Research in regression models for the dependence of grain quality indicators on agrobiological factors

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Abstract. The article discusses the impact of various agricultural and climatic factors on the yield of durum wheat in a continental climate. Among agrobiological factors, four were selected empirically; linear correlation was estimated by constructing multivariate regression models. The obtained regression equations for various indicators of quality are determined taking into account different rates of seeding. Based on the analysis of time series and the minimax criterion, the most optimal seeding rate for the coming period was determined.

1. Introduction

One of the main agricultural crops of Russia is spring durum wheat, grown throughout the country, including in the Orenburg region. This agricultural crop has sufficiently strict requirements for growing conditions. The main factors limiting the production of durum wheat are the warm temperature regime and the lack of moisture in the soil.

Grain production is usually considered a universal, functional and system-forming area in the socio-economic policy of any state.

Grain production exceeds various other areas of crop production, according to the dimensions of the arable land used, the scale of workers involved and used, material and economic resources. The main approach to the implementation of state grain policy is to increase the conduct of the grain industry to the level required volume of production and grain quality. The ratio and totality of the impact of external conditions affects the indicators of productivity and grain quality.

In order to increase the stability of durum wheat production and the effectiveness of implemented agricultural measures, it is necessary to take into account the weather characteristics of a given territory, study its influence on crop yields, identify the most optimal parameters of weather factors that contribute to the formation of high yields of this crop.

To improve the assessment and forecasting of wheat quality indicators, various mathematical methods, the Internet and information technologies are currently widely used. The use of mathematical and regression models for forecasting in agriculture is largely due to the introduction of highly informative research methods into practice.

A method for predicting certain quality indicators in winter wheat was developed by V.N. Strashnii [1]. The author obtained a whole set of prognostic models for several regions of the Central Black Earth Region of Russia.

A.N. Derevianko developed a method for predicting the value of some winter wheat quality
indicators for the regions of the Chernozem zone of the European part of the country [2]. For the purpose of assessing climatic conditions by the degree of their influence on the quality of wheat, the author investigated a number of agrometeorological factors. The author developed agroclimatic zoning of the European part of the country in order to identify regions favorable for the cultivation of high-quality wheat, compiled their maps, and made forecasts.

In [3], the processes of photosynthesis, respiration, accumulation of carbohydrates and proteins in the grain, absorption and redistribution (from the vegetative organs) of nitrogen, and leaf aging are considered depending on the state of the crop at the time of flowering and external conditions (light exposure, temperature) during the filling period.

Zhao Jun-fang, Guo Jian-ping, WU Ding-rong, Fang Shi-bo, E You-hao studied grain quality indicators taking into account the application of nitrogen and leaching of nitrates in various parts of the Netherlands and came to the conclusion that there are great prospects for the so-called «organic management» [4].

In [5], the results of the analysis of the correlation dependences between the SDS sedimentation index and the main grain quality characteristics of durum winter wheat are presented. An analysis of the correlation dependences revealed the presence of reliable positive relationships between SDS indicators with vitreous nature and vitreous nature; a close positive correlation was found between grain unit indicator and vitreous nature.

The article [6] reflects the results of studies on the pre-sowing treatment of spring wheat seeds with an ozone-air agent of various concentrations and exposures to increase sowing qualities, yield and grain quality in the conditions of the Kostroma region. Seed processing was carried out in special devices - ozonizers, which can maintain a given ozone concentration and processing time.

In [7], the effect of fertilizers on the qualitative characteristics of winter and spring wheat grains in the regions of the Upper Volga is shown. It was also shown that, along with an increase in productivity, even with an increase in the doses of mineral fertilizers applied before sowing, higher doses of nitrogen in the fertilizing favorably affected the qualitative signs of grain.

The theoretical approach proposed in [8] by the authors for adaptive interval analysis and forecasting of agroecological objects was further developed in the formulated scientific hypothesis of the similarity of productivity and quality indicators of wheat related to a common object - the wheat production process, limited by the temperature and precipitation conditions in this environment of agrobiogeocenosis.

2. Materials and methods
The main indicators of the quality of grain of spring durum wheat are:
- protein content, % (y1);
- gluten content, % (y2);
- glassiness, % (y3);
- grain unit, grams / liter (y4).

The data for analysis were obtained as a result of cooperation with the Federal State Budget Scientific Institution “Federal Scientific Center for Biological Systems and Agricultural Technologies of the Russian Academy of Sciences”.

