ISSN: 0017-2294

DOI Link: https://doi.org/10.61586/bsn3X
Vol.65, Issue.11, Part.1, Nov 2025, PP.15-25

ASSESSING THE PRODUCTIVITY OF MAIZE IN MOLDOVA IN THE CONTEXT OF CLIMATE CHANGE

[1] Caisin Larisa, [2] Dubit Daniela, [3] Scripnic Elena

[1],[2],[3] - Technical University of Moldova
e-mail: larisa.caisin@mpasa.utm.md

Received Feb 2025 Accepted Oct 2025 Published Nov 2025

Abstract
The present study provides a comprehensive assessment of maize productivity under climate variability in the Republic of Moldova, based on research conducted in 2024 at "Garma GRUP" LLC, Firladeni village, Hincesti district. The investigation focused on grain and silage yields, soil physical and chemical characteristics, water availability, and the applied technological model. Particular attention was given to soil bulk density and moisture reserves, as these parameters are critical determinants of crop performance under increasingly frequent drought and heat stress events associated with climate change.

The results revealed that the bulk density of carbonatic sandy-loam chernozem ranged between 1.15 and 1.26 g/cm³, while ordinary clay-loam chernozem showed higher variability, from 1.05 to 1.38 g/cm³. Excessive soil compaction was detected in the 30–40 cm horizon, exceeding optimal thresholds for root development and water infiltration. At planting, available soil moisture reserves were relatively modest, measured at 71.18 mm for ordinary chernozem and 67.15 mm for carbonatic chernozem. By the time of harvest, these values had decreased sharply to 31.27 mm and 27.37 mm, respectively, reflecting a significant water deficit throughout the growing season.

Biological indicators of crop establishment demonstrated high germination potential (91.8–95.1%), but survival rates were considerably lower (60.4–80.8%), highlighting the stress conditions affecting maize plants during critical growth stages. Even under supplementary irrigation, green biomass production remained unsatisfactory, ranging only from 47 to 54 t/ha. This underperformance suggests that current irrigation strategies and technological measures are insufficient to fully mitigate the effects of soil degradation and water scarcity.

These findings underscore the vulnerability of Moldovan maize production systems to climate-induced stresses and emphasize the urgent need for adaptive strategies, including soil conservation practices, optimized irrigation management, and the introduction of drought-tolerant hybrids. The study contributes to a better understanding of the interactions between soil quality, water availability, and crop productivity, offering valuable insights for researchers, policymakers, and farmers aiming to enhance resilience and sustainability in the national agricultural sector.

Key words: Corn, Field germination capacity, Precipitation, Silage, Soil

INTRODUCTION

The Republic of Moldova is an agricultural nation where corn (*Zea mays L*.) plays a crucial role in the economy and food security. However, the impacts of climate change pose significant challenges to the productive capacity of corn in the region. Variations in temperature and precipitation patterns threaten not only the quantity but also the quality of corn yields, as evidenced by recent studies indicating that climatic factors directly influence agricultural productivity (Lobell et al., 2011; Godfray et. Al., 2010). Understanding these dynamics is essential for developing effective strategies to mitigate the adverse effects of climate change on crop production (Thornton, 2010). This study aims to evaluate the productive capacity of corn in Republic of Moldova under changing climate conditions, providing insights that can influence the sustainable agricultural practices and policy decisions to enhance resilience in the face of environmental uncertainties.

In the livestock sector, the issue of plant protein assurance is highly relevant, as animals are currently receiving only about half of the required amount (105–110g). Ensuring ecological sustainability and animal production through effective management of crops and irrigation, in the context of the sector's resilience to climate change, has become increasingly important (FAO, 2017; Girla and Cazmali, 2012).

Globally, the cultivation of forage crops is expected to increase for two primary reasons: a shift in human diets toward animal-based products and the absolute growth of the world population. As diets become more protein-rich, particularly in developing countries, there is a growing demand for livestock products, which in turn drives the need for higher forage production to support livestock nutrition (Lupașcu et al, 2004; Steinfeld et al., 2006). Additionally, the world population is projected to continue rising, leading to an ever-increasing demand for food (Godfray et al., 2010). This surge in demand necessitates the expansion of forage crops, as they are essential for maintaining healthy livestock and ensuring food security in the face of population growth (FAO, 2017).

