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**COMPARATIVE ASSESSMENT OF GERMINATIVE ENERGY AND
GERMINATIVE CAPACITY IN FIVE CHICKPEA CULTIVARS
EVALUAREA COMPARATIVĂ A ENERGIEI GERMINATIVE ȘI A
FACULTĂȚII GERMINATIVE LA CINCI CULTIVARE DE NĂUT**

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REZUMAT

Semințe de la cinci soiuri de năut, și anume Alamo, Flamenco, Maragià, Reale și Sultano, cultivate în Mereni, județul Constanța, au fost analizate pentru energia germinativă și facultatea germinativă, prin experimente standard de germinare în laborator. Cea mai ridicată energie germinativă a fost observată la Sultano (48%), urmată de Flamenco și Maragià (38% și 36%). Cea mai mică valoare a fost găsită la Reale (16%). Cea mai mare facultate germinativă a fost găsită la Maragià (76%), urmată de Sultano (68%) și Reale (64%). Alamo s-a clasat pe locul cel mai scăzut în ceea ce privește facultatea germinativă, cu doar 60%.

ABSTRACT

Seeds from five chickpea cultivars, namely Alamo, Flamenco, Maragià, Reale and Sultano grown in Mereni, Constanța county were analyzed for germinative energy and germinative capacity, through standard laboratory germination experiments. The highest germinative energy was observed in Sultano (48%), followed by Flamenco and Maragià (38 and 36%). The lowest value was found in Reale (16%). The highest germinative capacity, was found in Maragià (76%), followed by Sultano (68%) and Reale (64%). Alamo ranked the lowest in terms of germinative capacity, with only 60%.

Cuvinte cheie: năut, semințe, germinare, energie germinativă, facultate germinativă

Keywords: chickpea, seeds, germination, germinative energy, germinative capacity

**INTRODUCERE
INTRODUCTION**

Legumes (Fabaceae) are some of the most important crop plants worldwide, being used for food production, as fodder or for enhancing nitrogen

content in soils. Among them, after field peas and common beans, chickpea (or Bengal gram, Egyptian pea, garbanzo; *Cicer arietinum* L.) is the third most cultivated species. A native of the Middle East, it is now grown in a wide variety of tropical and temperate regions around the world, including North America, Europe and the Mediterranean, Africa, South Asia and Australia. Europe is responsible for only 0.4% of the global production (around 525,000 ha of the total 15 million worldwide, as of 2021) (Koul et al. 2022; Ciontu et al., 2024).

In Romania, it is a crop drawing an increasing interest from farmers. The areas cultivated with this species have grown from below 700 ha (with 720 t yearly yield) prior to 2018, up to over 1,200 ha (Pânzaru et al., 2022; Ciontu et al., 2024)

The aim of this research was to comparatively evaluate some cultivars commonly grown in Southeastern Romania in terms of seed germination potential.

MATERIAL ȘI METODĂ DE CERCETARE

MATERIAL AND METHOD

The five cultivars studied were Alamo, Flamenco, Maragià, Reale and Sultano. Chickpea seeds were collected from a field experiment conducted under farm conditions in Mereni, Constanța County, Romania, during the 2024-2025 agricultural year. The crop was established under minimum tillage conditions, following winter wheat as the preceding crop. All five chickpea cultivars were subjected to identical agronomic practices. Sowing was performed at a depth of 6 cm, with a density of 60 germinable seeds/m², giving a seeding rate of 160 kg/ha, and 45 cm row spacing. Germination was slightly delayed due to late spring frosts.

Climatic conditions during the growing season (March–July 2025) were characterized by a gradual increase in average monthly temperatures from 4.2°C to 22.6°C in July, with absolute maximum of 40.1°C and minimum of –11.9°C in early spring. Precipitation was unevenly distributed, with lower-than-normal rainfall recorded in most months, causing moderate drought conditions during key growth stages. The number of rainy days was also limited, particularly in June.

Weed control included a pre-emergence herbicide treatment with acetonitrile (600 g/L, suspension concentrate formulation, 4 L/ha). This was followed by mechanical hoeing and a post-emergence treatment with fluazifop-P-butyl (125 g/L, 2 L/ha). Two foliar fertilization treatments were applied during the BBCH 19–69 growth stages, using a complex NPK fertilizer at 2 L/ha. Pest

control was performed using a biological insecticide containing *Beauveria bassiana* (strain ATCC 74040) and *Metarhizium anisopliae* (strain MA 43), applied at 2 L/ha. Disease control included a fungicide treatment with tebuconazole (250 g/L, EW formulation, 0.5 L/ha). Harvesting was carried out mechanically on 25 July 2025.

According to literature, Alamo is a cultivar belonging to the Kabuli variety, with early to medium life cycle and seeds characterized by a beige wrinkled testa (Martoccia et al. 2025).

Flamenco is an early cultivar, first registered in France, in 1991, also Kabuli and with wrinkled seed coat (Bomers et al. 2025; Martoccia et al. 2025).

Maragià is an Italian Kabuli cultivar, developed in 2016 (Bomers et al. 2025).

Reale is an Italian Kabuli cultivar, registered in 2002 (Bomers et al. 2025).

Sultano is an early-medium Kabuli cultivar, characterized by a smooth beige seed coat. It was registered in 1990, Italy, where it is the most commonly grown cultivar. It has small-medium seeds, with smooth testa, drought-resistant and suitable for flour production (Bomers et al. 2025; Martoccia et al. 2025).

50 seeds from each cultivar were taken into analysis. They were placed over water-filled ceramic seed sprouters, on a layer of cotton wadding. Incubation occurred at room temperature, with periodic watering, using warm water.

The number of normally-germinated grains was counted after 4, respectively 8 days. Normal germination was considered when seedling root length was at least equal to the seed length and the shoot had at least 50% of the seed length. The first recorded value was the germinative energy, while the second, the germinative capacity (Boldor et al. 1983). Both were expressed as percentages of the initial seed amount.

REZULTATE ȘI DISCUȚII RESULTS AND DISCUSSIONS

Results are shown in Figures 1-3.

The highest germinative energy was observed in Sultano, namely 48% (24 germinated grains after 4 days of incubation), followed at a significant distance by Flamenco and Maragià (38 and 36%). The lowest value was found in Reale (16%), while Alamo also had a low germinative energy (20%).

The highest germinative capacity, on the other hand, was found in Maragià (76%), followed by Sultano (68%). Alamo had the lowest germinative capacity (60%), while the others had 62-64%.

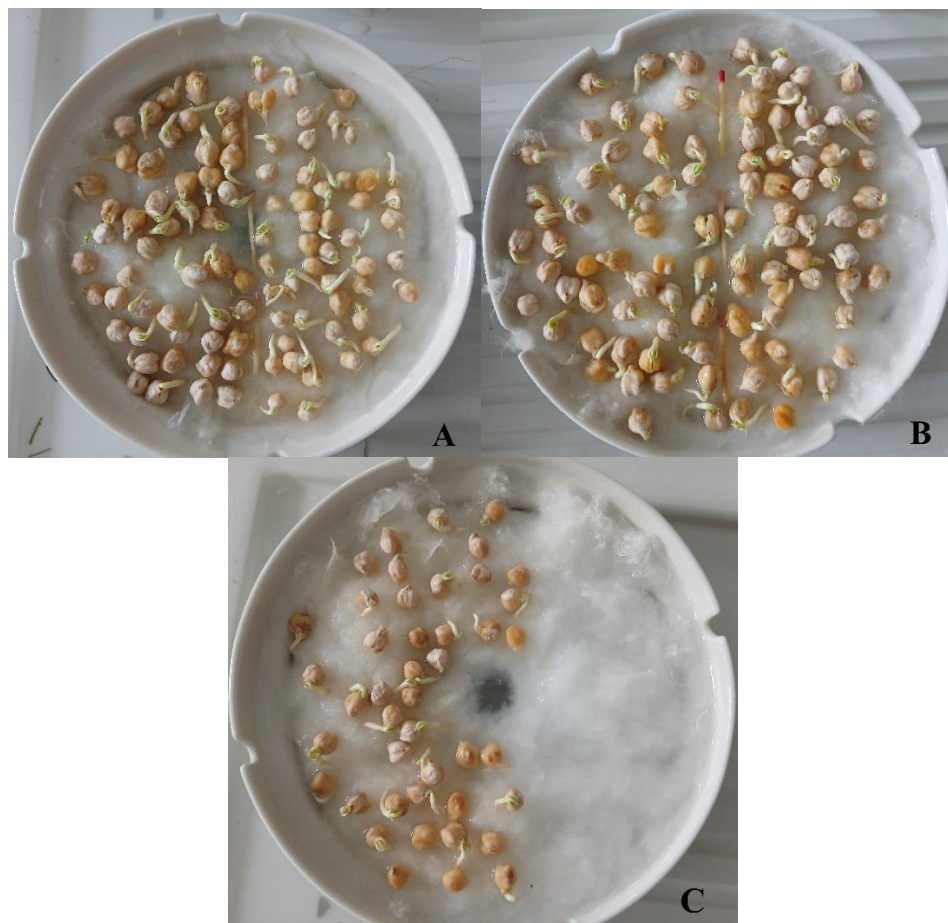


Figure 1: Germinated seeds after 4 days, indicating germinative energy of selected chickpea cultivars Alamo, Flamenco (A), Maragià, Reale (B) and Sultano (C).

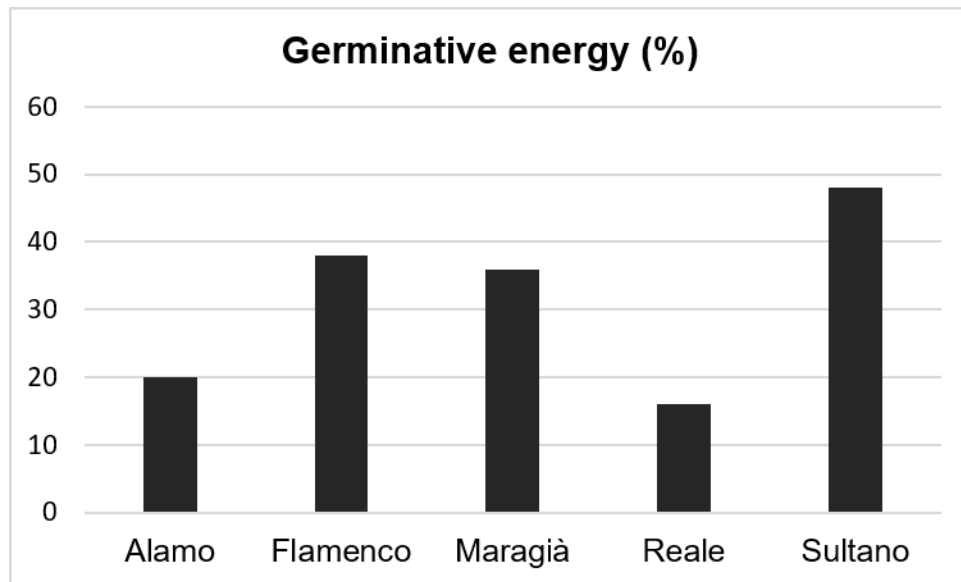


Figure 2: Comparative germinative energy of selected chickpea cultivars (%).

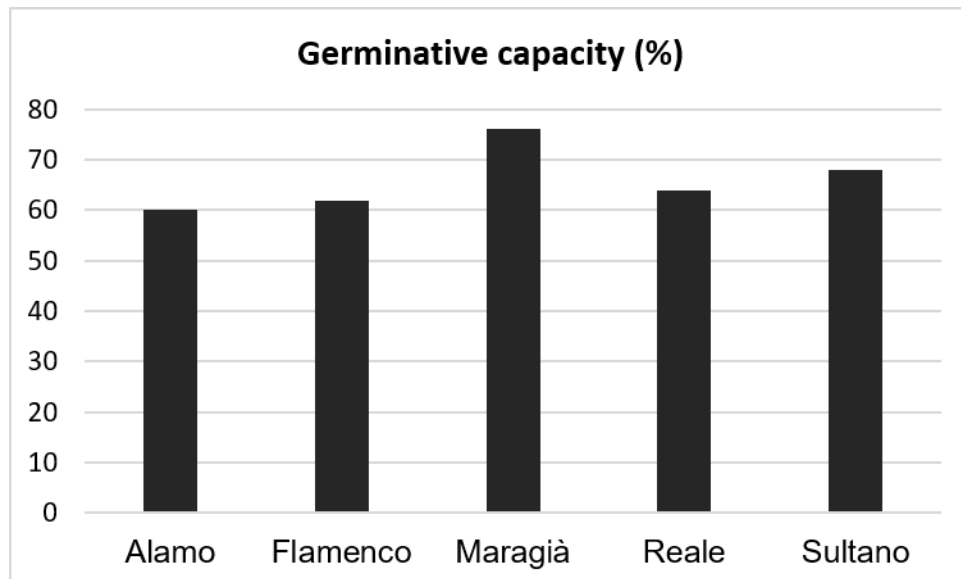


Figure 3: Comparative germinative capacity of selected chickpea cultivars (%).

Germination parameters are known to be variable among chickpea cultivars. A study on 22 varieties in India, found total germination rates (after 21 days), varying between 88 and close to 100% under laboratory conditions, with lower values in Kabuli cultivars than Desi. It should be noted that germination

under field conditions was always lower, going down to 39% (Lamichaney et al. 2016). Seven Egyptian cultivars have shown germination rates of 53.83-76.83, after 14 days (Kandil et al 2012).

Various environmental factors affect germination parameters in chickpea. Salinity can lead to a drop down to 39% in final germination rate after 14 days (Kandil et al 2012). Chemicals, such as organic seed primers can raise germination rates from 58 to over 76% (Zaman et al. 2025). Seed damage caused by insect pests may cause 4-69% aborted seeds and 3 to over 12% abnormally-developed seedlings, depending on the number of lesions induced (Tiruyinet et al. 2025). Non-thermal plasma sometimes used to disinfect seeds and prevent fungal diseases can raise germination rates by 10% (Vélez et al. 2025). Magnetic fields may lead to slight decreases in germination parameters, although they can enhance seedling growth and, in an experiment, even metaphysical energy (meditation) was tested, with no notable effects on the actual germination (Sharma et al. 2014).

CONCLUZII CONCLUSIONS

Among the five tested cultivars, the highest germinative energy was observed in Sultano (48%), distantly followed by Flamenco and Maragià (38 and 36%). The lowest value was found in Reale (16%). The highest germinative capacity, was found in Maragià (76%), followed by Sultano (68%) and Reale (64%). Alamo ranked the lowest in terms of germinative capacity, with only 60%.

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**COMPARATIVE ASSESSMENT OF GERMINATIVE ENERGY AND
GERMINATIVE CAPACITY IN SEVEN MAIZE CULTIVARS
EVALUAREA COMPARATIVĂ A ENERGIEI GERMINATIVE ȘI A
FACULTĂȚII GERMINATIVE LA ȘAPTE CULTIVARE DE PORUMB
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REZUMAT

Cariopse provenite de la șapte soiuri hibride de porumb, și anume Pioneer P 0216, P 0710 și P 9415, Bayer DKC 4109, DKC 4391 și DKC 5810 și Syngenta SY Torino, cultivate în zona centrală a platoului Cernavodă, județul Constanța, au fost analizate pentru energia germinativă și capacitatea germinativă, prin experimente standard de germinare în laborator. Cea mai ridicată energie germinativă a fost observată la P 9415 (52%), urmată îndeaproape de DKC 5810 și SY Torino (50%). Cea mai mică valoare a fost găsită la P 0716 (24%). Cea mai ridicată facultate germinativă a fost găsită la DKC 5810 (86%), urmată de P 9415 (84%) și DKC 4391 (82%). P 0716 a prezentat, de asemenea, cea mai scăzută facultate germinativă, cu doar 62%.

ABSTRACT

Grains from seven hybrid maize cultivars, namely Pioneer P 0216, P 0710 and P 9415, Bayer DKC 4109, DKC 4391 and DKC 5810 and Syngenta SY Torino grown in central Cernavodă plateau, Constanța county were analyzed for germinative energy and germinative capacity, through standard laboratory germination experiments. The highest germinative energy was observed in P 9415 (52%), closely followed by DKC 5810 and SY Torino (50%). The lowest value was found in P 0716 (24%). The highest germinative capacity, was found in DKC 5810 (86%), followed by P 9415 (84%) and DKC 4391 (82%). P 0716 also ranked the lowest in terms of germinative capacity, with only 62%.

Cuvinte cheie: porumb, boabe, germinare, energie germinativă, facultate germinativă

Keywords: maize, grains, germination, germinative energy, germinative capacity

INTRODUCERE

INTRODUCTION

Maize or corn (*Zea mays* L.) is one of the most important crop plants grown worldwide, also being grown on large areas in Romania. New cultivars are being developed, mainly through hybridization, each year. The main purpose is adaptation to local climate, growth conditions, phytopathogens and also a higher yield and improved nutritional profile.

Some of the main differences among maize cultivars can be seen in the grains, in terms of biometrical and biochemical properties. One of the important parameters that can be subjected to analysis is seed germination.

The aim of this research was to comparatively evaluate some cultivars commonly grown in Southeastern Romania in terms of seed germination potential.

MATERIAL ȘI METODĂ DE CERCETARE MATERIAL AND METHOD

The seven hybrid cultivars studied were P 0216, P 0710 and P 9415 (all developed by Pioneer), DKC 4109, DKC 4391, DKC 5810 (Bayer) and SY Torino (Syngenta). All grain samples were collected in 2024 from local farmers in Constanța county, and taken for laboratory analyses to the „Ovidius” University. Farms where samples originated are located in the central Cernavodă plateau, on the middle course of the Carasu Valley, an area with carbonaceous chernozem soils. The average monthly temperature for the 2024 year was 14.8°C (the normal average for the area being 11.6°C). Annual precipitation was 318.10 mm (compared to the normal value of 436 mm). The terrains cultivated with the nine hybrids were irrigated with three water aspersion interventions, each intervention involving a volume of 400 m³ water per hectare.

According to producer-provided data, P 0216 is a semi-tardive (FAO 450), drought-resistant hybrid, also, showing a strong root system. Cobs have high insertion, while grains are dentate. It is resistant to corn smut and the 1,000-grain weight is 365-400 g.

P 0710 is another semi-tardive hybrid (FAO 450), exhibiting deep roots, and good resistance to drought, but also eroded soils and fall. 1,000-grain weight is 430-450 g.

P 9415 is semi-early (FAO 340), resistant to drought and acidic soils. 1,000-grain weight is 355-395 g (Corteva Agriscience).

Bayer Dekalb DKC 4109 is an early (FAO 300-340), average-flowering, drought-resistant hybrid, with low to median cob insertion, dentate grains and a good behavior on a wide variety of local climates and densities.

Bayer Dekalb DKC 4391 is another early hybrid (FAO 300-340), with similar features to the previous, except for a higher seed drying.

Bayer Dekalb DKC 5810 is a late hybrid (FAO 450-490), with good disease resistance and high flowering capacity (Corteva Agriscience).

SY Torino is another early hybrid (FAO 300-340), adapted to medium-intensive technology conditions. It is highly productive and it has a good drying rate (Syngenta).

All analyzed cultivars were previously shown to possess important amounts of antioxidant compounds (Popoviciu et al. 2024; Popoviciu et al. 2025; Radu et al. 2025).

50 grains from each cultivar were taken into analysis. They were placed over water-filled ceramic seed sprouters, on a layer of cotton wadding. Incubation occurred at room temperature, with periodic watering, using warm water.

The number of normally-germinated grains was counted after 4, respectively 14 days. Normal germination was considered when seedling root length was at least equal to the seed length and the shoot had at least 50% of the seed length. The first recorded value was the germinative energy, while the second, the germinative capacity (Boldor et al. 1983). Both were expressed as percentages of the initial seed amount.

REZULTATE ȘI DISCUȚII

RESULTS AND DISCUSSIONS

Results are shown in Figures 1-3.

The highest germinative energy was observed in Pioneer P 9415, namely 52% (26 germinated grains after 4 days of incubation), closely followed by Bayer DKC 5810 and Syngenta SY Torino, both with 50%. The lowest value was found in P 0716 (24%), while all the other cultivars had energies of 34-36%.

The highest germinative capacity, on the other hand, was found in DKC 5810 (86%), closely followed by P 9415 (84%) and DKC 4391 (82%). Despite their remarkable initial stage, grains of SY Torino had a final rate of germination of only 68%, similar to that of P 0216 (70%). P 0716 also ranked the lowest in terms of germinative capacity, with only 62%.

Germination parameters are known to be variable among maize cultivars. A study on seven varieties, four parental donors and three single cross, double

cross, and three-way cross hybrids in Hungary found germination rates close to 100% after 12 days in all varieties (Omar et al. 2022). A research on 9 cultivars grown in Türkiye found (one-day) germination energies of 45-100% under normal conditions, dropping down to as low as 0.8 at severe drought (with extremely variate responses to this factor among studied varieties; Açıkbaş et al. 2026).

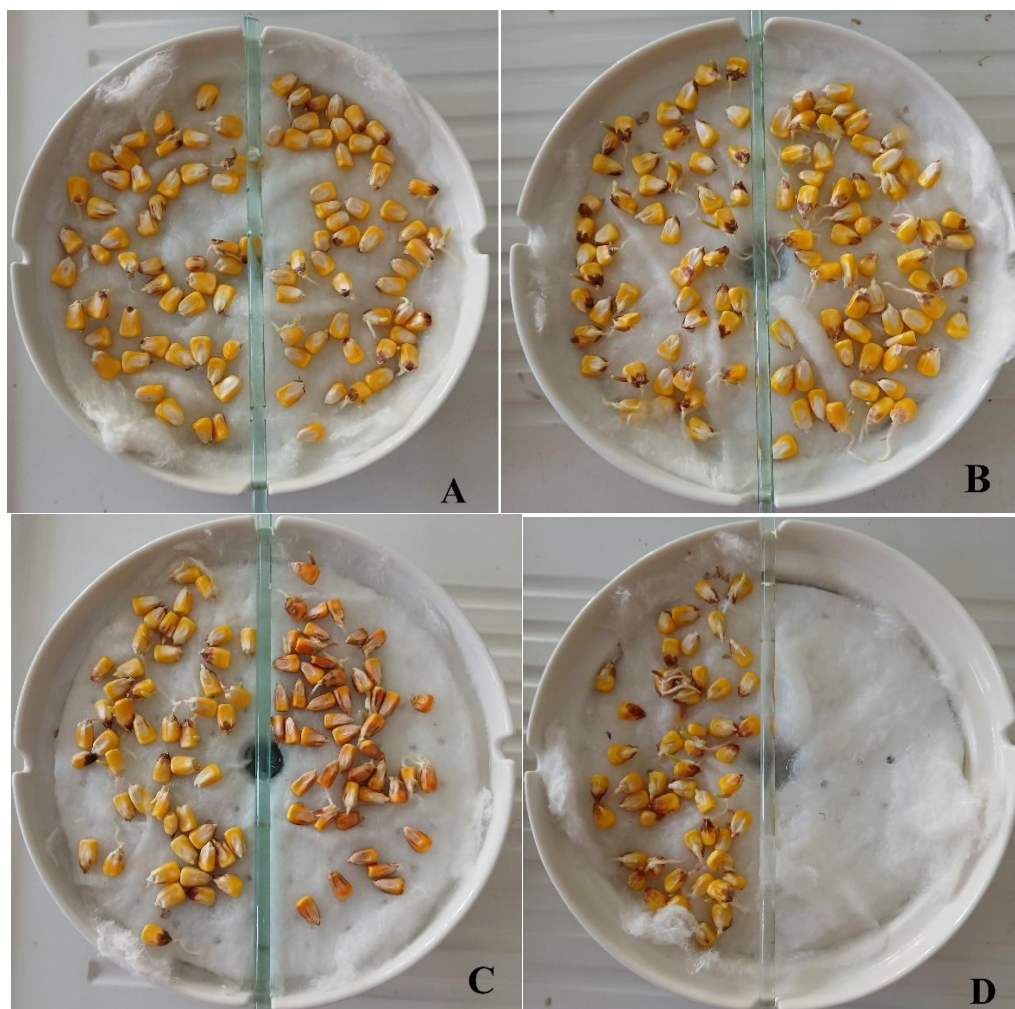


Figure 1: Germinated seeds after 4 days, indicating germinative energy of selected maize cultivars P 0216, P 0710 (A), P 9415, DKC 4109 (B), DKC 4391, DKC 5810 (C) and SY Torino (D).

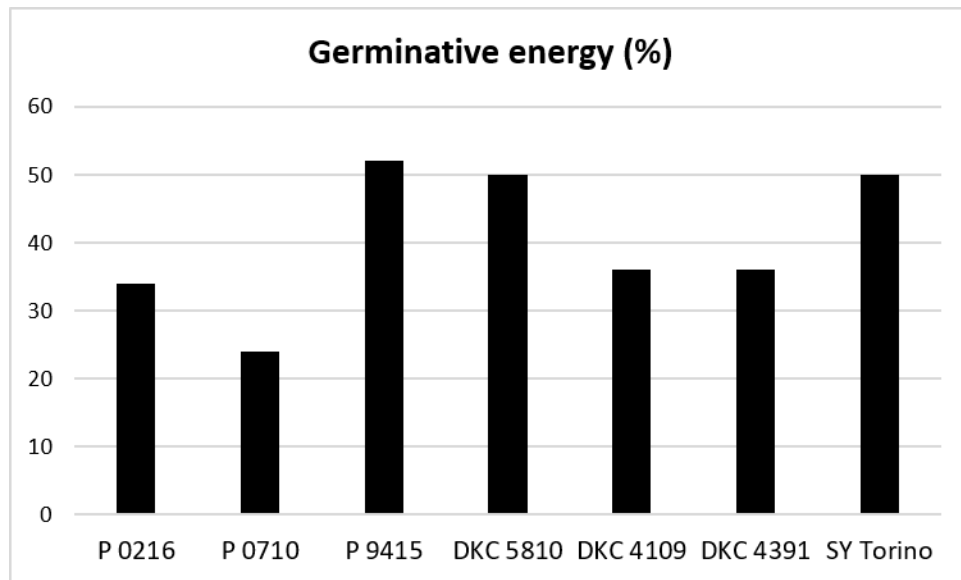


Figure 2: Comparative germinative energy of selected maize cultivars (%).