The observations were carried out by the method of state variety testing of agricultural crops. As a result of many tests, checks for the presence of multicollinearity and rejection of uninformative factors, the following were selected as key indicators affecting the quality of grain:
- the presence of a seed stimulant, yes / no (x1);
- the presence of fertilizers, yes / no (x2);
- average daily air temperature, °C (x3);
- amount of precipitation, mm (x4).

Also, the paper considers five different seed rates that are typical for this region.

For the purposes of a full assessment of factors included in the model, standard methods of statistical data processing, methods of modeling time series, and also some provisions of the theory of decision-
making were used. The test data were checked for compliance with the normal distribution law using
the Pearson chi-square test. The relationship between the resulting indicators and the source data was
estimated using the non-parametric Spearman correlation coefficient. The construction of regression
equations was carried out using the least squares method, the significance of the obtained regression
coefficients was estimated using the Fisher F-test. Grain quality assessment was carried out based on
the minimax criterion. The processing of statistical data was carried out using the software package MS Excel and Statistica 8.0.

3. Results and discussion
For each of the seeding rates using the least squares method, regression equations are obtained, which
are shown in table 1.

Table 1. Regression equations for the dependence of grain quality on agroclimatic and
agrotechnological factors

| Seeding rate, kg / ha | Grain quality indicators |
|-----------------------|--------------------------|
|                       | Protein content | Gluten content | Glassiness | Grain unit |
| 2.5                   | y=20.205+0.326x1+0.043x2 | y=-41.75+4.09x1+0.375x2 | y=290.778+2.396x1+0.043x2 | y=775.702+9.188x1+0.043x2 |
| 3                     | y=15.583+0.659x1+0.27x2 | y=13.009+1.259x1+0.5x | y=173.567+2.011x1+0.5x | y=944.777+11.166x1+0.5x |
| 3.5                   | y=16.514+2.006x1+0.27x2 | y=-113.588+9.616x1+1x | y=-309.447+1.308x1+0.27x2 | y=-823.566+2.58x1+0.27x2 |
| 4                     | y=2.626+1.525x1+0.213x2 | y=116.488+8.002x1+0.25x2 | y=-544.338+11.296x1+0.25x2 | y=976.163+25.024x1+0.25x2 |
| 4.5                   | y=20.14+2.918x1+0.315x2 | y=-69.272+8.147x1+0.255x2 | y=-17.494+9.909x1+0.255x2 | y=-1133.67+18.573x1+0.255x2 |

Evaluation of the most important parameters obtained as a result of the multiple linear regression
equations allows us to determine that the presented models have high reliability (by the significance
level of the Fisher test F <0.05 for each of the cases listed in the table).

It should also be noted that the multiple correlation coefficient for the equations found is not less
than 0.81, which characterizes a fairly strong correlation of grain quality indicators with the initial
agroecological factors.

To evaluate the effectiveness of each of the models, a time series analysis was used. The data
collected over a large time period, containing the values of agroclimatic factors in the climate of the
Orenburg region, allowed us to obtain predicted values of the average annual temperature and humidity
based on the analysis of time series [9]. The results obtained in this study can be used to obtain predicted
values of crop quality for the coming year (table 2).

The choice of a specific seeding rate to achieve the highest grain quality is carried out according to
the minimax criterion. According to the selection rules, if at least one of the quality parameters does not
reach the desired value, then the grain is assigned to a lower class. Therefore, it is necessary to choose
a seeding rate at which the minimum value of any quality parameter would correspond to the highest
class.

To achieve the first class of grain, the following parameters are required:
- protein content > 13.5%;
- gluten content > 28%;
- glassy > 85%;
- grain unit > 770 grams / liter [10].

According to table 2, the achievement of all quality indicators not lower than the specified values is possible only with a sowing rate of 2.5 kg / ha.

Thus, the developed regression equations give a fairly accurate idea of what sowing rate must be observed to obtain optimal results.

| Seeding rate, kg / ha | Protein content | Grain quality indicators |
|-----------------------|----------------|-------------------------|
|                       |                | Gluten content | Glassiness | Grain Unit |
| 2.5                   | 13.9           | 31           | 88         | 796        |
| 3                     | 14.2           | 25           | 84         | 817        |
| 3.5                   | 13.3           | 26           | 86         | 759        |
| 4                     | 12.1           | 29           | 87         | 822        |
| 4.5                   | 13.8           | 34           | 79         | 768        |

4. Conclusion
As a result of the study, regression dependences of grain quality indicators on agroecological factors were obtained. It was determined that the highest grain quality for the coming year can be achieved with a sowing rate of 2.5 kg / ha. The regression equations developed in this work give a fairly accurate idea of what sowing rate must be observed to obtain optimal results.

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