to determine the activity of proteolytic and amylolytic enzymes in wheat grains with various degrees of damage by thrips.

Proteolytic activity of wheat grain, damaged by thrips.

Depending on the extent of the damage to the grain, the protease activity was relatively increasing, regarding intact grain with the maximum value of this number in the grain with a strong degree of damage. (Fig. 2).

At the same time, during the study period, the activity of proteolytic enzymes was maximal in cases of strong damage by thrips of grains of the Kinelskaya 60 and Kinelskaya 61 varieties and the species of T. dicoccum and T. spelta (on average up to 1,83 times). The minimum activity of the enzyme complex studied is traced in the highly damaged grain of the Kinelskaya 59 and Grekum 3152 varieties and the T. persicum and T. sphaerococcum species (on average up to 1,3 times). This trend may again be caused by the ratio of the main grain biopolymers: since the varieties and species of wheat with the maximum activity of proteases in the damaged grain are characterized by high protein content, the pest produces in large quantities those hydrolases that split this biopolymer. The predominance in the grain of wheat of other biopolymers, in particular carbohydrates, stimulates the formation of hydrolases that readily hydrolyze them, in particular, the enzyme - amylase.

ISSN: 0975-8585



Legend and abbreviations:

●	Intact grain (control);	○	Weak damaged grain;
□	Medium damaged grain;	△	Strong damaged grain;
К-61	Kinelskaya 61;	К-59	Kinelskaya 59;
Гр.3152	Grekum 3152;	К-60	Kinelskaya 60;
Тул. 5	Tulaykovskaya 5;		
Tr.dic	Triticum dicoccum;	Tr.sp.	Triticum spelta;
Tr.per	Triticum persicum;	Tr.sph.	Triticum sphaerococcum.

Fig 2: Changes in the activity of proteolytic and amylolytic enzymes depending on the degree of damage to the grain of various wheat species and varieties by thrips

Amylolytic activity of wheat grains damaged by thrips.

Depending on the degree of grain damage, a consistent increase in the activity of amylases was observed due to injected native pest enzymes that provide preliminary "extra-intestinal" preparation of the food substrate. At the same time, with respect to intact grain, the increase in the total activity of amylases in the damaged grain was on the average approximately 1,3 times less. The greatest increase in amylolytic activity was in the damaged grain varieties Kinelskaya 59, Grekum 3152 and species T. persicum, T. Sphaerococcum, an average of 2,6 times, and the lowest - in the damaged grain varieties Kinelskaya 61. Kinelskaya 60 and Tulaykovskaya 5, on average in 1,4 times.

Thus, in the wheat grains damaged by thrips, the activity of proteolytic enzymes increased on average up to 1,8 times, and the activity of amylases increased on average up to 2.6 times, which confirms the carbohydrate orientation of feeding of wheat thrips. In turn, an increase in the activity of proteolytic and amylolytic enzymes in the damaged grain of wheat indicates the presence of extraintestinal digestion in wheat thrips, and since the activity of proteases is insignificant and does not have a significant disaggregating effect on proteinaceous grain molecules, this grain is suitable for bread baking

REFERENCES

[1] Andjus, L. First record of Echinothrips americanus in Serbia / L. Andjus, M. Jovic, S. Tardan // Hellenic Plant Protect. J. – 2009. – Vol. 2. – P.71-73.

[2] Bakaeva N.P. Effect of wheat thrips on the protein content of grain of spring wheat / N.P. Bakaeva, Yu. V. Tershukova // Agrarian Science. 2013. - № 7. - P. 15-16.

[3] Andjus L., Spasic R., Dopudja M. Thrips from coloured water traps in Serbian wheat fields // Thrips and topsoviruses: Proceedings of the 7th International Symposium on Thysanoptera, 2001.
[4] Reitz, S.R. Thrips: Pests of Concern to China and United States / S.R. Reitz, Y.-L. Gao, Z.-R. Lei // Agric. Sci. China. – 2011. – Vol. 10, № 6. – P.867- 892.
[5] Varga, L. Larval and adult food preferences of the poinsettia thrips Echinothrips americanus Morgan, 1913 (Thysanoptera: Thripidae) / L. Varga, P.J. Fedor, M. Suvák [e.a]. // J. Pest Sci. – 2010. – Vol. 8. – P.319- 327.
[6] Gaafar N., Ei-Wakeil N., Volkmar C. Assessment of wheat ear insects in winter wheat varieties in central Germany // J. Pest Sci., 2011. 84. P. 49–59.
[7] Kakol E., Kucharczyk H. The occurence of thrips (Thysanoptera, Insecta) on winter and spring wheat in chosen regions of Poland // Acta Phytopathologica et Entomologica Hungarica, 2004. 39 (1/3). P. 263–269.
[8] Moritz, G. Modern methods in thrips-identification and information (Insecta, Thysanoptera) / G. Moritz, C. Delker, M. Paulsen [e.a.] // Bull. EPPO. – Paris, 2000. – Vol. 30. – P.591-593.
[9] Pochinok, Kh.N. Methods of biochemical research of plants / Kh.N. Pochinok. - Kiev, 1976. - 297 p.
[10] Bakaeva, N.P. The content of total protein and starch in grain of various varieties of spring wheat in the Middle Volga region. / N.P. Bakaeva, Yu.G. Shulaeva // Agricultural Biology. -2005, - №3. - P. 39-44.
[11] Pleshkov, B.P. Workshop on plant biochemistry / B.P. Pleshkov. - M .; Agropromizdat, 1985. 255 p.
[12] Ermakov, A.I. Methods of Biochemical Research of Plants. Ermakov, V.V. Arasimovich, N.P. Yarosh. - L .: Agropromizdat. 1987. - 430 p.
[13] Tretyakov, N.N. Practical work on plant physiology / N.N. Tretyakov - M .: Agropromizdat, 1990. - 271 p.
[14] Tanskiy, V.I. Biological basis of harmfulness of insects / V.I. Tanskiy – M.: Agropromizdat, 1988. - 182 p.
[15] Dospekhov, B.A. Methodology of field experience / B.A. Dospekhov. - Moscow: Kolos, 1979. - 416 p.
[16] Kodanev, I.M. Improving the quality of grain / I.M. Kodanev. - M.: Kolos, 1976. - 304 p.
[17] Bakaeva, N.P. Saltykova, O.L. Protein and its fractional composition in the grain of spring wheat, depending on the soil tillage systems and weediness of crops / N.P. Bakaeva, O.L. Saltykova // News of the Samara State Agricultural Academy. -2017. - №3. - P. 3-7.
[18] Bakaeva, N.P. The state of the carbohydrate-amylase complex of grain of winter wheat of different varieties, depending on the treatment with microfertilizers ZHUSS in combination with nitrogen fertilizers / N.P. Bakaeva, N.Yu. Korzhavina, O.L. Saltykova // News of the Samara State Agricultural Academy. - 2017. - No.1. - P. 30-34.
[19] Nasyrova, Yu.G. Influence of proteolytic and amylolytic activity of grain on quality of bread from wheat flour / Yu.G. Nasyrova, M.Yu. Kiseleva // Success of Modern Science and Education. 2016. - T. 1. - No. 4. - P. 6-9.