REVIEW

on a PhD Dissertation for obtaining the educational and scientific degree "**Doctor**" in: field of higher education 6. Agricultural sciences and veterinary medicine, professional field 6.1 Crop production, scientific specialty Crop production.

Author of the dissertation: Todor Kostadinov Gubatov, self-training PhD student at the Department of Crop Science at the Agricultural University, Plovdiv, Bulgaria.

The topic of the dissertation: Interaction between environmental conditions and grain yield in common wheat (*Triticum aestivum* L.) varieties

Reviewer: Prof. Dr Hristofor Kirchev Kirchev, Agricultural University, Plovdiv, a field of higher education 6. Agricultural sciences and veterinary medicine, professional field 6.1 Crop production, scientific specialty Crop production, appointed as a member of the scientific jury by order № RD-16-650 / 27.07.2020 by the Rector of Agricultural University.

1. Brief introduction of the candidate.

Todor Kostadinov Gubatov was born on July 4, 1958 in the village of Bozveliysko, Varna region. In 1979 he graduated from the Polytechnic High School in Provadia, and in the period 1979-1983 he studied and graduated from the Higher Agricultural Institute (now the Agricultural University) in Plovdiv as an Agronomist, majoring in Plant Protection. During the period 1983-1986 he worked as an Agronomist in plant protection in the agro-industrial complex in the village of Vetrino, region Varna. After successfully passing a competitive exam in 1986 he started working as a Research Assistant in Biotechnology in the section of Wheat Breeding at the Institute of Wheat and Sunflower (currently Dobrudzha Agricultural Institute) General Toshevo. In 1988, he completed a 5-month course at Colorado State University in the United States and qualified as a biotechnologist specializing in stress resistance. In 1991 he founded the company Agronom I Holding EOOD, related to the breeding and seed production of wheat, trade-in field crops and agricultural goods, where he is still a manager.

2. The relevance of the problem.

Although in our country research on the topic of genotype × environment has been conducted for about 30 years, so far no important crop has made a comprehensive study of the effects of the interaction genotype × environment on productivity and comprehensive evaluation of the variety through the available large set from methods and approaches, regardless of the accumulated knowledge about it nowadays. Wheat is the most widely used crop for research related to the effect of the environment on the phenotype. This is no coincidence, given that it is the world's main food plant, which is why scientists are working hard to improve it. The long growing season of winter wheat is

the reason for organizing large-scale research on the subject, which affects a very wide range of its features or properties, starting from the productivity and quality of the grain and reaching the genes and physiological processes in individual organs. They involve teams of different specialists who try to study the best possible influence of nature on wheat by applying an inter-disciplinary approach to analysis. In the present study, the emphasis is on the efficiency and objectivity of the assessment of the interaction of the variety with the environment. Particular attention is paid to the comparison between the methods and approaches for assessing the behaviour of the variety in terms of its adaptability and plasticity.

3. Objectives, tasks, hypotheses and research methods.

The present study is organized to study in detail the varieties of common wheat created in the private company "AGRONOM I HOLDING EOOD". The peculiarities of the interaction of the genotype with the environment on the grain yield of wheat have been studied to determine the breeding and production value of any individual varieties in specific conditions. The information that is analyzed is the result of applying the most modern approaches to this type of research.

The aim of the study is clearly formulated, namely to study in as much detail as possible the patterns associated with the influence of environmental conditions on the variation and level of the grain yield trait in common wheat.

To fulfil the set target, several tasks have been set. The main tasks are three. Each of them, in turn, contains specific sub-tasks that are related to the main aspects of the researched problem. 1. To study the influence of environmental conditions on grain yield. 1.1. To determine the degree of effects of the conditions on the manifestation of the grain yield as the main productivity trait. 1.2. To establish the accuracy of the interaction of the genotype with the environmental conditions in the productivity of wheat. 1.3. To study the reaction of the genotype, its stability and plasticity in different conditions concerning grain yield. 2. To study the possibilities of different statistical methods and approaches for extracting correct information about the genotype × environment interaction in wheat grain production. 3. To analyze the suitability of different approaches for objective assessment of a particular variety in terms of a compromise combination between the manifestation of the grain yield trait and its plasticity and stability.

