REVIEW

regarding a PhD Thesis for the conferment of the educational and scientific degree "Doctor" (PhD)

Field of Higher Education: 6. Agricultural Sciences and Veterinary Medicine
Professional Field: 6.1. Crop Science
Scientific Specialty: Fodder Production, Meadow Cultivation

Author of the Thesis: **GEORGI KRAEV STANCHEV**
Full-time Doctoral Student at the Department of Crop Science, Agricultural University – Plovdiv

Thesis Title: "Investigation of the potential capacity of natural and artificial grasslands for CO_2 sequestration"

Reviewer: Prof. Boryana Georgieva Churkova, PhD; Research Institute of Mountain Stockbreeding and Agriculture (RIMSA) – Troyan.
Field of Higher Education: 6. Agricultural Sciences and Veterinary Medicine;
Professional Field: 6.1. Crop Science;
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Appointed as a member of the Scientific Jury by Order № RD-16-475 / 02.04.2026 of the Rector of the Agricultural University (AU).

1. Brief Presentation of the Candidate

GEORGI KRAEV STANCHEV was born on February 28, 1984. During the period 2011–2018, he studied at the Agricultural University – Plovdiv, where he obtained a Bachelor's degree in "Agroforestry Systems and Mountain Agriculture," followed by a Master's degree in "Crop Protection." From 2004 to 2011, he worked as a driver for Martineli Ltd. (Varna) and Triera Ltd. (Plovdiv). Between February and August 2016, he held the position of inspector-agronomist at SGS Bulgaria Ltd., and from November 2017 to April 2018, he worked as an irrigation systems foreman at Irisist Ltd. (Sofia). Since November 2021, he has held the academic position of Assistant Professor and currently serves as a lecturer. He was enrolled as a full-time PhD student at the Department of Crop Science by Order № RD 26-40 / 03.12.2019 of the Rector of the Agricultural University.

The PhD student has successfully passed the doctoral exam in Fodder Production and Meadow Cultivation (Protocol № 19 / 05.12.2019), as well as exams in the following disciplines: Database Information Retrieval and Information Processing (30.06.2021), English Language Part I (21.07.2020), Teaching Methodology (01.07.2021), English Language Part II (01.2021), and Statistical Data Processing (30.06.2021). He has successfully completed three modules of English language courses for doctoral students, evidenced by Certificate № K-15 / 16.02.2022. He was officially discharged from the doctoral program with the right to defend his thesis according to Order № RD 26-30 / 04.04.2022. He has published 3 articles related to the dissertation, one of which is a solo publication, and the others are co-authored with his scientific supervisors.

2. Relevance of the Research Problem

The topic of this dissertation is exceptionally relevant as it investigates the potential of natural and artificial grasslands for CO_2 sequestration. The ability of grasslands to contribute to the mitigation of climate change by identifying the components that stimulate carbon uptake and developing innovative management practices—is of critical importance for increasing the capacity of ecosystems to absorb CO_2.

The dissertation focuses on seeking solutions to address the consequences of a changing climate, offering opportunities to promote sustainable meadow cultivation to reduce emissions and the negative effects of global warming. In this context, the research contributes to a scientifically grounded presentation of the potential of natural and artificial grasslands for carbon capture, which is essential for long-term ecological balance. This underscores the timeliness and significance of the study, particularly in enhancing the quality of produced fodder while maintaining environmental stability.

3. Aim, Objectives, Hypotheses, and Research Methods

The scientific research aims to investigate the capacity of natural and artificial grasslands for carbon dioxide sequestration. To achieve this objective, the following tasks were developed:

1. Investigation of the carbon sequestration and storage capacity of natural grasslands;
2. Investigation of the carbon sequestration and storage capacity of artificial grasslands;
3. Establishing the relationship between climate, species composition, and carbon accumulation in plants and soil.

The subjects of the study are four research sites (polygons), one consisting of an artificial grassland and three featuring natural grasslands from diverse habitats, distributed as follows:

- Site 1 – artificial grassland located at the experimental field of the Agricultural University of Plovdiv;
- Sites 2, 3, and 4 – natural grasslands located in the regions of Rozino (Plovdiv district), Beklemeto (Troyan region), and Devin.

Each site is described in detail, including mapping, aspect, altitude, and GPS coordinates.

The following methodologies and parameters are thoroughly detailed: Determination of species composition within the grasslands using the Braun-Blanquet method;Analysis of soil organic carbon content; Basal cover of the grasslands; Dynamics of CO_2 fluxes.

Additionally, the research incorporates climate data for the study regions for the period 1991–2020 and statistical processing performed using multiple regression analysis. These comprehensive methods aim to optimize meadow cultivation practices to ensure high-quality fodder production while enhancing environmental carbon sinks.

