Prediction of disease resistance of high-quality wheat varieties using method of calculating generalized estimates

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Abstract. The article calculates generalized estimates of the resistance of wheat varieties grown in several regions of the Republic of Uzbekistan to Yellow Rust, Brown Rust, and Flour Dew. In this regard, the classification of wheat varieties according to their resistance to disease, the latency of the features, the calculation of the weight of the features, and the use of these to calculate the generalized estimates were carried out.

As a result, several features played an important role in assessing the disease resistance of wheat varieties, and some did not play a significant role. The article also proves the importance of new features that occur when some features are latent with other features. As a result, representatives of disease-resistant bread wheat varieties with high generalized estimates were identified.

1 Introduction

The article considers the issue of assessing the resistance of wheat varieties grown in several regions of the Republic of Uzbekistan to wheat diseases such as Yellow Rust, Brown Rust, and Flour Dew.

Today, developing disease-resistant varieties is one of the most important tasks of wheat selection. Especially in recent years, the epithets of rust diseases are causing great damage to the grain fields of the Republic. As a result, these diseases hurt grain yield and quality. This is a huge loss to the amount of grown crops and farmers' income.

To solve the above problems, creating resistant and hardy wheat varieties is important. At the same time, to select varieties resistant to other environmental factors, selection scientists are conducting experiments on artificial disease sites to determine the disease resistance and yield of wheat in the quarantine areas of plant research institutes. Based on the results of the experiments, positive results are being achieved in this area through information technology and artificial intelligence.

With this in mind, the task of the article is to assess the susceptibility of wheat varieties to disease based on several features (parameters) identified in the experiment. Classification intervals are also determined according to the numerical values corresponding to the different characteristics of wheat varieties obtained from the experimental results, and the

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weights (contributions) of the features are used to help assess the resistance of wheat varieties to various diseases. Using the established separation of intervals and weights, a generalized estimate of the disease resistance of wheat varieties is made.

The file we use, which contains information about the experiment's results, will be arranged in a certain order, such as the serial number, object name, attributes of the objects, and their names. We'll call this file a selection file later.

We call the parameters that represent the descriptions of the object's features. Features can be divided into several types. Below we describe some of them.

A quantitative feature is a sign that has a unit of measurement. *For example,* 35 years old, 175 cm, 88 kg, etc.

A nominal feature is a feature that can only be identified by identification. *For example,* white, black, yellow, and brown colors are identified when hair color is considered a feature.

The first literature is devoted to the issues of intelligent data processing using methods of artificial intelligence and pattern recognition. It examines the latest research on the computation of generalized estimates and related issues of visualizing objects, splitting quantitative features into intervals of the dominance of class objects, and constructing decision trees. Methods for calculating local metrics and constructing models based on them are proposed to detect hidden logical patterns [1].

The creation of high-quality varieties of wheat and an increase in grain production in all countries of the world is one of the urgent tasks. Therefore, the main task of breeders today is to create in the southern regions of the country intensive varieties of bread wheat, suitable for soil and climatic conditions, resistant to drought and heat, diseases and pests and lodging, high-yielding, fully complying with industrial requirements [3].

The growing season of plants is one of the main indicators that determine the suitability of a variety for growing in certain conditions. The length of a common wheat plant's growing season determines the yield and reflects the plant's resistance to drought, disease, and environmental stress factors [7, 11].

One of the main features of the climate of wheat-growing regions in Uzbekistan is the arid conditions. Frequent droughts in Uzbekistan significantly impact the plant during the growing season of wheat, leading to a decrease in yield and grain quality. Drought reduces the accumulation of organic matter in plants, slows leaf growth, and shortens the working surface through the main photosynthesis [8, 9].

In the main grain-growing countries, the annual loss of yellow rust is 0.1-5%, and in rare cases 5-25%. Areas at high risk of yellow rust are now the northwestern United States, East Asia (northwestern and southwestern China), South Asia (Nepal) and Central Asia (Uzbekistan, Tajikistan, Kyrgyzstan, Turkmenistan, and South Kazakhstan), Australia, and East Africa [13].