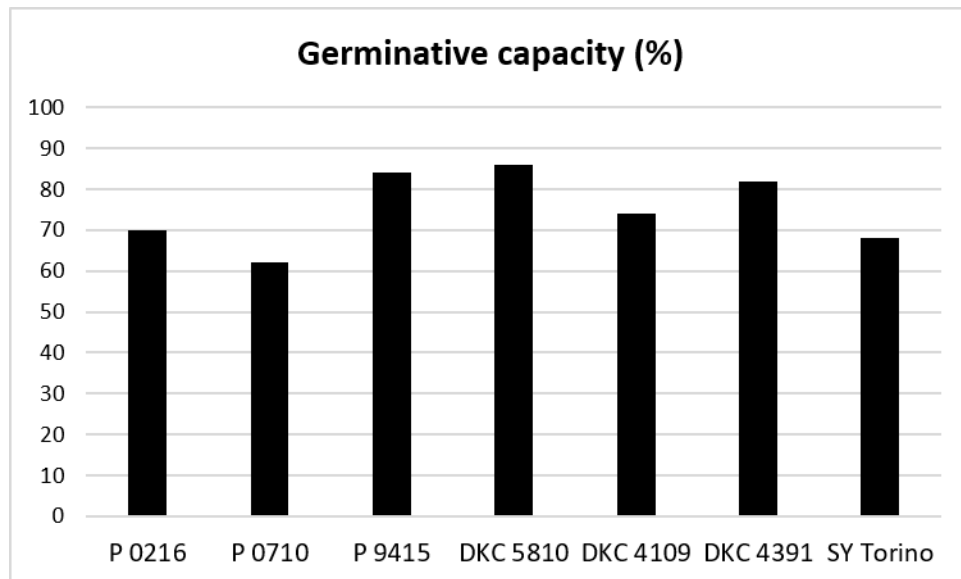


Figure 3: Comparative germinative capacity of selected maize cultivars (%).

Seed water content and storage conditions also impacts these parameters. An experiment found germination energies of 93% at 11% moisture, going below 80% at 20% moisture. Prolonged storage and low temperatures further decreased both germination energy and capacity (Domin et al. 2020). Another study

evidentiated the role of oxygen, with 68% germination rate (after 7 days) in normal storage and over 94% at low-oxygen storage (Abadia et al 2024). Aging-stimulating compounds are also lowering germination rates. A study on four Serbian cultivars found a highly variable germination rate after 9 days, from 28.7 to 92.5% in control batches, dropping down to 13.5% in some treatments (Dragičević et al. 2010). Even magnetic fields have an impact, raising germination rates (45 days) from 60-70% in control seeds close to 100% in some experimental batches (Ali et al. 2024).

CONCLUZII CONCLUSIONS

Among the seven tested cultivars, the highest germinative energy was observed in P 9415 (52%), closely followed by DKC 5810 and SY Torino (50%). The lowest value was found in P 0716 (24%). The highest germinative capacity, was found in DKC 5810 (86%), followed by P 9415 (84%) and DKC 4391 (82%). P 0716 also ranked the lowest in terms of germinative capacity, with only 62%.

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**INFLUENCE OF FERTILIZATION ON SUNFLOWER SEED YIELD
AND QUALITY UNDER THE PEDOCLIMATIC CONDITIONS OF
NORTHERN DOBROGEA**

**INFLUENȚA FERTILIZĂRII ASUPRA PRODUCȚIEI ȘI
CALITĂȚII SEMINȚELOR DE FLOAREA-SOARELUI ÎN
CONDIȚIILE PEDOCLIMATICE DIN NORDUL DOBROGEI**

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REZUMAT

Floarea-soarelui (*Helianthus annuus* L.) reprezintă una dintre cele mai importante plante oleaginoase cultivate în România, însă productivitatea acestei culturi este frecvent limitată de secetă și temperaturile ridicate din perioada de vegetație. Scopul prezentului studiu a fost evaluarea influenței fertilizării suplimentare asupra producției și calității semințelor de floarea-soarelui în condițiile pedoclimatice din nordul Dobrogei, în anul agricol 2025. Experimentul a fost realizat în condiții de fermă utilizând hibridul P64LP170 și a inclus două variante de fertilizare: fertilizarea de bază cu 20 t ha⁻¹ gunoi de grajd și 250 kg ha⁻¹ Eurofertil Plus 36 (V1), respectiv aceeași fertilizare de bază completată cu 150 kg ha⁻¹ Top Phos SILIUP 40 aplicat după cea de-a doua prașilă mecanică (V2). Au fost evaluați principalii indicatori morfologici, productivi și calitativi ai culturii: densitatea plantelor, înălțimea plantelor, greutatea semințelor pe calatidiu, masa a 1000 de boabe, masa hectolitrică, producția de semințe, umiditatea și conținutul de ulei al semințelor. Anul agricol 2025 a fost caracterizat printr-un deficit pluviometric accentuat, în perioada martie–august înregistrându-se doar 122,4 mm precipitații, reprezentând aproximativ 54% din media multianuală, concomitent cu temperaturi peste valorile normale. În aceste condiții, fertilizarea suplimentară a determinat creșterea densității plantelor cu 31,2%, a înălțimii plantelor cu 9,6%, a greutății semințelor pe calatidiu cu 24,9%, a masei a 1000 de boabe cu 4,0% și a producției de semințe cu 58,7%, comparativ cu varianta martor. De asemenea, masa hectolitrică și conținutul de ulei au înregistrat creșteri moderate, în timp ce umiditatea semințelor a rămas relativ constantă. Rezultatele obținute demonstrează că fertilizarea suplimentară constituie o verigă tehnologică eficientă pentru îmbunătățirea productivității și menținerea calității semințelor de floarea-soarelui în condițiile climatice restrictive specifice nordului Dobrogei.

ABSTRACT

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops cultivated in Romania, where drought and high temperatures frequently limit crop productivity. The present study evaluated the influence of supplementary fertilization on sunflower yield and seed quality under the pedoclimatic conditions of northern Dobrogea during the 2025 growing season. A field experiment was conducted using the hybrid P64LP170 under two fertilization treatments: basal fertilization consisting of 20 t ha⁻¹ cattle farmyard manure and 250 kg ha⁻¹ Eurofertil Plus 36 (V1), and the same basal fertilization supplemented with 150 kg ha⁻¹ Top Phos SILIUP 40 applied after the second mechanical cultivation (V2). The evaluated parameters included plant density, plant height, seed weight per capitulum, thousand-seed weight, test weight, seed yield, seed moisture, and oil content. The 2025 growing season was characterized by severe drought, with total precipitation of only 122.4 mm during the March–August period, representing approximately 54% of the long-term average, accompanied by above-average temperatures. Despite these unfavorable climatic conditions, supplementary fertilization significantly improved crop performance. Compared with the control treatment, V2 increased plant density by 31.2%, plant height by 9.6%, seed weight per capitulum by 24.9%, thousand-seed weight by 4.0%, and seed yield by 58.7%. Test weight and oil content also showed slight improvements, while seed moisture remained similar between treatments. The results demonstrate that supplementary fertilization represents an effective agronomic practice for improving sunflower productivity and maintaining seed quality under drought-prone conditions in northern Dobrogea.

Cuvinte cheie: *Helianthus annuus*; fertilizare; secetă; producția de semințe; conținut de ulei; Dobrogea.

Keywords: *Helianthus annuus*; drought; fertilization; seed yield; oil content; Dobrogea.

INTRODUCERE INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the world's most important oilseed crops due to its high seed oil content and its wide range of applications in human nutrition, animal feeding, and the food industry. In Romania, sunflower occupies a prominent position within the cropping system, and the country is consistently ranked among the leading sunflower producers in the European Union (Csépi, 2018). The economic importance of this crop is supported by its

adaptability to diverse pedoclimatic conditions and the continuously growing demand for high-quality vegetable oil.

In recent years, climate change has intensified the frequency of drought events and extreme temperatures, significantly affecting the growth and productivity of agricultural crops. The Dobrogea region is considered one of the most drought-prone agricultural areas in Romania, being characterized by low precipitation and high evapotranspiration rates (Bandoc and Prăvălie, 2015). Under these conditions, the optimization of crop management practices has become essential for maintaining stable and profitable sunflower production. Constantin et al. (2025) reported that sunflower performance in the Dobrogea region is strongly influenced by climatic variability, particularly by drought and heat stress occurring during the growing season.

Numerous studies have demonstrated that water deficit restricts vegetative growth, impairs capitulum development, and reduces dry matter accumulation, ultimately leading to lower seed yield and quality (Gholinezhad et al., 2009; Tahir et al., 2002). Furthermore, Soorninia et al. (2012) showed that the response of sunflower plants to drought stress varies according to genotype, whereas Ghaffari et al. (2023) reported that drought conditions may adversely affect both seed oil content and fatty acid composition. At the regional scale, Harsányi et al. (2021) confirmed the detrimental effects of agricultural drought on sunflower production and emphasized the importance of adopting cultivation practices adapted to current climatic conditions.

Besides hybrid selection, fertilization is one of the most important agronomic practices influencing both crop productivity and seed quality. A balanced nutrient supply promotes root system development, enhances physiological processes, and improves the efficiency of water utilization under limited soil moisture conditions. Jenaru and Ion (2024) demonstrated that the application of complex fertilizers and the selection of appropriate fertilization methods can significantly increase sunflower yield. Similar findings were reported by Eremia (2017), who highlighted the importance of crop management practices in maximizing the productive potential of sunflower hybrids cultivated in southern Romania.

Considering the increasing climatic variability and the need for more efficient use of agricultural inputs, evaluating different fertilization strategies has become essential for optimizing sunflower production technology. Therefore, the present study aimed to assess the influence of fertilization on sunflower seed yield and quality under the pedoclimatic conditions of northern Dobrogea using the hybrid P64LP170, with the objective of identifying an effective fertilization strategy capable of improving crop performance under drought-prone conditions.

MATERIAL ȘI METODĂ DE CERCETARE MATERIAL AND METHOD

The field experiment was conducted during the 2025 growing season under farm conditions in Vasile Alecsandri village, Stejaru commune, Tulcea County, located in the northern Dobrogea region of Romania. The experimental area is characterized by a temperate continental climate with pronounced aridity, low precipitation, and high temperatures during the growing season, conditions that frequently expose sunflower crops to drought stress.

The preceding crop was pea (*Pisum sativum* L.), which is recognized for its beneficial effects on soil fertility through biological nitrogen fixation. The biological material consisted of the sunflower hybrid P64LP170 (Corteva Agriscience), developed for the Clearfield® Plus production system and characterized by high yield potential, drought tolerance, and genetic resistance to the major races of *Orobanche cumana* and *Plasmopara halstedii*.

The experiment included two fertilization treatments arranged in three replicates. The control treatment (V1) received basal fertilization consisting of 20 t ha⁻¹ cattle farmyard manure incorporated before autumn plowing, followed in spring by the application of 250 kg ha⁻¹ Eurofertil Plus 36, a compound fertilizer containing 12% P₂O₅, 24% K₂O, 15% SO₃, 14% CaO, and 0.2% B, applied during seedbed preparation. The second treatment (V2) received the same basal fertilization supplemented with 150 kg ha⁻¹ Top Phos SILIUP 40 after the second mechanical cultivation. This fertilizer contains 21% P₂O₅, 7% K₂O, and 15% SO₃, together with zinc and boron, and is formulated to stimulate root development and improve nutrient and water use efficiency under drought conditions.

Sunflower was sown on 8 April 2025 using a precision planter at an approximate depth of 5 cm and a planting density of 57,000 viable seeds ha⁻¹. Seedbed preparation was carried out using a cultivator after fertilizer incorporation. Crop emergence began on 17 April 2025 and was uniform across the experimental area.

Weed control was performed during the growing season using two post-emergence herbicides. Broadleaf weeds and sunflower broomrape (*Orobanche cumana*) were controlled with Saltus 80 SL (80 g L⁻¹ imazamox) applied at 0.8 L ha⁻¹, while annual and perennial grass weeds were controlled with Rango (40 g L⁻¹ quizalofop-P-tefuryl) at 1.0 L ha⁻¹. Two mechanical inter-row cultivations were performed to reduce weed competition, improve soil aeration, and minimize soil water losses through evaporation.

Crop protection against insect pests was ensured by applying Faster Delta (deltamethrin) at 0.5 L ha^{-1} , whereas diseases were controlled with Retengo 200 EC (200 g L^{-1} pyraclostrobin) applied at 1.0 L ha^{-1} before flowering. Besides its fungicidal activity, pyraclostrobin contributes to improved photosynthetic efficiency and increased tolerance to heat and drought stress.

The crop was harvested mechanically at the end of August 2025, when the seeds reached physiological maturity. The evaluated parameters included plant density (plants m^{-2}), plant height (m), seed weight per capitulum (g), thousand-seed weight (g), test weight (kg hL^{-1}), seed yield (kg ha^{-1}), seed moisture content (%), and oil content (%). Thousand-seed weight was determined according to the ISTA methodology, test weight was measured using an ML-HECTO 100 instrument, and seed oil content was determined by the Soxhlet extraction method.

Experimental data were recorded for each replicate and expressed as mean values for each fertilization treatment. The results were used to evaluate the effects of supplementary fertilization on sunflower productivity and seed quality under the pedoclimatic conditions of northern Dobrogea, Romania.

REZULTATE ȘI DISCUȚII

RESULTS AND DISCUSSIONS

The 2025 growing season was characterized by exceptionally warm and dry conditions in the northern Dobrogea region, creating unfavorable environmental conditions for sunflower development. Mean monthly air temperatures exceeded the long-term averages throughout the entire vegetation period, with the largest positive anomalies recorded in June and July (Table 1). The average temperature reached 27.8°C in July, exceeding the multiannual average by 5.2°C , while June recorded an anomaly of 4.3°C . These high temperatures coincided with the reproductive stages of sunflower, increasing evaporative demand and intensifying heat stress.

Rainfall distribution was highly irregular throughout the growing season (Table 1). Total precipitation between March and August reached only 122.4 mm, representing approximately 54% of the long-term average (225.8 mm). The most severe water deficit occurred in June, when only 0.2 mm of rainfall was recorded compared with the normal value of 53.2 mm. Although precipitation slightly exceeded the long-term average in May, the subsequent drought during June–August substantially limited soil water availability during capitulum formation, flowering, and seed filling.

The combination of prolonged drought and above-average temperatures created severe pedological and atmospheric drought conditions, which likely reduced crop productivity and limited the expression of the genetic yield potential of the sunflower hybrid. Under these circumstances, nutrient management became an important factor in improving crop performance and mitigating the adverse effects of water stress.

Table 1. Monthly air temperature and precipitation during the 2025 growing season compared with the long-term averages.

Month	Temperature normal (°C)	Temperature 2025 (°C)	Rainfall normal (mm)	Rainfall 2025 (mm)
March	4.2	9.7	21.7	4.6
April	10.5	10.8	33.5	23.4
May	16.2	16.9	50.2	52.4
June	20.4	24.7	53.2	0.2
July	22.6	27.8	35.6	20.8
August	22.6	26.1	31.6	21.0
Total precipitation	—	—	225.8	122.4

The application of supplementary fertilization positively influenced all evaluated morphological, productive, and quality parameters of sunflower (Table 2). Compared with the control treatment (V1), plants receiving additional fertilization (V2) exhibited improved vegetative development, higher productivity, and slightly better seed quality despite the severe drought conditions recorded during the 2025 growing season.

Table 2. Effect of fertilization on sunflower growth, yield and seed quality

Trait	V1	V2	Increase (%)
Plant density (plants m⁻²)	3.08	4.04	31.2
Plant height (m)	1.57	1.72	9.6
Seed weight per capitulum (g)	39.28	49.07	24.9
Thousand-seed weight (g)	54.73	56.92	4.0
Test weight (kg hL⁻¹)	42.03	42.91	2.1
Seed yield (kg ha⁻¹)	1210.12	1920.73	58.7
Oil content (%)	45.85	46.20	0.8
Seed moisture (%)	10.39	10.29	-1.0

Plant density at harvest increased from 3.08 plants m⁻² in the control treatment to 4.04 plants m⁻² following supplementary fertilization, corresponding to an increase of 31.2%. A similar trend was observed for plant height, which increased from 1.57 m to 1.72 m, indicating that additional nutrient supply promoted vegetative growth and improved plant establishment under water-limited conditions (Figure 2). Supplementary fertilization also enhanced the main yield components. Seed weight per capitulum increased from 39.28 g to 49.07 g, representing an improvement of 24.9%, while thousand-seed weight increased by 4.0%, reaching 56.92 g in treatment V2. Test weight showed a smaller increase, from 42.03 to 42.91 kg hL⁻¹, suggesting improved seed filling and greater seed uniformity.

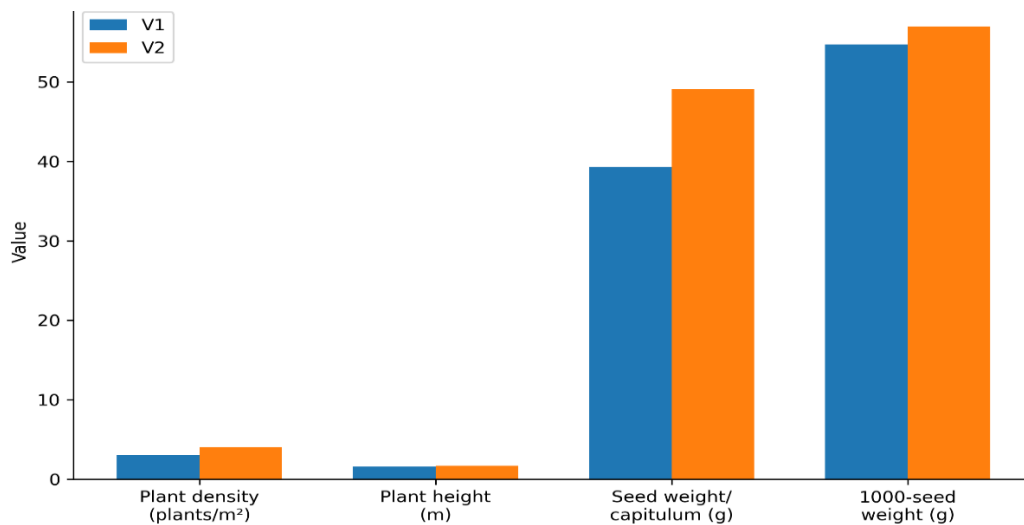


Figure 2. Effect of fertilization on plant density, plant height, seed weight per capitulum and thousand-seed weight.

The greatest response to supplementary fertilization was observed for seed yield. The control treatment produced 1,210.12 kg ha⁻¹, whereas treatment V2 reached 1,920.73 kg ha⁻¹, corresponding to a yield increase of 710.61 kg ha⁻¹ (58.7%). This substantial increase demonstrates that additional nutrient supply improved the capacity of sunflower plants to maintain reproductive development and seed filling under the hot and dry conditions that prevailed during the experiment (Figure 3). Seed quality parameters were less affected than yield components. Oil content increased slightly from 45.85% to 46.20%, whereas seed moisture at harvest remained almost unchanged (10.39 and 10.29%, respectively). These results indicate that supplementary fertilization mainly

enhanced crop productivity while maintaining high seed quality under drought conditions.

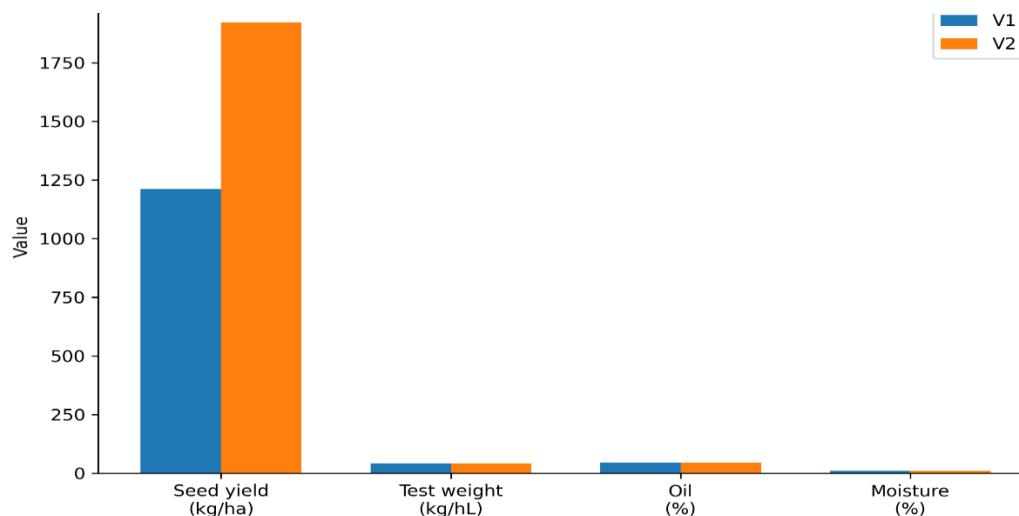


Figure 3. Effect of fertilization on seed yield, test weight, seed moisture and oil content.

The results of the present study demonstrated that supplementary fertilization improved both sunflower productivity and seed quality under the pedoclimatic conditions of northern Dobrogea. Although the 2025 growing season was characterized by severe drought and above-average temperatures, additional nutrient supply positively influenced plant development, resulting in increased plant density, plant height, seed weight per capitulum, thousand-seed weight, seed yield, and oil content.

The climatic conditions recorded during the experiment played a major role in limiting crop performance. Total rainfall during the growing season represented only about half of the long-term average, while temperatures during June and July substantially exceeded normal values. Similar climatic constraints have previously been reported for the Dobrogea region, where prolonged drought and high evapotranspiration are considered the main factors limiting agricultural productivity (Bandoc and Prăvălie, 2015). Likewise, Constantin et al. (2025) emphasized that increasing climatic variability has become one of the major challenges affecting sunflower production in southeastern Romania.

Water deficit occurring during the reproductive stages is known to reduce biomass accumulation, seed filling, and final yield. Previous studies conducted by Gholinezhad et al. (2009) and Tahir et al. (2002) demonstrated that drought stress significantly decreases sunflower productivity by reducing the number and

weight of seeds. Furthermore, Soorninia et al. (2012) reported considerable differences among sunflower genotypes in their response to water deficit, highlighting the importance of selecting drought-tolerant hybrids. The satisfactory performance of the hybrid P64LP170 observed in the present study suggests a good adaptation to water-limited environments, although yield potential remained constrained by the severe climatic conditions.

Among all evaluated parameters, seed yield exhibited the greatest response to supplementary fertilization, increasing by nearly 59% compared with the control treatment. Similar responses have been reported by Jenaru and Ion (2024), who showed that balanced fertilization significantly improves sunflower productivity through enhanced nutrient availability during the critical stages of crop development. Eremia (2017) also highlighted that appropriate fertilization strategies represent one of the most effective agronomic practices for maximizing the productive potential of sunflower hybrids cultivated under Romanian conditions. In addition to yield improvement, supplementary fertilization promoted greater plant height, higher plant density at harvest, and increased seed weight per capitulum, indicating improved vegetative growth and assimilate accumulation. Although increases in thousand-seed weight, test weight, and oil content were more moderate, these parameters consistently showed higher values in the fertilized treatment. According to Ghaffari et al. (2023), adequate nutrient availability may partially alleviate the negative effects of drought on oil accumulation by maintaining metabolic activity during seed filling. The slight increase in oil content observed in the present study supports this assumption.

The results indicate that supplementary fertilization represents an effective management practice for improving sunflower performance under drought-prone conditions. While fertilization cannot completely compensate for severe water deficits, it can enhance crop resilience by supporting vegetative growth, improving reproductive development, and increasing yield and seed quality. These findings provide useful information for optimizing sunflower fertilization strategies under the increasingly variable climatic conditions characteristic of northern Dobrogea.

CONCLUZII CONCLUSIONS

The results of the present study demonstrated that supplementary fertilization had a positive effect on sunflower growth, productivity, and seed quality under the pedoclimatic conditions of northern Dobrogea during the 2025 growing season.

Compared with the control treatment, the application of 150 kg ha⁻¹ Top Phos SILIUP 40 after the second mechanical cultivation increased plant density at harvest, plant height, seed weight per capitulum, thousand-seed weight, test weight, seed yield, and oil content. The most pronounced response was recorded for seed yield, which increased by 58.7%, indicating that supplementary fertilization significantly improved crop performance despite the severe drought conditions recorded during the growing season.

The climatic conditions of 2025, characterized by high temperatures and a marked precipitation deficit, represented the main limiting factor for sunflower production. Nevertheless, the additional nutrient supply contributed to maintaining plant development and improving seed filling, partially reducing the negative effects of water stress.

The results indicate that supplementary fertilization can be considered an effective agronomic practice for improving sunflower productivity and maintaining seed quality under drought-prone conditions. Further multi-year studies are recommended to validate these findings under different climatic conditions and to optimize fertilization strategies for sustainable sunflower production in northern Dobrogea.

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**EVALUATION OF THE EFFECT OF DIFFERENTIAL
FERTILIZATION ON YIELD AND GRAIN QUALITY OF THREE
BREAD WHEAT CULTIVARS UNDER THE PEDOCLIMATIC
CONDITIONS OF OLTINA, CONSTANȚA COUNTY, ROMANIA
(2024–2025)**

**EVALUAREA EFECTULUI FERTILIZĂRII DIFERENȚIATE
ASUPRA PRODUCȚIEI ȘI CALITĂȚII LA TREI SOIURI DE GRÂU
PENTRU PANIFICAȚIE ÎN CONDIȚIILE PEDOCLIMATICE DIN
ZONA OLTINA, JUDEȚUL CONSTANȚA (2024–2025)**

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REZUMAT

Producția de grâu pentru panificație în sud-estul României este tot mai frecvent afectată de perioadele de secetă, temperaturile ridicate și variabilitatea climatică accentuată, ceea ce impune optimizarea tehnologiilor de fertilizare pentru menținerea nivelului și calității producției. Scopul prezentei cercetări a fost evaluarea efectului fertilizării diferențiate asupra producției și principalilor indicatori de calitate la trei soiuri de grâu pentru panificație (Falado, Centurion și Otilia), cultivate în condițiile pedoclimatice din comuna Oltina, județul Constanța, în anul agricol 2024–2025. Experimentul a fost organizat după metoda blocurilor randomizate, cu trei repetiții, utilizând un dispozitiv bifactorial format din trei soiuri și trei variante de fertilizare: V0 (martor), V1 (fertilizare într-o singură etapă) și V2 (fertilizare în două etape). Performanța culturii a fost evaluată prin determinarea densității plantelor, densității spicelor la recoltare, numărului de boabe pe spic, masei a 1000 de boabe (MMB), masei hectolitrică, umidității boabelor și producției de boabe. Condițiile climatice din perioada de vegetație au fost caracterizate prin temperaturi peste media multianuală și un deficit cumulat de precipitații de aproximativ 48,5 mm comparativ cu valorile normale, determinând instalarea unui stres hidric moderat în fazele critice de dezvoltare ale culturii. Fertilizarea a influențat pozitiv toate componentele producției analizate. Cea mai ridicată producție a fost obținută la soiul Falado, în varianta cu fertilizare în două etape (V2), atingând 7618 kg/ha, urmat de Centurion cu 6558 kg/ha și Otilia cu 5838 kg/ha. Varianta V2 a înregistrat, de asemenea, cele mai mari valori ale masei a 1000 de boabe, respectiv 46 g la soiurile Falado și Centurion și 45 g la Otilia. Masa hectolitrică s-a situat peste limita minimă admisă pentru grâul destinat panificației la toate soiurile analizate, cea mai ridicată valoare fiind înregistrată la soiul Falado (79 kg/hl). Rezultatele

obținute demonstrează că fertilizarea diferențiată contribuie la creșterea producției și îmbunătățirea calității boabelor în condiții de deficit hidric, iar răspunsul culturii depinde de particularitățile genetice ale fiecărui soi și de eficiența utilizării elementelor nutritive. Dintre soiurile evaluate, Falado a prezentat cel mai ridicat potențial productiv și cea mai bună adaptare la condițiile pedoclimatice din sud-estul României, iar fertilizarea în două etape s-a dovedit cea mai eficientă strategie pentru maximizarea producției de grâu în condiții de cultură neirigată.

