

## REVIEW

on a dissertation for obtaining the educational and scientific degree "Doctor" in: field of higher education Agricultural sciences and veterinary medicine, professional field 6.1. Plant growing, the scientific specialty Agrochemistry.

**Author of the dissertation:** Ivan Dimitrov Velinov full-time Ph.D. student at the Department of Agrochemistry and Soil Science at the Agricultural University, Plovdiv.

**Dissertation topic:** "Influence of nitrogen fertilization on the yield and quality of sorghum for grain"

### 1. Brief presentation of the applicant.

The Ph.D. student Ivan Velinov was born in the village of Markovo in 1991. He received his secondary education at the Vocational High School of Home Appliances, special technician of telecommunication systems. In the period 2010-2014 he studied at the Agricultural University of Plovdiv, specialty "Agronomy of the tropics and subtropics". After graduating from university he attended a course in Computer Systems and Technologies in the period 2012-2014, organized at the Center for Continuing Education at the Agricultural University of Plovdiv. The student Velinov graduated with a master's degree in "Ecology of settlement systems" which he studied at the Agricultural University of Plovdiv in the period 2014-2016. During his master's degree at the Agricultural University, Mr. Velinov under the Erasmus program conducted training during the summer semester of the academic year 2014/2015 at the University of Kassel, Germany. He is included to study in the specialty "International Organic Agriculture", where he successfully passes exams in 4 subjects. In 2017 he successfully passed the exam in the Department of Agrochemistry and Soil Science for a full-time Ph.D. student in Agrochemistry. The experimental part of his doctoral studies was completed in 2020. Ph.D. student Velinov stated in his autobiography that he speaks English excellently and German at a good level.

### 2. Relevance of the problem.

Sorghum is becoming an increasingly important fodder crop in the context of intensifying the process of global warming, which is associated with rising annual temperatures and the increasingly dry periods in the summer in our latitudes. The main advantage of the crop in these conditions is its relatively good development and productivity with limited soil moisture. So more mass cultivation of sorghum in Bulgaria can be expected in the near future. Optimizing the nutrition of sorghum with the main nutrient nitrogen is undoubtedly an urgent goal, because it is the element that most strongly affects the growth and fruiting of crops.

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

A clear and achievable goal of the research is set - study of nitrogen fertilization in sorghum cultivation. The main goal is achieved by solving 5 specific tasks, which include research related to establishing the impact of nitrogen fertilization on the absorption of essential nutrients and their distribution in sorghum, the impact of fertilization on crop productivity and grain quality, as well as accumulation, the distribution and reuse of dry biomass, nitrogen and phosphorus in plants. The set additional tasks aim to study the main indicators for agronomic, energy and economic efficiency of nitrogen fertilization in the crop as well as to establish mathematical dependences of productivity, grain quality and basic parameters for nitrogen efficiency.

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

The dissertation is well structured. It contains all the mandatory sections for such scientific work: introduction, literature review, material and methods, results and discussion, conclusion and literature. The dissertation is 208 pages long. The obtained results are presented in 108 tables and 10 figures.

### **5. Discussion of the results and used literature.**

The Literature Review section is very well written. It discusses 278 publications, of which only 31 are in Cyrillic and the rest are in Latin. The description of the used literature is well done, following a single bibliographic standard. However, some of the cited literature sources in the Literature section are not cited in the text of the dissertation, which should not be allowed. For example: Berry, P., Stockdale, E., Sylvester Bradley, R., Philipps, L., Smith, K., Lord, E., Watson, C., Fortune, S., 2003. N, P and K budgets for crop rotations on nine organic farms in the UK. *Soil Use Management*, 19: 112–118, UK is not cited in the main text.

Data and results published by many authors are discussed. The section sequentially discusses various indicators characterizing sorghum, such as crude protein content, starch content, ash content, influence of nitrogen fertilization on yield, etc.

The Material and Methods section describes in detail the experiments performed (two pot and one field) and the methods used in the study. The experiments are methodically properly planned and conducted. In the first pot experiment the influence of the increasing rates of nitrogen on the development of sorghum was studied. In the second vessel experiment, the combined fertilization of the crop with nitrogen, phosphorus and potassium was studied. In the field experiment, only the independent fertilization of the crop with nitrogen was studied. The experiment included 6 variants with the same increasing step of the applied nitrogen fertilizer from 0 to 30 kg / da (the step is 6 kg / da). In all three experiments, the effect of nitrogen fertilization on the content of nitrogen, phosphorus and potassium in the parts of plants (leaves, stems and roots) was determined.