Agricultural practices will need to adapt, incorporating more sustainable and efficient methods for forage production for meeting the above-mentioned demands. This could involve improving forage crop varieties, optimizing land use, and implementing integrated farming systems that enhance both crop and livestock productivity while minimizing environmental impacts (Thornton, 2010). The strategic development of forage crops will be crucial for addressing the challenges of food security and sustainable agriculture in the coming decades (Cassidy, 2013).

Over the last decade, the cultivation of corn for silage and green mass has expanded significantly due to its crucial role in ensuring the availability of forage. Corn is particularly important for feeding animals, as silage made from corn is the most widely used fodder. A hectare of corn for silage can provide up to 15,000 feed units (UN), with a low crude protein content (5-10% of dry matter), at a ratio of 60-65 UN:1 PB. Despite this, corn intended for silage is considered the "winter pasture" for animals, as it is well consumed by all species due to its high digestibility (Guș and Rusu, 2008; Yin and Struik, 2015).

The intensive growth of corn's vegetative mass begins after the fifth leaf forms, which occurs approximately in the first decade of June. However, moisture supply

to the crop (in the 1.0 m soil layer) during the growing season in the current climate of southern region of Republic of Moldova does not exceed 45-50% of the optimal amount, while in the northern and central regions it ranges between 60-70%. Therefore, to increase corn production in Republic of Moldova, irrigation is necessary (Starodub, 2011).
Changes in climatic conditions are altering agricultural cultivation methods in many regions. In Europe, the rate of warming ranged between 0.13 and 0.24°C per decade over 20-year periods since 1976, with the ten warmest years on record occurring after 2000 (Zhao et al., 2017).
In July, according to literature sources, corn enters the critical phases of inflorescence and flowering, during which moisture requirements are at their peak. Average daily air temperatures between +19 and +21°C, combined with sufficient precipitation, ensure optimal growth of corn during this period.
In August, corn enters the milk and dough stages of kernel development. During this period, the moisture requirements of corn decrease significantly, and the multi-year average moisture reserves in the one-meter soil layer should be between 70 and 100 mm (Starodub, 2011).
Climat conditions are significantly influencing agricultural practices, particularly for crops like corn that are highly sensitive to temperature and moisture levels during critical growth phases. In Europe, warming trends highlight the necessity of adapting cultivation techniques to sustain crop yields. The optimal growth of corn in July requires specific temperature and moisture conditions, which, if unmet, can lead to suboptimal development and reduced productivity. By August, as moisture requirements decline, maintaining sufficient soil moisture reserves becomes essential for supporting corn's kernel development stages. These findings underscore the importance of adjusting agricultural strategies to evolving climatic patterns to ensure crop resilience and yield stability in the future.

MATERIALS AND METHODS

The research involved both fieldwork and laboratory analyses. The fieldwork was conducted in 2024 in the central region, on two fields belonging to the agricultural unit "Garma GRUP" SRL, located in Firladeni vill., Hincesti district, Republic of Moldova.
Field research was carried out on two fields:
- field nr.1, with an area of 50 hectares, is represented by a typical loamy-clay chernozem;
- field nr.2, with an area of 63 hectares, is characterized by a loamy-sandy carbonated chernozem.

The humus content in the arable layer of the typical chernozem ranged between 1.92% and 2.56%, while in the carbonated chernozem, it ranged from 2.12% to 3.02%. The soils are characterized with a sufficient content of nitrogen and potassium, a low level of mobile phosphorus, and a neutral soil solution reaction.
Soil preparation after harvesting the predecessor crop (winter wheat) included stubble plowing (14-15cm), subsoiling (28-30cm), and full cultivation. In the spring, prior to sowing, pre-sowing cultivation was carried out to the depth of seed incorporation (5cm).

For establishing the corn silage crop, the semi-late single-cross hybrid *Porumbeni 4612* was used. The hybrid is registered in Moldova for both grain and silage cultivation and belongs to the FAO 460 maturity group. The vegetation period in local conditions ranges from 120 to 125 days, and the plant reaches a height of 210-230 cm.

The corn for silage was sown on 10th of April, 2024, with a seeding rate of 66,000 seeds per hectare, spaced 50 cm between rows. Along with sowing, fertilization was applied using JKU liquid fertilizer (N11P37) at a rate of 50 kg/ha.