ABSTRACT

Winter wheat production in southeastern Romania is increasingly challenged by recurrent drought events, high temperatures, and increasing climatic variability, making the optimization of fertilization practices essential for maintaining grain yield and quality. The present study evaluated the effect of differentiated fertilization on the productivity and quality of three bread wheat cultivars (Falado, Centurion, and Otilia) cultivated under the pedoclimatic conditions of Oltina, Constanța County, during the 2024–2025 growing season. A two-factor field experiment was established using a randomized block design with three replications. The experimental factors consisted of three wheat cultivars and three fertilization treatments: V0 (control), V1 (single fertilization), and V2 (split fertilization). Agronomic performance was assessed through crop establishment, spike density at harvest, grains per spike, thousand-kernel weight (TKW), hectoliter weight, grain moisture, and grain yield. Climatic conditions during the growing season were characterized by above-average temperatures and a cumulative precipitation deficit of approximately 48.5 mm compared with the long-term average, resulting in moderate water stress during critical developmental stages. Fertilization significantly improved all evaluated production components. The highest grain yield was obtained by the cultivar Falado under split fertilization (7618 kg ha⁻¹), followed by Centurion (6558 kg ha⁻¹) and Otilia (5838 kg ha⁻¹). Split fertilization also produced the highest thousand-kernel weight, reaching 46 g in Falado and Centurion and 45 g in Otilia. Hectoliter weight remained above the commercial quality threshold for all cultivars, with Falado recording the highest value (79 kg hL⁻¹). The results demonstrate that differentiated fertilization enhances both yield and grain quality under drought-prone conditions and that cultivar response depends on genetic characteristics and nutrient-use efficiency. Among the evaluated cultivars, Falado showed the highest productive potential and the best adaptation to the environmental conditions of southeastern Romania, while split fertilization

proved to be the most effective fertilization strategy for maximizing wheat productivity under rainfed conditions.

Cuvinte cheie: grâu pentru panificație; fertilizare diferențiată; producția de boabe; masa a 1000 de boabe; masa hectolitrică; Dobrogea; stres hidric; performanța soiurilor.

Keywords: bread wheat; differentiated fertilization; grain yield; thousand-kernel weight; hectoliter weight; Dobrogea; drought stress; cultivar performance.

INTRODUCERE INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is one of the world's most important cereal crops, providing a substantial proportion of human caloric and protein intake and representing the principal raw material for the baking industry. Maintaining both high grain yield and technological quality has become increasingly challenging under current climate variability, particularly in regions characterized by recurrent drought and elevated temperatures during the growing season. Consequently, improving agronomic practices that enhance crop productivity while maintaining grain quality has become a priority for sustainable wheat production (Panaitescu and Niță, 2011; Gherban and Sala, 2025).

Among agronomic management practices, fertilization represents one of the most influential technological factors controlling wheat productivity. Nitrogen availability directly affects tillering, leaf area development, photosynthetic activity, spike fertility, grain filling, and ultimately grain yield. Besides increasing productivity, balanced fertilization improves several quality attributes important for bread-making, including thousand-kernel weight, hectoliter weight, grain protein concentration, and overall technological performance (Shi et al., 2010; Gherban and Sala, 2025). However, the efficiency of fertilizer utilization largely depends on environmental conditions, cultivar characteristics, and nutrient application strategy.

Recent studies have demonstrated that fertilizer management should be optimized according to local pedoclimatic conditions rather than relying exclusively on generalized recommendations. Under water-limited environments, split nitrogen applications frequently improve nutrient use efficiency by synchronizing nitrogen availability with crop demand while reducing nutrient losses. Moreover, integrated fertilization strategies may partially alleviate drought-induced reductions in yield through improved crop

vigor and prolonged photosynthetic activity (Răus et al., 2025). Nevertheless, excessive or poorly synchronized fertilization may reduce nutrient use efficiency and increase production costs without proportional agronomic benefits.

In addition to fertilization, the interaction between nutrient management and soil conservation practices has received increasing attention in recent years. Conservation and reduced tillage systems improve soil structure, water infiltration, and moisture retention, creating more favorable conditions for nutrient uptake and crop development. Long-term experiments have shown that combining appropriate fertilization with conservation tillage enhances soil physical properties and contributes to greater yield stability under climatic stress (Glaş and Kulig, 2008; Cakpo et al., 2025; Ispas et al., 2025). Furthermore, integrated crop management influences weed competition and resource utilization efficiency, emphasizing the importance of considering fertilization within the broader technological system (Cheţan et al., 2025; Radu et al., 2025; Vaheed et al., 2025).

The Dobrogea region, located in southeastern Romania, represents one of the country's most drought-prone agricultural areas. The region is characterized by low annual precipitation, irregular rainfall distribution, high evapotranspiration rates, and frequent heat waves occurring during the critical reproductive stages of winter wheat. These environmental constraints substantially affect crop establishment, grain filling, and final yield, making efficient fertilization strategies essential for stabilizing production under rainfed conditions (Lungu et al., 2010; Panaitescu et al., 2014; Manole et al., 2023). Recent regional studies further demonstrate that cultivar adaptability and crop performance vary considerably according to local environmental conditions and technological management, highlighting the necessity of conducting field experiments under representative farming conditions (Mihai-Florea et al., 2024; Stroe et al., 2025a; Stroe et al., 2025b).

Although numerous studies have evaluated the influence of nitrogen fertilization on wheat production, comparatively fewer investigations have simultaneously assessed the response of different bread wheat cultivars to differentiated fertilization strategies under the specific climatic conditions of southeastern Romania. Such information is particularly important for optimizing fertilizer recommendations capable of improving both yield and grain quality while increasing production stability under increasingly variable climatic conditions.

Therefore, the objective of the present study was to evaluate the effects of differentiated fertilization strategies on grain yield and quality of three bread wheat cultivars cultivated under the pedoclimatic conditions of Oltina, Constanţa

County, during the 2024–2025 growing season. Particular emphasis was placed on determining the influence of fertilization intensity on crop establishment, harvest density, thousand-kernel weight, hectoliter weight, and final grain yield, with the aim of identifying agronomic practices capable of maximizing wheat performance under the environmental conditions specific to the Dobrogea region.

MATERIAL ȘI METODĂ DE CERCETARE

MATERIAL AND METHOD

The study was carried out during the 2024–2025 agricultural season under commercial farming conditions in Oltina Commune, Constanța County, southeastern Romania, with the objective of evaluating the effect of differentiated fertilization on the productivity and grain quality of three bread wheat (*Triticum aestivum* L.) cultivars. The experimental site is located in the Dobrogea region, characterized by a temperate continental climate with strong Pontic influences, hot and dry summers, relatively mild winters, irregular precipitation distribution, and frequent drought events. The experiment was established on a fertile Chernozem soil after winter oilseed rape, considered an excellent preceding crop for winter wheat due to early harvest and favorable effects on soil structure.

Three bread wheat cultivars commonly cultivated under the pedoclimatic conditions of southeastern Romania were included in the experiment: Falado, Centurion, and Otilia. The trial was arranged as a two-factor randomized block experiment with three replications. Factor A consisted of cultivar (Falado, Centurion and Otilia), whereas Factor B included three fertilization strategies: V_0 (control, without supplementary fertilization), V_1 (single mineral fertilization), and V_2 (split fertilization with an additional foliar application during vegetation). Each cultivar occupied approximately one hectare, within which the three fertilization treatments were established under identical agronomic conditions.

The crop was grown using the conventional tillage system practiced by the farm. After rapeseed harvest, the soil was ploughed to approximately 25 cm and prepared using a seedbed cultivator. Seeds were treated before sowing with a systemic fungicide containing tebuconazole (60 g L^{-1}) at a rate of 0.5 L t^{-1} seed together with a starter fertilizer (2.5 L t^{-1}). Sowing was performed on 14 October 2024 at a row spacing of 12.5 cm, a depth of approximately 4 cm, and a seeding rate of 220 kg ha^{-1} , corresponding to about $410 \text{ viable seeds m}^{-2}$.

Basal fertilization consisted of 250 kg ha^{-1} Nitrophoska® Special (NPK + Mg + S) applied at sowing. In treatment V_2 , an additional foliar fertilizer (Cereals Mix), containing nitrogen, magnesium, manganese, zinc, sulfur, copper

and boron, was applied at a rate of 2 kg ha⁻¹ during stem elongation (BBCH 30–32). Weed control included a pre-sowing glyphosate application (Roundup Extra, 360 g L⁻¹, 1.5 L ha⁻¹) followed by a post-emergence herbicide (Elysian, 0.9 L ha⁻¹) applied during tillering (BBCH 21–25). Disease control consisted of Impulse Pro 425 EC (tebuconazole + spiroxamine + prothioconazole) applied at 0.8 L ha⁻¹ between BBCH 31 and BBCH 39, while insect pests were controlled using Wizard (esfenvalerate 5%) at 0.3 L ha⁻¹ whenever the economic threshold was reached. Harvesting was performed mechanically on 12 July 2025 (BBCH 89), when grain moisture had decreased below 12%.

Crop performance was evaluated throughout the growing season by determining plant density after emergence and at harvest, number of grains per spike, thousand-kernel weight (TKW), test weight, and grain yield. Plant density was assessed by counting plants and productive spikes on standardized sampling areas in each experimental plot. Thousand-kernel weight was determined on representative grain samples using an analytical balance, while test weight was measured according to standard laboratory procedures. Grain yield was determined after mechanical harvest and expressed as kg ha⁻¹.

The experimental data were statistically processed using descriptive statistics, including mean values, minimum and maximum values, and standard deviation for each measured parameter. The effects of cultivar, fertilization treatment, and their interaction on grain yield and quality traits were evaluated by two-way analysis of variance (ANOVA), and mean comparisons were performed using Tukey's honestly significant difference (HSD) test at $P < 0.05$. Statistical analyses were performed using R software (version 4.5.1).

REZULTATE ȘI DISCUȚII

RESULTS AND DISCUSSIONS

The climatic conditions recorded during the 2024–2025 growing season played a decisive role in the development, grain filling, and final productivity of winter wheat under the pedoclimatic conditions of Oltina, Constanța County. Monthly temperature and precipitation patterns differed from the long-term climatic averages, creating contrasting conditions throughout the crop cycle (Figures 1 and 2).

The autumn period provided generally favorable conditions for crop establishment. Mean air temperature reached 5.9°C in November and 4.6°C in December, while long-term averages were 7.2°C and 2.3°C, respectively (Figure 1). Although November was slightly cooler than normal, the recorded temperatures remained within the optimal range for germination and early

vegetative growth. In contrast, December and January were considerably warmer than the climatic averages. The mean temperature reached 5.2°C in January, exceeding the long-term mean (0.5°C) by almost 5°C, allowing winter wheat plants to maintain physiological activity for a longer period before winter dormancy.

The coldest month was February, when the mean air temperature decreased to 0.0°C, while the absolute minimum reached −13.9°C. Despite this short cold period, no significant winter damage was observed, indicating a good winter hardiness of the three cultivars included in the experiment.

Spring was characterized by a rapid increase in temperature. Mean temperatures increased from 9.7°C in March to 10.8°C in April and 16.4°C in May, remaining above or close to the long-term averages. The highest thermal conditions were recorded during June, when the monthly mean reached 24.2°C, compared with the climatic normal of 20.4°C, while the absolute maximum temperature reached 37.6°C (Figure 1). Such elevated temperatures accelerated grain maturation and shortened the grain-filling period.

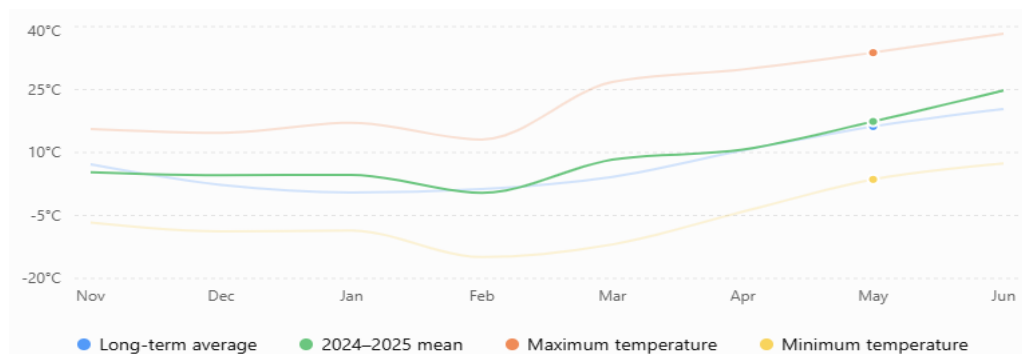


Figure 1. Monthly air temperature during the 2024–2025 wheat growing season compared with the long-term climatic average in Oltina, Constanța County.

The rainfall distribution was highly uneven during the experimental season (Figure 2). Water reserves accumulated during autumn due to abundant rainfall in November (56.6 mm) and particularly December (92.8 mm), both exceeding the corresponding long-term averages. These favorable moisture conditions supported uniform emergence and early crop establishment.

A pronounced rainfall deficit occurred during late winter and early spring. Only 17.4 mm of precipitation were recorded in January, followed by 5.4 mm in February and 4.6 mm in March, well below the corresponding climatic averages. This dry period coincided with the resumption of vegetative growth, increasing the risk of water stress during tillering and stem elongation.

Rainfall conditions improved temporarily during May, when 52.4 mm were recorded, closely matching the long-term average and providing favorable moisture during heading and early grain filling. However, June was extremely dry, with only 0.2 mm of precipitation compared with the normal value of 53.2 mm. Combined with very high temperatures, these conditions intensified terminal drought stress and accelerated physiological maturity. The 2024–2025 growing season was characterized by warm winter conditions followed by severe spring drought and high temperatures during grain filling. Under these environmental conditions, balanced fertilization became particularly important for maintaining crop growth and maximizing grain yield. The differentiated fertilization strategies evaluated in the present study were therefore tested under realistic climatic conditions representative of the increasing drought risk currently affecting the Dobrogea region.

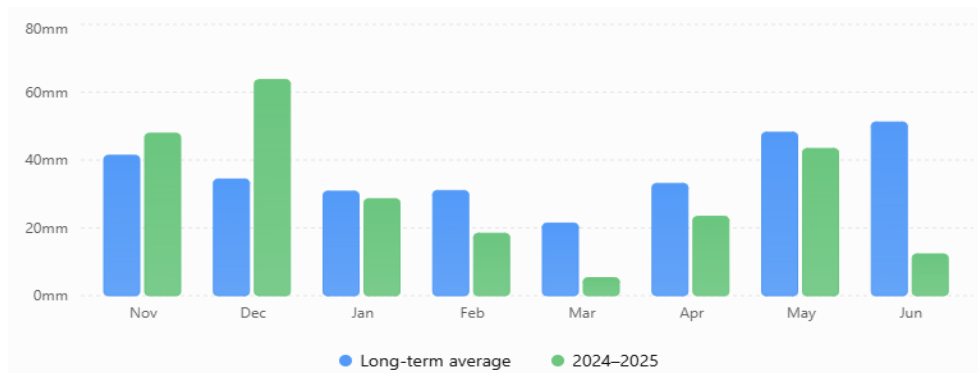


Figure 2. Monthly precipitation and rainy days during the 2024–2025 growing season

Crop establishment was generally uniform across all treatments, indicating favorable seedbed conditions and appropriate sowing technology. Fertilization positively affected plant density at emergence for all three cultivars. In Falado, plant density increased from 300 plants m^{-2} in the unfertilized control (V0) to 323 plants m^{-2} under V1 and 330 plants m^{-2} under V2, representing increases of 7.7% and 10.0%, respectively. Similar responses were recorded for Centurion, where density increased from 302 plants m^{-2} in V0 to 321 plants m^{-2} (+6.3%) and 326 plants m^{-2} (+7.9%). For Otilia, plant density increased from 294 plants m^{-2} in the control to 319 plants m^{-2} (+8.5%) and 321 plants m^{-2} (+9.2%) under the highest fertilization level. The low variation among replications confirmed the uniform establishment of the experimental crop.

Differences became more evident at harvest. Spike density exceeded the initial plant population in all treatments due to productive tillering, although the magnitude of this increase depended on cultivar and fertilization strategy. The highest spike density was recorded in Falado under V1 (594 spikes m^{-2}), followed by V2 (552 spikes m^{-2}) and the control (513 spikes m^{-2}). For Centurion, spike density reached 556, 528, and 496 spikes m^{-2} under V1, V2, and V0, respectively, while Otilia produced 533, 499, and 478 spikes m^{-2} . Compared with the unfertilized control, fertilized treatments consistently maintained a larger number of productive tillers until maturity, indicating a positive effect of nutrient supply on tiller survival.

Although the 2024–2025 growing season was characterized by limited precipitation during spring, fertilization improved crop establishment and favored the formation and maintenance of fertile tillers. Among the evaluated cultivars, Falado showed the greatest capacity to respond to improved nutrient availability, whereas Centurion and Otilia also exhibited positive but slightly smaller increases. These results indicate that adequate fertilization contributes not only to successful crop establishment but also to the development of a productive canopy capable of supporting higher grain yields under the pedoclimatic conditions of southeastern Romania.

The number of grains per spike varied according to both cultivar and fertilization strategy (Figure 3). Across all treatments, mean values ranged from 22 to 30 grains per spike, indicating moderate variability among cultivars. The highest value was recorded for Falado under the split fertilization treatment (V2), reaching 30 grains per spike, followed by 27 grains under V1 and 26 grains in the unfertilized control. The Centurion cultivar showed relatively stable values, ranging from 26 grains per spike in V0 and V1 to 27 grains under V2. Otilia exhibited the lowest grain number, increasing from 22 grains per spike in the control treatment to 25 grains under V1 and 26 grains under V2.

Fertilization produced a moderate but consistent increase in grain number per spike. Depending on the cultivar, improvements ranged from 1 to 4 grains per spike, suggesting that this yield component was less responsive to nutrient supply than spike density or thousand-kernel weight. The relatively low standard deviations (± 1 – 2 grains) indicate good experimental precision and limited variability among replicates. These results suggest that grain number per spike is primarily under genetic control, while fertilization contributes mainly to maximizing the expression of the cultivar's productive potential under the prevailing environmental conditions.

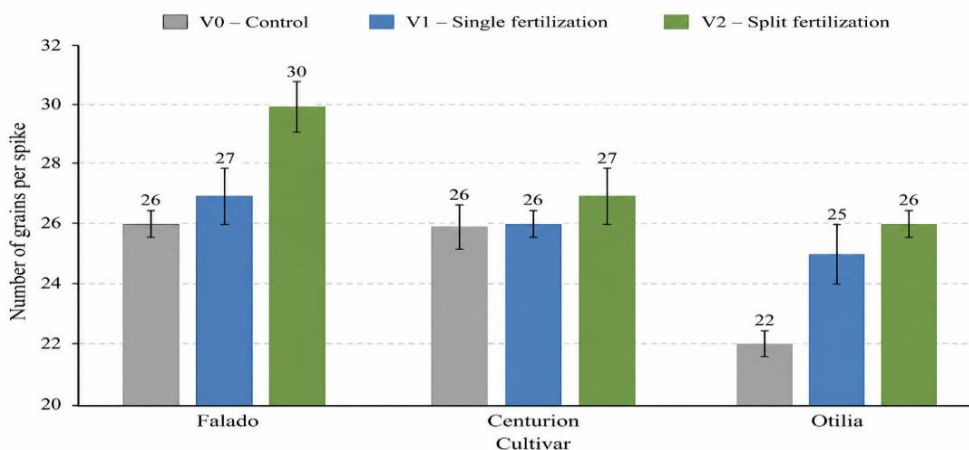


Figure 3. Number of grains per spike of three winter wheat cultivars under different fertilization treatments.

Thousand-kernel weight (TKW) is one of the most important yield quality components, reflecting grain filling efficiency and the capacity of plants to accumulate dry matter during the grain-filling period. The obtained results demonstrate a clear positive effect of fertilization on TKW across all three winter wheat cultivars (Figure 4).

The highest TKW values were consistently recorded under the split fertilization treatment (V2). In Falado, TKW increased from 41 g in the unfertilized control (V0) to 43 g under V1 and 46 g under V2, representing an overall increase of 12.2% relative to the control. A more pronounced response was observed in Centurion, where TKW increased from 36 g in V0 to 41 g under V1 and 46 g under V2, corresponding to an improvement of 27.8%. The cultivar Otilia exhibited the strongest relative response to fertilization, with TKW increasing from 32 g in the control to 40 g under V1 and 45 g under V2, representing an increase of 40.6%.

The low standard deviations ($\pm 1-2$ g) indicate high experimental precision and excellent consistency among field replicates. Although all cultivars responded positively to improved nutrient supply, the magnitude of the response differed according to their genetic background. Falado maintained relatively high TKW values even under limited nutrient availability, whereas Centurion and especially Otilia exhibited a greater dependence on fertilization for achieving optimal grain development.

Despite the reduced precipitation recorded during the grain-filling period, the fertilized treatments maintained higher kernel weights than the unfertilized control, indicating that improved nutrient availability partially compensated for

the adverse climatic conditions. The additional nutrient supply probably prolonged photosynthetic activity during the final stages of crop development, enhancing assimilate translocation towards the developing grains and improving grain filling.

The results demonstrate that increasing fertilization intensity significantly improved thousand-kernel weight, particularly under the split fertilization strategy (V2). This finding highlights the importance of balanced nutrient management for maximizing grain quality and improving the productive performance of winter wheat cultivars under the pedoclimatic conditions of southeastern Romania.

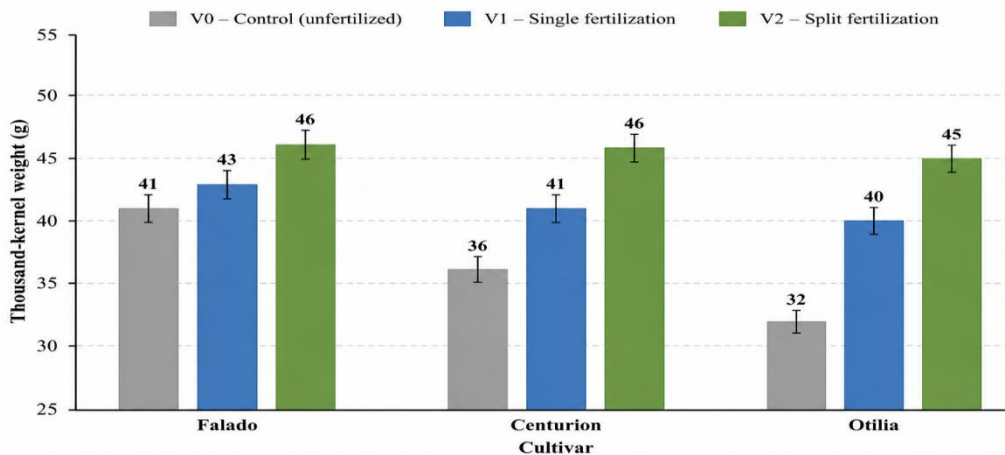


Figure 4. Effect of fertilization treatments on thousand-kernel weight (TKW) of three winter wheat cultivars (Falado, Centurion, and Otilia).

Grain yield was strongly influenced by both cultivar and fertilization strategy, representing the combined effect of spike density, number of grains per spike, and thousand-kernel weight (Figure 5). Across all cultivars, the highest yields were consistently obtained under the split fertilization treatment (V2), whereas the unfertilized control (V0) produced the lowest grain yields. Among the evaluated cultivars, Falado achieved the highest productivity, increasing from 5472 kg ha⁻¹ in the control treatment to 6899 kg ha⁻¹ under V1 and 7618 kg ha⁻¹ under V2. Compared with the control, grain yield increased by 26.1% under V1 and 39.2% under V2, highlighting the excellent capacity of this cultivar to utilize additional nutrient inputs. The cultivar Centurion exhibited a similar response. Grain yield increased from 4643 kg ha⁻¹ in V0 to 5925 kg ha⁻¹ under V1 and 6558 kg ha⁻¹ under V2, corresponding to yield improvements of 27.6% and 41.2%,

respectively. These results indicate that enhanced nutrient availability effectively supported biomass accumulation and grain filling throughout the growing season.

Although Otilia produced the lowest yields among the tested cultivars, it showed the greatest relative response to fertilization. Grain yield increased from 3365 kg ha⁻¹ in the unfertilized control to 5330 kg ha⁻¹ under V1 and 5838 kg ha⁻¹ under V2, representing increases of 58.4% and 73.5%, respectively. This pronounced response suggests that Otilia is more dependent on adequate nutrient supply to express its productive potential.

The superior performance of the V2 treatment can be explained by the combined improvement in yield components, particularly the higher thousand-kernel weight and the increased number of grains per spike. Despite the water deficit recorded during spring and early summer, split fertilization maintained better plant nutrition during the critical stages of grain formation and filling, contributing to improved assimilate accumulation and higher final grain yield.

