



REVIEW

on a dissertation work for obtaining the educational and scientific degree "doctor" in: field of higher education 6 "Agricultural sciences and veterinary medicine", professional direction 6.1. "Plant breeding", the scientific specialty "Melioration"

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Dissertation topic: REGULATED IRRIGATION REGIME

Reviewer: Prof. Dr. Alexander Todorov Matev, Agricultural University – Plovdiv, field of higher education 6 "Agricultural sciences and veterinary medicine", professional direction 6.1. "Plant breeding", the scientific specialty "Melioration"

Appointed as a member of the scientific jury by order No. RD-16-1308/19.12.2022 of the Rector of AU – Plovdiv.

1. Brief presentation of the candidate.

The PhD student Nadia Stoyanova Hristova is a graduate of Agrarian University - Plovdiv, and in 2007 she obtained a Bachelor's degree in "Agronomy-Hydromelioration", and then, a Master's degree in "Viticulture and Winemaking". Since 2014 to the present, she has been working in the Agricultural Academy, as a senior expert agronomist (Seed production) in Maritsa Vegetable Crops Research Institute (MVCRI) - Plovdiv. The accumulated knowledge and skills throughout this period give reason to assume that Nadya Hristova has the necessary basis for successfully conducting research activities. In 2019, she successfully passed a competition and was enrolled as a full-time PhD student in the Department of Meliorations, Land Regulation and Agrophysics at the Agricultural University, Plovdiv. An advantage in this particular case is the coincidence between the specialty of the bachelor's degree and that of the doctorate. In addition, the doctoral student has an intermediate level (spoken and written) of German and English, which enables her to use a wider range of literary sources.

In connection with the procedure for the defense of the dissertation, the doctoral student has submitted the necessary additional documents according to the requirements, as follows:

- documents attesting to bachelor's and master's degrees;
- positive opinion from the commission for verification of the scientometric indicators of PhD students;
- the original scientific publications, based on which the additional scientometric criteria are met (35 points out of the required 30);
- completed scientometric table according to the NACID model;
- documents attesting to specialized training in connection with the implementation of the individual plan of the PhD studies;
- auto-abstract

2. Actuality of the problem.

The problems in modern irrigated agriculture are related to the shortage of irrigation water and the prolonged periods of drought during the growing season of most agricultural crops. Under these conditions, the implementation of an optimal irrigation regime is difficult, and in most cases it is impossible. For decades, scientists have been looking for science-based compromises in crop irrigation to minimize the negative effects of permanent or intermittent water deficits. The presented dissertation is entitled "Regulated irrigation regime", which is in sync with the problems presented above. That makes it actual. In addition, the dissertation resolves important details related to evapotranspiration and irrigation regime of an understudied vegetable crop - lettuce. The lack of sufficient information about the irrigation regime of this agricultural crop is also confirmed by the relatively few literary sources found by the author. All this confirms the actuality of the presented dissertation work.

3. Aim, tasks, hypotheses and methods of research.

The aim of the dissertation is, through a field experiment, to study the possibilities of optimizing the irrigation regime of lettuce with two irrigation techniques (drip and micro-sprinkling), and based on the obtained experimental results, to establish the parameters of the "Water-yield" relationship and to be specified the economically optimal irrigation regime. In order to achieve the aim, the PhD student has formulated 6 tasks, which are the basis for drawing up the methodological plan. It is structured correctly, which implies the correct conduct of the two-year field experiment (2020-2021). It represents two parallel one-factorial field experiments. The scheme of their placing is described in detail (including a schematic), which is in accordance with the culture cultivation technology and is based on the relevant literary sources. Substantial attention is paid to the parameters of the irrigation techniques used. The variants in both experiments are classic for this type of research, covering a wide range of annual irrigation rate changes by reducing irrigation rates. Two variants were used for controls – no irrigation and optimal irrigation. For the study of the regulated water deficit, on the basis of the hypothetical optimal variant, variants with 20 and 40% reduction of irrigation rates are included. The "Water-Yield" relationship was established in terms of the irrigation rate and in terms of evapotranspiration, using existing equations. It is important for this type of research to establish the values of the biophysical coefficients of evapotranspiration (ET), and in the present dissertation, those based on the temperature sum, the air water pressure deficit and the reference ET have been calculated. As a task to the experiment, the determination of some photosynthetic parameters is included, as well as establishment of useful for science and practice dependencies. The economic analysis is based on components related to the income and costs of salad production.