Many varieties lose their resistance to disease as they are zoned. The disease resistance of varieties is unstable because the composition of the races is constantly mutated, or new races can emerge due to evolution. Methods of disease prevention Planting these resistant varieties is the most efficient and reliable way in terms of both economic and environmental impact [7].

Hazratkulova noted that there are 2 different types of endurance: vertical and horizontal. In vertical tolerance, the plant is resistant to only one specific race, while in horizontal tolerance, the plant is resistant to all races [10].

In horizontal resistance, many genes control the plant, the disease develops slowly in the plant, and the spore size is small. The study of the composition of races that cause brown rust in Central Asian countries, especially in Uzbekistan, began in 1932, and until 1989, 32 race species were studied, of which 77 race species dominated in the region for many years [15].

In rust diseases, stem rust plays a major role in damaging productivity. In the last decade, the damage caused by it has been significantly reduced due to the creation of varieties resistant to this disease. The last epiphytosis occurred in the United States in 1904, 1916-1955, and reduced wheat yields by 40%. Still in Africa, West Asia and the Far East, Australia, New Zealand, and South America, stem rust rapidly damages wheat fields [13].

In determining the resistance to rust diseases, it is important to study the resistance in the germination phase, along with the rapid development phase. From these experiments, it is possible to determine whether the variety is resistant to rust diseases and controlled by one or more genes [12].

The intellectual analysis of the data presented in the 2nd literature is a selection of materials on modern methods of research, which describe in detail such concepts as measurement scale, binary relations and their properties, and forms of logical laws [2].

In the 4th literature, by solving relevant problems, the problem of measuring the signs that make up the database (selected files) of a large volume and the use of suitable scales for them is addressed. For example, selected files with quantitative and nominal features are investigated: 100×5 and 103×5 [4].

In the 5th and 6th literatures, it is considered the breadness and stiffness of differentiated wheat varieties, as well as the generalized estimates of several symptoms. Deterministic and iterative algorithms are used to calculate generalized estimates [5,6].

2 Methods

We will select 17 quantitative features of wheat varieties as experimental features and include the following designations in their names:

x1 - degree of disease resistance, %;

x2 - the day from tube to tip;

x3 - the day from germination to ripening;

x4 - plant height, cm;

x5 - length of last joint, cm;

x6 - spike length, cm;

x7 - number of spikes, pcs;

x8 - resistance to lodging down, ball;

x9 - yield from the plot, kg;

x10 - productivity, c/ha;

x11 - 1000 grains weight, gr;

x12 - grain nature, gr/l;

x13 - the amount of protein, %;

x14 - grain moisture, %;

x15 - the amount of gluten, %;

x16 - IDK;

x17 - grain vitreous, %;

We express the weights of the features with numbers in the interval [0, 1], In this case, 1 (one) is the maximum value of the weight, and 0 (zero) is the minimum value of the weight.

The weight of the feature x1, in the selection file under consideration is 1 (one). Because that's the way the classes are divided. That is, non-diseased varieties are classified as Class 1 and the rest as Class 2. The quantities obtained based on the remaining features and their combinations $\left(x_i * x_j; x_i / x_j; x_j / x_i \right)$ represent the weights of the features in the classification of wheat varieties. Accordingly, to calculate the weights of the features and the generalized values of the objects, we do the following:

1. First, we process the data in the selected file from the experiment. To do this, we

process parameters such as the date and percentage determined by the experiment's results and convert them into quantitative features as integers or real numbers.

2. We classify the objects in the selection file according to their quality. For example, we consider non-diseased varieties to belong to the 1st class and the rest to the 2nd class.

3. We divide each feature column into two intervals. In this case, $c_0 - i -$ is the smallest value in the feature, $c_2 - i -$ is the largest value in the feature, and $c_1 - i -$ is limit of the interval separation of the feature.

4. We calculate the number of features belonging to the first and second classes according to the defined intervals in $i -$ feature and define them as follows: $u_{ij} - i -$ is belonging to the interval the number of $j -$ class representatives (here, $i, j \in 1, 2$).