The results demonstrate that differentiated fertilization significantly enhanced winter wheat productivity under the pedoclimatic conditions of southeastern Romania. Among the three cultivars, Falado showed the highest absolute yield potential, whereas Otilia exhibited the greatest relative response to increased fertilization intensity, confirming the importance of adapting fertilization strategies to cultivar characteristics.

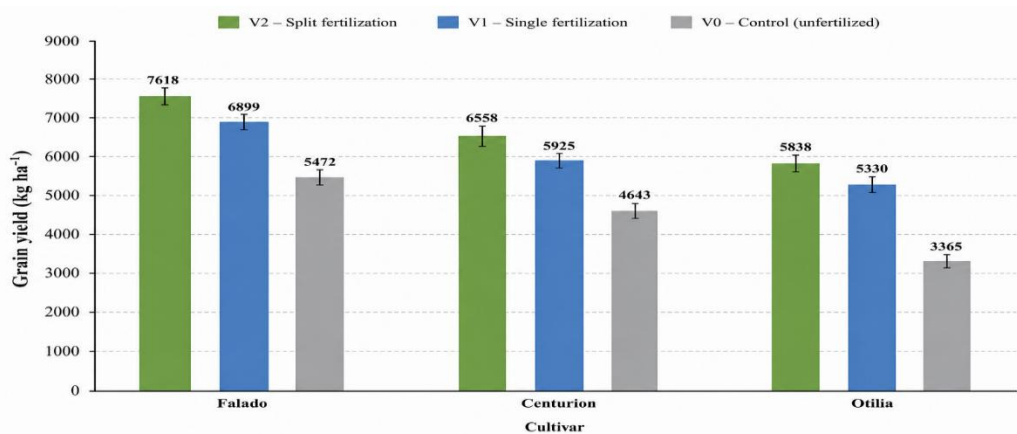


Figure 5. Effect of different fertilization treatments (V0, V1 and V2) on grain yield of the winter wheat cultivars Falado, Centurion and Otilia during the 2024–2025 growing season.

The results of the present study demonstrate that differentiated fertilization substantially improved grain yield and quality parameters of winter

wheat under the pedoclimatic conditions of southeastern Romania. Across all three cultivars, increasing fertilization intensity resulted in progressive increases in grain yield, thousand-kernel weight (TKW), and hectoliter weight, although the magnitude of the response differed among cultivars. The superior performance of the split fertilization treatment (V2) confirms that adequate nutrient availability during stem elongation and grain filling promotes assimilate accumulation and kernel development. Similar results were reported by Gherban and Sala (2025), who observed significant improvements in wheat quality indices as nitrogen rates increased. Likewise, Răus et al. (2025) demonstrated that appropriate fertilizer management under hydric stress conditions contributes to maintaining plant growth and stabilizing grain yield. The increase in thousand-kernel weight observed in the present experiment is also consistent with the findings of Shi et al. (2010), who reported that long-term nitrogen fertilization enhances grain development and improves grain quality through improved nutrient accumulation during kernel filling. Although all cultivars responded positively to fertilization, Falado exhibited the highest yield potential, whereas Otilia showed the greatest relative response to increasing nutrient supply, suggesting differences in nutrient use efficiency among genotypes.

The climatic conditions recorded during the 2024–2025 growing season, characterized by below-average precipitation during spring and elevated temperatures during grain filling, represented a major limiting factor for crop productivity. These environmental conditions are typical of the Dobrogea region, where recurrent drought events frequently reduce cereal yields (Lungu et al., 2010; Panaitescu et al., 2014). Under such conditions, balanced fertilization becomes an essential agronomic practice for maximizing water and nutrient use efficiency. Similar conclusions were reported by Manole et al. (2023), who emphasized that adapting crop management technologies to the climatic conditions of southeastern Romania significantly improves production efficiency. Recent studies conducted in Dobrogea also highlighted the importance of selecting adapted cultivars together with optimized crop management practices to improve yield stability under rainfed conditions (Mihai-Florea et al., 2024; Stroe et al., 2025a; Stroe et al., 2025b). Furthermore, Chețan et al. (2025) demonstrated that integrated crop management, including balanced mineral fertilization, contributes not only to increased wheat productivity but also to improved crop competitiveness and resource use efficiency. Overall, the present results confirm that the interaction between cultivar characteristics and differentiated fertilization plays a decisive role in achieving high grain yields and maintaining grain quality under the increasingly variable climatic conditions of southeastern Romania.

CONCLUZII CONCLUSIONS

The results obtained under the pedoclimatic conditions of Oltina, Constanța County, during the 2024–2025 growing season demonstrated that differentiated fertilization significantly influenced both grain yield and quality parameters of the evaluated winter wheat cultivars. Despite the occurrence of water deficit during the spring and early summer, the applied fertilization strategies contributed to maintaining crop performance and improving the main yield components.

Among the three cultivars, Falado exhibited the highest productive potential, achieving a maximum grain yield of 7618 kg ha⁻¹ under the split fertilization treatment (V2). This cultivar also recorded the highest hectoliter weight (79 kg hL⁻¹) and one of the highest thousand-kernel weight values (46 g), indicating an efficient utilization of the applied nutrients and excellent adaptation to the environmental conditions of southeastern Romania.

Centurion also responded positively to increasing fertilization intensity, reaching 6558 kg ha⁻¹ under V2 while maintaining high thousand-kernel weight and satisfactory grain quality. The cultivar combined good yield stability with consistent quality traits, confirming its suitability for intensive production systems.

Although Otilia produced the lowest absolute grain yield among the evaluated cultivars, it exhibited the greatest relative response to fertilization, with grain yield increasing from 3365 kg ha⁻¹ under the unfertilized control to 5838 kg ha⁻¹ under split fertilization. This result indicates that its productive performance can be substantially improved through appropriate nutrient management.

The progressive increase in fertilization intensity positively influenced all major production components, including crop establishment, spike density, grains per spike, thousand-kernel weight, and final grain yield. Split fertilization (V2) consistently produced superior results, suggesting that supplying nutrients during critical growth stages enhanced nutrient availability during stem elongation and grain filling, particularly under the climatic constraints recorded during the study.

Grain quality was also maintained at high levels. Thousand-kernel weight increased with fertilization in all cultivars, while hectoliter weight remained above the commercial quality threshold for bread wheat. Grain moisture at harvest remained below 13%, confirming that the crop reached physiological maturity under favorable harvesting conditions.

The study demonstrates that optimizing fertilization management is essential for maximizing both yield and grain quality under the drought-prone conditions of Dobrogea. The results support the recommendation of split fertilization as the most effective nutrient management strategy for winter wheat production in the region. Among the tested cultivars, Falado proved to be the most suitable for achieving high and stable yields under intensive fertilization, while Centurion and Otilia also showed good adaptation and productive potential when adequate nutrient supply was ensured. These findings provide useful agronomic information for improving fertilization practices and selecting appropriate cultivars for sustainable winter wheat production in southeastern Romania.

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**APPLICATION OF NO-TILL AND STRIP-TILL TECHNOLOGIES IN
WHEAT AND SUNFLOWER PRODUCTION
FOLOSIREA TEHNOLOGIEI NO-TILL ȘI STRIP-TILL,
LA GRÂU ȘI FLOAREA-SOARELUI**

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REZUMAT

Agricultura conservativă a devenit o strategie importantă pentru îmbunătățirea sustenabilității producției agricole în condițiile unei variabilități climatice tot mai accentuate. Prezenta lucrare a evaluat performanța tehnologiilor no-till și strip-till aplicate la cultura grâului de toamnă (*Triticum aestivum* L.) și a florii-soarelui (*Helianthus annuus* L.), cultivate în condiții de fermă în sud-estul României, în anul agricol 2024–2025. Grâul de toamnă a fost cultivat în sistem no-till, utilizând soiurile Balaton și Apache, iar floarea-soarelui a fost cultivată în sistem strip-till, folosind hibridul Performer. Performanța agronomică a fost evaluată prin determinarea numărului de frați fertili și a producției de boabe la grâu, respectiv a densității plantelor și a producției de semințe la floarea-soarelui. Condițiile climatice din perioada de studiu au fost caracterizate prin precipitații sub media multianuală și temperaturi ridicate, generând un stres hidric moderat până la sever, în special în fazele reproductive ale culturilor. În sistemul no-till, soiul Apache a înregistrat un număr mai mare de frați fertili și o producție de 5.530 kg ha⁻¹, comparativ cu 5.190 kg ha⁻¹ la soiul Balaton. Floarea-soarelui cultivată în sistem strip-till a menținut o densitate corespunzătoare a plantelor și a realizat o producție medie de aproximativ 3.800 kg ha⁻¹, în ciuda condițiilor prelungite de secetă. Rezultatele demonstrează că ambele sisteme de lucrări conservative au menținut un nivel ridicat al productivității, reducând în același timp mobilizarea solului și contribuind la conservarea umidității acestuia. Implementarea sistemelor no-till la grâu și strip-till la floarea-soarelui reprezintă o strategie practică și durabilă pentru producția agricolă în regiunile predispușe la secetă din sud-estul României.

ABSTRACT

Conservation tillage has become an important strategy for improving the sustainability of crop production under increasingly variable climatic conditions. The present study evaluated the performance of no-till and strip-till technologies for winter wheat (*Triticum aestivum* L.) and sunflower (*Helianthus annuus* L.) cultivated under commercial farming conditions in southeastern Romania during

the 2024–2025 growing season. Winter wheat was established under a no-tillage system using the cultivars Balaton and Apache, while sunflower was cultivated under strip-tillage using the hybrid Performer. Agronomic performance was assessed by determining the number of fertile tillers and grain yield in wheat, together with plant density and seed yield in sunflower. Climatic conditions during the experimental period were characterized by below-average precipitation and elevated temperatures, creating moderate to severe water stress, particularly during the reproductive stages of crop development. Under no-tillage, Apache produced a higher number of fertile tillers and achieved a grain yield of 5,530 kg ha⁻¹, compared with 5,190 kg ha⁻¹ for Balaton. Sunflower cultivated under strip-tillage maintained a satisfactory plant stand and reached an average seed yield of approximately 3,800 kg ha⁻¹ despite the prolonged drought conditions. The results demonstrate that both conservation tillage systems successfully maintained crop productivity while reducing soil disturbance and improving soil moisture conservation. The implementation of no-till in wheat and strip-till in sunflower represents a practical and sustainable management strategy for agricultural production in the drought-prone environments of southeastern Romania.

Cuvinte cheie: agricultură conservativă; no-till; strip-till; grâu de toamnă; floarea-soarelui; producție agricolă durabilă.

Keywords: conservation agriculture; no-till; strip-till; winter wheat; sunflower; sustainable crop production.

INTRODUCERE INTRODUCTION

Soil tillage is one of the fundamental components of crop production technology, directly influencing soil physical properties, water availability, nutrient dynamics, root development, and ultimately crop productivity. Conventional tillage systems based on moldboard ploughing have long represented the dominant agricultural practice because they provide favorable conditions for seedbed preparation and weed control. However, repeated intensive soil disturbance has been associated with increased production costs, accelerated organic matter mineralization, soil compaction, erosion, and greater vulnerability to drought, particularly in regions characterized by limited precipitation (Bîlteanu, 1998; Budoï and Penescu, 1996).

Increasing climatic variability and the need for sustainable agricultural production have encouraged the adoption of conservation agriculture practices

that reduce soil disturbance while maintaining crop productivity. These systems aim to preserve soil structure, improve water infiltration and retention, reduce erosion, and lower fuel consumption, thereby increasing the economic and environmental sustainability of agricultural production (Cociu, 2011). Conservation tillage has therefore become an important component of modern farming systems, especially in semi-arid regions where water represents the principal limiting factor for crop growth.

Among conservation agriculture practices, no-till and strip-till technologies have received increasing attention because they minimize soil disturbance while preserving crop residues on the soil surface. No-till involves direct seeding into undisturbed soil covered with crop residues, whereas strip-till consists of tilling only narrow strips where seeds are placed, leaving the inter-row area undisturbed (Guş et al., 2003). Compared with conventional tillage, these technologies reduce the number of field operations, decrease fuel consumption, improve soil aggregation, and contribute to maintaining soil moisture during critical periods of crop development (Guş, 1994; Guş et al., 2004).

The agronomic benefits of conservation tillage are particularly evident under drought conditions. Surface crop residues reduce evaporation losses, moderate soil temperature fluctuations, improve rainfall infiltration, and enhance biological activity within the soil profile. These mechanisms contribute to improved water use efficiency and greater crop resilience during periods of water deficit (Jitäreanu et al., 1998). Furthermore, reduced soil disturbance helps preserve soil organic matter and improves the long-term stability of soil structure, contributing to sustainable agricultural production (Muşat, 2013).

The adoption of conservation tillage also depends on soil characteristics. Chernozem soils, which dominate large agricultural areas of southeastern Romania, possess high natural fertility and favorable physical properties but are susceptible to compaction and moisture loss when subjected to intensive tillage operations (Moise, 2009). Consequently, reducing soil disturbance through no-till or strip-till practices may improve the conservation of soil resources while maintaining crop productivity under increasingly variable climatic conditions.

Winter wheat (*Triticum aestivum* L.) and sunflower (*Helianthus annuus* L.) are among the most economically important field crops cultivated in Romania. Wheat generally responds favorably to direct drilling under conservation agriculture due to improved soil moisture conservation during establishment and grain filling. Sunflower, on the other hand, is well suited to strip-till systems because localized soil loosening promotes rapid root

development while preserving residue cover between rows, reducing evaporation and protecting the soil against erosion (Diaconu et al., 1978; Săndoiu, 2012).

Although conservation tillage has been increasingly adopted by Romanian farmers, the comparative evaluation of no-till for wheat and strip-till for sunflower under the pedoclimatic conditions of southeastern Romania remains limited. Therefore, the present study evaluates the implementation of these two conservation technologies under commercial farming conditions, emphasizing their influence on crop establishment, plant development, and productivity. The results provide practical information regarding the suitability of conservation tillage systems for sustainable crop production in drought-prone environments similar to those of Dobrogea.

MATERIAL ȘI METODĂ DE CERCETARE

MATERIAL AND METHOD

The study was conducted during the 2024–2025 growing season on a commercial farm located in Ostrov (Almălău Commune), Constanța County, southeastern Romania, under the pedoclimatic conditions specific to the Dobrogea region. The research aimed to evaluate the implementation of two conservation tillage systems, namely no-till in winter wheat (*Triticum aestivum* L.) and strip-till in sunflower (*Helianthus annuus* L.), under commercial farming conditions.

Winter wheat was cultivated following rapeseed as the preceding crop using the no-tillage system. Two commercial cultivars, Balaton and Apache, were sown on approximately 110 ha using a direct seeder (Pierobon) without prior soil tillage. Sowing was carried out on 20 October 2024 at a seeding rate of 200 kg ha⁻¹ and a row spacing of 21 cm. Basal fertilization consisted of 150 kg ha⁻¹ diammonium phosphate (DAP) applied at sowing. Weed control included a pre-sowing glyphosate treatment followed by a post-emergence herbicide application. During spring, 150 kg ha⁻¹ urea was applied together with a biological fertilizer (N-Bacter). One fungicide treatment was performed during vegetation to protect the crop against foliar diseases, while harvest was carried out mechanically between 10 and 12 July 2025.

Sunflower was established under strip-tillage on approximately 180 ha using the commercial hybrid Performer. Strip tillage was performed before sowing, while the inter-row area remained undisturbed and covered with crop residues. Sowing was carried out on 24 March 2025 using a Mizzuri Etufarm strip-till planter at a density of 65,000 viable seeds ha⁻¹, a row spacing of 70 cm, and a sowing depth of approximately 5 cm. Basal fertilization consisted of 150

kg ha⁻¹ diammonium phosphate (DAP). Weed control included a pre-sowing glyphosate application, while crop protection against insect pests was achieved through one insecticide treatment after crop establishment. The crop was harvested mechanically at physiological maturity in August 2025.

The experimental evaluations were carried out under field conditions using representative samples collected from the production fields. For winter wheat, ten plants were randomly selected from each cultivar before winter dormancy to determine the number of fertile tillers per plant. Grain yield was determined after harvest and adjusted to a standard grain moisture content of 14%. For sunflower, plant density at harvest was determined using three representative sampling areas of 10 m² each. Seed yield was measured after mechanical harvesting and corrected to a standard moisture content of 9%.

The collected data were processed using descriptive statistical analysis, and the results were summarized as mean values presented in tables and graphical illustrations to evaluate the agronomic performance of no-till wheat and strip-till sunflower under the environmental conditions of southeastern Romania.

REZULTATE ȘI DISCUȚII

RESULTS AND DISCUSSIONS

The climatic conditions recorded during the experimental period had a considerable influence on the performance of both winter wheat and sunflower cultivated under conservation tillage systems. The Dobrogea region is characterized by a temperate continental climate with frequent drought episodes, high summer temperatures, and irregular rainfall distribution, factors that strongly influence crop establishment and productivity.

Winter wheat developed under relatively favorable moisture conditions during autumn establishment, allowing satisfactory emergence and tillering before winter dormancy. However, rainfall during spring was below the long-term average, while temperatures gradually increased during grain filling, accelerating crop maturation. Despite these conditions, the no-tillage system contributed to improved soil water conservation through residue retention on the soil surface, reducing evaporation losses and maintaining more favorable soil moisture throughout the growing season.

The climatic conditions were considerably more restrictive for sunflower. High temperatures associated with limited rainfall during late spring and summer coincided with the critical reproductive stages of flowering and seed filling. Under these circumstances, the strip-tillage system provided several agronomic advantages by loosening the seed row while preserving undisturbed residue-

covered interrows, contributing to better water conservation and reducing soil temperature fluctuations. Consequently, crop development remained satisfactory despite the pronounced drought conditions. The climatic conditions observed during the 2024–2025 agricultural year highlight the importance of conservation agriculture practices in southeastern Romania. Both no-till and strip-till systems contributed to improving crop resilience under water-limited conditions by conserving soil moisture and reducing the negative effects of prolonged drought, confirming their suitability for sustainable crop production in the Dobrogea region.

The results showed that both winter wheat cultivars adapted well to the no-tillage production system despite the severe drought conditions recorded during the 2024–2025 growing season. Apache produced a slightly higher number of fertile tillers (4.2 plant^{-1}) than Balaton (3.8 plant^{-1}), indicating a greater tillering capacity under direct drilling conditions. This difference was also reflected in grain yield, where Apache achieved 5530 kg ha^{-1} , exceeding the yield of Balaton (5190 kg ha^{-1}) by approximately 340 kg ha^{-1} .

Although both cultivars experienced water deficit during grain filling, the no-tillage system contributed to maintaining favorable soil moisture by preserving crop residues on the soil surface and reducing evaporation losses. The satisfactory grain yields obtained under these climatic conditions confirm that conservation agriculture can improve wheat resilience in the semi-arid environments of southeastern Romania. The observed cultivar differences were mainly associated with their genetic capacity for tillering and grain filling rather than with differences in crop establishment, which was uniform across the experimental field.

Table 1. Agronomic performance of winter wheat under no-tillage conditions

Parameter	Balaton	Apache
Fertile tillers plant^{-1}	3.8	4.2
Grain yield (kg ha^{-1})	5190	5530

Despite the severe drought and high temperatures recorded during the 2024–2025 growing season, both wheat cultivars produced satisfactory yields. Apache recorded the highest grain yield, reaching 5530 kg ha^{-1} , while Balaton achieved 5190 kg ha^{-1} , corresponding to a yield advantage of approximately 6.6% for Apache. The higher productivity of Apache can be associated with its greater tillering capacity, which resulted in a higher number of productive stems per unit area. The difference between cultivars indicates that genotype plays an

important role in determining crop performance under conservation agriculture, particularly under drought-prone conditions.

Although precipitation during the growing season was limited, the retention of crop residues on the soil surface reduced soil water evaporation and contributed to maintaining favorable moisture conditions during the critical reproductive stages. Consequently, both cultivars expressed good productive potential despite the climatic constraints. The obtained yields demonstrate that the no-tillage system is capable of sustaining stable wheat production under the pedoclimatic conditions of southeastern Romania while reducing soil disturbance. These findings support the adoption of conservation agriculture as an effective strategy for improving production stability and resource-use efficiency in regions frequently affected by drought.

The strip-tillage system ensured good crop establishment and satisfactory plant development under the pedoclimatic conditions of the 2025 growing season. By loosening only the seed row while maintaining crop residues between rows, this conservation practice improved seedbed conditions and reduced soil water losses through evaporation. These characteristics are particularly important in southeastern Romania, where sunflower is frequently exposed to drought during the reproductive period.

Plant density at harvest remained uniform throughout the experimental field, indicating successful crop establishment and good plant survival despite the unfavorable climatic conditions. The strip-tillage system provided an adequate environment for root development while preserving soil structure and moisture in the inter-row area.

Grain yield reached approximately 3.8 t ha^{-1} , demonstrating that sunflower responded positively to strip-tillage under commercial farming conditions. Although the 2025 season was characterized by reduced rainfall and elevated temperatures, the conservation of soil moisture contributed to maintaining satisfactory seed filling and final productivity.

Table 2. Agronomic performance of sunflower cultivated under strip-tillage

Parameter	Value
Plant density at harvest (plants ha^{-1})	61,500
Grain yield (kg ha^{-1})	3,800

The results indicate that strip-tillage represents a suitable conservation practice for sunflower production in the Dobrogea region. The combination of localized soil loosening and residue retention helped maintain favorable soil conditions throughout the growing season, allowing the crop to achieve stable

productivity despite the occurrence of prolonged drought. These findings highlight the potential of strip-tillage as an effective alternative to conventional tillage, particularly in environments where water availability is the principal limiting factor for crop production.

The results obtained under commercial farming conditions demonstrate that both conservation tillage systems provided satisfactory crop performance under the climatic conditions of southeastern Romania. Although no-till and strip-till differ in the degree of soil disturbance, both technologies share the common objective of preserving soil structure, reducing moisture losses, and improving the efficiency of resource utilization.

Winter wheat responded well to the no-tillage system, achieving grain yields between 5.19 and 5.53 t ha⁻¹, despite the limited rainfall recorded during the spring growing period. Direct seeding into undisturbed soil preserved crop residues on the surface, contributing to improved soil moisture conservation and satisfactory tillering. Among the two cultivars, Apache showed slightly superior performance, indicating a better adaptation to the environmental conditions encountered during the experimental year.

Similarly, sunflower cultivated under strip-tillage maintained a satisfactory plant stand and produced approximately 3.80 t ha⁻¹. Localized soil loosening within the seed row promoted root development while maintaining crop residues between rows, thereby reducing soil evaporation during the critical reproductive stages. This combination proved particularly advantageous under the severe drought conditions that characterized the 2025 growing season.

From an agronomic perspective, no-till appeared particularly suitable for winter wheat because direct drilling allowed rapid crop establishment with minimal soil disturbance. In contrast, strip-till offered additional benefits for sunflower by combining localized seedbed preparation with residue retention, facilitating early root development while maintaining soil water reserves.

Both technologies demonstrated their suitability for conservation agriculture under the pedoclimatic conditions of Dobrogea. Their implementation reduced the number of field operations, minimized soil disturbance, and maintained satisfactory crop productivity under drought-prone conditions. These results support the wider adoption of conservation tillage systems as sustainable alternatives to conventional soil management in southeastern Romania.

The results obtained in the present study demonstrate that both no-tillage and strip-tillage systems ensured satisfactory crop performance under the drought-prone conditions of southeastern Romania. Although the 2024–2025 growing season was characterized by reduced rainfall and elevated temperatures,

winter wheat and sunflower maintained stable productivity, highlighting the capacity of conservation agriculture to mitigate the negative effects of climatic stress.

The favorable performance of winter wheat under no-tillage confirms previous observations that reduced soil disturbance improves soil physical conditions while maintaining sufficient moisture for crop establishment and vegetative development. Guş (1994) emphasized that reducing tillage intensity contributes to limiting soil degradation and improving the efficiency of water utilization, particularly under dry climatic conditions. Similarly, Guş et al. (2004) reported that conservation tillage systems reduce the number of field operations while maintaining satisfactory crop productivity through better preservation of soil structure and organic matter.

The grain yields recorded for both wheat cultivars indicate that direct drilling can successfully replace conventional tillage without negatively affecting crop performance. These findings agree with the conclusions of Cociu (2011), who demonstrated that conservation agriculture technologies represent economically viable alternatives capable of sustaining agricultural productivity while simultaneously reducing production costs and preserving soil resources. The slightly superior performance of the Apache cultivar also highlights the importance of genotype selection when conservation agriculture technologies are adopted under commercial farming conditions.

For sunflower, the strip-tillage system proved particularly suitable under the climatic conditions of Dobrogea. Localized soil loosening combined with permanent residue cover promoted satisfactory plant establishment and stable grain yield despite the severe drought recorded during the reproductive period. Similar observations have been reported by Guş et al. (2003), who indicated that strip-tillage improves soil water conservation while providing favorable conditions for early root development and nutrient uptake. The maintenance of crop residues between rows also contributes to reducing evaporation losses and protecting the soil surface against erosion.

An additional advantage of conservation tillage is the preservation of soil quality over the long term. According to Moise (2009), Chernozem soils possess high natural fertility but become susceptible to structural degradation and moisture loss when subjected to repeated intensive tillage. Under these conditions, minimizing soil disturbance contributes to maintaining soil aggregation, biological activity, and water infiltration, thereby improving the sustainability of agricultural production. Similar conclusions were reported by Budoï and Penescu (1996) and Jităreanu et al. (1998), who emphasized that

appropriate soil management practices are essential for preserving fertility and ensuring stable crop production under variable climatic conditions.

The results obtained in the present study support the increasing interest in conservation agriculture in Romania. Compared with conventional soil management, both no-tillage and strip-tillage reduce fuel consumption, labor requirements, and the number of field operations while maintaining competitive crop yields. As highlighted by Muşat (2013), although conventional ploughing remains widely used, conservation technologies have become increasingly attractive due to their agronomic, economic, and environmental benefits. Likewise, Săndoiu (2012) underlined that adapting tillage intensity to local soil and climatic conditions is fundamental for achieving sustainable crop production.

The present findings confirm that conservation tillage technologies represent effective management strategies for wheat and sunflower cultivation under the pedoclimatic conditions of southeastern Romania. Their implementation contributes not only to maintaining satisfactory productivity under drought conditions but also to improving long-term soil conservation and the sustainability of modern agricultural systems.

CONCLUZII

CONCLUSIONS

The results obtained under the pedoclimatic conditions of southeastern Romania demonstrate that conservation tillage systems represent effective and sustainable alternatives to conventional soil management for both winter wheat and sunflower production.

