# REVIEW

on dissertation work for obtaining the educational and scientific degree "doctor" in: field of higher education 6. Agrarian sciences and veterinary medicine, professional field: 6.1 Crop science, scientific specialty: Crop science

**Author of the dissertation: Georgi Stoyanov Raykov** self - training PhD student at the Department of Crop Science at the Agricultural University, Plovdiv.

**The topic of the dissertation:** "An effective methodology for identification of highly productive and stable winter wheat genotypes by combining traditional and innovative statistical approaches"

**Reviewer: Prof. Dr. Radka Veleva Ivanova**, Agricultural University, Plovdiv, a field of higher education 6. Agricultural science and veterinary medicine, professional field 6.1 "Crop production", scientific specialty "Crop production", appointed from the Rector of the Agricultural university, as a member of the Scientific Jury with Order No. RD-16-208 / 02.02.2026.

## 1. Brief introduction of the candidate.

Georgi Raykov was born on 29.07.1982 in the town of General Toshevo. In 2000 he graduated from secondary education at the "Nikola Yonkov Vaptsarov" Secondary School - General Toshevo. At the Agricultural University - Plovdiv, in 2006 he graduated with a bachelor's degree, majoring in "Field Crops", and in 2008, a master's degree in "Plant Bio-Technologies". From 2008 to 2012 he worked in the town of Langford - England, as a work process manager and coordinator of a packaging workshop. During the period 2012-2015 he was a research worker at the Wheat and Sunflower Institute - General Toshevo in the "Wheat Breeding" section. From 2015-2018 he worked as a breeder at the company "Agronom" in the town of Dobrich (soft wheat breeding). He is currently an agricultural producer of field crops. Since 2025, he has been enrolled in the Department of Plant Breeding at the Agricultural University - Plovdiv, as a doctoral student, an independent form of study. During this period, Georgi Raykov successfully passed the doctoral minimum in Plant Breeding. He speaks excellent English and at a good level Russian, has the necessary computer literacy and uses a wide range of software products.

## 2..Relevance of the problem.

Common wheat is a crop that has been the basis of human civilization for millennia and an important source of food for billions of people around the world. Therefore, the creation of genotypes with high and stable yields is a major problem in breeding programs aimed at obtaining new varieties with high productivity, suitable for cultivation in different conditions and regions. The trends of climate change on the planet, which have been permanently established in recent years, limit the possibilities for realizing the biological potential of already created varieties. The traditional increase in yield through intensification of production is not enough. It is necessary to accelerate the implementation of innovative approaches for assessment, new methodological solutions

and an integrated approach that combines traditional breeding practices with modern statistical and biotechnological tools. To this end, multivariate statistical methods, ecological models and analysis of the genotype × environment interaction are gaining increasing importance as strategic tools for accelerating genetic progress in the conditions of climate change. That is why the doctoral student focuses the study on the need for a clearly formulated analytical model that combines the strengths of traditional approaches - field trials, morphological assessment and traditional agronomic indicators - with the capabilities of modern multifactorial methods.

In this regard, the topic of the dissertation is not only relevant, but also has significant theoretical and practical applicability.

## 3. Purpose, tasks, hypotheses and research methods.

The aim of the study is formulated precisely and clearly, namely, to establish the possibility of combined application of traditional and innovative statistical approaches for complex assessment of common winter wheat varieties while simultaneously determining productivity, stability and adaptability under different growing conditions.

To achieve this aim, 5 main tasks have been set related to the influence of the genotype × environment interaction on the yield and stability of winter wheat; study of the relationships between the main components of productivity and final yield; application of multivariate statistical methods for grouping genotypes based on yield and structural traits; assessment of the yield stability of the samples, through integrated indicators and application of multi-trait approaches for grouping and classification of the studied genotypes with the aim of recommendations for breeding practice.

The scientific hypothesis envisages a study of the effect of variety/environment interaction, a comparison between methods and approaches for assessing the behavior of the variety from the point of view of its adaptability and plasticity.

To fulfill the goal and objectives of the study, in the period 2012-2014. in the region of the Dobrudja Agricultural Institute - General Toshevo, the doctoral student set up field experiments with 118 genotypes of common winter wheat (Triticum aestivum L.). of different origin (32 pcs., local Bulgarian, and 76 pcs. foreign).

The experiment was set up methodologically correctly, using the scheme of random blocks (Randomized Complete Block Design - RCBD), in three repetitions, and an experimental area of 7.5 m². The wheat was grown according to the generally accepted technology.