5. We use the following criterion to calculate the weights of the features:

$$\left(\frac{\sum_{i=1}^{2} u_i^1 \left(u_i^1 - 1 \right) + u_i^2 \left(u_i^2 - 1 \right)}{\sum_{i=1}^{2} |K_i| \left(|K_i| - 1 \right)} \right) \left(\frac{\sum_{j=1}^{2} \sum_{i=1}^{2} u_i^j \left(\left| K_{3-i} \right| - u_{3-i}^j \right)}{2 |K_1||K_2|} \right) \to \max \qquad (1)$$

Here, u_1^1, u_1^2 are the number of quantities in the interval $[c_0, c_1]$ and corresponding to the feature and classes considered. u_2^1, u_2^2 are the number of quantities in the interval $(c_1, c_2]$ and the feature K_1 and K_2 classes considered accordingly.

6. Generalized estimates of objects according to their class $K_i \, (i \in 1, 2)$ is calculated using the following function:

$$R\left(S_i \right) = \sum_{j=1}^{m} w_j \cdot t_j \cdot \left(x_j - c_1^j \right) / \left(c_2^j - c_0^j \right) \qquad (2)$$

Here $i -$ is the number of objects under consideration $(i \in N)$, $m -$ is the number of features $(m \in N)$, and also S_i, $i -$ is object (wheat variety)

The calculation of the functional t_j is based on the following iterative algorithm:

6.1. $R^o = 0$; $\{t_j = sign(\mathbf{x})\}, \mathbf{j} = \overline{1, m}, x \neq \mathbf{0}$ – is random number;

6.2. $R\left(S_i \right)$ be considered, $i = \overline{1, n}$, $n -$ is number of objects;

6.3. $R^1\left(S_a \right) = \min\left\{ R(S_j), \, S_j \in K_1 \right\}$, $R^2\left(S_b \right) = \max\left\{ R(S_d), \, S_d \in K_2 \right\}$;

6.4. $R^1 = R^1\left(S_a \right) - R^2(S_b)$. If $R^1 > 0$ or $R^1 < R^0$ then, go to step 6.7;

6.5. Be checked $R^o = R^1$;

6.6. $\{t_i\}, i = \overline{1, n}$ select the one that provides the maximum value of the difference $R(S_a) - R(S_b)$, and then go to step 6.2;

6.7. The end.

After the calculation of t_j, the ability to calculate the generalized estimates of objects similar to those considered can be done using the function (2).

3 Results and discussion

Below we analyze the results obtained for 245 bread wheat varieties grown in Uzbekistan according to their 17 features.

Accordingly, we solve the problem of dividing the features into intervals and calculating their weight. We latent the feature space to maximize the interval between features. That is, we also calculate the weights of the signs *i* and *j* and the weights of their combinations $\left(x_i * x_j ; x_i / x_j ; x_j / x_i \right)$. If the weights of the *i*-th and *j*-th features are greater than the weights of the features resulting from the combinations, both features are discarded and replaced by the large-weighted latent feature. Otherwise, features *i* and *j* will remain unchanged.