The no-tillage system ensured good crop establishment and stable grain yields in winter wheat, despite the limited rainfall recorded during the 2024–2025 growing season. Among the two cultivars evaluated, Apache showed slightly superior agronomic performance, producing more fertile tillers and achieving a higher grain yield than Balaton, indicating better adaptation to direct drilling under drought-prone conditions.

The strip-tillage system also proved highly suitable for sunflower cultivation. Localized soil loosening combined with residue retention between rows promoted satisfactory crop establishment, adequate plant density, and a grain yield of approximately 3.8 t ha⁻¹, despite the severe water deficit recorded during the reproductive period. These results confirm the capacity of strip-till to improve soil moisture conservation and support crop productivity under semi-arid environmental conditions.

From an agronomic perspective, both technologies reduced soil disturbance while maintaining competitive production levels. In addition to supporting satisfactory yields, conservation tillage contributes to preserving soil structure, reducing erosion risk, improving water-use efficiency, and decreasing the number of field operations, resulting in lower fuel consumption and production costs.

The present study confirms that the implementation of no-till for winter wheat and strip-till for sunflower represents a viable strategy for sustainable crop production in the Dobrogea region. Wider adoption of these conservation technologies may increase the resilience of agricultural systems to climate variability while contributing to the long-term conservation of soil resources and the sustainability of commercial farming in southeastern Romania.

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**STUDY ON THE CULTIVATION TECHNOLOGY OF THE SU ELLEN
BARLEY CULTIVAR AND THE YIELDS OBTAINED DURING THE
2024–2025 GROWING SEASON IN DUMBRĂVENI COMMUNE,
CONSTANȚA COUNTY**
**STUDIU PRIVIND TEHNOLOGIA DE CULTIVARE A SOIULUI
DE ORZ SU ELLEN ȘI PRODUCȚIILE OBȚINUTE ÎN ANUL
AGRICOL 2024–2025 ÎN COMUNA DUMBRĂVENI, JUDEȚUL
CONSTANȚA**

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REZUMAT

Orzul de toamnă (*Hordeum vulgare* L.) reprezintă una dintre cele mai importante culturi cerealiere cultivate în sud-estul României, unde variabilitatea climatică tot mai accentuată impune adoptarea unor tehnologii eficiente pentru menținerea unor producții stabile. Prezenta lucrare a avut ca obiectiv evaluarea tehnologiei de cultivare a soiului de orz de toamnă SU Ellen și analiza influenței diferitelor strategii de fertilizare asupra performanței culturii în condițiile pedoclimatice din comuna Tortoman, județul Constanța, în anul agricol 2024–2025. Experimentul de câmp a fost organizat după metoda blocurilor randomizate, utilizând trei variante de fertilizare: V0 (fertilizare de bază), V1 (fertilizare de bază + fertilizare suplimentară cu azot) și V2 (fertilizare de bază + fertilizare suplimentară cu azot + fertilizări foliare), fiecare în trei repetiții. Cultura a fost înființată în sistem de lucrări minime ale solului (minimum tillage), după floarea-soarelui ca plantă premergătoare. Evaluările au inclus densitatea culturii la răsărire și la recoltare, masa a 1000 de boabe (MMB) și producția de boabe. Condițiile climatice din perioada de vegetație au fost caracterizate prin temperaturi peste media multianuală și o distribuție neuniformă a precipitațiilor, cu un deficit hidric accentuat în primăvară și la începutul verii. Fertilizarea a influențat semnificativ toți indicatorii de producție analizați. Densitatea la recoltare a crescut de la 449 spice m⁻² în varianta martor la 626 spice m⁻² în varianta V2. Masa a 1000 de boabe a crescut de la 40 g la 53 g, iar producția estimată a crescut de la 4.270 kg ha⁻¹ în varianta martor la 7.890 kg ha⁻¹ în varianta intensiv fertilizată. Aplicarea combinată a fertilizării suplimentare cu azot și a fertilizărilor foliare s-a dovedit mai eficientă decât fertilizarea exclusiv cu azot, contribuind la o umplere mai bună a boabelor și la creșterea productivității culturii, în ciuda constrângerilor climatice. Rezultatele demonstrează că fertilizarea echilibrată, integrată cu sistemul minimum tillage,

reprezintă o strategie tehnologică eficientă pentru creșterea productivității orzului de toamnă și pentru îmbunătățirea rezilienței culturii în condițiile semiaride specifice regiunii Dobrogea.

ABSTRACT

Winter barley (*Hordeum vulgare* L.) is one of the most important cereal crops cultivated in southeastern Romania, where increasing climatic variability requires the adoption of efficient agronomic practices to maintain stable grain production. The present study evaluated the cultivation technology of the winter barley cultivar SU Ellen and the influence of different fertilization strategies on crop performance under the pedoclimatic conditions of Tortoman, Constanța County, during the 2024–2025 agricultural season. A field experiment was established using a randomized design with three fertilization treatments: V0 (basal fertilization only), V1 (basal fertilization + supplementary nitrogen), and V2 (basal fertilization + supplementary nitrogen + foliar fertilization), each replicated three times. The crop was grown under a minimum tillage system following sunflower as the preceding crop. Agronomic evaluations included crop density at emergence and harvest, thousand-kernel weight (TKW), and grain yield. Climatic conditions during the growing season were characterized by above-average temperatures and uneven rainfall distribution, with pronounced water deficits during spring and early summer. Fertilization significantly improved all production parameters. Crop density at harvest increased from 449 spikes m^{-2} in the control treatment to 626 spikes m^{-2} in V2. Thousand-kernel weight increased from 40 g to 53 g, while estimated grain yield rose from 4,270 kg ha^{-1} in the control to 7,890 kg ha^{-1} under the intensive fertilization strategy. The combined application of supplementary nitrogen and foliar fertilizers proved more effective than nitrogen fertilization alone, improving grain filling and overall crop productivity despite climatic constraints. The results demonstrate that balanced fertilization, integrated with minimum tillage, represents an efficient technological approach for enhancing winter barley productivity and improving crop resilience under the semi-arid conditions of the Dobrogea region.

Cuvinte cheie: *Hordeum vulgare* L.; orz de toamnă; fertilizare; minimum tillage; producția de boabe; masa a 1000 de boabe; Dobrogea; variabilitate climatică; agricultură durabilă.

Keywords: *Hordeum vulgare* L.; winter barley; fertilization; minimum tillage; grain yield; thousand-kernel weight; Dobrogea; climate variability; sustainable agriculture.

INTRODUCERE

INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the oldest cultivated cereal species and remains among the most important crops worldwide due to its adaptability to diverse environmental conditions and its wide range of uses in human nutrition, animal feeding, and the malting and brewing industries. Owing to its high agronomic plasticity, barley is cultivated across temperate regions, where it plays an essential role in sustainable crop rotations and cereal-based production systems (Gozukirmizi and Karlik, 2017; Blattner, 2018). In addition to its economic importance, barley has gained increasing attention because of the nutritional value of its grains, which contain valuable dietary fiber, proteins, vitamins, minerals, and bioactive compounds with recognized health-promoting properties (Moroşan et al., 2022; Feng et al., 2024).

In Romania, winter barley represents an important cereal crop, particularly in the southeastern part of the country, where favorable soil conditions allow high production potential. Nevertheless, crop productivity is increasingly influenced by climatic variability, especially by prolonged drought, heat stress, and irregular precipitation distribution during the growing season. The Dobrogea region is one of the areas most affected by these climatic constraints, with water deficit frequently becoming the main limiting factor for cereal production (Lungu et al., 2010; Panaitescu et al., 2014). Recent studies have shown that the response of barley cultivars differs considerably according to the climatic conditions of each growing season, emphasizing the importance of selecting adapted cultivars and implementing appropriate cultivation technologies (Miron et al., 2024; Pila and Stanciu, 2026).

The productive performance of winter barley is strongly influenced by the interaction between genotype, environmental conditions, and crop management practices. Agronomic factors such as sowing density, fertilization strategy, weed control, and crop protection play a decisive role in determining grain yield and quality. Cristea et al. (2024) reported that optimizing sowing density significantly influences both yield and grain quality, while Petcu et al. (2025) demonstrated that balanced nitrogen fertilization improves the productive performance of winter barley under the pedoclimatic conditions of southeastern Romania. Likewise, Toma and Dobrinioiu (2025) highlighted the importance of optimizing fertilization schemes to increase both grain yield and technological quality.

Efficient crop management also requires effective weed and disease control throughout the growing season. According to Cheţan et al. (2023), weed

management represents an essential technological component for maintaining crop competitiveness and maximizing barley productivity. Similarly, Manole et al. (2020) emphasized that the incidence of diseases can substantially reduce grain yield if appropriate phytosanitary measures are not applied. Recent investigations by Niță et al. (2025) further demonstrated that integrating modern cultivation technologies with balanced fertilization and crop protection strategies contributes to improving both grain production and quality.

Among the commercially available winter barley cultivars, SU Ellen has attracted increasing interest because of its high yield potential, good adaptability, and favorable agronomic characteristics under intensive production systems. However, information regarding its performance under the specific pedoclimatic conditions of Constanța County remains relatively limited. Evaluating cultivar performance under commercial farming conditions is essential for identifying suitable technological practices capable of ensuring stable production despite increasing climatic variability.

Therefore, the present study aimed to evaluate the cultivation technology applied to the winter barley cultivar SU Ellen and to assess the grain yields obtained during the 2024–2025 agricultural season under commercial farming conditions in Tortoman Commune, Constanța County. Particular attention was given to the influence of local pedoclimatic conditions and the applied technological practices on crop performance, with the objective of providing practical information for improving barley cultivation under the environmental conditions of southeastern Romania.

MATERIAL ȘI METODĂ DE CERCETARE

MATERIAL AND METHOD

The study was conducted during the 2024–2025 agricultural season under commercial farming conditions in Dumbrăveni Commune, Constanța County, southeastern Romania, with the objective of evaluating the cultivation technology applied to the winter barley (*Hordeum vulgare* L.) cultivar SU Ellen and assessing the influence of different fertilization strategies on crop productivity. The experimental site is located in the Dobrogea region, which is characterized by a temperate continental climate with Pontic influences, hot and dry summers, relatively mild winters, irregular rainfall distribution, and annual precipitation generally below 450 mm. The experimental field is established on a Chernozem soil, typical of southeastern Romania, characterized by moderate to high natural fertility, favorable structure, moderate humus content, and good nutrient availability. Nevertheless, under the frequent drought conditions of the

region, soil water availability often becomes the principal limiting factor for crop productivity.

The experiment was established after sunflower, considered a favorable preceding crop for winter barley. Soil preparation followed the minimum tillage system adopted by the farm. After sunflower harvest on 24 August 2024, crop residues were chopped and uniformly distributed across the soil surface. A shallow disc cultivation was subsequently performed to reduce water losses, stimulate weed emergence, and facilitate the following field operations. Following the first significant rainfall event, the soil was cultivated using a field cultivator to prepare a suitable seedbed while preserving soil moisture.

The biological material consisted of the winter barley cultivar SU Ellen, an extra-early two-row cultivar characterized by high yield potential, excellent tillering capacity, good lodging resistance, stable productivity, and tolerance to drought, heat stress, and the major foliar diseases affecting barley. Certified seed with high purity and germination capacity was used throughout the experiment.

The field trial was arranged as a randomized experiment with three fertilization treatments, each replicated three times under similar soil and topographic conditions. The treatments consisted of: V0, representing the control treatment with basal fertilization only; V1, consisting of basal fertilization followed by supplementary nitrogen fertilization; and V2, consisting of basal fertilization, supplementary nitrogen fertilization, and foliar fertilizer applications during the growing season. Experimental plots corresponding to V0 and V1 covered 3 ha each (1 ha per replicate), whereas treatment V2 was implemented on a larger commercial field, although only three representative 1-ha plots were considered for the experimental evaluation. Winter barley was sown on 15–16 October 2024 at a seeding rate of 200 kg ha⁻¹, corresponding to approximately 400 viable seeds m⁻² for all treatments.

Basal fertilization was applied on 13 October 2024 using 170 kg ha⁻¹ of Eurocereal (Tamac), containing 10% total nitrogen (N), 24% P₂O₅, 20% SO₃, 0.1% boron, and 0.1% zinc. Additional nitrogen fertilization was applied in early March 2025, when treatments V1 and V2 received 150 kg ha⁻¹ ammonium nitrate to stimulate spring regrowth and tillering. Weed control was performed on 30 March 2025 using the herbicide Sekator, containing amidosulfuron (100 g L⁻¹), iodosulfuron (25 g L⁻¹), and mefenpyr-diethyl (250 g L⁻¹). Crop protection included two fungicide and insecticide applications. The first treatment, applied on 12 April 2025, consisted of Deltasap (deltamethrin, 25 g L⁻¹), Starpro (tebuconazole, 430 g L⁻¹), and Zingaro (azoxystrobin, 250 g L⁻¹). During the same operation, treatment V2 additionally received the foliar fertilizer Fertiactyl Trium, supplying nitrogen, phosphorus, potassium, and micronutrients. A second

supplementary nitrogen application of 100 kg ha⁻¹ ammonium nitrate was performed on 24 April 2025 exclusively in treatment V2. The final phytosanitary treatment was applied on 3 May 2025 using Nativo Pro (prothioconazole + trifloxystrobin) and Lamdex Extra (lambda-cyhalothrin), while treatment V2 additionally received the foliar fertilizer Ferticover Nitron, containing nitrogen together with boron, copper, iron, manganese, molybdenum, and zinc. Mechanical harvesting was performed on 22 June 2025 at full physiological maturity.

Crop performance was evaluated throughout the growing season using identical sampling procedures for all treatments. Plant density at emergence was determined by counting plants on eight adjacent rows over one linear meter at three representative sampling points positioned diagonally across each plot. Plant density at harvest was determined using the same methodology by counting productive spikes, and results were expressed as spikes m⁻². Thousand-kernel weight (TKW) was determined in the Crop Science Laboratory using representative grain samples collected separately from each treatment, with three analytical replicates. Grain yield was obtained after mechanical harvesting and expressed as kg ha⁻¹.

The collected data were subjected to descriptive statistical analysis. Arithmetic means and percentage differences among treatments were calculated to evaluate the influence of fertilization on crop establishment, maintenance of productive plant density, grain development, and final yield under the climatic conditions specific to the Dobrogea region. This methodological approach allowed the comparison of fertilization strategies under commercial farming conditions while minimizing the influence of environmental variability.

REZULTATE ȘI DISCUȚII

RESULTS AND DISCUSSIONS

Climatic conditions recorded during the 2024–2025 growing season strongly influenced barley growth and yield formation. Air temperature and precipitation distribution represented the main environmental factors affecting crop establishment, tillering, stem elongation, grain filling and physiological maturity.

The thermal regime recorded from November 2024 to June 2025 generally favored crop establishment and spring development (Figure 1). During autumn, mean monthly temperatures ranged from 4.6 to 5.9°C, allowing rapid emergence and good establishment before winter dormancy. December (4.6°C) and January (5.2°C) were considerably warmer than the long-term averages (2.3

and 0.5°C, respectively), extending vegetative activity and promoting early biomass accumulation. The coldest month was February, when the mean temperature decreased to 0.0°C, while the absolute minimum reached −13.9°C. Despite these low temperatures, the winter barley cultivar SU ELLEN exhibited good winter hardiness, with no visible reduction in plant density after winter. Following dormancy, mean temperatures increased rapidly during spring, reaching 9.7°C in March, 10.8°C in April, 16.4°C in May, and 24.2°C in June, all equal to or exceeding the long-term averages. Absolute maximum temperatures increased progressively from 27.4°C in March to 37.6°C in June, accelerating physiological development and shortening the grain-filling period.

The thermal conditions were favorable for crop growth, particularly during tillering and stem elongation. However, the elevated temperatures recorded during late spring and early summer increased evaporative demand and intensified the effects of water deficit during grain filling.

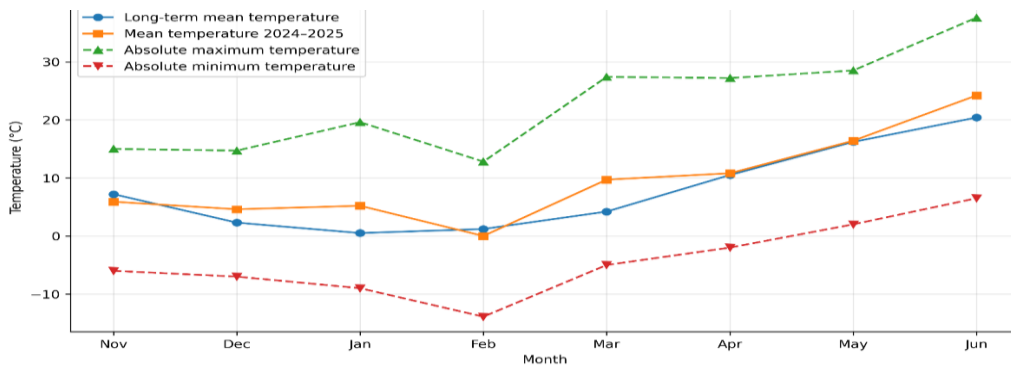


Figure 1. Temperature evolution during the barley growing season in 2024–2025 compared with the long-term average in the Tortoman area.

The precipitation regime showed marked temporal variability throughout the growing season. During autumn, rainfall exceeded the climatic averages, creating favorable soil moisture conditions for sowing and crop establishment. Total precipitation reached 56.6 mm in November and 92.8 mm in December, considerably higher than the corresponding long-term averages (40.4 and 34.0 mm, respectively). Consequently, substantial soil water reserves were accumulated before winter. In contrast, severe rainfall deficits occurred from January to April. Monthly precipitation declined to 17.4 mm in January, 5.4 mm in February, 4.6 mm in March, and 23.4 mm in April, all below the long-term climatic means. This dry period coincided with the resumption of vegetative growth, when crop water demand increased substantially.

Rainfall conditions improved during May, when 52.4 mm of precipitation was recorded, closely matching the climatic average (50.2 mm). This rainfall supported spike development and grain filling. Nevertheless, June was extremely dry, with only 0.2 mm of precipitation compared with the normal value of 53.2 mm, while simultaneously experiencing the highest temperatures of the growing season. These conditions accelerated crop maturation and reduced the duration of grain filling. The distribution of rainy days further emphasized the irregular precipitation pattern (Figure 2). December recorded the highest rainfall frequency, with 15 rainy days (>0.1 mm), including 6 days exceeding 5 mm and 4 days exceeding 10 mm. Conversely, February and March experienced very few effective rainfall events, limiting soil water replenishment during a critical stage of crop development. Although rainfall frequency increased again in May (12 rainy days, including 7 events above 5 mm), only one rainy day was recorded during June, confirming the severe drought conditions that prevailed during crop maturity.

The 2024–2025 growing season was characterized by warm winter conditions followed by a prolonged spring water deficit and extremely dry conditions during grain maturation. Despite these climatic constraints, the minimum tillage system contributed to conserving soil moisture accumulated during autumn and winter, while the applied fertilization strategy supported crop development and allowed the SU ELLEN cultivar to maintain satisfactory productivity under the semi-arid conditions of Dobrogea.

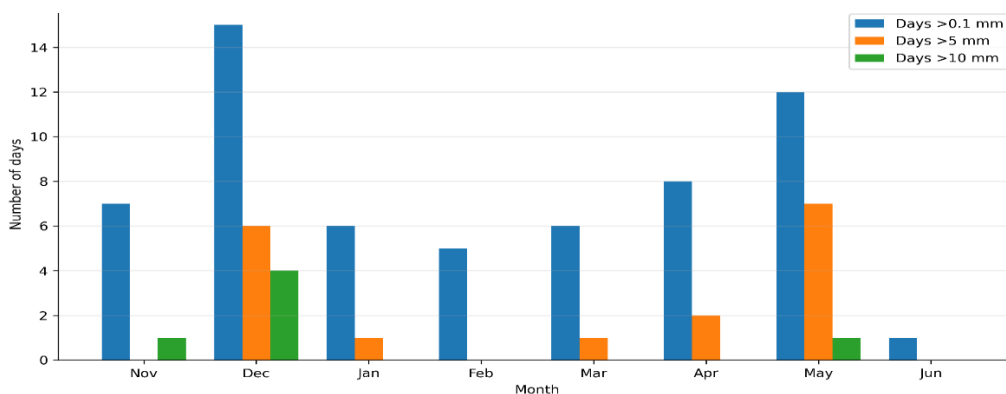


Figure 2. Distribution of rainy days during the barley growing season in 2024–2025 in the Tortoman area.

Although the initial sowing density was identical for all treatments (approximately 400 viable seeds m^{-2}), crop establishment showed some variation among the experimental plots. Emergence density ranged from 306 plants m^{-2} in V0 to 326 plants m^{-2} in V1 and 368 plants m^{-2} in V2. Because supplementary

nitrogen and foliar treatments were applied after crop establishment, these differences should primarily be interpreted as field variability in emergence and early plant establishment rather than as a direct fertilization effect.

Differences among treatments became substantially more pronounced at harvest. The control treatment (V0) produced 449 productive spikes m^{-2} , whereas supplementary nitrogen fertilization increased this value to 522 spikes m^{-2} in V1. The highest density was recorded in V2, with 626 productive spikes m^{-2} , corresponding to an increase of approximately 39.4% compared with V0. The results indicate that improved nutrient availability during spring supported tiller survival and the formation of a greater number of productive spikes under the water-limited conditions of the 2024–2025 growing season.

Grain development responded similarly to increasing fertilization intensity. Thousand-kernel weight (TKW) increased from 40 g in V0 to 44 g in V1, representing a 10.0% increase, while the combined application of additional nitrogen and foliar fertilizers in V2 resulted in a TKW of 53 g, 32.5% higher than the control (Figure 4a). The higher TKW recorded in V2 indicates improved grain filling and dry matter accumulation despite the high temperatures and severe precipitation deficit observed toward the end of the growing season.

The strongest treatment response was observed for grain yield. The control treatment produced 4,270 kg ha^{-1} , while supplementary nitrogen fertilization increased yield to 5,460 kg ha^{-1} , corresponding to an improvement of 27.9%. Treatment V2 achieved the highest grain yield, 7,890 kg ha^{-1} , representing an increase of 84.8% compared with V0 and approximately 44.5% compared with V1. The combined response of productive spike density and thousand-kernel weight explains the substantial yield advantage recorded under the more intensive fertilization strategy (Figure 4b).

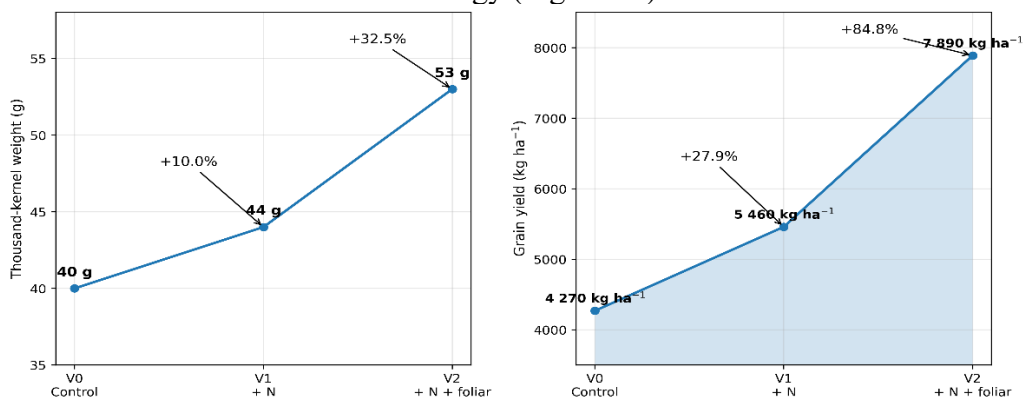


Figure 3. Effect of fertilization strategy on thousand-kernel weight 4a, and grain yield 4b of the SU Ellen winter barley cultivar.

The synthesis of the evaluated parameters shows a consistent improvement from V0 to V2, particularly for productive spike density, TKW, and grain yield. Under the climatic conditions of the experimental year, characterized by spring rainfall deficits and high temperatures during grain maturation, the additional nitrogen and foliar nutrient supply was associated with improved maintenance of productive tillers and more efficient grain filling. Among the tested treatments, V2 provided the highest agronomic performance of the SU Ellen winter barley cultivar.

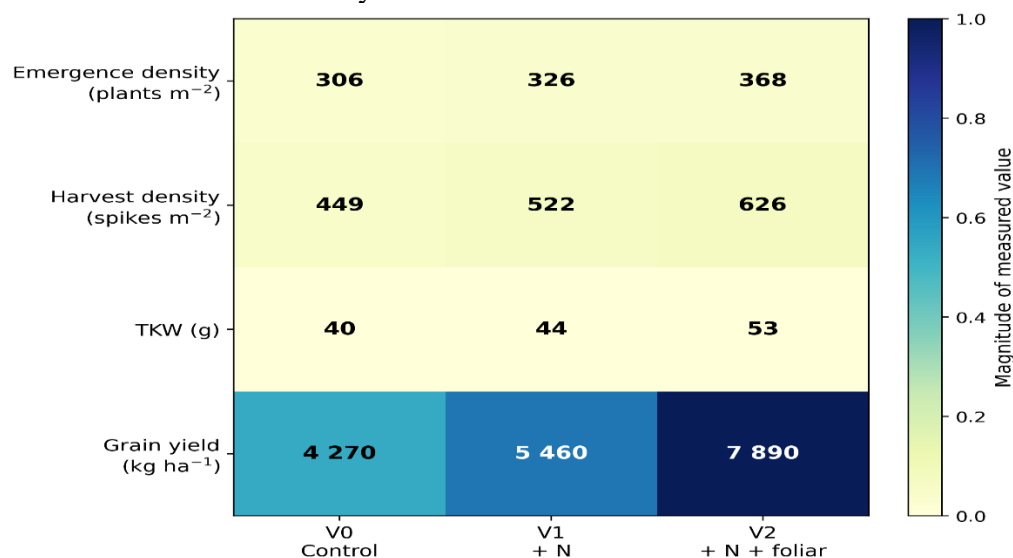


Figure 4. Synthesis of the response of the main agronomic parameters of SU Ellen winter barley to different fertilization strategies.

The present study demonstrated that balanced fertilization substantially improved the productive performance of the winter barley cultivar SU Ellen under the pedoclimatic conditions of Dobrogea. The progressive increase in harvest density, thousand-kernel weight (TKW), and grain yield observed from the control treatment (V0) to the intensive fertilization treatment (V2) confirms that nutrient availability remains one of the principal factors determining winter barley productivity, particularly under semi-arid environments.