Measurements were made on repetitions to determine the degree of moisture availability in the crop at sowing and harvesting, by taking soil samples from the 0-100 cm layer. Soil samples were also taken to determine the bulk density.

Before harvesting (on 2nd of August, 2024), plant height and pre-harvest density were measured, as well as the green mass yield per square meter was identified (Kang et al., 2018; Vavilov, 1983).

Laboratory research was conducted in the Soil Science Laboratory of the Faculty of Agricultural, Forestry, and Environmental Sciences, Technical University of Moldova (UTM). Soil moisture content was determined by the thermostatic gravimetric method (drying the collected soil samples in an oven at 105°C) (Bucur, 2015). The total and accessible water reserves in the soil were then calculated mathematically.

Two irrigations were applied during the growing season (at the 5-7 leaf stage and 4 days before flowering) with an irrigation norm of 25 m^3/ha.

RESULTS AND DISCUSSION

Agricultural production is largely dependent on weather conditions and, as a result, is one of the most vulnerable sectors of the economy. Fluctuations in temperature and precipitation, as well as extreme climate events in recent times, significantly affect crop yields and livestock productivity, causing substantial economic losses and threatening the country’s food security.

According to literature data, with a one-degree Celsius increase in the global average air temperature, global crop yields are expected to decrease by at least 3.1%. In this context, maintaining the stability of plant production becomes crucial for the agricultural sector.

Climate change imposes abiotic stress on plants, and precipitation is of paramount importance as a factor influencing the growth and development of corn, followed by temperature and sunlight.

Climate change significantly affects agricultural productivity, particularly through abiotic stresses that plants experience, such as variations in temperature and precipitation. Among these factors, precipitation is significantly important for the growth and development of corn (*Zea mays L.*), as it directly influences soil moisture availability and, consequently, plant health and yield.

Research indicates that altered precipitation patterns due to climate change lead to water scarcity or excess, both of which can severely affect corn crops. For instance, drought conditions can cause water stress, resulting in reduced germination rates, stunted growth, and lower yields (Kang, 2018; Kumari et al., 2022). Conversely, excessive rainfall can lead to waterlogging, which inhibits root oxygenation and can promote diseases, further hindering corn development.

Temperature also plays a critical role in corn growth, with optimal temperature ranges being essential for photosynthesis, nutrient uptake, and overall plant metabolism. Elevated temperatures can exacerbate water stress conditions and can also lead to heat stress, negatively impacting grain filling and overall yield (Lobell, 2011).

Moreover, sunlight is a vital component in the photosynthetic process, which is crucial for corn's energy production and growth. Changes in the amount and intensity of sunlight due to climate variability can further compound the effects of temperature and precipitation on corn crops (Yin and Struik, 2015).

In summary, the interplay between climate change-induced abiotic stresses, particularly precipitation, temperature, and sunlight, is essential in understanding the growth dynamics of corn. Effective adaptation strategies, such as improved irrigation practices and the development of drought-resistant corn varieties, are crucial to mitigating the adverse effects of climate change on corn production.

Changes in precipitation patterns can significantly affect soil moisture availability, which is critical for optimal corn growth. Rising temperatures may also impact the plant's physiological processes, leading to reduced yields if not managed effectively. Furthermore, the amount of sunlight received during critical growth periods can influence the photosynthesis and overall crop productivity.

There is a need to mitigate the adverse effects of climate change to avoid the decried productivity in corn production and inefficient effect on growth and development of the plants. Improved irrigation practices can help ensure consistent water supply during dry spells, while the development of drought-resistant corn varieties can enhance resilience against water scarcity. Research has shown that these strategies can significantly improve yield stability under varying climate conditions (Lobell, 2011; Godfray, 2010). By implementing such adaptive measures, farmers can better navigate the challenges posed by climate change, ultimately supporting food security and economic stability in regions reliant on corn cultivation.

Analysis of meteorological data from the 2023-2024 agricultural year (fig. 1, 2) shows that the amount of precipitation recorded between September and February was at the multiannual average level of 203.3 mm, totaling 202.5 mm. In the spring of 2024, precipitation levels were 37.6 mm above normal, representing a 35% increase. These conditions allowed for the establishment of crops by the end of the first decade of April and facilitated uniform germination and emergence of the crops (fig. 1).

