Pesticides effect on the quantity and quality of gluten in spring wheat

V V Keler, O V Martynova and T G Ovchinnikova
Krasnoyarsk State Agrarian University, 90 Mira Avenue, 660049, Krasnoyarsk City, Russia

E-mail: vica_kel@mail.ru

Abstract. The purpose of the work was to determine the influence of agrotechnical cultivation methods on the quantity and quality of spring wheat gluten in the conditions of the Krasnoyarsk territory. The dynamics of gluten content in the grain of soft spring wheat depending on pesticides use after grain as previous crop was studied. The influence of grain background intensification on the gluten quality in grain in zoned varieties was established, and the most responsive of them to the use of a full range of protective measures were identified. The experiment was conducted using the method of competitive testing in Eastern Siberia in 2018-2019. The varieties «Novosibirskaya 15», «Novosibirskaya 31», «Novosibirskaya 41», «Altayskaya 70», «Krasnoyarskaya 12» and «Svirel» were studied. The results were processed using mathematical statistics. To obtain the highest index of the quantity and quality in soft spring wheat gluten of the studied varieties in Eastern Siberia it is recommended to use grain as previous crop with a full complex of herbicides, fungicides and insecticides.

1. Introduction
Providing the country with high-quality products and raw materials with the lowest cost of labor and material resources is one of the priorities at the present stage. Unfortunately the difference between the level of food demand and the state in agricultural production is very significant [1]. In this regard, an important place in improving the economic efficiency of crop production is occupied by increasing crop yield, which is impossible without the use of advanced technologies, including plant protection measures as a necessary element.

Protection of spring crops from harmful factors has a fairly high potential to increase the yield and quality of grain, as evidenced by their phytosanitary condition. It is established that crop losses are reduced and every ruble spent on protective measures is paid back by 4-10 rubles due to improving the quality of grain and its productivity by using highly effective modern chemical means of protection against harmful organisms. At the same time it becomes important not only to use pesticides safely, in a timely and sufficient manner, but also to clarify the possibilities for their targeted effect on physiological and biochemical processes, the content of mineral elements in plants, other components, and quantitative and qualitative indicators of the crop yield, especially in extreme conditions of crop cultivation [2].

With the increase in grain production special attention is paid to improving its technological qualities – the strength of flour, gluten quantity and quality, protein content, and others. Grain quality is the second crop yield. The higher the gluten content in flour and the better its quality is, the stronger the
flour and the better the baking properties of flour are [3]. One of the main indicators that affect the grain quality is the level of cultivation technology. The problem solution requires the full use of the possibilities in science and practice to form high-quality grain at all production stages.

Due to the relevance of this issue the purpose of the work was to determine the impact of agrotechnical cultivation methods on the quantity and quality of spring wheat gluten in the conditions of the Krasnoyarsk territory.

Tasks set during the research:

- To study the dynamics of the gluten amount in the grain of soft spring wheat depending on the pesticides use after the previous grain.
- To establish the effect of grain background intensification on the gluten quality in grain in zoned varieties of soft spring wheat.
- To identify the most responsive varieties of the studied culture to the use of a full range of protection means.

2. Methods and results

The paper analyzes the research results to assess the impact of modern plant protection products on the quantity and quality of gluten in varieties included in the state register of zoning in the Krasnoyarsk territory, cultivated in the experimental field on the basic farm of the Krasnoyarsk state agrarian university in 2018-2019. The soil of the experimental site was represented by luvi chernozem, medium-sized, medium-humus, heavy-loam. Tillage was carried out in accordance with the requirements of zonal farming systems and generally accepted recommendations for the Krasnoyarsk forest-steppe.

After a preliminary soil analysis for the nutrients availability these varieties were sown in the second decade of May using the competitive test method [4] with a selective mounted pneumatic seeder SSNP-16 with a seeding rate of 5.0 million grains/ha, the method of sowing was ordinary, the depth was 5 cm. The size of the plot was 50 m², the size of the sites for crop accounting was 12 m², the repeatability was fourfold, and the method of placing plots was systematic [5].

As plant protection means fungicides, herbicides and insecticides were used VialTrast, aqueous suspension 0.4 l/t; Pallas 45, oil dispersion 0.5 l/ha; Zenon Aero, emulsion concentrate 1 l/ha; Tsunami, emulsion concentrate 0.15 l/ha, and the preparation Ultromag Profi 2 l/ha was added to the tank mixture to reduce stress in plants during treatment with pesticides. The gluten content was determined by the method of the state standard 27839-2013 [6]. As a result of the research the materials of the competitive variety testing were processed by mathematical statistics using the StatSoft ® STATISTICA 6.0 package [7].

Wheat is the most high-protein crop, its grain protein content ranges from 10 to 20 %, and under optimal conditions it can reach 20 to 25 % [8]. The protein content in the grain affects the yield, with an increase in protein, the yield of wheat increases.

The gluten amount can vary from 11 % to 59 % depending on the place of crops, growing location, moisture and heat in the studied year, genotypic characteristics of the varieties, diet, farming characteristics, and the genotype-environmental interaction [9].