4. Visualization and Presentation of Results

The doctoral dissertation is structured into 175 pages, distributed as follows: Title page; Contents (2 pages); Introduction (3 pages); Literature Review (36 pages); Aim and Objectives (1 page); Materials and Methods (7 pages); Soil and Climatic Characteristics (6 pages); Results and Discussion (80 pages); Conclusions (3 pages); Scientific and Theoretical Contributions (1 page); Scientific and Applied Contributions (1 page); and Bibliography (35 pages). The bibliography comprises 288 literary sources, of which 10 are in Cyrillic and 278 in Latin script. The work includes 37 tables and 61 figures. The chosen structure is logically aligned with the title and the primary research objective. The extensive number of references demonstrates a high level of literary awareness regarding the dissertation's subject matter.

The "Literature Review" section consists of eleven subsections, systematized according to the goals and tasks of the dissertation. An in-depth analysis of the significance of carbon dioxide and its impact on climate is provided. The second subsection presents natural sources of carbon dioxide as a complex of natural processes, including volcanic activity, ocean-atmosphere exchange, respiration of living organisms, and microbial mineralization of soil organic matter. Anthropogenic sources of CO_2, such as fossil fuel combustion, industrial production, construction, land-use changes, deforestation, and intensive agricultural practices, are also identified.

Subsections 5 and 6 track the influence of CO_2 concentrations on global warming and plants. Methods for the sequestration and storage of carbon dioxide are outlined, representing a set of natural and technological processes viewed as a combination of physical, chemical, biological, and geological mechanisms for carbon capture and storage. These findings are essential for optimizing meadow cultivation strategies that improve grassland health and the quality of produced fodder.

The significance of meadows and pastures is presented as one of the most vital natural resources for the development of livestock farming, the maintenance of sustainable agroecosystems, and their role in the global carbon cycle. The management of grasslands and its impact on CO_2 sequestration and climate change are further explored. It is highlighted that the uptake and accumulation of CO_2 in grassland ecosystems occur primarily through photosynthesis, during which atmospheric CO_2 is converted into organic compounds incorporated into plant tissue.

The final eleventh subsection demonstrates that the comprehensive literature review—illustrating the importance of grasslands and their impact on CO_2 sequestration—serves as a sufficient prerequisite for future policies and strategies aimed at climate change mitigation. It is scientifically substantiated and proven that the sustainable management of these ecosystems, including optimized meadow cultivation, has the potential to contribute significantly to stabilizing the carbon balance, limiting global warming processes, and achieving long-term ecological and economic sustainability. This approach ensures the production of high-quality fodder while safeguarding the environmental functions of the land.

5. Results Discussion and Literature

The main section, "Results and Discussion," consists of nine subsections, including an agrometeorological characterization and the determination of: species composition and basal cover of the grasslands, soil carbon content, CO_2 uptake activity per unit area, diurnal variation of CO_2 fluxes, and diurnal fluctuations in soil respiration. The capacity for carbon sequestration and storage in natural and artificial grasslands was investigated, establishing the relationship between climate, species composition, and carbon accumulation in plants and soil. Statistical processing of the data was also performed.

The first subsection presents a detailed characterization of meteorological conditions, analyzing deviations in mean monthly air temperatures and precipitation during the experimental period. The duration of the growing season is also presented. A detailed analysis was conducted on the composition of the vegetation by groups—grasses, legumes, and forbs—and by species. The mean height of the grassland and the number of species from the coenotic groups influencing the basal cover at the different research sites are presented. A trend toward increased and stabilized species diversity was established, represented by more complex and sustainable semi-natural grasslands. The dominance of grass species (Poaceae) across all sites was proven, alongside the role of legumes (Fabaceae) in soil nitrogen enrichment and productivity enhancement, and the influence of forbs in maintaining biodiversity and ecological plasticity. The Beklemeto site was identified as the most balanced in terms of ecological plasticity, species diversity, and structural integrity.

In subsection 3 (Figures 14, 15, and 16), soil organic carbon content is tracked by year across the four sites. It is demonstrated that organic carbon content is highest in mountainous regions, where plant communities exhibit a high capacity for carbon accumulation, directly dependent on climatic conditions. The Beklemeto site again showed the highest potential for carbon accumulation. Subsection 4 analyzes CO_2 uptake activity, expressed through photosynthetic activity during the active growth period. The highest photosynthetic activity was recorded in May and October, while the lowest was in July, indicating the strong influence of climatic conditions on the carbon balance.

The characterization of diurnal CO_2 flux variations in subsection 5 shows a dominance of uptake during daylight hours and release during the night, depending on climatic factors. Figures 22, 23, and 24 illustrate diurnal changes in soil respiration; the data interpretation proves that the intensity of this process is highly dependent on temperature, humidity, and organic matter content, which, in combination with photosynthesis, determine the capacity of phytocoenoses to accumulate organic carbon. Temperature, moisture, vegetation type, and organic matter content are identified as key factors determining the variability of soil respiration (subsection 6).