To achieve the aim and the tasks of the study, field trials were conducted, which cover two periods of four and two years, during which signs and indicators related to the yield were studied. A total of over 40 varieties of wheat created in Bulgaria have been studied. Nineteen of them were established in Agronom I Holding, three varieties (Laska, Svilena and Iveta) are distributed in production by the company under a 20-year license agreement with Dobrudzha Agricultural Institute. In the first 4-year experiment, covering 5 points of study for comparison, two standard varieties were used: Enola and Pryaspa. In the second 2-year field experiment, the varieties Pryaspa, LG Avenue and LG Anapurna were used in 3 test points for standards. The test sites are selected to be representative of the individual grain-producing regions of the country. The experiments were set in three replications, against the background of 24 (first experiment) and 40 (second experiment) studied varieties, respectively. In each of the selected points the varieties are grown in plots of 10 m^2 For the purposes of the development, a large number of statistical analyzes were used. These programs are used because each of them provides different opportunities for extracting information on some of the three groups of statistical

analyzes and in this respect their capabilities complement each other for the purposes of the study.

4. Visualization and presentation of the obtained results.

The dissertation, presented for review contains 185 typewritten pages, 46 tables, 23 figures. The list of cited literature contains a total of 215 literary sources, of which 25 in Cyrillic and the remaining 190 in Latin. The dissertation contains all generally accepted sections for this type of presentation, namely: Designations and abbreviations - 2 pages; Contents - 1 page; Introduction - 3 pages; Literary review - 31 pages; Aim and tasks of the research - 1 page; Material and methods - 17 pages; Results and discussion - 97 pages; Inference - 3 pages; Conclusions - 3 pages; Contributions - 2 pages and Literature - 23 pages.

The literature review is divided into subsections describing the general problem statement, phenotype and genotype, concepts of stability, statistical methods for measuring genotype × environment interaction, simple (standard) analysis of variation, stability analysis by parametric approach, regression coefficient (b_i) and deviation from the mean square (S^2d_i), coefficient of determination (R^2 or r^2), ecovalence (W^2i), Shukla parameter for the stability of variation (σ_i^2), the manifestation of the variety as a measure (Pi), "crossed" Interactions and nonparametric analysis, multivariate analysis methods, principal component analysis (PCA), principal coordinate analysis, factor analysis, cluster analysis, additional basic effects analysis and multiplicative interaction (AMMI) and a new conceptual model through Biplot analysis.

5. Discussion of the results and used literature.

As a result of the precisely performed field experiments, the obtained data are described in the Results and Discussion section. The section is divided into 6 subsections, each of which is followed by brief conclusions.

In the first subsection, it is summarized that the variation of the grain yield trait is very strong as a result of the influence of the conditions of the year, the test point and the genotype as a factor. The interaction of the trait with the environmental conditions is about 32% of its total variation and is mainly due to the combined effect of the interaction year × point (88%). Interaction between the genotype and the environment is also non-linear with a share of about 20%, which generally makes it difficult to correctly assess the response of each variety to others in the group.

In the subsection "Methods for estimating grain yield variation" it can be concluded that in general Kang's model cannot be accepted as a criterion for assessing the suitability of other models for the analysis of variation in experiments. The other models studied are effective in identifying varieties in terms of the magnitude of their variation in the group. This is a serious prerequisite for these models to be used as a possible tool for assessing the stability of a variety individually or in a group. Therefore, through the values of any of the studied methods (alone), it is not possible to make a simultaneous assessment of the level of the trait and its degree of variation.

In the third subsection "Methods for compromise evaluation of the variety by size and stability of grain yield," it is summarized that the studied indices for evaluation of the behaviour of the trait in various environmental conditions give correct information about the stability of each variety. The "ASV" (AMMI stability value) index does not provide

objective information on the variation of varieties when it is necessary to compare them with each other. The most effective for differentiating the varieties according to their variation are the models of AMMI GGE, especially through their graphics module.

In the subsection "Suitability of simple methods for assessment of the level and stability of grain yield," it can be concluded that the approach for assessment by ranking by statistical indices is correct and fully applicable for differentiation of valuable varieties from each studied group. The information on the grain yield behaviour of the individual variety is relative to the background of the group in which it is tested and thanks to it, it can be placed in any of the four groups. The grouping of varieties by a compromise between grain yield and stability can be done by elementary statistical approaches (indices), which have been well known for a long time. This grouping is not always similar in the individual approaches, which always causes mistrust and uncertainty in the interpretation of the results obtained. For this reason, the author recommends using the latest statistical software programs that are designed specifically for these purposes (GenStat, GGEBiplot, GEST, Genes, Stable).