Based on the above considerations, we present a Fig.1 of latent post-latent weights of features classified in the selected file on the resistance level to Yellow Rust, Brown Rust, and Flour Dew.
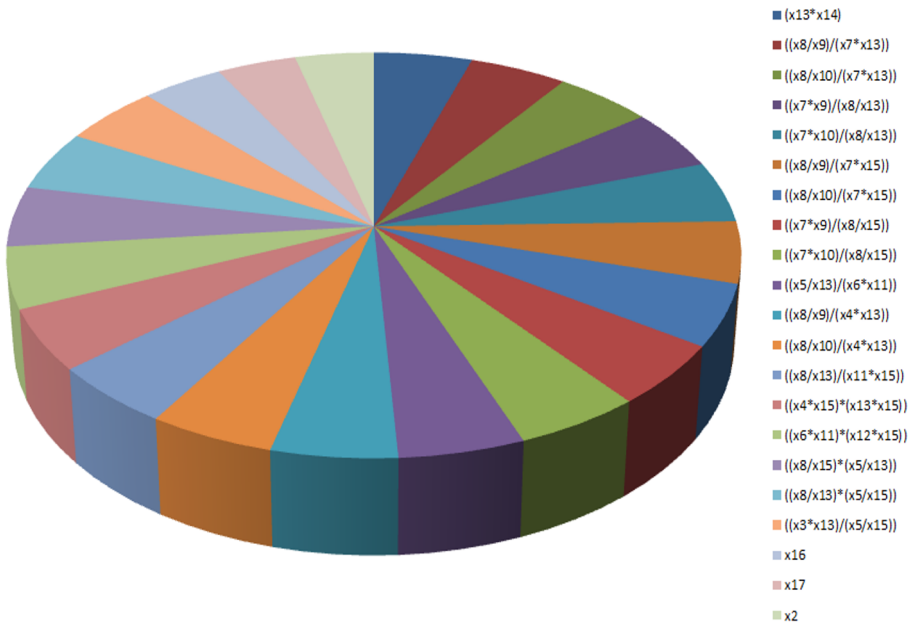

Fig. 1. Weights of features in Yellow Rust

As can be seen from diagram 1, (x13 * x14), ((x8 / x9) / (x7 * x13)), ((x8 / x10) / (x7 * x13)), ((x7 * x9) / (x8 / x13)), ((x7 * x10) / (x8 / x13)) latent features have higher weights than others. Features such as x13, x7, and x8 also played an important role in forming such latent features.
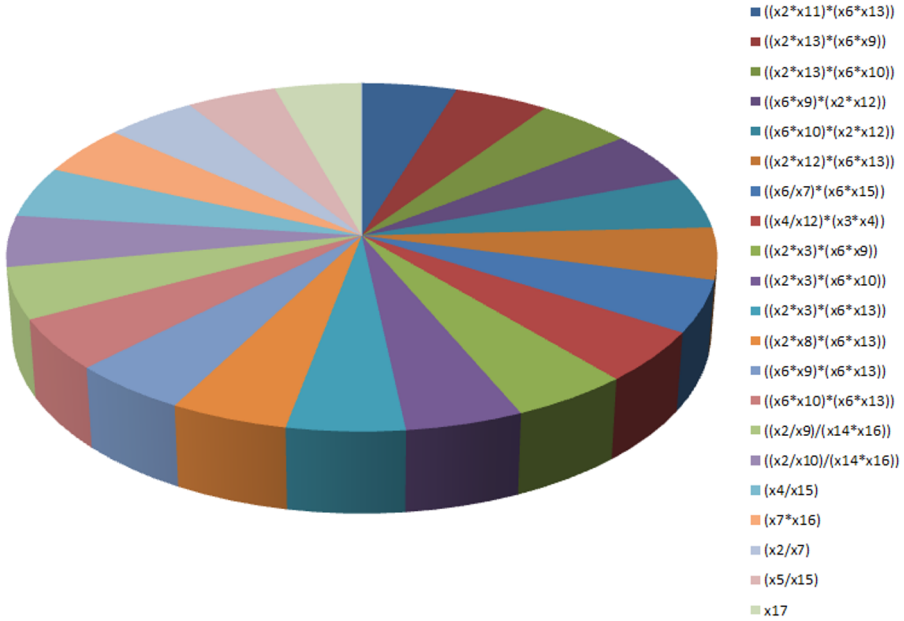
Fig. 2. Weights of features in Brown Rust