4. Visibility and presentation of the results obtained.

The dissertation has a volume of 142 pages. It has a good scientific style and correctly used terminology. It contains 6 chapters, and the main part of the volume of the dissertation, as a rule, is occupied by the literature review and the results (respectively 19 and 44%). The soil and climatic characteristics of the place of the experiment are in a separate section preceding the results, which I consider to be correct. An integral part of the work are the tables and graphs and diagrams, which give a complete overview of the values of the considered components and ensure clarity in the analysis of the results. The total number of tables is 46, and graphs - 49. All of them are tailored to the specificity of the information they present so that they can be easily read and help the textual analysis.

5. Discussion of results and used literature.

The literature review can be mainly divided into two parts. The first part explains the regulated irrigation regime in principle, and the second one refers to the watering regime of the lettuce. A total of 226 literary sources were used for its writing (some of them are used in the methodology), of which only 28 are in Cyrillic, and all the rest are in Latin (mainly English). This is a clear indication of a lack of information about the conditions in Bulgaria, even more so considering that the majority of Cyrillic sources were used in the methodology of the experiment.

The analysis of the results follows chronologically the methodical plan. Looking carefully at this section, it becomes clear that the task of the PhD has been accomplished. The new knowledge acquired by the PhD student, as a result of attending methodical courses during the three-year period of study, is applied. So she fulfills the educational part. The analyzes used are not accidental, but according to the specific purpose. Thus, for example, the meteorological characterization was made by considering statistical series of 30 members each (including the experimental years), on which the parameters (arithmetic mean, C_v and C_s) were established. Thus, an accurate characterization of the years and a more correct interpretation of the results of the experiment is possible. They are presented graphically by means of graphs, which gives reason to consider with conviction that the PhD student has excellent computer skills. Proof of this is the applied dispersion analysis of the yield data, which determines the warranty of the differences obtained between the individual variants. Microsoft Excel was used again, and its application in the thesis did not end there. Mathematical dependencies and the equations to which they are subordinate are derived, and a large part of them are also presented by means of graphics. Outside of the disciplines defined in the individual plan, during her PhD studies, Nadya Hristova also studied some specialized computer programs, which gave her the opportunity to quickly and correctly establish the parameters of the relationship "Water-yield" using linear and power equations. All of this proves that the educational part of the doctoral program was successfully completed. Regarding the scientific part, the necessary results are also available, which are a consequence of a properly conducted field experiment and the acquired good theoretical training. The experiment was conducted correctly, using the method of long plots, which, with small experimental areas and the irrigation techniques used, is more appropriate than the block method. Variants are set in three repetitions. They are placed in sequence. This enables the application of appropriate statistical analyses. The recommendations from previous studies were followed, regarding the level of pre-irrigation soil moisture (80%FC) and the depth of wetting of the soil during irrigation, and thus the hypothetical optimal irrigation variant was formulated. In all other variants, irrigation rates are reduced according to the methodology. The yield results indicate that, whenever possible, lettuce should be irrigated optimally to obtain maximum yield with high quality. The expectation that the moderate decrease in irrigation rates (by 20%) will have a minimal negative impact is not justified. The yield decreases by around and over 14%, and with a 40% reduction in the norms - by 22-23%. Based on this, the PhD student recommends a moderate correction of the norms only in the conditions of limited water resources. However, the data confirm the disproportionate change in yield compared to the change in irrigation rates. This is also proven by the exported data on IWUE. It is highest at the smallest rate and decreases as it increases. The relationship "Irrigation rate-yield" has been studied for both irrigation techniques, and from a mathematical point of view the two presented variants have almost the same accuracy,