For the production of bread products, the content of protein and gluten in the raw materials is of great importance, since the quality of the resulting products depends on them. Therefore, an important role is played by growing grain with high content of these quality indicators.

Flour used for baking needs must contain at least 28% of gluten, the quality of which corresponds to group I. In the course of our experience we found that the only variety that can form the proper gluten amount of the best quality for the previous grain without applying pesticides is «Novosibirskaya 15» – 31.1% (table 1).
Table 1. Indicator of gluten amount in spring wheat under the influence of various cultivation backgrounds, 2018-2019 (%).

| Variety                  | Previous grain | Previous grain + pesticides |
|--------------------------|----------------|-----------------------------|
|                          | 2018 | 2019 | 2018 | 2019 |
| «Novosibirskaya 15»      | 24.3 | 31.1 | 25.2 | 33.5 |
| «Novosibirskaya 31»      | 27.8 | 26.2 | 25.4 | 28.0 |
| «Novosibirskaya 41»      | 23.9 | 26.6 | 24.8 | 28.6 |
| «Altayskaya 70»          | 26.1 | 22.6 | 26.2 | 29.9 |
| «Krasnoyarskaya12»       | 24.3 | 26.0 | 30.8 | 33.1 |
| «Svirel»                 | 25.4 | 26.4 | 25.6 | 34.9 |
| Average                  | 25.3 | 26.5 | 26.3 | 31.3 |
| Range of variability     | 23.9-27.8 | 22.6-31.1 | 24.8-308 | 28.0-34.9 |

Figure 1. Variation in the gluten amount in spring wheat varieties when using pesticides, % (2018).

All other varieties contain it only from 22 to 26 %, and the variety «Altayskaya 70», being valuable wheat by its baking characteristics, has only 22 %. Thus, the previous grain without means of intensification is practically not suitable for the cultivation of strong wheat varieties and does not allow them to realize their potential.

Figure 1 shows that the variety «Krasnoyarskaya12» was the most responsive to the use of plant protection products in 2018. The difference between previous grain and previous grain with the use of modern protection means was 6.5 %. In the other presented varieties the gluten amount increased by 1% in average.

Data from figure 2 allow us to conclude that all varieties raise the gluten amount when applying a full range of protection against pests and diseases. In 2019 the level of gluten increased by 4.8 % in average. Thus, the use of pesticides on the previous grain will allow producers to get better quality crop from the modern assortment of spring soft wheat.
A two-factor analysis of variance was performed to determine which plays the greatest role: the variety or background, the results are shown in table 2.

Table 2. The dispersion analysis result of the intensification effect on the amount of gluten in soft spring wheat.

| Source of variation | SS      | df | MS        | F        | P-Value    | F critical |
|---------------------|---------|----|-----------|----------|------------|------------|
| Variety             | 27.44708| 5  | 5.489417  | 0.938955 | 0.484004   | 2.901295   |
| Background          | 129.5379| 3  | 43.17931  | 7.385742 | 0.002886   | 3.287382   |
| Inaccuracy          | 87.69458| 15 | 5.846306  | -        | -          | -          |
| Subtotal            | 244.6796| 23 | -         | -        | -          | -          |

According to the results of the data dispersion analysis, it was found that the variation in the amount of gluten by varieties was not statistically significant (P>0.05). Factor A (Variety) had actual Fisher ratio of 0.93 less than the critical 2.90, so there is probability of 95% that the amount of gluten in soft spring wheat grains does not depend on the variety. It was found that this indicator depends on the background of cultivation, since the P-Value was 0.002 (P<0.005) and was statistically significant, which means that the content of gluten amount depends on the background of previous intensification. The indicator for the influence strength of the "Background" factor is 53%.

The influence of the gluten quality index in the studied varieties under the intensification influence of the cultivation background is shown in table 3.

Based on the above data it can be noted that for the previous grain the quality characteristics of gluten are at the level of 64 units of MDG in 2018 on average, in 2019 they are at the level of 67 units of MDG, and in the case of pesticides using they are on average at the level of 63 and 69 units of MDG respectively (figure 3 and 4).
Table 3. Indicator of gluten quality in spring wheat under the influence of various cultivation backgrounds, 2018-2019 (unit of measuring deformation of gluten (MDG)).

| Variety                  | Previous grain | Previous grain + pesticides |
|--------------------------|----------------|----------------------------|
|                          | 2018 | 2019 | 2018 | 2019 |
| «Novosibirskaya15»       | 63.2 | 62.4 | 61.0 | 65.2 |
| «Novosibirskaya 31»      | 65.4 | 73.2 | 67.3 | 72.4 |
| «Novosibirskaya 41»      | 61.8 | 58.0 | 62.2 | 59.4 |
| «Altayskaya 70»          | 63.7 | 71.6 | 64.9 | 77.1 |
| «Krasnoyarskaya12»       | 64.3 | 70.1 | 59.9 | 71.2 |
| «Svirel»                 | 69.2 | 70.3 | 65.8 | 72.4 |
| Average                  | 64.6 | 67.6 | 63.5 | 69.6 |
| Range of variability     | 61.8-69.2 | 58.0-73.2 | 59.9-67.3 | 59.4-77.1 |

Figure 3. Variation of gluten quality in spring soft wheat varieties when using pesticides, units of MDG (2018).