In the subsection "Comparison of models for assessing the level and stability of grain yield," it is analyzed that the ranking assessment of varieties can be successfully used to identify those in the group with the desired high yield and adaptation to different environmental conditions. The application of different approaches for assessment of the level and stability of the yield gives similar information when arranging the varieties from the studied group, as there is no fundamental difference between them. All applied modern methods for the analysis of the genotype × environment interaction are sufficiently informative, which is why they are effective for differentiating the behaviour of varieties in a wide range of growing conditions.

The last subsection "Evaluation of wheat varieties through the stability of grain yield in ecological trials for zoning" summarizes that the measurement of variation in grain yield of a variety grown in different conditions is an action that is mandatory for its objective assessment against the rest of the group. The assessment of the stability of the individual varieties by grain yield is most objective when using the corrected average index (AR6). Combining the classical method (averaging the data from different conditions) with correction by the stability of the genotype is the right approach for grouping the varieties to zoning them in specific environmental conditions. The arrangement of the studied varieties by the spatial representation of the yield ranks and its stability is an effective way for complex assessment of the genotype. The assessment of the stability of grain yield of each variety can be done quickly, accurately and correctly, using modern statistical packages created for this purpose.

Based on the obtained and analyzed results, the PhD student makes a short Inference and formulates 20 conclusions, which summarize the study in an abbreviated form.

The cited literature, including 215 literature sources, shows the excellent theoretical training of the PhD student and his high level of awareness of the fundamental and latest scientific achievements on the researched problems both at Bulgaria and abroad.

6. Contributions to the dissertation.

The excellent theoretical and practical training of the PhD student, as well as the precisely performed experiments and analyzes of the data from them, allow him to form

10 contributions, divided into two groups (Scientific-theoretical - 6 pcs. And scientific-applied - 4 pcs.) As follows :

Scientific-theoretical contributions

1. Grain yield in wheat is a productive trait that is highly dependent on environmental conditions due to the complex change in traits from which it is formed.
2. The interaction of the grain yield trait with the environmental conditions has a complex and multi-component character, which is difficult to predict and analyze without experiments against the background of the unpredictable conditions of the seasons.
3. The analysis of the change (variation) of the grain yield of the variety, grown in different conditions, is obligatory for its objective assessment, against the background of the other varieties of the group.
4. The information about the grain yield behaviour of the individual variety is relative to the background of the group in which it is tested and thanks to it it can be characterized in any of the four groups according to the size of the yield and its stability.
5. Each of the analyzed methods for assessment of the genotype * environment interaction in itself gives part of the information about the behaviour of each variety in the conditions of multifactor field experiments, which, however, is not sufficient for its correct comparison with the other studied varieties.
6. Ranking approaches for the evaluation of varieties can be successfully used to identify those varieties of the experiment with high yield and strong adaptability (adaptation) to different environmental conditions.

Scientific-applied contributions

1. Relatively informative for grouping varieties by yield and stability are the non-parametric approach of Huhn (1979) and the parametric method of Francis and Kannenberg (1978) in which the relationship between grain yield and its stability is most pronounced.
2. When applying the indices "ASV" and "GA" it is not possible to obtain correct information about the degree of variation of a particular variety in the group, therefore they should not be used for this purpose.
3. Combining the classical method (averaging the data from the different conditions) with the correction of the stability of the genotype is a correct approach for grouping the varieties to zoning them in specific environmental conditions.
4. New varieties created in the last few years exceed yield and stability standards, despite the strong interaction of yield with environmental factors.

7. Critical remarks and questions.

I do not have any critical remarks and questions, as the dissertation submitted to me for review fully meets the requirements of the Academic Staff Development Act and the Regulations for its application.

8. Published articles and citations.

According to the minimum scientometric requirements, specified in the Regulations for application of the Law for development of the academic staff, 3 publications related to the dissertation are indicated, which fully cover the required number of points.

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

Although no citation reference is provided, (in principle not required) a reference in world-renowned databases of scientific information identifies two citations (without auto-citations) in Scopus.

CONCLUSION:

Based on the different research methods learned and applied by the PhD student, the correctly performed experiments, the summaries and conclusions made, I believe that the presented dissertation meets the requirements of Law for development of the academic staff and the Rules of the Agricultural University for its application, which gives me a reason to evaluate it **POSITIVE**.

I allow myself to suggest to the esteemed Scientific Jury also to vote positively and to award Todor Kostadinov Gubatov the educational and scientific degree "***Doctor***" in the scientific specialty Crop production.

Date: 08.09.2020
Plovdiv

REVIEWER: .....
(Prof. Dr. Hristofor Kirchev)