Harvest density increased from 449 spikes m⁻² in the control treatment to 626 spikes m⁻² in the most intensively fertilized treatment. The maintenance of a higher number of productive tillers throughout the growing season directly contributed to the increased grain yield. Similar observations were reported by Cristea et al. (2024), who emphasized that crop density is a key determinant of both grain quantity and quality in winter barley, with optimized agronomic management contributing to improved stand uniformity and productivity.

Thousand-kernel weight also responded positively to increasing fertilization intensity, increasing from 40 g in the control treatment to 53 g in treatment V2. Nitrogen availability during stem elongation and grain filling is known to enhance assimilate accumulation in developing kernels. Comparable responses were reported by Petcu et al. (2025), who showed that nitrogen fertilization significantly improved kernel development and yield performance of two-row winter barley cultivated in southeastern Romania. Likewise, Toma and Dobrinioiu (2025) demonstrated that optimizing fertilization schemes contributes not only to increased grain yield but also to improved technological quality of barley intended for processing.

The highest grain yield (7,890 kg ha⁻¹) was obtained under the combined application of basal fertilization, supplementary nitrogen, and foliar fertilization (V2). Compared with the control treatment, yield increased by almost 85%, highlighting the cumulative contribution of balanced nutrition throughout the growing season. Similar conclusions were reached by Niță et al. (2025), who reported that integrated fertilization technologies improve both grain production and crop stability under the environmental conditions of Romania. Their results indicate that efficient nutrient management becomes increasingly important under years characterized by climatic variability.

Weather conditions strongly influenced crop performance during the 2024–2025 growing season. Although rainfall recorded during autumn favored crop establishment, prolonged precipitation deficits and above-average temperatures during spring increased drought stress during stem elongation and grain filling. Such climatic conditions are characteristic of the Dobrogea region and have frequently been identified as major constraints limiting cereal productivity (Lungu et al., 2010; Panaitescu et al., 2014). More recently, Pila and Stanciu (2026) demonstrated that increasing climatic variability has become one of the principal drivers of cereal yield fluctuations in Romania, emphasizing the need for adaptive agronomic technologies capable of mitigating drought effects.

The satisfactory performance of the SU Ellen cultivar under these environmental conditions confirms the importance of selecting cultivars adapted to regional climatic constraints. Similar observations were reported by Miron et al. (2024), who showed that modern barley cultivars cultivated in Dobrogea exhibit different adaptive responses to current climatic conditions, with genotype selection representing an important component of sustainable cereal production. The genetic improvement of barley during recent decades has also contributed to increased yield potential, improved stress tolerance, and better adaptation to diverse production environments (Gozukirmizi and Karlik, 2017).

The positive response obtained under the intensive fertilization treatment also agrees with the findings of Hrivna et al. (2024), who demonstrated that adequate nitrogen supply combined with complementary nutritional strategies improves yield components by stimulating root development and maintaining physiological activity during periods of environmental stress. In addition, maintaining healthy crops throughout the growing season is essential for maximizing the benefits of fertilization. Chețan et al. (2023) emphasized that efficient weed management represents a fundamental technological component because it reduces competition for water and nutrients, thereby allowing barley crops to fully exploit available production resources.

Beyond increasing grain yield, improving grain quality has become increasingly important due to the growing demand for barley as both feed and food raw material. Moroșan et al. (2022) reported considerable variation in grain quality among Romanian barley cultivars, while Feng et al. (2024) highlighted the nutritional and functional value of barley grain and its by-products, emphasizing that agronomic practices capable of improving grain development may also contribute to enhancing its nutritional value.

The results obtained in the present study demonstrate that balanced fertilization represents one of the most effective agronomic tools for improving winter barley productivity under the semi-arid conditions of southeastern Romania. The integration of appropriate fertilization strategies with adapted cultivars and conservation-oriented crop management may contribute significantly to maintaining stable cereal production under increasingly variable climatic conditions.

CONCLUZII CONCLUSIONS

The present study demonstrated that the cultivation technology applied to the winter barley cultivar SU Ellen ensured satisfactory crop establishment and high grain productivity under the pedoclimatic conditions of Tortoman, Constanța County, during the 2024–2025 agricultural season. Despite the occurrence of periods characterized by elevated temperatures and limited precipitation during spring and early summer, the crop maintained good agronomic performance due to the combination of appropriate soil management and balanced fertilization.

Fertilization significantly influenced all evaluated production parameters. Progressive increases in crop density at harvest, thousand-kernel weight, and grain yield were observed with increasing fertilization intensity, confirming that

nutrient availability is a major determinant of barley productivity under semi-arid conditions.

The most intensive fertilization strategy (V2), combining basal fertilization, supplementary nitrogen, and foliar nutrient applications, produced the highest agronomic performance, reaching 626 spikes m⁻², a thousand-kernel weight of 53 g, and an estimated grain yield of 7,890 kg ha⁻¹, clearly outperforming both the control treatment and the nitrogen-only treatment.

The climatic conditions of the 2024–2025 growing season emphasized the importance of adopting cultivation practices capable of improving crop resilience to drought. The minimum tillage system, together with an adequate fertilization program, contributed to maintaining crop vigor, improving grain filling, and maximizing the productive potential of the SU Ellen cultivar.

The results indicate that integrating conservation-oriented soil management with balanced fertilization represents an effective strategy for sustainable winter barley production in the Dobrogea region. These findings provide useful information for farmers seeking to optimize fertilization practices while maintaining stable yields under increasingly variable climatic conditions.

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**ASPECTS OF UTILIZING FIBROUS FEEDS IN THE NUTRITION OF
FATTENING YOUNG SHEEP
ASPECTE ALE UTILIZĂRII NUTREȚURILOR FIBROASE ÎN
HRANA TINERETULUI OVIN SUPUS ÎNGRĂȘĂRII**
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REZUMAT

Lucrarea de față abordează tematica optimizării utilizării resurselor vegetale fibroase și grosiere în alimentația tineretului ovin supus procesului de îngrășare. Partea aplicativă a lucrării testează experimental limitele biologice de toleranță ale mieilor din rasa Merinos la diferite niveluri și surse botanice de fibre. Rezultatele demonstrează existența unui prag critic de 20% celuloză brută în substanța uscată a rației. Depășirea acestui prag prin suprasaturarea dietei cu fibroase a determinat prăbușirea sporului mediu zilnic și a lăsat animalele sub greutatea comercială la finalul celor 140 de zile de control experimental. În schimb, reducerea celulozei într-o rație intensivă bazată pe concentrate a deblocat potențialul genetic de creștere al mieilor, generând performanțe maxime și scurtarea ciclului de îngrășare cu 24 de zile. Acest fapt a optimizat rulajul în fermă și a oferit cea mai bună eficiență economică. Lucrarea oferă fermierilor recomandări practice clare: utilizarea rațiilor intensive cu nivel scăzut de celuloză în primele faze pentru un rulaj rapid, excluderea paielor de grâu în favoarea ciocălăilor de porumb mărunțiți și posibilitatea aplicării unor rețete de oportunitate economică prin utilizarea deșeurilor agricole ieftine în procente de până la 30%, cu condiția obligatorie a echilibrării proteice a amestecului.

ABSTRACT

This scientific paper evaluates the biological limits, production performance, and carcass quality traits associated with the inclusion of variable levels and botanical sources of fibrous and coarse feeds in the diets of fattening young Merino lambs. The experimental framework investigates the physiological transition from a milk/pasture diet to high-energy formulations post-weaning. It identifies a critical biological threshold of 20% crude cellulose in the dry matter of the ration. Exceeding this threshold limits voluntary feed intake due to reticulo-ruminal capacity constraints. This leads to a severe drop in average daily gain (ADG) and prevents animals from reaching commercial weight. Conversely, lowering crude cellulose to 11.9% in intensive concentrate-based diets unlocks

genetic growth potential. This increases ADG to 210 g/day and shortens the fattening period by 24 days. Among agricultural by-products, ground corn cobs demonstrated superior palatability and ruminal degradability compared to wheat straw and corn stalks. Furthermore, the structure of the diet modulates energy partitioning and tissue lipid deposition. Highly concentrated rations stimulate visceral adipogenesis (increasing perirenal fat by 95%). Meanwhile, diets including 20% corn cobs redirect energy to increase intramuscular fat to a peak of 5.83%, enhancing meat marbling. Finally, the study demonstrates that young sheep tolerate up to 30% corn cobs in fibrous mixtures. This provides an economically viable feeding strategy, provided strict protein balancing is maintained at a minimum of 10.5%–11% digestible protein.

Cuvinte cheie: tineret ovin, nutrețuri fibroase, îngrășare intensivă, calitatea cărnii, parametri ruminali.

Keywords: young sheep, fibrous feeds, intensive fattening, meat quality, Merino lambs, ruminal homeostasis.

INTRODUCERE INTRODUCTION

Maximizing the growth potential of young sheep to obtain carcasses with high commercial value is a primary objective in modern animal science. The success of fattening systems depends directly on nutritional management and the adaptation of the animals' digestive tract. Post-weaning, lambs go through a critical period: their forestomachs are structurally and functionally underdeveloped, and the ruminal microflora is not yet adapted to efficiently break down high levels of crude cellulose (above 20-25%).

Voluntary feed intake is controlled by two main mechanisms:

- Physical (volumetric) regulation: This mechanism dominates in rations with dry matter digestibility up to 65%, being limited by the anatomical capacity of the reticulo-rumen and tension stretch receptors.
- Chemical (metabolic) regulation: This system activates when the dietary energy density exceeds the threshold value of 2.47 kcal Digestible Energy/g DM. Above this level, duodenal chemoreceptors and the influx of volatile fatty acids (VFAs) signal satiety, causing feed intake to drop linearly to maintain a constant caloric intake.

The choice of technological vector reconfigures the metabolism of the lambs: the intensive system (permanent confinement) maximizes growth velocity but involves high costs and risks of ruminal acidosis; the extensive system

(pasture-based) provides premium quality meat (rich in Omega-3 fatty acids and CLA) but results in a slow growth rate; while the semi-intensive system represents the ideal balance. In this context, optimizing both the level and the botanical source of fiber is essential to stimulate early rumen development without penalizing average daily gain.

MATERIAL ȘI METODĂ DE CERCETARE

MATERIAL AND METHOD

1. Animals and Experimental Design

The experimental trials were conducted using male Merino lambs. For each distinct nutritional experiment, animals were homogeneous in initial body weight and age, organized into uniform groups of 10 heads per group. All animals were housed in indoor pens under identical microclimatic conditions.

2. Diets and Feed Processing

The experimental rations were formulated across three operational sub-periods: accommodation (10–14 days), proper fattening (60–80 days), and finishing (15–20 days). The inclusion of fibrous components peaked during the proper fattening stage, while concentrate proportions followed an inverse pattern, peaking during finishing.

To manipulate particle size and counteract sorting behaviors, roughages were physically processed:

- Alfalfa hay (*Medicago sativa*), wheat straw, and corn stalks were chopped using a hammer mill fitted with a 12 mm screen.
- Corn cobs were processed into coarse meal using a roller mill.

All total mixed rations (TMR) and clean drinking water were supplied *ad libitum*.

3. Evaluated Parameters and Analytical Methods

- **Biometric and Growth Performance:** Individual body weights were recorded at the beginning, at intermediate intervals, and at the end of each trial. Average Daily Gain (ADG) was computed. Total feed intake was tracked daily per group to calculate specific consumption metrics: Nutrient Units (NU/kg gain), Digestible Protein (DP g/kg gain), and Concentrate Intake (kg/kg gain).

- **Slaughter and Carcass Traits:** At the end of the fattening periods, representative animals (3 heads per group) were slaughtered according to standard zootechnical procedures. Dressing percentage (slaughter yield), carcass quality grading, and the absolute weight of visceral (perirenal) fat depots were determined.

- **Chemical Analysis of Meat:** Tissue samples were collected from the *Longissimus dorsi* muscle. Samples were analyzed in triplicate to determine Dry Matter (%), Crude Protein (%), Ether Extract/Fat (%), and Crude Ash (%) using standard chemical methods.

REZULTATE ȘI DISCUȚII RESULTS AND DISCUSSIONS

1. Experiment 1: High vs. Low Dietary Fiber Proportions

This trial compared a high-fiber ration (Group I: 60% roughage) against an intensive, concentrate-rich formulation (Group II: 32% roughage).

Table 1: Formulation and Nutritional Content (Experiment 1)

Component / Value	Group I (60% Fibrous)	Group II (32% Fibrous)
Alfalfa Hay (%)	40	32
Corn Cobs (%)	20	-
Corn Grain (%)	26	50
Sunflower Meal (%)	10	12
Minerals & Premix (%)	4	6
Dry Matter (DM %)	87.2	86.2
Digestible Protein (DP %)	10.0	11.1
Nutrient Units (NU)	68.2	86.0
Crude Cellulose (%)	19.8	11.9

Reducing roughage in Group II significantly lowered crude cellulose (from 19.8% down to 11.9%) and increased dietary energy density from 68.2 to 86.0 NU.

Table 2: Growth Performance and Economic Efficiency (Experiment 1)

Parameter	U.M.	Group I	Group II
Fattening Duration	days	140	120
Initial Body Weight	kg	17.09±0.34	17.66±0.31
Final Body Weight	kg	40.50±1.38	41.91±1.29
Average Daily Gain (ADG)	g	168±5.22	210 ±10.13
Feed Conversion: NU / kg gain	-	5.82	5.38
Feed Conversion: DP / kg gain	g	708	704
Concentrate Conversion	kg	2.42	3.88

Group II lambs achieved higher final body weights 41.91 kg and a significantly faster growth rate of 210 g/day. This energetic acceleration shortened the production cycle by 24 days. Although Group II consumed more expensive concentrates (3.88 kg concentrates/kg gain, the reduction in total feeding days lowered maintenance costs. This improved overall financial efficiency, yielding a lower cost per unit of gain.

2. Experiment 2: Testing Upper Biological Limits of Dietary Cellulose

This experiment examined extreme roughage saturation by comparing Group I (62% fiber) with Group II (76% fiber).

Table 3: High vs. Extreme Dietary Fiber Levels (Experiment 2)

Component / Value	Group I (62% Fibrous)	Group II (76% Fibrous)
Alfalfa Hay (%)	50	66
Corn Cobs (%)	12	10
Corn Grain (%)	26	19
Sunflower Meal (%)	8	1
Minerals & Premix (%)	4	4
Digestible Protein (DP %)	10.3	9.6
Nutrient Units (NU)	66.1	58.9
Crude Cellulose (%)	19.7	21.6

Pushing alfalfa hay to 66% in Group II forced crude cellulose past the threshold to 21.6%, while dropping energy density to 58.9 NU.

Table 4: Growth Limits and Economic Penalties (Experiment 2)

Parameter	U.M.	Group I	Group II
Fattening Duration	days	140	140
Initial Body Weight	kg	17.50±0.37	17.27±0.27
Final Body Weight	kg	35.77±1.34	31.10±1.31
Average Daily Gain (ADG)	g	131±7.32	100±7.65
Feed Conversion:	-	6.57	6.50
NU / kg gain			
Feed Conversion:	g	862	880
DP / kg gain			
Concentrate Conversion	kg	2.72	1.70

Under extreme fiber load, Group II growth plummeted to a critical low of 100 g/day. After 140 days, these lambs failed to achieve acceptable commercial slaughter weights 31.10 kg. This demonstrates an allometric survival mechanism. Under energy and protein deficits, skeletal extension and vital organs prioritize

remaining nutrients. Consequently, actin and myosin synthesis in muscle tissue stops to reduce basal ATP expenditure. This leaves lambs narrow, long-legged, and economically unviable for meat production.

3. Experiment 3: Evaluating Botanical Sources of Coarse By-Products

This trial evaluated different coarse agricultural by-products by keeping total roughage constant at 61% and isolating the source: Wheat Straw (Group 1), Corn Stalks (Group 2), or Corn Cobs (Group 3).

Table 5: Production Responses to Botanical Sources (Experiment 3)

Parameter	U.M.	Group 1 (Wheat Straw)	Group 2 (Corn Stalks)	Group 3 (Corn Cobs)
Fattening Duration	days	124	124	124
Initial Body Weight	kg	15.47±0.27	15.82±0.27	15.77±0.21
Final Body Weight	kg	30.70±0.62	28.94±0.83	35.16±0.74
Average Daily Gain (ADG)	g	124±7.12	139±9.28	157±8.37
Conversion: NU / kg gain	-	6.67	6.28	6.27
Conversion: DP / kg gain	g	928	860	840
Concentrate Conversion	kg	3.16	2.96	2.90

While baseline chemical values were kept uniform (10.7% DP and 64 NU), the structural nature of the plants caused distinct outcomes. Group 3 (Corn Cobs) achieved the highest growth velocity (157 g/day) and the lowest specific protein overhead (840 g DP/kg gain). In contrast, wheat straw (Group 1) restricted performance (124 g/day) and required the highest amount of concentrate supplementation (3.16 kg). This reflects the advanced lignification of wheat straw, which increases resistance to ruminal microbial breakdown.

4. Experiment 4: Escalating Insertion of Ground Corn Cobs with Protein Correction

This study tested whether increasing corn cobs from 10% to 30% could maintain production if balanced with protein adjustments.

Table 6: Balanced Escalation of Corn Cobs (Experiment 4)

Component / Parameter	U.M.	Group 1 (10% Cobs)	Group 2 (20% Cobs)	Group 3 (30% Cobs)
Alfalfa Hay	%	50	41	30

Corn Cobs	%	10	20	30
Corn Grain	%	26	23	19
Sunflower Meal	%	10	12	17
Digestible Protein (DP)	%	10.4	10.7	10.6
Crude Cellulose	%	19.2	20.0	22.1
Average Daily Gain (ADG)	g	165±9.12	157±8.88	164±9.38
Conversion: NU / kg gain	-	6.42	6.27	6.28
Conversion: DP / kg gain	g	857	840	876

Tripling the cob inclusion raised crude cellulose to 22.10% in Group 3. However, raising sunflower meal to 17% successfully stabilized protein supply. As a result, Group 3 maintained a competitive ADG (164 g/day), matching Group 1 (165 g/day). This confirms that young Merino sheep can adapt to higher levels of fibrous agricultural by-products without sacrificing growth, provided the diet is properly balanced for protein.

5. Slaughter Metrics and Energy Allocation Dynamics

Dietary composition altered carcass yields and visceral adipogenesis:

- **Concentrate-Driven Deposition:** Rations based primarily on concentrates achieved a high dressing percentage (47.10%). However, this intensive starch intake accelerated volatile fatty acid pathways toward systemic visceral lipogenesis. This increased internal perirenal fat depots by 95% (+0.560 kg) without improving intramuscular lipid distribution.

- **Fibrous-Driven Deposition:** Incorporating processed corn cobs at moderate levels (20%) redirected energy partitioning. This structural adjustment shifted lipogenesis away from visceral fat organs, favoring balanced lipid distribution. This optimization led to a 21% increase in premium Quality Class 1 carcasses compared to straw-fed groups.

6. Chemical Composition and Marbling Quality of the Meat

Tissue analysis of the Longissimus dorsi confirmed that dietary structure alters muscle composition.

Table 7: Longissimus dorsi Chemical Profile (%)

Experimental Context	Dry Matter (%)	Crude Protein (%)	Ether Extract / Fat (%)	Crude Ash (%)
A. High vs. Low Fiber				

Lot 1 (60% Fibrous)	26.32	21.56	3.62	1.11
Lot 2 (33% Fibrous)	27.94	23.71	3.22	1.01
B. Coarse Varieties				
Lot 1 (Wheat Straw)	26.52	21.89	3.50	1.14
Lot 2 (Corn Stalks)	26.60	21.07	3.83	1.13
Lot 3 (Corn Cobs)	26.62	19.62	5.83	1.17
C. Cob Escalation				
Lot 1 (10% Cobs)	26.96	22.22	3.62	1.12
Lot 2 (20% Cobs)	26.62	21.62	3.83	1.17
Lot 3 (30% Cobs)	26.32	21.07	4.14	1.11

[LONGISSIMUS DORSI COMPOSITION TRENDS]

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graph TD
    A["[ LONGISSIMUS DORSI COMPOSITION TRENDS ]"] --> B["[ Concentrate-Rich Diets ]"]
    A --> C["[ Processed Corn Cob Diets ]"]
    B --> D["• Unlocks maximum protein synthesis reaching 23.71% CP."]
    B --> E["• Limits intramuscular marbling retaining low fat (3.22%)."]
    C --> F["• Redirects lipogenesis pathways. Accumulates intramuscular fat, peaking at 5.83%. Enhances sensory traits like juiciness and tenderness."]

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[Concentrate-Rich Diets]

- Unlocks maximum protein synthesis reaching 23.71% CP.
- Limits intramuscular marbling retaining low fat (3.22%).

[Processed Corn Cob Diets]

- Redirects lipogenesis pathways. Accumulates intramuscular fat, peaking at 5.83%. Enhances sensory traits like juiciness and tenderness.

High-energy concentrate diets unlocked protein deposition, peaking at 23.71% crude protein. However, adding processed corn cobs (Section B, Lot 3) increased intramuscular fat to a peak of 5.83%. This accumulation within the muscle fibers provides desirable marbling. This improves the technological and sensory traits of the meat, enhancing both juiciness and tenderness after cooking.

Crucially, total mineral content (crude ash) remained highly stable between 1.01% and 1.17% across all groups. This consistency shows that mineral homeostasis in the muscle tissue is well-regulated and unaffected by changes in dietary fiber structure.

CONCLUZII CONCLUSIONS

- **Cellulose Threshold Limits:** Post-weaning lamb growth is highly constrained by forestomach development, establishing a strict biological threshold of 20% crude cellulose in the diet's dry matter. Exceeding this limit limits voluntary feed intake and blocks efficient nutrient digestion.
- **Concentrate Optimization:** Lowering the dietary crude cellulose fraction to 11.9% within an intensive ration containing 50% corn grain unlocks the animals' genetic growth potential. This ensures a maximum average daily gain of 210 g/day and shortens the overall fattening cycle by 24 days.
- **Botanical Hierarchy:** The productive response of lambs to a constant 20% level of coarse feeds is dictated by the botanical source. Ground corn cobs serve as the most efficient metabolic resource, whereas highly lignified wheat straw severely penalizes growth and decreases farm profitability.
- **Adipose Redirection:** Dietary structure alters energy partitioning and tissue lipid deposition. While grain-heavy concentrate rations stimulate visceral adipogenesis (increasing perirenal fat accumulation), the inclusion of processed corn cobs shifts this process, driving a 5.83% increase in intramuscular fat that ensures excellent meat marbling.
- **Nutritional Adaptability:** Young Merino sheep exhibit high digestive plasticity, tolerating up to 30% ground corn cobs within a fibrous matrix without sacrificing growth (maintaining a competitive gain of 164 g/day), provided the ration is rigorously balanced with nitrogen sources to maintain a minimum of 10.5%–11% digestible protein.

RECOMMENDATIONS FOR PRACTICAL APPLICATION

- **Enforce Cellulose Limits:** Avoid total mixed rations exceeding 20% crude cellulose for young lambs post-weaning to prevent volumetric rumen blockages and drop-offs in daily weight gain.
- **Prioritize Corn Cobs:** Utilize ground corn cobs as the primary low-cost agricultural by-product instead of wheat straw or corn stalks when formulating cost-effective fiber sources.
- **Apply Strict Protein Corrections:** When using up to 30% low-quality coarse feeds, always raise the inclusion of high-protein oilseed meals (such as sunflower meal) to at least 17% to compensate for nutrient dilution.
- **Implement High-Energy Finishing:** Transition lambs to a low-fiber, high-concentrate diet (around 11.9% crude cellulose) during the final finishing phase to accelerate marketing readiness and improve slaughter dressing yields.

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**OPTIMIZAREA PERFORMANTELOR BIOPRODUCTIVE ȘI A
CALITĂȚII OULUI LA HIBRIDUL LOHMANN LSL CLASSIC
EXPLOATAT ÎN BATERII MODERNIZATE**

**OPTIMIZATION OF BIOPRODUCTIVE PERFORMANCE AND
OF EGG QUALITY IN THE LOHMANN LSL CLASSIC HYBRID
REARED IN MODERNIZED CAGES**

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REZUMAT

Prezenta lucrare științifică evaluează în detaliu eficiența tehnologică, biologică și bioeconomică a hibridului de găini ouătoare Lohmann LSL Classic. Cercetările au fost efectuate în cadrul sistemului de exploatare intensiv în baterii verticale modernizate de la S.C. Avicola Lumina S.A.. Programul experimental a fost structurat pe două direcții majore de cercetare aplicată. Prima direcție a vizat optimizarea calității biologice și nutriționale a oului de consum. Aceasta s-a realizat prin introducerea în rația furajeră zilnică a unor materii prime funcționale, respectiv semințe de in extrudate și extract de struguri. S-a determinat obținerea de „ouă funcționale” superioare. Analizele de laborator au indicat o creștere de cinci ori a conținutului total de acizi grași polinesaturați din seria Omega-3 (580 mg/100 g). De asemenea, s-a înregistrat o majorare cu peste 150% a concentrației de luteină (24,5 mg/kg). A doua direcție experimentală a monitorizat regenerarea fiziologică a păsărilor la vârsta de 62 de săptămâni. S-a aplicat protocolul de năpârlire forțată prin Varianta Rapidă bazată pe postul zootehnic controlat. Rezultatele experimentale post-năpârlire au validat eficiența biologică a acestei tehnologii. S-a înregistrat o creștere semnificativă a intensității ouatului cu 15,40%, atingându-se un vârf secundar de producție de 86,80% în săptămâna 70. Coaja calcară a înregistrat o îmbunătățire structurală cu 35,8% a rezistenței la rupere (42,8 N). Acest fapt a diminuat procentul de ouă sparte la un minim tehnologic de 1,90%. Managementul integrat al microclimatului industrial și manipularea rațiilor de precizie au asigurat indici de conversie stabili, situați între 2,09 și 2,11 kg furaj/kg ou. Lucrarea recomandă utilizarea calcarului granulat macrometric (2-4 mm) în proporție de 65-70% pentru optimizarea cineticii de calcificare nocturnă a cojii oului.

