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STAGE-SPECIFIC SPRINKLER IRRIGATION EFFECTS ON WHEAT YIELD IN THE GREAT ISLAND OF BRĂILA

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Abstract. *Efficient water and nutrient management represent a major challenge in modern wheat production systems, especially under increasing climatic variability. Beyond yield response, understanding the interaction between irrigation scheduling, soil moisture dynamics and nitrogen availability is essential for optimizing crop performance. This study aims to evaluate the effects of stage-specific sprinkler irrigation on soil water regime and nitrogen forms, and their influence on wheat yield formation under the pedoclimatic conditions of the Insula Mare a Brăilei, Romania. The experimental field is established within the Agricultural Research and Development Station Brăila, using a multifactorial design that includes irrigation regimes applied at key phenological stages (stem elongation, heading and grain filling), wheat varieties adapted to local conditions, and two crop density levels. Soil analyses focus on moisture content and nitrogen dynamics, including nitrate (NO_3^-), ammonium (NH_4^+) and related forms, monitored in relation to irrigation timing. Plant measurements include growth parameters, yield components and grain quality indicators such as protein and gluten content. The working hypothesis assumes that irrigation applied at critical growth stages modifies soil moisture distribution and nitrogen availability, improving nutrient uptake efficiency and contributing to yield stability. Preliminary observations indicate that irrigation timing influences both nitrogen transformation processes and plant response, suggesting a strong interaction between water management and nutrient dynamics. The expected results will contribute to the development of integrated irrigation strategies that optimize both, water use efficiency and nitrogen utilization, providing practical recommendations for high-performance wheat production systems under local environmental conditions.*

Keywords: *soil moisture; nitrogen dynamics; nitrate; ammonium; water use efficiency*

INTRODUCTION

Climate change in recent decades represents one of the greatest challenges for modern agriculture, directly influencing the stability and level of agricultural production [5], [10].The increase in the frequency and intensity of drought phenomena, together with the uneven distribution of precipitation, determines the emergence of critical periods of water deficit, especially in the plain areas of SouthEastern Romania.

In this context, wheat (*Triticum aestivum* L.), considered one of the most important agricultural crops at national and global levels, is strongly affected by variations in the water regime [2], [6]. Its economic and food importance requires the identification of efficient technological solutions, capable of ensuring the stability of production and maintaining the quality of the grains, even in unfavorable climatic conditions. In Romania, where the case study is located, consumption reached 118.4 kg/capita in 2023 in the food consumption model [9].

The Big Island of Braila represents one of the most productive agricultural areas in Romania, characterized by fertile soils and a well-developed irrigation system. However, even under these conditions, water management remains a critical factor, as inefficient use of resources can lead to significant economic losses and reduced efficiency of applied inputs.

Nowadays, irrigation is no longer seen only as a measure to supplement water deficit, but as an essential element of crop technology, which must be integrated and optimized according to the requirements of the plant and environmental conditions. Numerous studies highlight that not only the amount of water applied influences production, but especially the timing of its application in relation to crop phenophases [4], [6], [12]. Water absorption by wheat plants is very high in 3-leaves stages and during tillering, then decrease in the winter period, then tillering phase is the first critical phases of nutrition in winter wheat during vegetative period, then decrease in winter, but immediately in spring the absorption increases by 20% in the training phase of the straw [8]. Critical phases of wheat vegetation, such as straw elongation, earing and grain filling, are periods in which the water requirements of the plant increase significantly. Applying irrigation at these times can contribute to reducing water stress, improving physiological processes and increasing the efficiency of nutrient use.

On the other hand, the interaction between the soil moisture regime and the dynamics of nutrients, especially nitrogen, is an essential aspect in determining the crop response. Water influences mineralization, nitrification and nitrogen mobility in soil, directly affecting its availability to plants [8], [11]. Under optimal humidity conditions, nitrogen is more easily accessible, which favors its absorption and efficient use in the processes of growth and production formation.

In the absence of a correlation between irrigation and nutrient availability, imbalances may occur that lead either to nitrogen losses through leaching or to limiting its absorption, which negatively affects both production and grain quality. Thus, integrated water and nutrient management becomes a key direction in modern agriculture, ensuring both productivity and sustainability [5], [12].

In this context, this paper aims to analyze the influence of sprinkler irrigation staging on wheat production, through the interaction between soil moisture, nitrogen availability and plant response. The study is based on observations and determinations made in the first year of doctoral research, with the objective of identifying functional relationships between technological factors and crop performance.

The importance of the research lies both in its scientific contribution, by deepening the mechanisms underlying the interaction between water and nutrients, and in the practical applicability of the results, which can be used to optimize crop technologies in the specific conditions of the Big Island of Brăila.