GORTERIA ISSN: 0017-2294
2025 65(11)

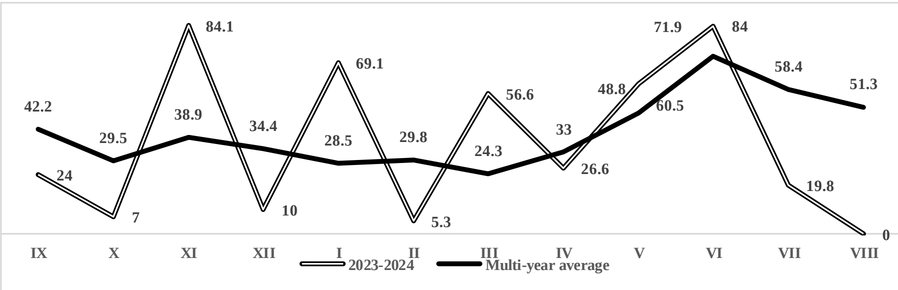

Figure 1. Atmospheric Precipitation (mm) in the 2023-2024 agricultural year, Central Region of the Republic of Moldova

The corn silage crop experienced water stress during the heatwave in July and August, with a precipitation deficit of 66% and 100%, respectively. The agricultural year was characterized by insufficient atmospheric deposits, with only 80% of the normal precipitation recorded, making summer the driest season, with a precipitation deficit of 42.8%.

Data on the average air temperature recorded in the 2023-2024 agricultural year show an increase of 3.6 °C above the multiannual average (9.9 °C). The spring of 2024 was warmer than normal by 2.6 °C (9.9 °C), while summer was marked by high temperatures exceeding the norm (20.9 °C) by 3.2 °C to 3.7 °C (fig. 2).

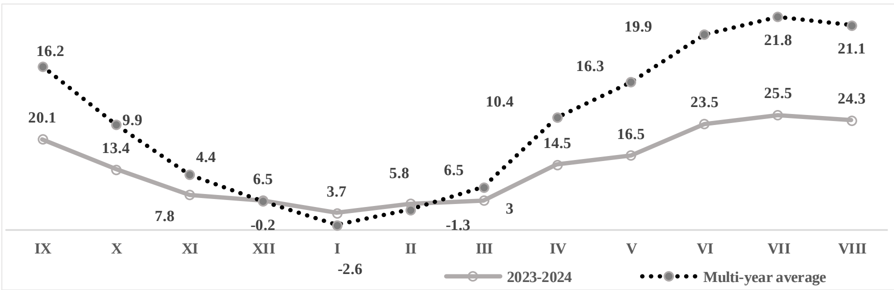

Figure 2. Monthly Average Temperature (°C) in the 2023-2024 agricultural year, Central Region of the Republic of Moldova

The acceleration of climate change necessitates that each agricultural region implements various methods to mitigate the impact of these climatic changes in order to enhance the stability of agricultural crop production. One potential solution is irrigation.

The physical properties of soil significantly influence how it functions and affect plant growth and water regime. One of the soil's agro-physical parameters that impacts both the formation of biomass and crop productivity is bulk density. Understanding the values of bulk density is essential for characterizing soil tilth, porosity (both total and aeration), and calculating hydro-physical indices (total and available moisture reserves, etc.) for various purposes (Lal, 2009).
In most soils, bulk density ranges from 1.0 to 1.6 g/cm³, being lower in soils with high organic matter content compared to those with low organic matter content. Additionally, structured soils typically exhibit lower values in the upper layers (with the exception of compacted sub-horizons known as hardpans) compared to the lower parts of the profile (Yin and Struik, 2015).
Data from the specialized literature (Bucur, 2016; Coskun and Brito, 2020) demonstrate that the soil's arrangement affects its water retention capacity, permeability to water and air, resistance to agricultural operations, root penetration, and the degree of soil compaction. Low values of bulk density diminish the soil's significance, making agricultural operations difficult.
Research conducted on the fields of the agricultural unit "Garma Grup SRL" revealed the following values of bulk density (fig. 3) in the corn silage agrocenosis.