The section presents data on temperature and precipitation conditions during the sorghum vegetation for the three experimental years. The data refer to the period January – August. The sowing of the crop was done at the end of April, i.e. the information for the previous months is redundant. These data are discussed in terms of their influence on sorghum development during the experimental period. The study was conducted with a French sorghum variety - hybrid EU Alize. The methods used for analysis of soil and plants, for determining the productivity and quality of the grain, as well as the indicators for determining the efficiency of nitrogen fertilization are described.

The Results and Discussion section examines the results of the two vessel trials and the field trials. The results are very well summarized in tables, and in their discussion the results of research by other authors on the topic are indicated.

A very good solution is that at the end of each section a short summary of the results is made.

As a result of the first vessel experiment, the influence of fertilization with increasing norms of nitrogen on the entry of the element into young plants and its distribution among the organs of plants (leaves, stems and roots) was established. The plants are grown to the stage of formation of the 5th leaf. The effect of nitrogen fertilization on the absorption and distribution of the other two important nutrients - phosphorus and potassium - has also been studied. The level of nitrogen nutrition of  $N_{600}$  is noted as the most optimal for the development of the plants - the formation of the largest amount of dry mass and increased content of nutrients in the plants has been reported.

In the second vessel experiment, the influence of the combined fertilization with the three main nutrients NPK was investigated, and the experiment was conducted until the sorghum matured. The results of the experiment show that the highest productivity is the variant with  $N_{600}$  in which phosphorus and potassium are imported in quantities -  $P_{200}K_{200}$ . In addition to being highly productive, this option improves the quality of the grain, as it has the highest nitrogen content. Nitrogen content is directly related to higher protein content in the grain. Data on the content of grain protein in the grain are presented by the Polish experience.

Fertilization with the three nutrients has little effect on the harvest index - there are relatively small differences in the indicator between the different variants of the experiment.

The results of the three-year field experiment provide the most reliable data on the impact of nitrogen fertilization on sorghum productivity. It is not surprising that the yield as a whole is strongly influenced by the precipitation during the year, as it was the highest in the relatively wet 2018 and the lowest in the dry 2017.

Based on the field experiments, it was found that nitrogen fertilization significantly affects the productivity of sorghum and grain protein yield. The highest crop yields and grain protein yields were obtained at relatively high nitrogen rates of 18 and 24

kg N / da, respectively. The calculated harvest index is higher at lower nitrogen rates from N<sub>6</sub> to N<sub>18</sub>.

The test weight of the grain was slightly affected by nitrogen fertilization, but when determining the mass of 1000 seeds, an increase in the indicator was observed in the variants with 12 and 18 kg N / da. Based on the research, the export of nitrogen, phosphorus and potassium with the whole plant, separately with the grain and straw, as well as the consumption of the three elements for the formation of a unit of grain production and the corresponding amount of associated biomass (100 kg) were determined. Logically, the highest export of nitrogen, phosphorus and potassium was reported at the highest nitrogen rates - N<sub>24</sub> and N<sub>30</sub>. The results related to the export of nutrients per unit of production have significant practical value because they can be used in determining fertilizer rates in the cultivation of the crop.

With increasing nitrogen fertilizer rates, the amount of gross energy accumulated in production increases. The highest average values for this indicator were obtained at rates N<sub>18</sub> and N<sub>24</sub> (10579.8 MJ / da).

The correlations between grain yields and different parameters of grain protein and the parameters for dry mass reutilization, as well as the parameters for nitrogen and phosphorus reutilization, which give an idea of the mutual influence of these indicators, are calculated, where both positive and negative interactions between pairs of indicators was found.

Partial nitrogen productivity for grain and partial nitrogen productivity for grain protein logically decrease with increasing nitrogen rates. Of great importance for the practice is the established agronomic efficiency of nitrogen for grain, which is highest at fertilizer rates of 12 and 18 kg N / da. The partial nutrient balance for nitrogen is close to one at a relatively low nitrogen level of 12 kg N / da. The absorption of imported nitrogen from fertilizers at this nitrogen rate is also relatively high over 50%.

The energy efficiency of fertilization is increased to a nitrogen rates of 18 kg N / da. Higher rates reduce this efficiency.