As can be seen from the Fig. 2, $((x2 * x11) * (x6 * x13))$, $((x2 * x13) * (x6 * x9))$, $((x2 * x13) * (x6 * x10))$, $((x6 * x9) * (x2 * x12))$, $((x6 * x10) * (x2 * x12))$ latent features have higher weights than others. Features such as $x2$, $x6$, and $x13$ also play an important role in forming such latent features.
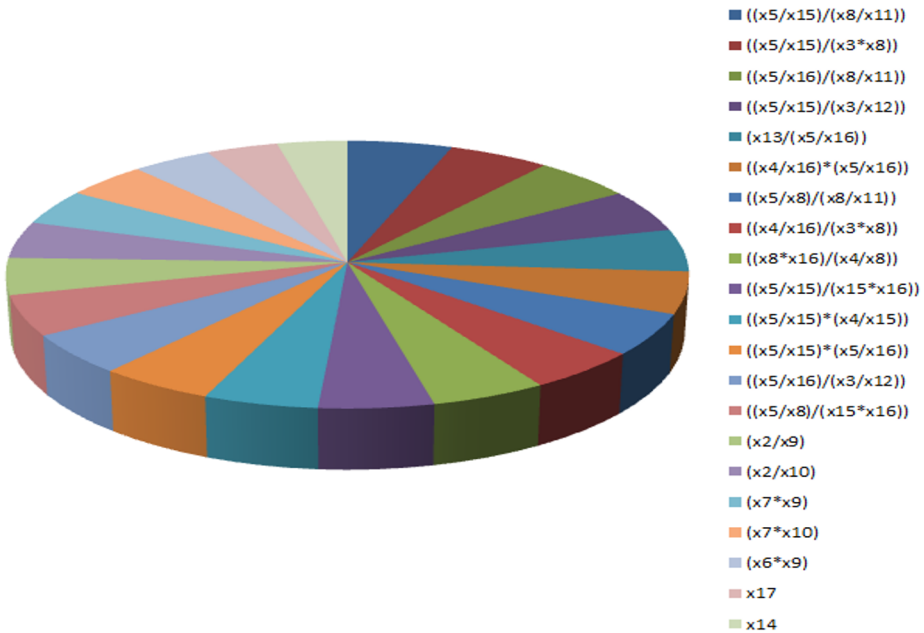

Fig. 3. Weights of features in Flour Dew

As can be seen from the Fig. 3, ((x5 / x15) / (x8 / x11)), ((x5 / x15) / (x3 * x8)), ((x5 / x16) / (x8 / x11)), ((x5 / x15) / (x3 / x12)), (x13 / (x5 / x16)) latent features have higher weights than others. Features such as x5, x8, and x15 also play an important role in forming such latent features.

The above results suggest that some of the features (For example, corn blight) are not important in assessing the disease resistance of wheat varieties. However, when several features are latent with other features, it can be observed that wheat varieties play an important role in assessing disease resistance. For example, in Yellow Rust, "Protein amount" * "Grain moisture", in Brown Rust, "Day to tuber" * "1000 grain weight" * "Grain length" * "Protein amount", Flour Dew in disease ("Last joint length" / "Gluten content") / ("Resistance to lying down" / "1000 grain weight"). So, these latent features play an important role in assessing the disease resistance of wheat varieties.

4 Conclusions

Using a bread ware tool designed to solve the problem, it was determined that the wheat varieties belong to the disease-resistant class based on the calculated feature weights. Their generalized estimates were also calculated using the program.

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According to the results of the calculations, it was found that the bread wheat varieties KR18-BWYT2IR-247 and KR18-BWYT2IR-2052 belong to the class of resistance to all diseases considered at the same time for the 3 types of diseases studied.

In addition, calculations have shown that several varieties belong to only one or two disease-resistance classes. *For example,* KR18-BWYT2IR-1761, KR18-BWYT2IR-704, KR18-BWYT2IR-596 in Yellow Rust and KR18-BWYT2IR-373, KR18-BWYT2IR-469, KR18-BWYT2IR-2 in Brown Rust, in Flour Dew disease, bread wheat varieties such as KR18-BWYT2IR-2496, KR18-BWYT2IR-1144, KR18-BWYT2IR-1787 were identified as high-value representatives of the disease resistance class. If the parameters obtained in the experimental results include the presence of features related to weather, climatic conditions, soil composition, and local and mineral fertilizers, the prediction of the degree of disease resistance of wheat varieties will be more accurate provides.

The developed breadware can be used to predict wheat varieties' disease resistance and calculate generalized estimates of their yield and drought tolerance.

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