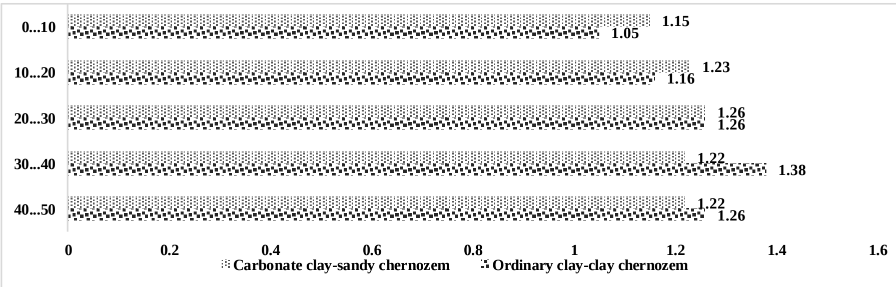

Figure 3. Depth, cm. Bulk Density of Soil (g/cm³) Under Corn Silage Cultivation, Firladeni village, Hincești District, 2024

In the clayey-sandy carbonated chernozem, the analyzed parameter values in the 0-50 cm layer ranged from 1.15 to 1.26 g/cm³, increasing gradually with depth and indicating light compaction at a depth of 20-30 cm (1.26 g/cm³), while remaining within optimal limits for plant development (1.1 – 1.3 g/cm³). In the typical clayey chernozem, the values of this physical soil parameter fluctuated between 1.05 g/cm³ in the 0-10 cm layer and showed compaction (1.38 g/cm³) beyond the optimal limit in the 30-40 cm layer. The use of bulk density in calculating soil moisture content and water reserves revealed that both researched fields were approximately equally supplied with moisture during both sowing and harvesting (fig. 4, 5).

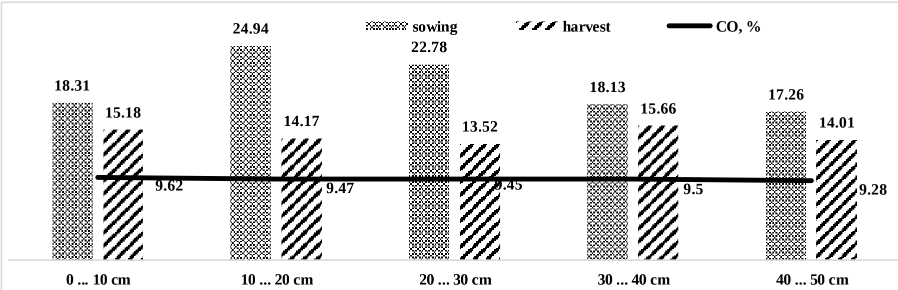

Figure 4. Moisture content (%) in the 0–50 cm soil layer on ordinary chernozem under silage maize cultivation

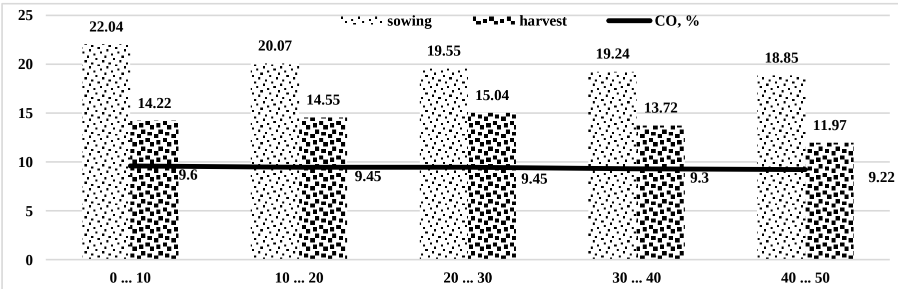

Figure 5. Moisture content (%) in the 0–50 cm soil layer on calcareous chernozem

Laboratory analyses showed that moisture levels in ordinary chernozem ranged from 17.26% to 27.94% at sowing and from 13.52% to 15.66% at harvesting, while in carbonaceous chernozem, moisture levels ranged from 18.85% to 22.04% at sowing and from 11.97% to 15.04% at harvesting. The calculation of the total and available water reserves in the soil revealed that the values for both varieties of chernozem were similar.

The total water reserve ranged from 132 mm in ordinary chernozem to 127.02 mm in carbonaceous chernozem on the day of sowing, while before harvesting, it varied between 88.67 mm and 84.54 mm, respectively.

