The role of weather conditions in the formation of yield and quality of winter wheat grain in Central Chernozem Region

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Abstract. The article presents studies on the influence of weather conditions on the yield and quality of winter wheat food grain in Central Chernozem Region of Russia. At the same time, weather risks were identified and analyzed using correlation and regression analyses. To reduce them to a minimum, a set of measures is needed, one of which is the selection of modern varieties that are more adapted to a specific place of growth. The soft wheat variety Synthetic is shown as an example that weather conditions affect not only the yield of winter wheat, but also the quality of the crop grain. The level of yield was more influenced by precipitation than by air temperature. The thousand-kernel weight was closely and positively correlated with the air temperature; a negative correlation was found between the air temperature and the content of raw gluten in the grain.

1. Introduction

Winter wheat is a leading small grain crop in Central Chernozem Region (CChR). The meteorological conditions of the region make it possible to consistently obtain high yields of high quality grain of this crop. This paper considers the issue of the influence of weather conditions (air temperature, precipitation) on the yield and quality indicators of winter wheat grain.

Climate is one of the most important factors of both soil formation and the formation of high yields, technological qualities of grain as well. Air temperature on which the timing of agricultural technological work depends is an important climatic factor. Along with the air temperature, soil temperature is also important. In the surveyed area, both on the surface and at different depths, the annual temperature variation is not the same. The temperature of the soil surface and at a depth of 25 cm rises and falls similarly to the air temperature, that is, it has its minimum in January and maximum in July. The depth of soil freezing depends on the depth of snow cover, its texture and moisture content. The soil of CChR usually freezes to a depth of 80-100 cm. Precipitation is the second important factor in climatic conditions. In experiments with crops, when determining the yield or technological qualities, average annual rainfall and total precipitation for the growing season of the studied crop are taken into account.

The combination of climatic conditions with certain soil differences, the use of material and technical resources play a decisive role in the planning of agriculture and obtaining high yields [1]. The best soils for agricultural use are leached chernozems, which have significant reserves of humus,
nitrogen, a high degree of saturation with bases, and a weak reaction of soil solution. However, it should be noted that the leached chernozems contain insufficient amounts of available forms of phosphoric acid and potassium. Therefore, timely application of phosphorus and potassium fertilizers has a very positive effect on increasing the productivity of agricultural plants [2].

Under modern conditions of agriculture, in order to achieve the set goals, i.e. obtaining a high, high-quality and environmentally friendly yield of crops, it is necessary first of all, to observe crop rotations with correct alternation of crops, as well as the selection of modern varieties [3–5]. Preference should be given to varieties that are more adapted to specific growing conditions [6].

Breeders now offer varieties that can give high yields while maintaining product quality. With the correct selection of the variety, planned farming is possible, which makes it possible to level or minimize weather risks [7].

2. Statement of the problem
The conducted research is necessary to adjust agricultural technology of cultivated crops in order to obtain a high yield of good quality products. It is desirable to study the set problems posed in years with different meteorological conditions.

3. Materials and methods
The research was carried out at the experimental plot of Kursk FARC in the village of Panino, Medvensky District of Kursk Region. The experiment was deployed in space and time. The variants were allocated systematically. The area of the sowing plot is 25.0 x 8.1 m². In the experiment winter wheat was grown in a cereal-fallow-row crop rotation with black and green manure fallow and in a field crop rotation against different backgrounds of mineral fertilizers. In the paper average for the experiment values of crop yield and grain quality are taken for the analysis. During the years of the research considered in the paper the winter wheat variety "Synthetic" selected in Belgorod FARC was experimentally grown. The variety is mid-season, resistant to lodging and drought. Winter hardness is average. It is recommended for cultivation in Kursk, Belgorod and Voronezh regions. The average yield in the region is 3.63 t/ha. With good agricultural technology and favorable weather conditions, the yield can reach 6.0-6.5 t/ha.