The range of the trait variability varies from 58.0 to 77.1 units of MDG in 2018 and 2019. All samples are characterized by good gluten quality with the exception of «Altayskaya 70» for the previous grain with pesticides in 2019. This is because wheat of this variety is valuable.

The most responsive variety for the complex use of plant protection products was «Novosibirskaya 31» in 2018 (figure 4). The quality of gluten increased by 1.9 % after applying plant protection products, but it was not too significant.
Figure 4. Variation in gluten quality in the varieties of spring soft wheat with the application of pesticides, units of MDG, (2019).

Table 4 shows the results of the data dispersion analysis that characterize the effect of intensification levels on the gluten quality of soft spring wheat grains in the studied varieties.

Table 4. The result of the dispersion analysis about the intensification effect on the quality of soft spring wheat gluten.

| Source of variation | SS      | df  | MS       | F        | P-Value   | F critical |
|---------------------|---------|-----|----------|----------|-----------|------------|
| Variety             | 304.4171| 5   | 60.88342 | 6.174319 | 0.002671  | 2.901295   |
| Background          | 140.5013| 3   | 46.83375 | 4.749512 | 0.01601   | 3.287382   |
| Inaccuracy          | 147.9113| 15  | 9.86075  | -        | -         | -          |
| Subtotal            | 592.8296| 23  | -        | -        | -         | -          |

The obtained data indicate that the quality of gluten depends on both the variety and the cultivation background, since the P-Value of the factors «Variety» and «Background» is 0.002 and 0.016 respectively, and this means that the differences are statistically significant (P <0.005 and P <0.05).

The indicator for the strength of the influence factor «Variety» is 51.3 % and indicates that the gluten quality is more genetically determined. Gluten in all varieties belongs to group I and is excellent. The previous grain and use of pesticides have a weaker effect on this indicator, since the indicator for the strength of the influence factor «Background» corresponds to 23.7 %.

Based on the research the following conclusions are formulated:

1. The indicator for the gluten amount depends on the cultivation background, since the P-Value was 0.002 (P <0.005), which is statistically significant. The index of influence strength is 53 %. In the variety factor the actual Fisher ratio of 0.93 is less than the critical 2.90, so there is 95% of probability that the gluten amount in the grains of soft spring wheat in these varieties is not genetically stable.

2. It was found that the quality of gluten depends on both the variety and the cultivation background, since the P-Value of the factors «Variety» and «Background» is 0.002 and 0.016 respectively, and this
means that the differences are statistically significant (P <0.05). The indicator for the strength of the influence factor «Variety» is 51 % and indicates that the gluten quality is more genetically determined.

3. The most responsive varieties for the use of a full pesticides range in terms of the gluten amount were «Svirel» (the amount of gluten increased by 8 %), «Altayskaya 70» (by 7%) and «Krasnoyarskaya12» (by 6%). The gluten quality can be improved by 1-2 % in average after applying plant protection products, which is not too significant.

References

[1] Keler V V 2007 Ecological and varietal features of technological qualities formation of spring wheat in forest-steppe of the Krasnoyarsk territory (Krasnoyarsk: Krasnoyarsk state agrarian university) p 123
[2] Amirov M F 2012 Influence of pre-sowing seed treatment with microelements on the yield and quality of spring durum wheat grain Bulletin of the Kazan state agrarian university 2 85-7
[3] Vedrov N G and Keler V V 2002 The nature of time variability in technological qualities of spring wheat in the Krasnoyarsk forest-steppe Bulletin of Krasnoyarsk state agrarian university 1 85-9
[4] Grigorieva A I 1985 Methods of state variety testing for agricultural crops (common part) (Moscow: Kolos) p 269
[5] Grigorieva A I 1989 Methods of state variety testing for agricultural crops (common part) (Moscow: Kolos) p 194
[6] GOST 27839-2013 wheat Flour. Methods for determining the quantity and quality of gluten: (NAT. the standard Grew. Federation: ed. official. : UTV. and now. by order of Feder. Agency for technical. regulation and Metrology from 3 Dec. 2018 no. 1050-St: Vved. first time: date entered. 2014-07-01 / Moscow: STANDARTINFORM, 2014) p 128
[7] Khizhnyak S V and Puchkova E P 2019 Mathematical methods in Agroecology and biology (Krasnoyarsk: Krasnoyarsk state agrarian university) p 244
[8] Keler V V 2008 Influence of hydrothermal conditions on protein formation of zoned spring wheat varieties in the forest-steppe of the Krasnoyarsk territory Bulletin of the Kazan state agrarian university 1 56-9
[9] Novikov N N 2003 Phytochemistry. Structure, properties and biological functions of the main organic substances in plants (Moscow: Moscow agricultural Academy) p 168