Through the proposed approach, the paper aims to contribute to the development of efficient irrigation strategies, adapted to the requirements of the wheat crop and to local pedoclimatic conditions, in order to increase productivity and production quality, under conditions of rational use of resources.

In other experiments, the variations observed in grain yield, among different varieties underscore the importance of genetic factors and environmental adaptation in determining wheat productivity and quality [4].

MATERIAL ȘI METHODS

The experimental design was based on established methodologies used in irrigation and crop response studies [6], [7].

The research was carried out within the Brăila Agricultural Research and Development Station, under the specific pedoclimatic conditions of the Big Island of Brăila, on an experimental area of approximately 6,300 m².

Experiment organization

The experiment was organized according to a three-factor model, following the interaction between irrigation regime, variety and crop density.

Experimental factors:

• Factor A – irrigation regime, with the following variants:

o A1 – non-irrigated (control)
o A2 – irrigation at emergence
o A3 – irrigation at straw elongation
o A4 – irrigation at grain filling
o combined variants (A2A3, A2A4, A3A4, A2A3A4)

Irrigations were applied in quantities of:

• 200 m³/ha in the fall of 2025 (23.10 and 06.11)
• 400 m³/ha in the spring of 2026 (11.03)

• Factor B – wheat varieties:

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o Abund
o Miranda
o Pitar
o Voinic
They presented a high germination capacity, with values between 89% and 98%
• Factor C – crop density:
o 300 germinable grains/m²
o 500 germinable grains/m²
Seeding rates were adjusted according to MMB and germination, varying between:
• 125–134 kg/ha (300 bg)
• 208–223.5 kg/ha (500 bg)

Cultivation technology

The applied technological works included:

• land preparation by weeding and discing (August 2025)

• basic fertilization with complex fertilizers (18.46.0, 103–106 kg/ha)

• sowing carried out in early October

• application of phytosanitary treatments (herbicides, insecticides, fungicides)

• additional fertilization with urea and complex fertilizers in spring

• application of biostimulants (Ambition Algae)

Soil analyses

Soil analyses were carried out before sowing (01.10.2025) and during the vegetation period.
The soil showed:
• pH = 7.6 (weakly alkaline)
• electrical conductivity = 176.6 mS
• low salinity (0.3%)
The nitrogen content was characterized by:
• $N\text{-}NO_3$ = 0.3 mg/l
• NH_4^+ = 0.7 mg/l
• $NH_3\text{-}N$ = 0.55 mg/l
Also, macroelements (P, K) and microelements (Zn, Fe, Ca, Mg) were determined.

Soil moisture determinations

Soil moisture was monitored at two times:

• 25.11.2025

• 15.04.2026

The determinations were made on soil profiles up to 100 cm, at intervals:

• 0–25 cm

• 25–50 cm

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• 50–75 cm

• 75–100 cm

The values obtained revealed:

• average moisture in the 0–25 cm layer: approx. 20–30%

• progressive decrease in moisture in depth

• significant variations between irrigation variants

Biometric measurements of plants

Measurements were made regarding:

• plant density, varying between:

o 652 and 896 plants/m², depending on the variant

• number of siblings, between:

o 1 and 4.5 siblings/plant

• root length, between:

o 7 and 15 cm

• plant height, determined on 20.04.2026:

o average values between 58 cm and over 74 cm, depending on the irrigation regime

Data analysis

The experimental data were centralized and analyzed comparatively, aiming at:
• the influence of the irrigation regime on soil moisture
• the correlation between moisture and nitrogen forms
• the impact on plant development and crop density

RESULTS AND DISCUSSIONS

The results obtained in the first year of research highlight the significant influence of the irrigation regime on soil water dynamics, nutrient availability and wheat crop development.

1. Soil moisture dynamics

Determinations carried out in November 2025 and April 2026 revealed significant variations in soil moisture depending on the irrigation regime and profile depth.

In the superficial layer (0–25 cm), moisture values varied:
• in autumn: approximately 20–30%
• in spring: decreasing trend, in some variants up to 14–20%

This decrease is consistent with findings reported in other studies, where soil moisture reduction during vegetation is mainly attributed to evapotranspiration and plant water consumption [5], [10].:
• intense water consumption by plants
• losses through evapotranspiration
• redistribution of water in the soil profile

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In deeper layers (50–100 cm), moisture presented more stable, but generally lower values, which suggests a limitation of root access to water in the absence of additional irrigation.

The applied irrigation regime contributed to maintaining an optimal level of moisture in the root zone, but the differences between the variants indicate that the timing of water application is essential for the efficiency of its use (Figure 1).