ABSTRACT

The present scientific paper evaluates in detail the technological, biological, and bioeconomic efficiency of the Lohmann LSL Classic laying hen hybrid. The research was conducted within the intensive housing system in modernized vertical battery cages at S.C. Avicola Lumina S.A. The experimental program was structured into two major directions of applied research. The first direction aimed at optimizing the biological and nutritional quality of table eggs. This was achieved by introducing functional raw materials, namely extruded flaxseed and grape extract, into the daily feed ration. This resulted in the production of superior "functional eggs". Laboratory analyses indicated a fivefold increase in the total content of Omega-3 polyunsaturated fatty acids (580 mg/100 g). Furthermore, a more than 150% increase in lutein concentration (24.5 mg/kg) was recorded. The second experimental direction monitored the physiological regeneration of the birds at 62 weeks of age. A forced molting protocol was applied using the Rapid Method based on controlled fasting. The post-molting experimental results validated the biological efficiency of this technology. A significant increase in laying intensity of 15.40% was recorded, reaching a secondary production peak of 86.80% in week 70. The eggshell showed a 35.8% structural improvement in breaking strength (42.8 N). This reduced the percentage of cracked eggs to a technological minimum of 1.90%. Integrated management of the industrial microclimate and precision ration formulation ensured stable feed conversion ratios, ranging between 2.09 and 2.11 kg feed/kg egg. The paper recommends using large-particle limestone (2-4 mm) in a proportion of 65-70% to optimize the kinetics of nocturnal eggshell calcification.

Cuvinte cheie: găini ouătoare, Lohmann LSL Classic, baterii îmbunătățite, ouă funcționale, Omega-3, năpârlire forțată, rezistența cojii, management avicol.

Keywords: laying hens, Lohmann LSL Classic, modernized battery cages, functional eggs, Omega-3, forced molting, eggshell strength, poultry management.

INTRODUCERE INTRODUCTION

Contemporary industrial poultry farming faces a dual challenge: maximizing economic efficiency per unit of built volume and diversifying the product range by aligning with market demands for functional foods. Achieving high production performance within intensive housing systems in modernized battery cages is the result of a complex and dynamic balance between the genetic

potential of the birds and applied precision technological management. Egg production is not a static parameter, but a fluctuating biological function governed by a tight network of endogenous and exogenous factors. Among these, the hybrid genotype, indoor microclimate parameters, photoperiod schedule, and precision nutrition play the primary roles.

A deep understanding of these biological determinants allows the modern poultry technologist to directly intervene in the laying curve, optimize feed conversion, and maintain the structural quality of the eggshell throughout the economic cycle. High-productivity hybrids, such as those from selected German lines, possess a remarkable maximum production ceiling, capable of exceeding 320–350 eggs during a single standard cycle. However, as the flock advances in age, a slow and constant physiological decline in laying intensity sets in, accompanied by the progressive degradation of internal egg quality and eggshell strength. This fragility increases the incidence of cracked or rejected eggs on automatic sorting lines, penalizing farm profitability.

Another component of maximum interest in modern poultry science is the manipulation of the biochemical composition of table eggs. The bird, through its highly specialized enzyme system, possesses the metabolic capacity to directly transfer and deposit essential fatty acids and pigments from the feed ration into the yolk. This phenomenon allows the transformation of a standard egg into a high-value-added functional food, enriched with Omega-3 polyunsaturated fatty acids and carotenoids like lutein, with proven direct benefits in preventing cardiovascular and macular disorders in humans.

Parallel to optimizing biological quality, extending the economic lifespan of birds beyond 60 weeks of age represents a major technical goal. The forced molting process, induced through controlled zootechnical methods (controlled feed deprivation), acts as a programmed physiological trigger. It causes a temporary suspension of laying and complete tissue regression of the oviduct and ovary, followed by intense cellular structural regeneration. After the period of metabolic rest, the resumption of photoperiodic stimulation reactivates the hypothalamic-pituitary-gonadal neuroendocrine axis, causing the flock to progress along a secondary laying curve characterized by high intensity and a substantial restoration of eggshell structural quality.

This study aims to provide an integrated analysis of our own research results conducted on an industrial flock of laying hens, highlighting the direct impact of nutritional modifications and post-zootechnical regeneration protocols on the technical and bioeconomic indices of the operation.

MATERIAL ȘI METODĂ DE CERCETARE

MATERIAL AND METHOD

2.1. Institutional Framework and Description of the Material Base

Experimental research was conducted from 2024 to 2025 within the production facility of the S.C. Avicola Lumina S.A. poultry complex, located near Ovidiu, Constanța County. The company spans a total area of 195,575 m², with a useful built area of 62,981 m². The facility underwent a massive structural rehabilitation and complete technological upgrade in 2012. This process fully aligned the unit with European legislative requirements transposed through Council Directive 1999/74/EC on the protection and welfare of laying hens. The actual experimental activity was concentrated in Farm 1 (House 2).

2.2. Livestock Equipment and House Operations Management

The experimental house features advanced technologies for automated workflow management. Birds were housed in "ORIGINAL SPECHT" vertical monobloc battery cages. The load-bearing structure of these batteries consists exclusively of hot-dip galvanized steel profiles (zinc layer ≥ 275 g/m²) to ensure corrosion resistance. The batteries are distributed across 6 parallel rows and structured on 4 vertical tiers. The utilized length of each battery row is 102.60 m, with a total width of 1.55 m.

The housing units are divided into bird sections measuring 2.4 m in length and 1.1 m in depth. This setup establishes an optimized density of 43 birds per compartment. The nests are 0.60 m long. To comply with European standards, these enriched cages provide:

- Over 750 cm² of usable area per bird
- Perches offering a minimum of 15 cm per hen
- Abrasive litter for pecking
- Mechanical devices for claw shortening

The automated feeding system uses mobile feed hoppers equipped with specialized "Original SPECHT" dosing sleds. These components keep the feed troughs clean by pushing residues sideways and prevent the birds from sorting feed particles by size. Central feed transport from the outdoor silos to the digital scale, and subsequently to the hoppers, is performed via an "FA 90" feeder.

Watering is carried out through automated lines with 360°-activated nipple drinkers equipped with drip-saver trays. Each tier features an independent water tank to regulate pressure via a float valve. The network connects directly to the Ovidiu municipal pipeline managed by S.C. RAJA Constanța S.A. The system includes filters, a pulse-sensor water meter, and a dosing pump for pharmaceutical treatments.

During the logistical workflow of handling and transporting eggs to the automated MOBA packing station, the use of cardboard versus plastic egg trays

was comparatively evaluated. Although plastic trays present a marginal risk of mechanical damage due to material hardness, they offer major economic advantages. They provide superior durability and allow color-customization to easily identify source farms.

Regarding industrial biosecurity, these plastic trays allow for a rigorous protocol of deinfestation and chemical disinfection through mechanized washing—a process impossible to perform on cellulosic supports. The protocol implemented in the modernized farm comprised three correlated stages:

1. Thermomechanical washing at 60°C with tensioactive detergents to remove organic micro-residues.
2. Immersion or nebulization with broad-spectrum disinfectant solutions (bactericidal and virucidal formulas based on glutaraldehyde and quaternary ammonium salts).
3. Preventive treatment against ectoparasites.

This rigorous hygienic management eliminates the surface microbial load. Consequently, it prevents the risk of *Salmonella* spp. cross-contamination between the production houses and the packing station.

2.3. Poultry Manure Management and Bioclimatic Systems

The manure removal system was completely retrofitted in 2012, transitioning from a wet removal system to a dry manure management system. Beneath the wire flooring of each cage tier, dual polypropylene manure belts with a thickness of 1 mm and a width of 800 mm are operated. Pre-drying the manure to lower moisture levels below the critical 40% threshold is achieved via continuous warm air insufflation through perforated pipes positioned underneath the cages. This process successfully inhibits anaerobic bacterial fermentation and mitigates ammonia (NH₃) emissions. Belt cleaning is executed simultaneously across all tiers using a mechanical scraper system.

At the end of the house, the dried manure is collected by horizontal and vertical conveyors and discharged into trailers for transfer to three waterproofed concrete storage pads. These facilities consist of two units measuring 2,250 m² and one unit with a capacity of 2,160 m³, intended for manure mineralization. For occasional semi-liquid fractions, longitudinal gutters equipped with a cable-drawn scraper system are utilized. The effluent is transferred by a chopper pump to a "BAUER" solid-liquid separator, while the liquid fraction is discharged through an underground pipeline into a biological pond via an "EPEG" pump.

The environmental control system operates on the tunnel ventilation principle, automatically managed by a PCS 9100 climate control computer. Fresh air intake is achieved through electrically actuated wall inlets (flaps) fitted with filters for particulate filtration. Forced exhaust is provided by "TESO 6D71" axial

fans, each with a power rating of 1.1 kW and a nominal flow capacity of 32,000 m³/h. The system maintains an airspeed of 122 m/min at bird level, providing a convective cooling effect of 5–7°C during periods of summer heat stress and ensuring that the indoor ambient temperature remains below the 30°C threshold. Atmospheric gas concentrations are automatically regulated below biological toxicity limits: ammonia (NH₃ ≤ 20 ppm) and carbon dioxide (CO₂ ≤ 3000 ppm).

During the cold season (winter), the housing microclimate dynamics were managed by strictly correlating the minimum ventilation regimen with the maintenance of an optimal thermohygrometric balance. Ventilation rate calculations were calibrated according to flock age categories and physiological stages. Consequently, for laying hens in the production phase (aged 5–6 months and 9–10 months, respectively), the PCS 9100 climate computer automatically adjusted seasonal intake and exhaust regimens based on the following standardized technical parameters:

- For the 5–6 month flock: The winter ventilation rate was restricted to 1.0–1.2 m³/h per bird, compared to 2.6–3.2 m³/h in spring/autumn and 4.5–4.8 m³/h under summer operating conditions.
- For the 9–10 month flock: The minimum winter ventilation rate was set at 1.0–1.6 m³/h, increasing to 3.6–3.8 m³/h during transitional periods and 4.6–5.2 m³/h during the summer season.

This rigorous restriction of winter airflow aims to maintain ambient temperature within the thermoneutral zone (+17 to +22°C). This prevents the temperature from falling below the critical threshold of +15°C—which triggers an increase in feed consumption for thermogenesis—or below +2°C, where a severe drop in egg production occurs.

Simultaneously, relative humidity (RH) was monitored and maintained within a stable range of 60–70%. Experimental data indicated that winter relative humidity below 50% leads to excessively dry air, increased aerosolization of dust microparticles, and severe irritation of the birds' respiratory tract. Conversely, exceeding the critical threshold of 80% humidity in a warm house environment generates a microclimate conducive to fungal and parasitic proliferation. This phenomenon impairs natural thermoregulation mechanisms, induces severe respiratory heat stress, and predisposes the flock to secondary bacterial infections (such as *Escherichia coli*) due to the degradation of tracheal cilia.

Lighting is exclusively artificial, utilizing 25–40 W incandescent lamps positioned above the central walkways. During the production phase, the system operates on a fixed photoperiod regimen of 16 hours of light and 8 hours of darkness (16L:8D).

2.4. Biological Material and Experimental Protocol Design

The selected biological material consisted of a homogenous flock of 30,000 laying hens belonging to the Lohmann LSL Classic light-type hybrid. This four-way cross hybrid is recognized for its docile temperament, high adaptability to battery cage housing, and robustness against microclimate-induced stress. The flock was divided into two distinct groups and monitored throughout their production cycles:

- The Control Group (Standard): Fed a standardized corn-wheat-soybean meal-based diet during Phase I of the laying period, formulated to meet the nutritional requirements specified in the hybrid's management guide.
- The Experimental Group (Functional): Fed a structurally modified compound feed, where traditional energy sources were partially replaced with extruded linseed (flaxseed) and grape seed extract. The objective was to monitor the metabolic transfer of Omega-3 polyunsaturated fatty acids (alpha-linolenic acid) and natural antioxidants directly into the egg yolk.

At 62 weeks of age, a second research phase was initiated to study the physiological regeneration capacity of the flock. The birds were subjected to a rigorous induced molting protocol, applying the fast-induced variant based on the controlled feed withdrawal method. The protocol spanned 28 days and adhered to the national technical framework:

- Week 1 (Day 1): Total withdrawal of feed and water; implementation of a continuous darkness regimen within the house.
- Week 1 (Day 2): Allocation of a restricted 2-hour photoperiod; ad libitum drinking water; total feed deprivation.
- Week 1 (Days 3–7): Allocation of a 6-hour daily photoperiod; ad libitum water; maintenance of feed starvation to induce oviduct regression.
- Week 2 (Days 8–14): Stabilization of the photoperiod at 6 hours; ad libitum water and resting (maintenance) diet to restore primary digestive functions.
- Week 3 (Days 15–21): Extension of the photoperiod to 8–10 hours; ad libitum water and feed access.
- Week 4 (Days 22–28): Progressive light stimulation by increasing day length by 20 minutes per day; implementation of an intensive antioxidant vitamin supplementation program; gradual transition back to Phase I layer production feed.

2.5. Monitored Performance Indicators and Laboratory Analytical Methodologies

Quantitative performance parameters were recorded daily by monitoring laying intensity, specifically the hen-day egg production rate (egg production percentage relative to the number of hens present), utilizing optical sensors

located at the discharge end of the collection belts and integrated digital modules. The Feed Conversion Ratio (FCR) was calculated as the mathematical ratio between total feed intake and total egg mass produced, expressed as kilograms of feed consumed per kilogram of egg synthesized (kg feed/kg egg). Physical production parameters were determined by evaluating average egg weight (g) using a digital grading module integrated into a MOBA industrial sorting and grading machine, which features a nominal processing capacity of 25,000 eggs/hour.

Structural analysis of the calcareous eggshell was conducted by determining eggshell breaking strength, expressed in Newtons (N), utilizing digital laboratory testing equipment that applies static compression forces along the longitudinal (major) axis of the egg. Concurrently, the percentage of broken or micro-cracked eggs was monitored directly on the industrial grading and packing line.

Internal egg quality, focusing on the albumen protein structure, was quantified by measuring the height of the thick albumen using a digital micrometer. These measurements were automatically converted into Haugh Units (HU) based on individual egg weight. High-precision biochemical assays, specifically the profile of Omega-3 polyunsaturated fatty acids (PUFAs) and the micromolar concentration of lutein within the yolk, were performed using High-Performance Liquid Chromatography (HPLC) techniques within the specialized testing laboratories of the National Research-Development Institute for Animal Biology and Nutrition (IBNA Balotești).

REZULTATE ȘI DISCUȚII

RESULTS AND DISCUSSIONS

3.1. Impact of Nutritional Manipulation on Productive Performance and Yolk Biochemical Quality

The dietary inclusion of plant-based lipid sources, represented by extruded linseed, alongside bioactive compounds from grape seed extract, resulted in a profound biochemical restructuring of the table egg composition. The data centralized throughout the primary experimental period (weeks 25–45 of age) are presented comparatively in Table 1.

From a metabolic perspective, calibrating the energy density of the experimental rations required a rigorous differentiation between light-type hybrids (selective lines of the Leghorn breed, such as Lohmann LSL Classic) and semi-heavy strains (derived from the Rhode Island breed). Due to massive

variations in body weight at the onset of lay (1.30–1.40 kg for the light type versus 1.60–1.75 kg for the semi-heavy type), the absolute daily requirement for Metabolizable Energy (ME) exhibits a distinct allometric correlation: light hybrids strictly require 230–260 kcal ME/hen/day, whereas heavier strains demand between 280–310 kcal ME/hen/day to cover basal metabolism and thermal homeostasis.

Nutritional engineering calculations were based on the correlation between the gross caloric value of the synthesized egg mass and the biological energy transformation efficiency. A standard 60 g egg embeds a net energy of approximately 91 kcal (1.51 kcal/g of egg mass). Assuming an average conversion efficiency of dietary energy into egg energy of 45%, the following mathematical modeling equations were utilized to determine the production caloric requirement (over the basal maintenance requirement):

- For the production of a standard individual egg (60 g):

$$ME_{\text{egg}} = \frac{60 \text{ g} \times 1,51 \text{ kcal/g}}{0,45} = 201,3 \text{ kcal}$$

- To express the yield per 100 g of unitary egg mass:

$$EM_{100 \text{ g}} = \frac{100 \text{ g} \times 1,51 \text{ kcal/g}}{0,45} = 335,5 \text{ kcal}$$

These equations allowed for the optimization of the Experimental Group's diet to a level of 2,750–2,820 kcal ME/kg of feed. This adjustment effectively compensated for the genetically fixed physical appetite of the Lohmann hybrid (105–112 g/day), thereby preventing bird fattening or skeletal demineralization.

Table 1. Evolution of production performance and egg quality indicators according to the applied dietary treatment (Weeks 25–45)

Monitored Parameter	Control Group (Standard Diet)	Experimental Group (Functional Diet)	Statistical Significance (p-value)
Hen-day egg production (%)	94.20	94.65	p > 0.05
Average egg weight (g)	62.40	63.10	p < 0.05

Daily feed intake (g/hen)	111.20	112.50	$p > 0.05$
Feed conversion ratio (kg feed/kg egg)	2.11	2.09	$p < 0.05$
Total Omega-3 content (mg/100g yolk)	115.00	580.00	$p < 0.01$
Yolk lutein concentration (mg/kg)	9.80	24.50	$p < 0.01$

A comparative analysis of the data demonstrates that the primary production parameters, namely, the mean hen-day egg production rate (94.20% vs. 94.65%) and the daily compound feed intake (111.20 g/hen vs. 112.50 g/hen), did not exhibit statistically significant variations ($p > 0.05$). This technological outcome is highly critical, confirming that modifying the dietary formulation did not alter feed palatability or induce disruptions in the feeding behavior of the Lohmann LSL Classic hybrid, a well-regarded strain for its fine and genetically fixed appetite.

Conversely, a statistically significant increase ($p < 0.05$) in average egg weight was observed in the Experimental Group (63.10 g) compared to the Control Group (62.40 g). This dynamic is attributed to the optimized supply of limiting amino acids (specifically methionine) and the essential fatty acid profile provided by the extruded linseed. In modern poultry nutrition, these components are recognized as primary determinants of yolk volume and total egg weight. Furthermore, the enhanced feed conversion ratio, which reached 2.09 kg feed/kg egg, attests to a superior metabolic efficiency in converting dietary energy into egg mass.

The most substantial qualitative improvement was recorded among the biochemical parameters of the egg yolk. The total concentration of Omega-3 polyunsaturated fatty acids increased exactly fivefold in the Experimental Group, reaching a remarkable value of 580 mg/100 g of egg mass compared to only 115 mg/100 g in the Control Group ($p < 0.01$). The laying hens demonstrated a high capacity to absorb alpha-linolenic acid at the intestinal level and deposit it directly into the yolk as phospholipids, without altering the organoleptic

properties or flavor profile of the eggs. In parallel, carotenoid supplementation led to a >150% increase in yolk lutein concentration (24.50 mg/kg vs. 9.80 mg/kg, $p < 0.01$). This result validates the industrial technology implemented at S.C. Avicola Lumina S.A. for the production of "heart-healthy" functional eggs, offering a product with high therapeutic and health-promoting value for the modern consumer market.

3.2. Dynamics of Biocatabolic and Qualitative Parameters in the Second Production Cycle (Post-Molting)

The implementation of the induced molting protocol at 62 weeks of age induced a programmed and controlled physiological stress. Within the first 5 days following the onset of feed withdrawal, a complete cessation of egg production was observed. This effect resulted from the inhibition of gonadotropic hormone secretion (FSH and LH) by the adenohypophysis, triggered by the absence of both photoperiodic and energetic stimuli. Monitoring the body weight of the birds indicated a controlled loss of 26.4% of their initial body mass. This value aligns with optimal zootechnical standards required to achieve complete and efficient tissue regression of the oviduct, alongside the involution of ovarian follicles. Following the completion of the 4-week resting and regeneration protocol, and upon the resumption of photoperiodic stimulation by extending the day length to 16 hours/day, the flock entered the second production cycle.

Table 2. Technical schedules for fast and ultra-fast induced molting protocols applied in poultry management in Romania

Molting Variant	Week	Day	Recommended Management Measures
Fast Variant	Week 1	1	Complete feed and water withdrawal; continuous darkness.
		2	2-hour photoperiod provided, <i>ad libitum</i> water; total feed deprivation.
		3–7	6-hour photoperiod provided, <i>ad libitum</i> water; total feed deprivation.
	Week 2	8–14	6-hour photoperiod provided; <i>ad libitum</i> water and feed access.
	Week 3	15–17	8-hour photoperiod provided; <i>ad libitum</i> water and feed access.

	18– 21	10-hour photoperiod provided; <i>ad libitum</i> water and feed access.
	Week 22– 4 28	Photoperiod increased by 20 min/day; vitamin supplementation; <i>ad libitum</i> water and feed access.
Ultra-Fast Variant	Direct transition from the first-week schedule to the third-week schedule.	

The modifications in egg quality parameters recorded at 70 weeks of age are compared with the decline values observed at the end of the first production cycle in Table 3.

Table 3. Comparative analysis of egg production performance and structural indicators before and after the induced molting process

Analyzed Parameter	End of Cycle I (Week 60)	Start of Cycle II (Week 70)	Observed Trend / Improvement
Hen-day egg production (%)	71.40	86.80	+15.40%
Average egg weight (g)	64.80	66.20	+1.40 g
Eggshell breaking strength (N)	31.50	42.80	+35.8%
Percentage of broken/micro-cracked eggs (%)	6.80	1.90	-4.90%
Haugh Units (HU)	68.20	84.50	+16.30 HU

The centralized results biologically and economically validate the efficiency of the applied physiological regeneration technology. Upon the resumption of lay, the hen-day egg production rate increased rapidly, reaching a new secondary peak of 86.80%, which represents a net recovery of 15.40% compared to the decline value (71.40%) recorded during the pre-treatment phase. The average egg weight increased to 66.20 g, a developmental pattern characteristic of mature birds during their second production cycle.

The most significant qualitative advancement, carrying substantial implications for farm profitability, occurred within the calcareous eggshell.

Eggshell breaking strength exhibited a remarkable improvement of 35.8%, increasing from a critical threshold of 31.50 N (characteristic of brittle eggs from aged hens) to an excellent value of 42.80 N. This structural consolidation of the calcium carbonate deposited within the uterus (shell gland) translated directly into a significant reduction in the incidence of broken or downgraded eggs on the automated MOBA sorting line, dropping from an alarming 6.80% to a technological minimum of just 1.90%.

Simultaneously, the complete rejuvenation of the glandular epithelium within the oviduct, which is responsible for ovalbumin secretion, revitalized internal egg freshness. This was evidenced by a 16.30-unit increase in thick albumen quality, rising from 68.20 to 84.50 Haugh Units (HU). The experimental data demonstrate that eggs obtained from post-molt flocks fully regain the qualitative characteristics typical of young pullets at the onset of lay.

CONCLUZII CONCLUSIONS

4.1. Conclusions

1. The intensive housing system utilizing modernized vertical monobloc battery cages at S.C. Avicola Lumina S.A. guarantees comprehensive control over bioclimatic factors and biosecurity protocols, ensuring the achievement of high and stable feed conversion efficiency, ranging between 2.09 and 2.11 kg feed/kg egg.

2. Rigorous nutritional manipulation of the layer rations through the inclusion of extruded linseed and grape seed extract facilitates the metabolic transfer and natural enrichment of the egg yolk with Omega-3 polyunsaturated fatty acids (580 mg/100 g) and lutein (24.5 mg/kg), thereby generating high-value functional food products.

3. The implementation of the induced molting technology via the Fast Variant (controlled feed withdrawal method) at 62 weeks of age represents a highly viable technical and economic strategy for the biological rejuvenation of laying flocks. The second production cycle achieved a 15.40% increase in hen-day egg production intensity and reduced the incidence of broken or micro-cracked eggs below the critical 2% threshold.

4.2. Practical Recommendations

□ Dietary Calcium Optimization: It is recommended to widely implement coarse/granular limestone (particle size 2–4 mm) to constitute a

minimum of 65–70% of the total dietary calcium source, particularly during the second post-molt production phase. This practice ensures slow in-gizzard solubilization, optimizes the kinetics of nocturnal eggshell calcification, and prevents skeletal demineralization (cage layer fatigue).

□ Induced Molting Management: To optimize operational costs, the Fast Variant of induced molting should be applied exclusively to flocks maintaining an initial viability rate above 95% at the end of the first production cycle (culling age). Furthermore, it is mandatory to enforce strict monitoring of ventilation parameters and water quality during the critical feed withdrawal phase in the first week of the protocol. • Cellulose Threshold Limits: Post-weaning lamb growth is highly constrained by forestomach development, establishing a strict biological threshold of 20% crude cellulose in the diet's dry matter. Exceeding this limit limits voluntary feed intake and blocks efficient nutrient digestion.

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**EVALUATION OF THE CYTOTOXIC AND GENOTOXIC EFFECTS
OF ENERGY DRINKS USING THE ALLIUM CEPA TEST
EVALUAREA EFECTULUI CITOTOXIC ȘI GENOTOXIC
AL UNOR BĂUTURI ENERGIZANTE PRIN TESTUL ALLIUM CEPA**

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REZUMAT

Băuturile energizante sunt consumate frecvent de adolescenți și tineri adulți, deși compoziția lor complexă, bazată pe cofeină, taurină, îndulcitori, acidifișanți, conservanți și vitamine, ridică întrebări privind siguranța biologică. Studiul de față a evaluat efectul citotoxic și genotoxic al trei băuturi energizante disponibile comercial: Monster fără zahăr, Hell și Crazy Wolf, utilizând testul Allium cepa. Rădăcinile tinere au fost expuse timp de 6 și 24 de ore, iar ulterior preparatele obținute prin tehnica Feulgen-squash au fost analizate microscopic. Pentru fiecare variantă experimentală au fost numărate 500 de celule, fiind determinat indicele mitotic și tipurile de aberații cromozomiale. Rezultatele au evidențiat reducerea indicelui mitotic față de martor la toate variantele tratate, ceea ce indică un efect mitodepresiv consistent. Valoarea martorului a fost de 35,2, în timp ce valorile tratamentelor au variat între 17 și 21,8. Cele mai accentuate efecte au fost observate la Hell după 6 ore și la Monster fără zahăr după 24 de ore. La nivel microscopic s-au identificat profaze dominante, cromozomi picnotici, metafaze stelate, C-mitoze, punți cromatidice și heterocromatinizare. Datele susțin utilitatea testului Allium cepa ca metodă rapidă de screening citogenetic și indică necesitatea monitorizării efectelor celulare ale băuturilor energizante, în special în contextul consumului frecvent de către tineri.