In the process of the study, the doctoral student tracked the phases of wheat development, the most important indicators forming the yield; number of productive brothers per m2 (NPT), number of grains in one class (NGS), number of grains per m2 (NGM), weight of 1000 grains (g), (TGW) and grain yield (GY). In this study, traditional statistical methods for genotype/environment (GEI) estimation (Linear Mixed Models, Analysis of Variance (ANOVA), Regression Analysis, Cluster Analysis, Wricke Method, Shukla Method) were used, which create the basic framework on which modern multivariate methods and models (AMMI, IPCA, GGEbiplot, BLUP/REML), multi-trait indices (MTSI and MGIDI), machine learning algorithms (Random forests) and analyses were later developed. For graphical representations and processing of multivariate data, packages (such as ggplot 2 and factoextra) were also applied, which provide high-quality visualization and facilitate the interpretation of the results.

## 4. Visualization and presentation of the results obtained.

The dissertation submitted to me for review covers 168 pages. It contains sufficient factual material, well illustrated and supported by 19 tables, 8 figures and 5 appendices.

The structure is analogous to the established model for a doctoral dissertation and includes: Introduction, Literature review on the given topic, Aim and objectives, Material and methods of setting up the experiment, Soil and climatic characteristics, Results and discussion, Conclusions, Contributions and Cited literature. The section "Results and discussion" is the main part of the dissertation

## 5. Discussion of 'the results and used lilterature.

A targeted and in-depth literature review on the topic has been made, highlighting the views of a number of our and foreign researchers on the problem under consideration. 195 literary sources in Latin are cited, 20 by Bulgarian authors, and the remaining 175 by foreigners, which shows the very good awareness of the doctoral student about what has been achieved so far in our country and abroad in this area. This allows him to correctly and objectively interpret and compare the results obtained by him with those of other authors.

In the main section - "Results and Discussion" extensive experimental material obtained from the field experiments is presented, based on which, through appropriate statistical analyses and modern statistical programs, the maximum amount of information has been extracted.

At the beginning of the section, the doctoral student presents a thorough soil and climatic characteristic of the region in which the experiment was conducted (Dobrudzha Agricultural Institute - General Toshevo

A description of the meteorological conditions of each year of the study was made, which allows for an analysis of the variability between years and its role in the manifestation of the genotype × environment interaction.

As a result of the results obtained, the doctoral student established that:
The genotype × environment interaction (GEI) is statistically significant and determines the differences in the productivity and stability of each of the studied samples. Genotypes with predictable behavior in relation to changing environmental conditions were distinguished.

The combined use of different statistical approaches (AMMI, REML/BLUP) increases the reliability of analyzing the results for GEI, allowing for a simultaneous description of the structure of interactions and an assessment of genotypic potential.

According to the relative share of the influence of environmental conditions on the studied traits, the genotypes can be divided into two main groups: with a predominant influence on the average mass of 1000 grains (65%), grain yield (60%) and number of productive stems per m2 (43%) and with a similar effect in terms of the genotype, number of grains in the cluster (25%) and number of grains per m2 (22%).

For the majority of the traits, the interaction genotype x environment causes variation, in the order of 11-16%. The exception is the trait number of grains per m2, which stands out with a twice higher value (29%).

With significant differences in growing conditions, only the 1000-grain mass trait changes completely regularly, which indicates a relatively linear dependence on

changes in environmental conditions. For the other traits, number of productive stems and number of grains per m2, a "non-linear" change is established. In them, the variation in the second component reaches 44-45% of the total variation, values close to those of the first component.

Through various statistical approaches, it has been established that the magnitude of the yield (GY) depends to the highest extent on the number of grains per square meter (NGM). The 1000-grain weight (TGW) trait also has a significant, but secondary contribution, which helps to achieve the highest possible yield in some of the samples.

The number of productive siblings (NPT) and the number of grains per cluster (NGS) have an indirect influence on the final yield, as their effect is realized mainly through the formation of the trait number of grains per m2 (NGM), whose positive effect on the yield is direct.

The applied multivariate evaluation methods allow a clear distinction of genotypes into homogeneous groups, with clusters characterized by specific combinations of yield (GY) and main structural traits.

Through cluster analysis (K-means), three statistically distinguishable groups are distinguished and two effective strategies for obtaining high yield are outlined: first, by increasing the number of grains per square meter (NGM), at the same values of the mass per 1000 grains (TGW) and second, by increasing the values of the mass per 1000 grains (TGW) at a preserved level of the trait number of grains per square meter (NGM).

Based on multi-trait indices, a classification of genotypes into groups with different selection potential was performed, which facilitates the practical applicability of the results.