but I consider the correctly expressed advantage of the power relationship at $n=1.19$ and $n=1.25$, respectively for the two techniques. An essential part of this type of experiment is the study of evapotranspiration. In the present dissertation, for all variants and irrigation techniques, three important indicators that characterize it are covered. The first of them is related to its seasonal values, which give the difference to the natural income of water and the deficit that must be supplemented by irrigation. More accurate information about this is given by the results showing the relative share of the components that form it. Of these, the irrigation rate in all irrigation regimes occupies the largest share. Average daily values determine the ET trend and are an indicator of the change in its intensity. The information that the doctoral student presents in relation to the biophysical coefficients is very important. She analyzes and recommends the use of the temperature sum method as fast, accurate and free. In reality, it is in no way inferior to the FAO method, which in scientific circles is indicated as having no alternative. Using the relative yield and relative ET data for all variants and irrigation techniques, the PhD student analyzes and establishes the parameters of the "Yield-ET" relationship, recommending the use of a power relationship instead of a linear one. This recommendation is logical, regardless of the fact that the results of the three equations are close in terms of accuracy. Of interest to science and practice are some dependencies presented in the dissertation that have no direct relationship with the irrigation regime. For example, the relationship between leaf area index and yield, which is linear at $R \approx 1$. I find the relationship between fresh leaf mass and leaf area very useful. It could significantly facilitate the determination of the main photosynthetic parameters, eliminating the need to measure the leaf area in advance. An application in the analysis of vegetable samples from lettuce would also find the relationship between the fresh and dry biomass of the leaves. The economic analysis was done correctly, as the advantage both by years and with both irrigation techniques is categorically in favor of the optimum irrigated variant. The doctoral student summarizes the results of the experiment in a total of 13 conclusions, which I consider to be well formulated.

6. Contributions of the dissertation work.

Based on the results of the conducted experiment and their analysis and formulated conclusions, the contributions of the presented dissertation are distinguished, which can be conditionally divided into two groups – scientific and applied.

Scientific contributions

The components of the lettuce irrigation regime under two irrigation techniques were determined.

The parameters of the "Water-Yield" relationship were established for the studied crop, valid for the two irrigation techniques used. An alternative to the FAO equation is presented regarding the "Yield-ET" relationship.

Applied contributions

The parameters and the influence of the regulated irrigation regime, carried out with two micro-irrigation techniques (drip and micro-sprinkling) on the productivity of lettuce, and the results are applicable in practice, have been determined.

The biophysical coefficients of ET of lettuce were calculated - R , Z and K_c .

Dependencies between leaf mass and leaf area, as well as between fresh and dry biomass, which may be useful in practice, are derived.

7. Critical remarks and questions.

More attention has been given to the regulated irrigation regime in principle than to its influence on the development, productivity and evapotranspiration of lettuce. Probably, this is due to the few existing studies in this direction and significantly shapes the relevance of the dissertation.

I do not consider it necessary to represent the daily ET by means of regression equations, regardless of the demonstrated high mathematical accuracy.

What is the exact reason favoring the power equation for the "Yield-ET" relationship over the linear FAO formula, since the difference in accuracy between them is not that significant?

How to explain the extremely high correlation coefficient in the dependence between leaf area index and yield ($R \approx 1$).

8. Published articles and citations.

In connection with the dissertation work, the PhD student has presented a total of 3 scientific publications, which are co-authored and she is the first author. They are published in the Journal of Mountain Agriculture on the Balkans, which is on the list of refereed publications of NACID. Citation information is missing.

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

CONCLUSION:

Based on the various research methods learned and applied by the doctoral student, the correctly performed experiments, the generalizations and conclusions made, I believe that the presented dissertation meets the requirements of the LDASRB and the Rules of the Agricultural University for its application, which gives me reason to evaluate it **POSITIVELY**.

I allow myself to propose to the honorable Scientific Jury to also vote positively and to award to **Nadia Stoyanova Hristova** the Educational and Scientific Degree "Doctor" in the the scientific specialty "Melioration"

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Plovdiv

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