2. Influence on soil nitrogen forms

Soil chemical analyses revealed relatively low values of available nitrogen:

• N-NO_3 ≈ 0.3 mg/l

• NH_4^+ ≈ 0.7 mg/l

Under conditions of variable humidity, these nitrogen forms are influenced by:

• mineralization processes

• nitrification

• mobility in the soil

Correlation of humidity data with those regarding nitrogen indicates that:

• in irrigated variants, nitrogen availability was better

• in non-irrigated variants, there is a risk of blockage in nutrient absorption

Interpretation:

Water plays a determining role in nitrogen dynamics, influencing both availability and plant uptake efficiency, as also reported by previous studies [8], [11].

• losses through leaching (in excess water)

• limitation of absorption (in water deficit)

3. Crop response – density and development

Crop density data revealed values ranging from:

• 652 to 896 siblings/m², depending on the variant

Higher densities were recorded in variants with:

• high initial density (500 bg/m²)

• better moisture conditions

Regarding twinning, values between:

• 1 and 4.5 siblings/plant were observed, indicating high variability between variants

The irrigation regime directly influences:

• twinning capacity

• crop density stability

Under optimal moisture conditions, plants develop more fertile siblings, which contributes to increased production potential.

4. Vegetative development (plant height)

Determinations carried out in April 2026 revealed height values ranging from:

• approx. 58 cm to over 74 cm

The highest values were recorded in the variants with:

• combined irrigation (A2A3, A2A3A4)

• optimal density

Plant height reflects:

• nutritional status

• water availability

• intensity of physiological processes

Higher values indicate better vegetative development, but must be correlated with the risk of falling and the efficiency of resource use.

5. Irrigation – soil – plant interaction

The integrated analysis of the results highlights the existence of a direct relationship between:
• irrigation regime
• soil moisture
• nitrogen availability
• crop development

The variants with staged irrigation presented:
• a more uniform distribution of water in the soil profile
• a better availability of nitrogen
• a superior vegetative development

It is not the total amount of water that represents the decisive factor, but the synchronization of irrigation with crop phenological stages, as highlighted in previous research [4], [12].

6. Technological implications

The results obtained in the first year of study indicate the need to adapt crop technologies, especially regarding:
• the timing of irrigation application
• its correlation with fertilization
• continuous monitoring of soil moisture

Application of irrigation not correlated with soil condition can lead to:
• unnecessary water consumption
• reduced fertilization efficiency
• production losses

CONCLUSIONS

The research conducted in the first year of the study highlights the determining role of irrigation staging in optimizing wheat production under the specific conditions of the Big Island of Brăila.

The results obtained demonstrate that the irrigation regime directly influences the dynamics of soil moisture, the availability of nitrogen forms and the crop response, confirming the working hypothesis regarding the complex interaction between water, soil and plant.

Soil analyses showed that the moisture level is an essential factor in controlling the mobility and accessibility of nitrogen, especially of the nitric and ammoniacal forms. Under optimal humidity conditions, the processes of nitrogen transformation and absorption are intensified, which contributes to more efficient plant nutrition.

The determinations carried out at the crop level highlighted the fact that the irrigated variants, especially those with staged application, presented superior vegetative development, characterized by more stable densities, higher twinning capacity and higher plant height values. These aspects indicate a more efficient use of available resources and a higher productive potential.

The results emphasize that it is not the total amount of water applied that is the decisive factor, but the timing of its application, in relation to the critical vegetation phases of the crop. Synchronizing irrigation with the physiological requirements of plants leads to a more efficient use of water and to a reduction in nutrient losses.

From a practical point of view, the research highlights the need to adapt crop technologies by:
• applying irrigation in critical phases (straw elongation, earing, grain filling)
• correlating irrigation with fertilization, especially with nitrogen supply
• permanent monitoring of soil moisture to optimize the timing of watering

Through these measures, an increase in the efficiency of resource use, a stabilization of production and an improvement in grain quality can be achieved.

The obtained results are in agreement with previous studies emphasizing the importance of irrigation scheduling for optimizing wheat production [4], [12].

In conclusion, the results obtained constitute a solid basis for the development of integrated technological models, adapted to the conditions of the Big Island of Brăila, which would allow increasing the productivity of wheat crops under conditions of rational use of water and nutrients.