The calculation of the mineral balance of nitrogen in the soil shows that it becomes positive at fertilizer rates of 18 kg N / da and higher.

Based on the economic assessment, the economic and biological optimum of the use of nitrogen fertilizers in the cultivation of sorghum is determined, taking into account the impact of changes in the price of sorghum and nitrogen fertilizer.

## **6. Contributions of the thesis**

The main part of the conclusions made in the thesis has a scientifically applied character.

As a contribution it can be noted that for the first time in Bulgaria the indicators for efficiency of nitrogen fertilization in sorghum have been established.

Based on the conducted multifaceted study of the influence of nitrogen on the development and yields of cultivation of sorghum, the author of the thesis recommends for practice what are the optimal nitrogen fertilizer rates depending on the provision of the year with precipitation. It is emphasized that in order to achieve good product quality, nitrogen fertilization must be combined with the application of phosphorus fertilizers.

Of great importance for the calculation of the optimal fertilizer rates with the main nutrients in the cultivation of sorghum are the necessary amounts of these elements for the formation of unit of production (100 kg).

Sorghum has been found to be an effective crop in terms of converting nitrogen fertilizer into grain and grain protein yields, including at low levels of nitrogen nutrition.

In order to maintain a positive balance of nitrogen and phosphorus in the soil when growing sorghum, fertilizer rates must be at least 18 kg N / da for nitrogen and more than 5 kg P<sub>2</sub>O<sub>5</sub> / da for phosphorus.

#### **6. Critical remarks and questions.**

As a remark, I can note that most of the results are presented in the form of tables. The author was able to try to include more figures that facilitate the perception of emerging trends as a result of the study.

Some indices are indicated by their English abbreviations, without indicating their meaning in Bulgarian, such as PHI, KHI. It was better to use their Bulgarian designations.

Material and methods indicate when the millet was sown, but it was omitted to write when it was harvested.

Figure 10 lacks an indication of what is shown on the ordinates and abscissas of the two figures.

The mentioned omissions and weaknesses are mainly related to technical errors and do not underestimate the great work done by the Ph.D. student as well as the achieved results, but should be taken into account in order to avoid them in his future scientific work.

I have one question for the Ph.D. student.

What organic compounds move in the process of reutilization of dry matter in plants from the vegetative parts to the reproductive ones?

### **Published articles and citations.**

The Ph.D. student presents 3 publications written on the basis of the dissertation. Two of them are co-authored with his supervisors, and in one of them Ph.D. student Velinov is the first author.. These articles are published in the collection Scientific Papers. Series A. Agronomy, published by the University of Agriculture and Veterinary Medicine in Bucharest, Romania. One of the articles is an independent one, with which Ivan Velinov participated in the international scientific symposium "Agrosym 2019", which is being held in Bosnia and Herzegovina. The Ph.D. student has participated in two international conferences. The total number of points that the Ph.D. student collects as a result of the three publications is 30, which cover the requirement of a minimum of 30 points for admission to doctoral defense.

The author did not cite citations to articles with his participation.

The presented abstract in a total volume of 39 pages objectively reflects the structure and content of the dissertation. The data in it are presented only in tabular form.

### **CONCLUSION:**

During his Ph.D. studies, Ivan Velinov mastered the methods of establishing pot and field fertilizer experiments, used various methods for analysis of soils and plants, as well as ways to calculate indicators of nitrogen fertilization efficiency and the economic effect of fertilization of the crop. Last but not least, he learned to analyze and summarize the information obtained from the experiments and to write his thesis in strict and clear scientific language. All this shows that the Ph.D. student Ivan Velinov is a young scientist who can continue to develop in the field of agrochemistry and other similar sciences.

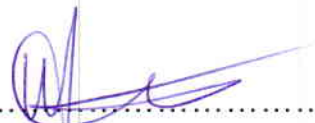
Based on all this, I believe that the presented thesis meets the requirements of ZRASRB and the Regulations of the Agricultural University for its application, which gives me reason to evaluate it **POSITIVELY**.

I allow myself to suggest to the esteemed Scientific Jury also to vote positively and to award the Ph.D. student Ivan Dimitrov Velinov the educational and scientific degree "Doctor" in the scientific specialty Agrochemistry.

**Date:** 26.04.2021

Plovdiv

**REVIEWER:** .....



(Prof. Ivan Manolov)