The calculated available reserves at sowing were 71.18 mm for ordinary chernozem and 67.15 mm for carbonaceous chernozem, while at harvesting, the reserves were 31.27 mm and 27.37 mm, respectively, for the two soil types.

According to literature data, moisture retention in the soil is one of the most pressing challenges in contemporary agriculture, particularly in arid regions and, in some years, in temperate climate zones. As highlighted by (Duncombe, 2020), soil moisture deficit can arise not only from insufficient precipitation but also from unproductive losses due to factors such as evaporation, runoff, and poor soil management practices. These unproductive losses can frequently amount to as much as 40-70% of the total moisture available in the soil, significantly impacting crop yields and overall agricultural productivity.

Addressing and reducing these moisture losses presents a substantial opportunity for enhancing agricultural efficiency and sustainability. Effective management strategies that focus on improving soil moisture retention can lead to more resilient farming systems capable of withstanding climatic variability. The modeling of cultivation technologies should, therefore, prioritize methods that maximize moisture accumulation and conservation. This includes adopting a protective approach to soil management, which not only helps retain water but also contributes to the enhancement of soil fertility. By implementing practices such as cover cropping, reduced tillage, and proper irrigation techniques, farmers can improve soil structure, increase organic matter, and ultimately foster healthier ecosystems (Cainarean et al., 2015; Duncombe, 2020; Smith et al., 2021).

Such proactive measures are essential for ensuring sustainable agricultural practices in the face of climate change and increasing food demands.

Reducing these losses represents a significant opportunity for increasing agricultural efficiency. The modeling of cultivation technologies should be aimed at maximizing the accumulation and conservation of moisture, adopting a protective approach to the soil while contributing to increased fertility.

The field germination capacity of the corn hybrid, sown in both researched fields, ranged from 91.8% (on ordinary chernozem), ensuring a density of 60,588 plants per hectare, to 95.1% (on carbonatic chernozem), with 62,766 plants emerging.

Before harvesting, the survival rate was determined, with values ranging from 60.4% to 80.8%, ensuring 40,266.1 to 80,770.3 plants per hectare at the time of harvest, respectively, on the different soil types.

The mean plant height on ordinary chernozem reached 233 cm, varying from 222 to 255 cm, whereas on carbonatic chernozem it ranged from 179 to 276 cm, with an average value of 251.6 cm. Under irrigation conditions, the average green mass yield per hectare varied between 47 and 54 tons.

CONCLUSION

The agricultural year 2023-2024 experienced a precipitation deficit of 20%, with the driest season being the heatwave period, where the lack of precipitation reached 42.8%. This situation impacted the entire ontogenetic cycle of corn.

The values of bulk density under the corn silage agrocenosis, on carbonatic loamy-sandy chernozem in the 0-50 cm layer, ranged from 1.15 to 1.26 g/cm³, while on ordinary loamy-clay chernozem, it ranged from 1.05 to 1.26 g/cm³, with compaction (1.38 g/cm³) exceeding the optimal limit in the 30-40 cm layer.

ISSN: 0017-2294

The calculated available reserves at sowing were 71.18 mm (ordinary chernozem) and 67.15 mm (carbonatic chernozem), while at harvest, they were 31.27 mm and 27.37 mm, respectively.
The field germination capacity of the hybrid sown in both researched fields ranged from 91.8% to 95.1%, with a survival rate of 60.4% to 80.8%, ensuring 40,266.1 to 80,770.3 plants per hectare at the time of harvest, respectively.
The yield of green mass obtained per hectare under irrigation conditions was between 47 and 54 tons per hectare.
In conditions of insufficient precipitation, it is recommended to perform rolling after sowing to increase the field germination rate. The irrigation norm should be calculated based on the specific moisture requirements of the crop. Adapting cultivation technologies to climate change, including the irrigation of crops through the implementation of sustainable agricultural best practices with minimal inputs and rational use of natural resources, can help address the challenges in this field [5, 15]. By integrating these approaches, farmers can enhance crop resilience and ensure better productivity even under adverse climatic conditions.