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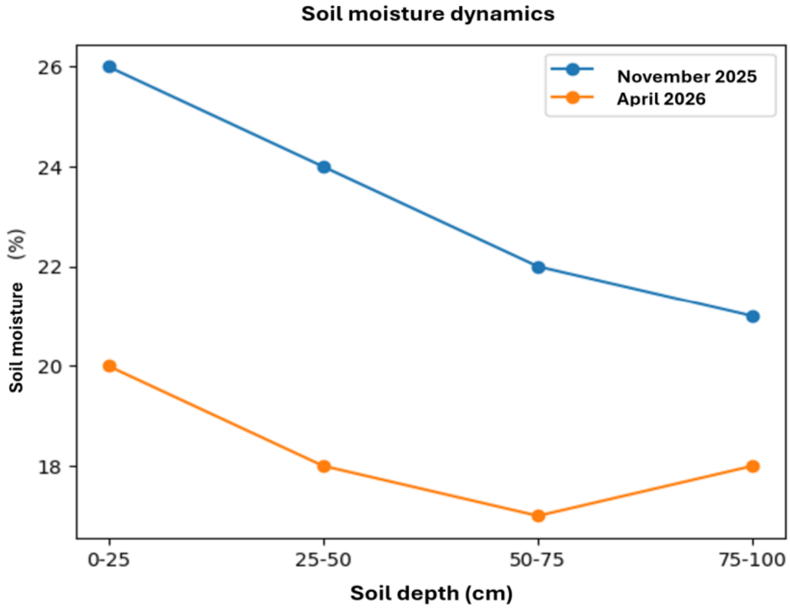

Figure 1. Soil moisture dynamics. A decrease in moisture is observed from autumn to spring, with a direct impact on water availability in the root zone

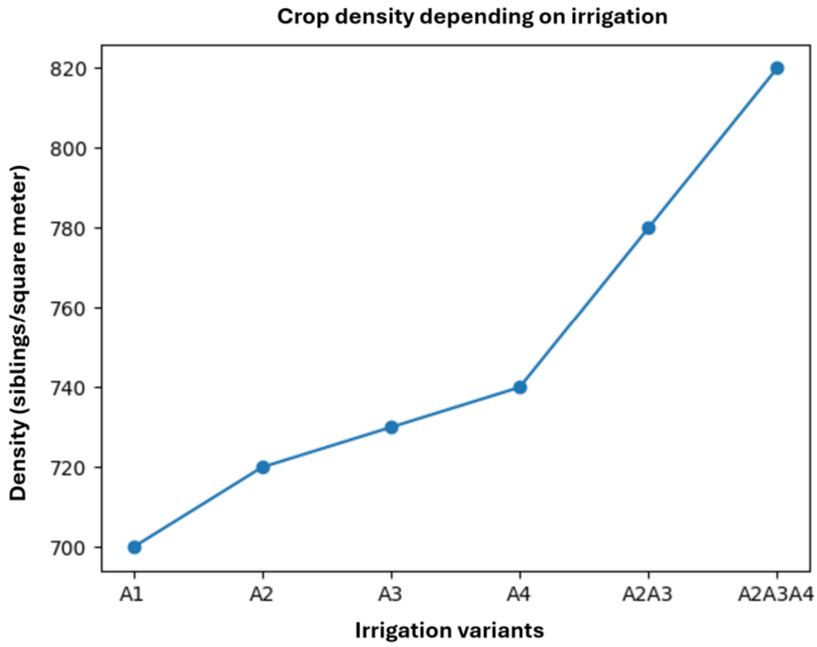

Figure 2. Higher and more uniform density is associated with optimized irrigation regimes.

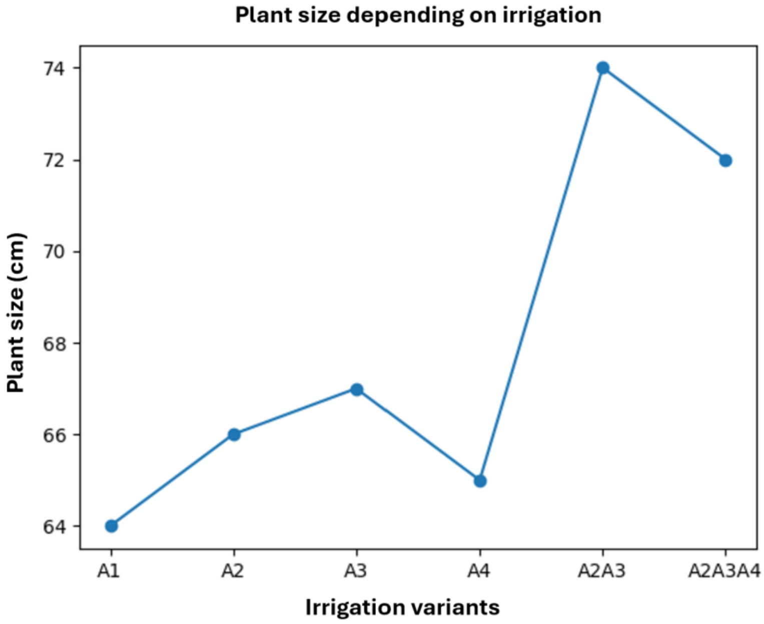

Figure 3. Variants with staged irrigation show higher waist, indicating more effective nutrition and hydration.