4. Results
The experimental data obtained over 5 years (Figure 1) show that the yield of winter wheat varies from year to year in significant ranges from 31.8 to 62.1 metric centner/ha (c/ha) and has a direct and average dependence (r = 0.73) on the amount of precipitation during the warm period. Comparative analysis and calculation of the coefficient of winter wheat yield variation confirm its high variability. The yield growth according to the trend for the years under study was only 10 c/ha. Only three years (2016, 2017 and 2020) out of five winter wheat the yields were high and their indicators were higher than the trend by 11-27%, while in 2018 and 2019 the yields were lower with deviations from the trend by 17-35%.

It is believed that winter wheat, in comparison with other crops, is less sensitive to changes in hydrothermal conditions during the spring-summer growing season [8]. In the studies conducted, that can be judged by the preservation of the unidirectional relationship between the correlation coefficients of yield and natural factors of influence. The approximation coefficient is low. This suggests that it is difficult to predict the impact of weather conditions. It is only possible to smooth out the negative effect of weather conditions by other factors to achieve high levels of productivity and provide the population with food grains.

The variability of grain quality indicators over the years was lower than the yield variability.

The weight of 1000 grains varied from 44.8 to 51.2 g. For three years of the research, large and leveled grain belonging to Group 1 (a very large grain over 40 g) according to the grain size classification of soft wheat was obtained. The trend line indicates a decrease in this indicator with an average strength of approximation.
During the years of the research, the effect of atmospheric precipitation on the weight of 1000 grains was insignificant and it was average on the content of raw gluten.

In 2019, there was less precipitation during the warm period than in other two years under study. This indicator was slightly higher in 2018 and maximum in 2020. A decrease in atmospheric precipitation in 2019 entailed a decrease in the weight of 1000 grains, while the content of raw gluten in the grain, on the contrary, increased. Increase in precipitation in 2018 and 2020 provided an increase in the weight of 1000 grains. But in 2020, despite the highest moisture supply, the weight of 1000 grains was inferior to that of 2018 (Fig. 2).

An increase in precipitation in 2020 reduced the gluten content in the grain, but that was not proportional. Thus, in 2018, precipitation was less than in 2020, but the decrease in the content of raw gluten in the grain was greater than in 2020.

As the air temperature rises, the weight of 1000 grains increases. This can be clearly seen in the diagram. The gluten content in the grain dropped with increasing precipitation.

The percentage of raw gluten in the grain varied over three years from 22.8 to 28.3. According to this indicator, the grain of 2018 corresponded to Grade 4, 2019 to Grade 2, and in 2020 to Grade 3.

**Figure 1. Influence of average air temperature and precipitation for the warm period of the year on the yield of winter wheat**

During the years of the research, the effect of atmospheric precipitation on the weight of 1000 grains was insignificant and it was average on the content of raw gluten.
5. Conclusion

For the research, various varieties are used, zoned in specific zones, with characteristic fixed features. In case of the Synthetic variety, it can be seen that its characteristics (yield, weight of 1000 grains, content of raw gluten), depending on the growing conditions, change over the years of research.

It is found that meteorological factors: precipitation and air temperature affect not only the yield of winter wheat, but also the quality of the yield. If precipitation influenced the grain yield of winter wheat to the greatest extent, the air temperature affected then the weight of 1000 grains and the content of raw gluten in the grain. One can say that with a high technological level of agriculture, the importance of climate is significant. But, in addition, under the conditions of the area studied, a rather large role is played by the variety, the crop itself, the established crop rotation systems, timely pesticide treatment of crops against diseases, pests and weeds, the rate of fertilization and other agro-technological operations, measures that contribute to obtaining high yields of high quality grain as well [9, 10].

Grain quality can be significantly improved by applying mineral fertilizers for primary tillage.

Indicators of yield and grain quality under different weather conditions vary significantly. Grains grown with low precipitation (2019) are characterized by a low weight of 1000 grains and a higher content of raw gluten.

As the amount of precipitation increased, the weight of 1000 grains tended to increase, while the content of raw gluten tended to decrease.

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