Acknowledgment
Authors would like to express sincere gratitude for the opportunity to conduct research within the project titled "Improving the Ecological Sustainability of Animal Production through the Management of Irrigated Forage Crops in the Context of Resilience of the Livestock Sector to Climate Change." This project, registered under Strategic Priority II "Sustainable Agriculture, Food Security and Food Safety" in the State Register of Projects in the Field of Science and Innovation (code 23.70105.5107.02), has provided us with invaluable support and resources. We appreciate the collaborative efforts and guidance that have significantly contributed to advancing our research on sustainable agricultural practices.

REFERENCES
Bucur, Gh. *Lucrări metodice la disciplina Agrotehnică.* Chişinău: UASM, 2016. pp. 5–10.
Cainarean, Gh. [et al.]. *Managementul durabil al terenurilor.* Chişinău: S. n., 2015. 192 p. ISBN 978-9975-53-493-2.
Cassidy, E. S., West, P. C., Gerber, J. S., Foley, J. A. (2013). *Redefining Agricultural Yields: From Tonnes to People Nourished per Hectare.* Environmental Research Letters, 8(3), 034015.
Coskun, D., & Brito, G. (2020). *Soil-Water-Plant Relationships and the Role of Fertilizers.*
Duncombe, J. U. (2020). *Moisture Retention and Agricultural Efficiency: A Review.* Journal of Agricultural Sciences, 15(3), 45–56.
FAO (Food and Agriculture Organization of the United Nations). (2017). *The Future of Food and Agriculture: Trends and Challenges.*

Gîrla, Daniela, Cazmalî, N. *Densitatea aparentă ca indice agrofizic de productivitate a agroecosistemelor.* In: *Eficienţa utilizării şi problemele protejării solurilor: lucrările conf. şt. cu participare intern.* Chişinău, 2012. p. 166–173. ISBN 978-9975-62-315-5.

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., & Pretty, J. (2010). *Food Security: The Challenge of Feeding 9 Billion People.* Science, 327(5967), 812–818.

Guș, P., Rusu, T. *Sistemele minime de lucrare a solului alternative pentru protecția mediului.* In: *Sisteme de lucrări minime ale solului: mat. simp. şt. cu particip. intern.* Cluj-Napoca: Risoprint, 2008. p. 9–18.

Kang, S., Zhang, L., & Li, F. (2018). *Drought stress in maize: Physiological and biochemical responses.* Plant Growth Regulation, 54(1), 37–50.

Kumari, A. [et al.]. *Climate Change and Its Impact on Crops: A Comprehensive Investigation for Sustainable Agriculture.* In: *Agronomy*, 2022. Vol. 12, nr. 3008. Available: https://doi.org/10.3390/agronomy12123008.

Lal, R. (2009). *Enhancing Soil Fertility for Sustainable Crop Production.* Advances in Agronomy, 98, 123–180.

Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). *Climate Trends and Global Crop Production Since 1980.* Science, 333(6042), 616–620.

Lupașcu, M. *Lucerna – importanța ecologică și furajeră.* Chișinău: Știința, 2004. p. 304. ISBN 9975-67-385-6.

Smith, L., Jones, A., & Brown, R. (2021). *Sustainable Agricultural Practices in a Changing Climate.* Environmental Management, 56(4), 832–843.

Steinfeld, H., Gerber, P. J., Wassenaar, T., Castel, V., Rosales, M., & de Haan, C. (2006). *Livestock's Long Shadow: Environmental Issues and Options.* FAO.

Starodub, V. *Fitotehnie.* Chișinău: Print-Caro, 2011. 600 p. ISBN 978-9975-4187-6-8.

Thornton, P. K. (2010). *Livestock Production: Recent Trends, Future Prospects.* Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1554), 2853–2867.

Vîntu, V. [et al.]. *Cultura pajiştilor şi a plantelor furajere.* Iaşi: Ion Ionescu de la Brad, 2004. 589 p. ISBN 973-7921-47X.

Yin, X., & Struik, P. C. (2015). *Modelling crop growth and development under changing climate conditions.* Field Crops Research, 151, 53–65.

Zhao, C. [et al.]. *Temperature increase reduces global yields of major crops in four independent estimates.* In: *Proceedings of the National Academy of Sciences of the United States of America*, 2017. Vol. 114, nr. 35. pp. 9326–9331. Available: https://doi.org/10.1073/pnas.1701762114.

Vavilov, P. P. *Practicum on Crop Production.* Moscow: Kolos, 1983. 352 p.