The results emphasize the need for long-term monitoring of the entire "vegetation-soil gas exchange" system to better understand the impact of climate change on the carbon balance and to develop strategies for sustainable meadow cultivation. Subsection 7 details the role of geographical location, grassland type, and land-use practices on long-term soil carbon storage. It is proven that the carbon cycle in grassland ecosystems is determined by the interaction of climatic, biotic, and soil factors, where climate sets the boundary, vegetation determines the efficiency of the carbon flow, and soil governs its accumulation (subsection 8).

Statistical processing via regression dependencies (subsection 9) shows a strong linear relationship between CO_2 uptake, temperature, and species composition, with a very high coefficient of determination. The regression analysis results confirm the dominant role of meteorological conditions in determining the intensity of carbon uptake by plants.

The appropriate methodology, in-depth analyses, and modern statistical processing substantiate the findings. The style and language of the dissertation are clear and precise, with results interpreted in a scientific manner and compared with the findings of other authors. Based on the results, 15 conclusions have been formulated, providing a clear overview of the scope and content of the dissertation, which ultimately contributes to the optimized production of fodder through sustainable management.

6. Contributions of the Dissertation

Based on the obtained results, the following contributions have been identified:

Scientific Contributions

1. A concept has been developed regarding the spatial differentiation of agroclimatic conditions as a function of altitude, proving their influence on the duration of the growing season, cumulative temperatures, and precipitation patterns.
2. Theoretical understanding of the impact of climate change on grasslands has been enriched by identifying trends toward rising temperatures, extended growing seasons, and increased frequency of droughts.
3. Patterns in the spatial organization and structural-functional differentiation of grassland phytocoenoses have been established in relation to climatic factors.
4. The link between species diversity, the functional structure of plant communities, and their ecological stability and self-regulation has been proven.
5. The role of key plant functional groups in the formation of productive and sustainable grassland ecosystems has been presented.

6. Theoretical knowledge of carbon cycle processes in grassland communities has been expanded through an analysis of the relationship between photosynthesis, soil respiration, and carbon accumulation.

7. Dependencies between climatic factors and the intensity of carbon exchange have been established, proving the leading role of temperature and moisture.

8. A distinction has been substantiated between grasslands with high instantaneous productivity and those with high potential for long-term carbon storage.

9. The concept of mountain grassland communities as stable carbon reservoirs in the context of global climate change has been further developed, highlighting their importance for sustainable meadow cultivation and the production of high-quality fodder.

Scientific and Applied Contributions

1. A comprehensive agroclimatic assessment of regions at different altitudes has been conducted, which can be utilized in agricultural planning and management.

2. The risk of drought in lowland areas has been evaluated, and zones with more favorable water regimes have been identified, providing practical value for the adaptive management of grasslands.

3. An approach for assessing the ecological stability of grassland ecosystems has been proposed, based on species diversity, structural characteristics, and climatic conditions.

4. The potential of various grassland communities for CO_2 accumulation has been quantitatively assessed, enabling the development of measures for climate change regulation.

5. The seasonal dynamics of soil organic carbon have been established, serving as a basis for the monitoring and evaluation of soil fertility and carbon balance.

6. The influence of climatic factors on photosynthetic activity and soil respiration has been proven, which can be applied in the development of sustainable ecological practices.

7. A regression model has been developed to evaluate the influence of climatic and ecological factors on carbon exchange within grassland communities.

8. Phytocoenoses with high potential for long-term carbon storage have been identified, suitable for various practices related to the restoration of the carbon balance.

9. The importance of maintaining high biodiversity and sustainable grassland management for optimizing the carbon balance has been established.

10. The results obtained can be used in developing climate change adaptation strategies and for the sustainable management of agroecosystems, ensuring both environmental stability and the production of high-quality fodder through optimized meadow cultivation.

7. Critical Remarks and Questions

I have no critical remarks.

8. Published Articles and Citations

Three publications are cited in relation to the dissertation: one as a sole author and two co-authored with the research supervisors. All three papers were presented at conferences and published in proceedings.

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

CONCLUSION

Based on the various research methods learned and applied by the doctoral candidate, the correctly executed experiments, and the generalizations and conclusions drawn, I consider that the submitted dissertation meets the requirements of the Act on Development of the Academic Staff in the Republic of Bulgaria (ADASRB) and the Regulations of the Agricultural University for its application. This gives me sufficient grounds to provide a **POSITIVE** assessment.

I take the liberty of proposing to the esteemed Scientific Jury to also vote positively and to award **GEORGI KRAEV STANCHEV** the educational and scientific degree of **"Doctor" (PhD)** in the scientific specialty **"Fodder Production and Meadow Cultivation."**

Date: 5.05.2026
City of Plovdiv

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