By using the multi-trait indices MGIDI, MTSI and WAASBY (50:50), it becomes possible to capture the more subtle and nonlinear interactions between genotype, environment and management, which are characteristic of real production conditions and through the combination of which the information obtained for the individual variety is enriched.

For accurate and objective selection of a variety, a combined and simultaneous assessment of productivity and stability was made. An assessment based only on absolute grain yield carries a risk of specific adaptation.

Combining the use of traditional and modern approaches provides opportunities for a complex assessment of the variety, which, depending on the differences in growing conditions, becomes its specific characteristic.

It has been established that grain yield and its main components are closely related to the temperature sum and water balance in the critical winter-spring and spring-summer periods during the vegetation period.

Varieties with broad adaptation have been identified thanks to their balanced combination of high productivity and stability, which makes them suitable for direct zoning in production.

## 6.Cqntributiorrs of the dissertation.

Based on the experimental work performed and the results obtained, doctoral student Georgi Raykov formulated his contributions, the most important of which can be presented as follows:

- **Scientific - theoretical contributions:**

1. It is clearly shown and statistically proven that against the background of the genotype x environment interaction in the main traits of productivity, a multi-layered evaluation of the variety is possible against the background of a large group of studied samples.

2. An integrated methodology for evaluating winter wheat varieties has been introduced, which combines multifactorial statistics (ANOVA, AMMI, REML), component analysis of yield and multi-trait integration (MGIDI, MTSI, WAASBY 50:50), summarized by the rank aggregation method (RRA).

3. The leading role of the number of grains per m2 (NGM) for stable high productivity in different environments has been proven.

4. Three fundamentally different, but mutually complementary statistical approaches to evaluation have been distinguished, which can serve as the basis for targeted evaluation of the variety in a given group, depending on the specific goal set.

5. A protocol has been developed whose logical stepwise reproduction, even when changing the specific parameters, leads to similar rankings of the analyzed varieties.

6. Grouping genotypes based on combinations of their specific trait levels is a significantly more precise assessment than that based solely on yield or a trait directly influencing it

- **Scientific - applied contributions:**

1. Genotypes with high productivity and stability are identified, suitable for introduction and use as starting material in crosses. .

2. Specific guidelines for selection choices are provided, based on prioritizing NGM at maintained TGW, which optimizes selection in different environments.

3. A transparent and easily reproducible evaluation protocol is developed, which reduces data processing time and increases reproducibility in breeding practice.

4. A specific statistical approach for balanced evaluation by combining productivity and stability is clearly indicated.

5. The application of integrated indices leads to a different ordering of genotypes compared to a classification based only on average yield, and this rearrangement reflects the real influence of the genotype × environment interaction.

## 7. Critical notes and questions

I have some notes and recommendations for the doctoral student.

- In his future work, he should pay more attention to the agronomic part of the studied problems.
- To better master agronomic terms.
- The titles of the tables should more accurately reflect their content (for example, Table 2. Descriptive statistics, and it reflects the elements of yield and yield).

- It is good for each section to end with a summary of the results.

Despite the remarks made, the value of the dissertation does not decrease.

## 8. Published articles and citations.

In connection with the dissertation, the doctoral student has published 2 articles, one of which is independent and one in co-authorship, thereby covering the minimum scientometric requirements of 30 points specified in the Regulations for the Application of the ZRASRB for the ONS "Doctor".

The submitted abstract objectively reflects the structure and content of the dissertation.

Although there are no requirements for providing citations for published materials, the doctoral student submits documents for 5 such.

## CONCLUSION:

Based on the made analysis of the scientific and applied activity of the doctoral student Rumyana Georgieva Georgieva, I consider that she meets the requirements of the Law for the Development of the Academic Staff of Republic Bulgaria and the Regulations of the Agricultural University for the acquisition of the educational and scientific degree "Doctor".

The doctoral student has acquired basic knowledge and skills necessary for conducting of scientific research, researching and summarizing the scientific literature on a specific scientific problem, arranging and conducting of field experiments, taking into account the results of the performed experiments and chemical analyzes, as well as the most important summarizing the results obtained and the formation of scientifically reasoned conclusions.

During the working process the doctoral student has mastered and applied modern methods for statistical analysis of the results.

All this gives me a reason to evaluate her overall activity **POSITIVELI** and to offer the venerable Scientific Jury also to vote positively and to award **Georgi Stoyanov Raykov** the educational and scientific degree **Doctor** in scientific specialty Crop Science.



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**Plovdiv**