ABSTRACT

Energy drinks are frequently consumed by adolescents and young adults, although their complex composition, based on caffeine, taurine, sweeteners, acidifying agents, preservatives, and vitamins, raises questions regarding biological safety. The present study evaluated the cytotoxic and genotoxic effects of three commercially available energy drinks: Monster sugar free, Hell, and Crazy Wolf, using the Allium cepa test. Young roots were exposed for 6 and 24 hours, after which preparations obtained using the Feulgen-squash technique were examined microscopically. For each experimental variant, 500 cells were counted, and the mitotic index and types of chromosomal aberrations were

determined. The results showed a reduction in the mitotic index compared with the control in all treated variants, indicating a consistent mitodepressive effect. The control value was 35.2, whereas treatment values ranged from 17 to 21.8. The most pronounced effects were observed for Hell after 6 hours and Monster sugar free after 24 hours. At the microscopic level, predominant prophase cells, pycnotic chromosomes, star metaphases, C-mitoses, chromatid bridges, and heterochromatinization were identified. The data supports the usefulness of the *Allium cepa* test as a rapid cytogenetic screening method and indicates the need to monitor the cellular effects of energy drinks, particularly in the context of frequent consumption by young people.

Cuvinte cheie băuturi energizante; *Allium cepa*; citotoxicitate; genotoxicitate; indice mitotic; aberații cromozomiale.

Keywords: energy drinks; *Allium cepa*; cytotoxicity; genotoxicity; mitotic index; chromosomal aberrations.

INTRODUCERE INTRODUCTION

The increasing consumption of energy drinks has raised growing concern regarding their effects on health, not only at the cardiovascular and neurological levels, but also at the cellular level. These products contain complex mixtures of bioactive compounds and food additives, among which caffeine, taurine, guarana, artificial sweeteners, acidifying agents, and preservatives may act individually or synergistically on cellular metabolism. The scientific literature indicates that the safety of regular consumption has not been fully established, and prolonged exposure to the components of these beverages may have relevant biological effects (Alabi et al., 2024; Higgins et al., 2010; Reissig et al., 2009; Singh & Chadha, 2024).

The *Allium cepa* test is widely used to evaluate cytotoxicity and genotoxicity because it allows direct observation of mitotic division and chromosomal aberrations in root meristematic cells (Chandraker et al., 2014; Sarıkaya et al., 2012). Its simplicity, sensitivity, and low cost recommend it as a preliminary screening method for chemicals, complex mixtures, effluents, food dyes, and consumer products (Zeidán-Chuliá et al., 2013). In this context, the present study aimed to comparatively evaluate the effects of three energy drinks on the root meristem of *Allium cepa* by determining the mitotic index and identifying cytogenetic changes.

MATERIAL ȘI METODĂ DE CERCETARE

MATERIAL AND METHOD

The biological material consisted of *Allium cepa* bulbs, whose roots were stimulated by keeping the bulbs in water until roots measuring 2–3 cm were obtained. Three energy drinks were tested: Monster Sugar Free, Hell, and Crazy Wolf. For each product, two exposure periods were established, 6 hours and 24 hours, resulting in six experimental variants, in addition to the control variant maintained in water.

After completion of the exposure period, the root tips were fixed in an ethyl alcohol–glacial acetic acid mixture at a 3:1 ratio, then subjected to acid hydrolysis with 1N HCl at 60°C and stained with Schiff reagent (Feulgen & Rossenbeck, 1924). Microscopic preparations were made using the squash technique in 45% acetic acid to spread the meristematic cells. The preparation was then examined under an ML-4IOR light microscope for cell counting. For both the control and each experimental variant, at least 5 slides were prepared; on each slide, at least 10 clear cells were counted from a minimum of 10 optical fields, recording the identification and classification of cells according to the different stages of cell division.

Cytogenetic analysis was performed using a light microscope, and cells in interphase and in the stages of mitosis: prophase, metaphase, anaphase, telophase, and cytokinesis, were recorded. The mitotic index was calculated as the percentage ratio between the number of cells undergoing mitosis and the total number of cells analyzed.

REZULTATE ȘI DISCUȚII

RESULTS AND DISCUSSIONS

The results obtained were summarized in Table 1, recording for each experimental variant both the total number of cells analyzed and the total number of cells in each stage of cell division, as determined from the experiments performed.

Calculation of the Mitotic Index

The discovery of the mitotic index laid the foundations of quantitative cytogenetics, representing the mathematical ratio between the number of cells undergoing mitosis, at any stage of cell division, and the total number of cells analyzed. The basic condition for obtaining relevant results is a minimum of 500 cells analyzed for each sample. Calculation formula: $MI = \text{number of cells in mitosis} / \text{number of cells analyzed} \times 100$.

Table 1. Results obtained by counting cells in the control variant and experimental variants 1–6

Variant	Total cells analyzed	Inter-phase	Mitosis	Pro-phase	Meta-phase	Ana-phase	Telo-phase	Cytokinesis
Control	500	324	176	82	34	22	20	18
V1	500	391	109	65	21	9	6	8
V2	500	415	85	40	16	8	10	11
V3	500	409	91	49	17	11	11	3
V4	500	415	85	31	20	12	13	9
V5	500	410	90	33	18	14	12	13
V6	500	393	107	54	23	10	11	9

The control variant showed a mitotic index of 35.2, corresponding to 176 cells undergoing mitosis out of a total of 500 cells analyzed. A reduction in the mitotic index was observed in all variants exposed to energy drinks, indicating inhibition of cell proliferation. After 6 hours of treatment, the mitotic index was 21.8 for Monster Sugar Free, 17 for Hell, and 18.2 for Crazy Wolf. After 24 hours of exposure, the values were 17 for Monster Sugar Free, 18 for Hell, and 21.4 for Crazy Wolf.

Table 2. Mitotic index determined for the experimental variants

Variant	Treatment	Exposure time	Mitotic index
Control	Water	-	35,2
V1	Monster Sugar Free	6 hours	21,8
V2	Hell	6 hours	17,0
V3	Crazy Wolf	6 hours	18,2
V4	Monster Sugar Free	24 hours	17,0
V5	Hell	24 hours	18,0
V6	Crazy Wolf	24 hours	21,4

For a clearer interpretation of the data, the results were analyzed along three directions: the dynamics of the mitotic index, the distribution of cells across the mitotic phases, and the types of chromosomal aberrations observed microscopically. This approach makes it possible to distinguish the cytotoxic effect, expressed as reduced cell proliferation, from the genotoxic effect,

expressed through the occurrence of morphological changes in chromosomes and the mitotic apparatus.

Results obtained for experimental variants with 6-hour treatment

In the experimental variants in which *Allium cepa* roots were exposed to energy drinks for 6 hours, a general decrease in the mitotic index was observed compared with the value recorded for the control variant, demonstrating the rapid onset of a cytotoxic and inhibitory effect on cell division shortly after exposure (fig. 1). Among all three experimental variants, V1, corresponding to treatment with Monster Sugar Free, although showing inhibition of the cell cycle compared with the control variant, exhibited the weakest cytotoxic effect. Therefore, we may hypothesize, but cannot state with certainty, that the weaker inhibition of cell division was due to the absence of sugar from its composition.

Results obtained for experimental variants with 24-hour treatment

Extending the treatment period to 24 hours maintained the general trend of pronounced cellular inhibition; however, the dynamics among the substances changed slightly, suggesting limited adaptation of the meristematic tissue to certain compounds, while toxicity was maintained.

In V4 treated with Monster Sugar Free, during this treatment interval, the mitotic index continued to decrease significantly compared with the 6-hour test, demonstrating that the toxic effect of this beverage accumulates over time, becoming much more restrictive to cell division as exposure is prolonged (fig. 2). In V5, treatment with Hell Energy produced a value very close to that recorded after 6 hours of treatment, confirming the persistence of a severe inhibitory effect on the mitotic cycle.

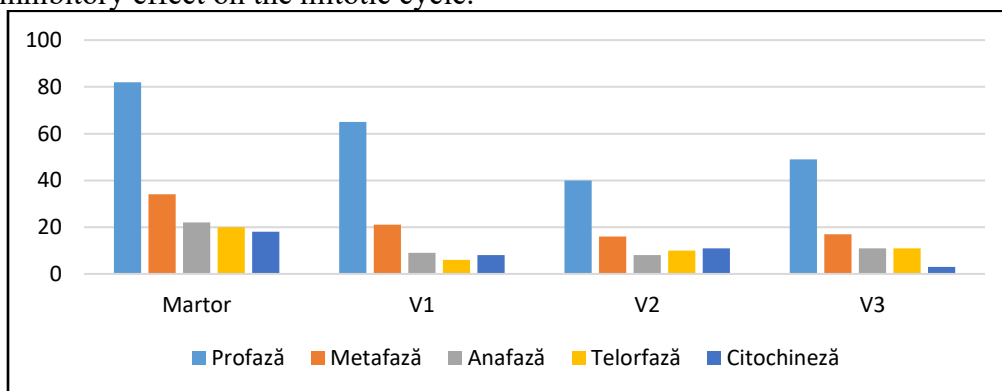


Fig. 1. Frequency of mitotic division across all phases in *Allium cepa* after treatment with each energy drink for 6 hours

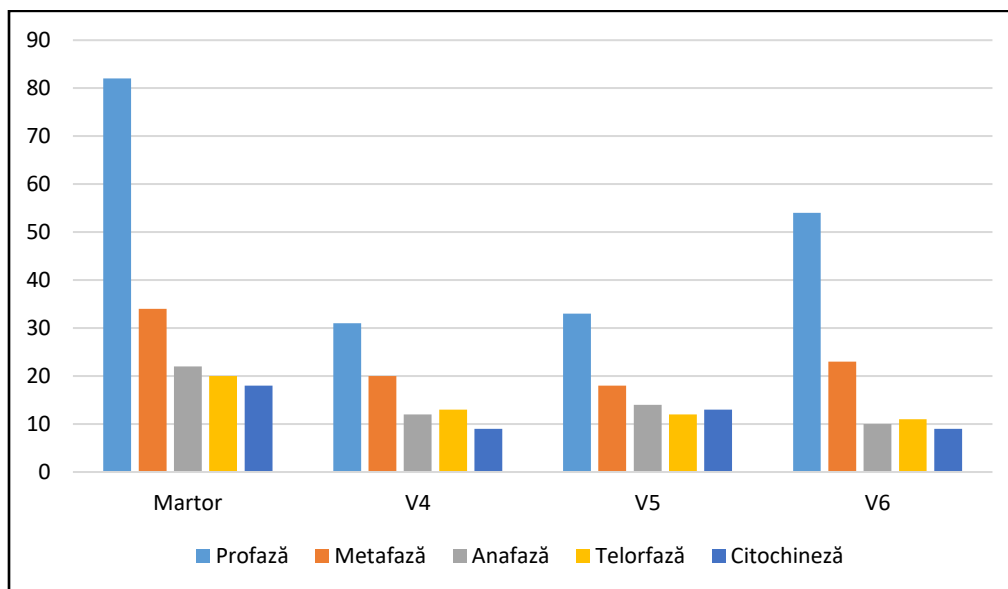


Fig. 2. Frequency of mitotic division across all phases in *Allium cepa* after treatment with each energy drink for 24 hour

Thus, this beverage appears to exert a highly consistent adverse effect. In contrast to the other experimental variants, V6, treated with Crazy Wolf, showed the weakest cytotoxic effect after 24 hours of treatment, suggesting either partial metabolism or reduced effectiveness of the active compounds in relation to plant cells. Nevertheless, this finding does not mean that the beverage can be disregarded regarding the negative effects produced at the cellular level during cell division.

In addition to the decrease in the mitotic index, microscopic analysis revealed cytogenetic changes characteristic of cellular stress. The most frequent observations were a predominance of prophase cells, heterochromatinization and chromosome overcondensation, star metaphases, pycnotic chromosomes, C-mitoses, and the appearance of chromatid bridges (fig. 3, 4, 5, 6, 7, 8, 9, 10). These changes indicate disruption of the mitotic spindle and possible clastogenic or aneugenic effects of compounds present in the tested beverages.

The reduction in the mitotic index in all treated variants confirms a mitodepressive effect of the energy drinks on *Allium cepa* meristematic cells. The effect appeared rapidly, as early as 6 hours of exposure, suggesting that active substances or combinations of additives may affect cell entry into division within a short period. This observation is supported by recent studies showing that

energy drinks can inhibit root growth and cell division and can induce chromosomal aberrations in the *Allium cepa* test.

Hell showed the strongest inhibitory effect after 6 hours, whereas Monster Sugar Free reached the same minimum mitotic index value after 24 hours. This difference may indicate either a greater initial toxicity of the Hell formulation or a progressive accumulation of the effect in the sugar-free variant. The presence of artificial sweeteners, caffeine, taurine, acidifying agents, and preservatives may contribute to the observed effects; however, the study does not allow the contribution of each individual ingredient to be isolated. Therefore, the results should be interpreted as the effect of the complete commercial mixture.

The observed aberrations, such as C-mitosis, star metaphases, and chromatid bridges, suggest impairment of the normal processes of chromosome condensation, attachment, and migration. These abnormalities are relevant because they may signal damage to the mitotic apparatus or genetic material. However, the results represent cytogenetic screening using a plant model and cannot be directly extrapolated to humans without further studies using animal models, mammalian cell cultures, and biochemical or molecular investigations.

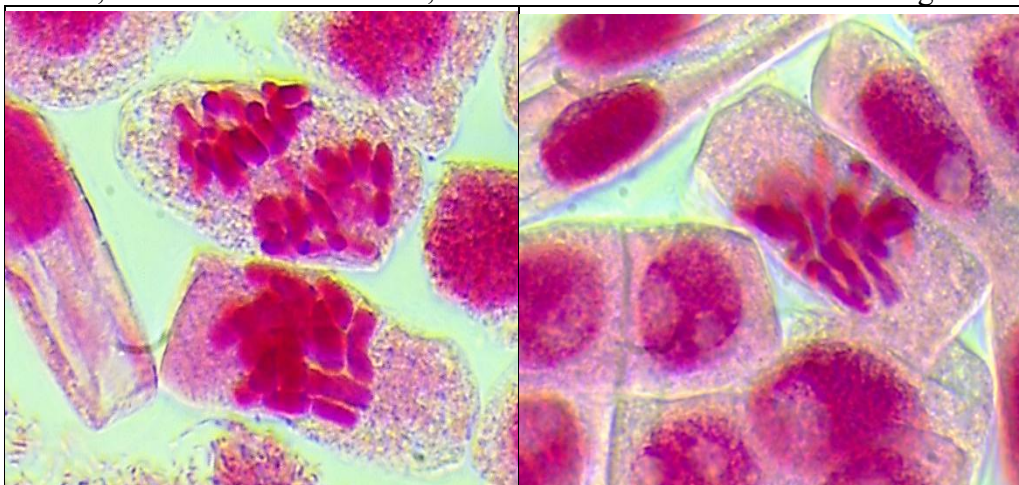
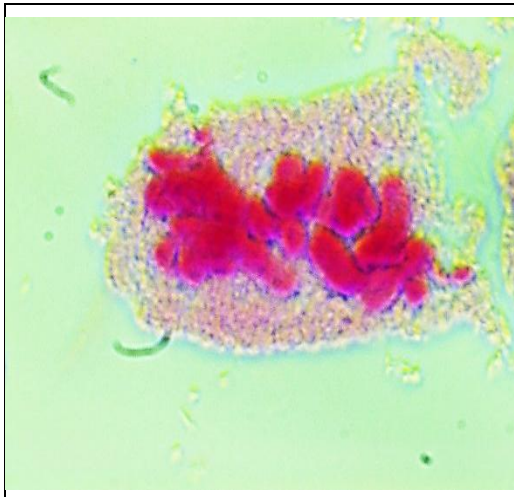
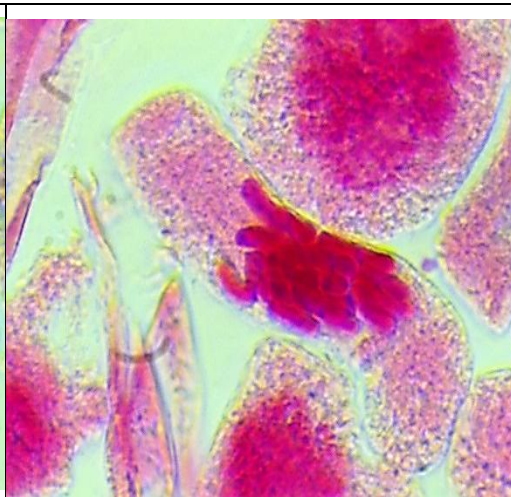
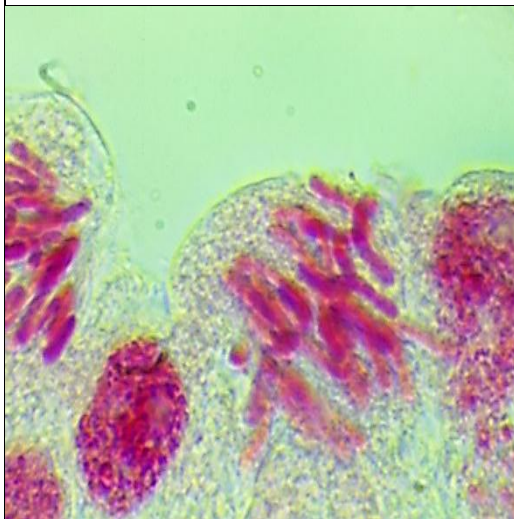
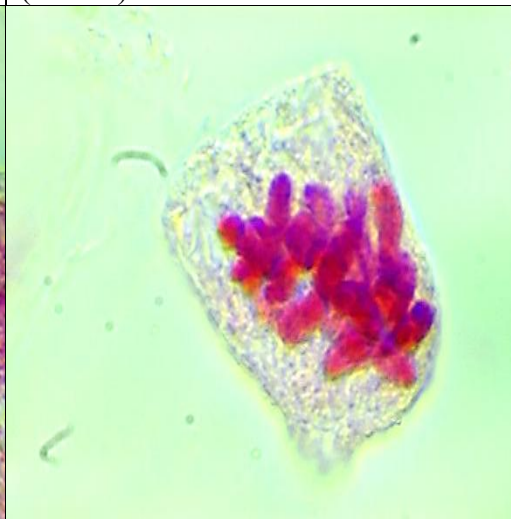
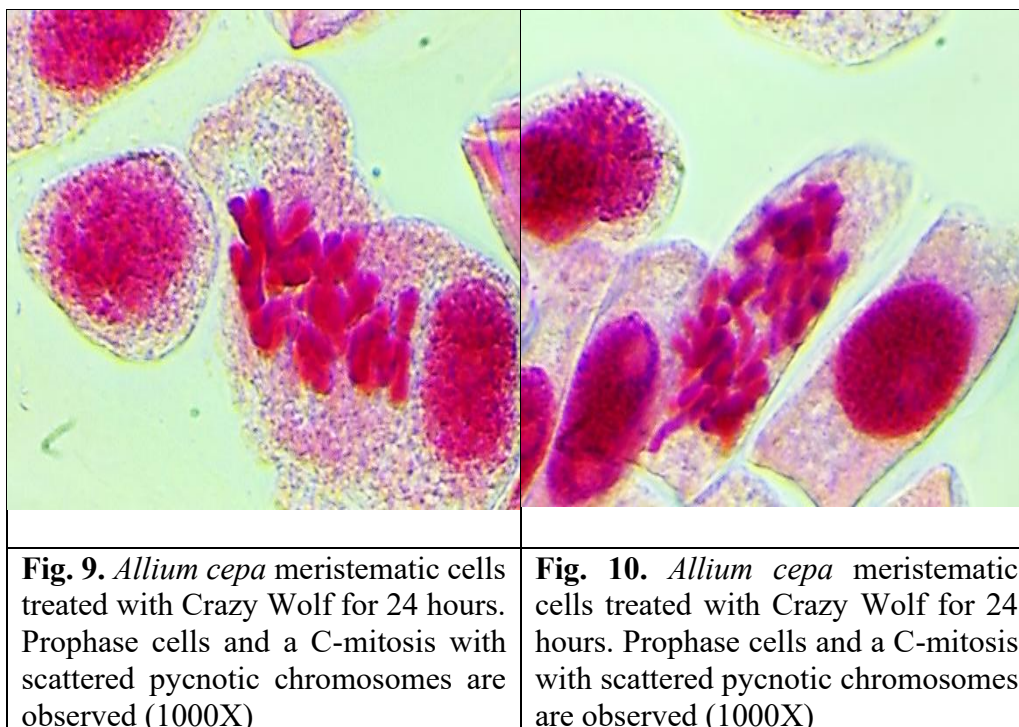


Fig. 3. *Allium cepa* meristematic cells treated with Monster Sugar Free for 6 hours. Prophase cells, an anaphase with a chromatid bridge, and a C-mitosis with scattered chromosomes are observed (1000X)

Fig. 4. *Allium cepa* meristematic cells treated with Monster Sugar Free for 6 hours. Numerous prophase cells and a central star metaphase are observed (1000X)

	
Fig. 5. <i>Allium cepa</i> meristematic cells treated with Hell for 6 hours. A star metaphase with pycnotic chromosomes is observed (1000X)	Fig. 6. <i>Allium cepa</i> meristematic cells treated with Crazy Wolf for 6 hours. Prophase cells and a C-mitosis with pycnotic chromosomes are observed (1000X)
	
Fig. 7. <i>Allium cepa</i> meristematic cells treated with Monster Sugar Free for 24 hours. A central star metaphase with lagging chromosomes is observed (1000X)	Fig. 8. <i>Allium cepa</i> meristematic cells treated with Hell for 24 hours. A star metaphase with pycnotic chromosomes is observed (1000X)



CONCLUZII CONCLUSIONS

The study demonstrates that all three tested energy drinks reduced the mitotic index of *Allium cepa* meristematic cells compared with the control variant. The decrease in the mitotic index, together with the presence of chromosomal aberrations, indicates a cytotoxic and genotoxic effect detectable by the *Allium cepa* test. The lowest mitotic index values were recorded for Hell after 6 hours and for Monster Sugar Free after 24 hours, both reaching 17.

The results support the inclusion of these products in more complex toxicological assessments, given their frequent consumption among young people. The *Allium cepa* test is confirmed as a useful preliminary screening tool; however, further research is needed to establish the molecular mechanisms involved and to assess the relevance of the results regarding human health.

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**RESEARCH ON THE EVALUATION OF REPRODUCTIVE INDICES
AND MILK PRODUCTION IN INTENSIVELY REARED
CARPATHIAN GOATS UNDER REPRODUCTIVE ACTIVITY
MODULATION
CERCETĂRI PRIVIND EVALUAREA INDICILOR DE
REPRODUCȚIE ȘI A PRODUCȚIEI DE LAPTE LA CAPRELE DIN
RASA CARPATINĂ ÎN CONDIȚIILE MODULĂRII ACTIVITĂȚII DE
REPRODUCȚIE CRESCUTE ȘI EXPLOATATE ÎN SISTEM INTENSIV**

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REZUMAT

Modularea activității de reproducție la caprine permite planificarea perioadei de montă și a fătărilor, utilizarea eficientă a biotehnologiilor de reproducție și valorificarea superioară a potențialului reproductiv și productiv al efectivelor.

Scopul studiului a fost evaluarea indicilor de reproducție, a producției de lapte și a duratei lactației la caprele primipare din rasa Carpatină, crescute și exploatate în sistem intensiv.

Materialul biologic a fost reprezentat de 100 de capre, repartizate în două loturi egale ($n = 50$). La L1, estrul a fost indus și sincronizat, urmat de însămânțarea artificială intracervicală cu material seminal proaspăt, în timp ce caprele din L2 au fost montate natural, după manifestarea estrului spontan.

L1 a înregistrat valori superioare ale fertilității și prolificității comparativ cu L2, respectiv 94.00% față de 90.00% și 155.32% față de 141.67%, fără diferențe semnificative statistic ($p > 0.05$). Producțiile medii zilnice de lapte determinate la trei controale succesive au fost de 0.91, 0.99 și 0.88 kg/capra în L1 și de 0.91, 0.98 și 0.85 kg/capra în L2, fără diferențe semnificative între controale ($p > 0.05$). Durata lactației a fost de 289 de zile în L1 și de 258 de zile în L2.

Rezultatele evidențiază faptul că inducerea și sincronizarea estrului, urmate de însămânțarea artificială, pot îmbunătăți indicii de reproducție și pot determina debutul mai precoce al lactației, fără influențe negative asupra producției de lapte.

ABSTRACT

Modulation of reproductive activity in goats enables the planning of mating and kidding periods, the efficient use of reproductive biotechnologies,

and the improved utilization of the reproductive and productive potential of the herd.

The aim of this study was to evaluate reproductive indices, milk yield, and lactation length in primiparous Carpathian goats reared under intensive farming conditions.

The biological material consisted of 100 goats allocated to two equal groups ($n = 50$). In L1, estrus was induced and synchronized, followed by intracervical artificial insemination with fresh semen, whereas the goats in L2 were naturally mated following the onset of spontaneous estrus.

L1 recorded numerically higher fertility and prolificacy rates than L2, namely 94.00% versus 90.00% and 155.32% versus 141.67%, respectively, without statistically significant differences ($p > 0.05$). Mean daily milk yields recorded during three successive milk recordings were 0.91, 0.99, and 0.88 kg/goat/day in L1 and 0.91, 0.98, and 0.85 kg/goat/day in L2, with no significant differences among recording times ($p > 0.05$). Lactation length was 289 days in L1 and 258 days in L2.

The findings indicate that estrus induction and synchronization followed by artificial insemination may improve reproductive indices and advance the onset of lactation without adversely affecting milk yield.

Cuvinte cheie: rasa Carpatină; capre primipare; indici de reproducție; sincronizarea estrului; însămânțare artificială; producția de lapte.

Keywords: Carpathian goat; primiparous goats; reproductive indices; estrus synchronization; artificial insemination; milk yield.

INTRODUCERE INTRODUCTION

The Carpathian goat has maintained an important position within the Romanian goat population due to its adaptability, resistance to environmental conditions, and ability to efficiently utilize local feed resources. These characteristics underline the biological value of the breed and the importance of implementing appropriate selection and breeding programmes to improve its productive and reproductive performance (Vlaic et al., 2024).

Reproductive management plays an essential role in determining mating schedules, kidding distribution, and the continuity of milk production in goat herds. The selection of an appropriate reproductive strategy should therefore

consider both the biological characteristics of the breed and the production objectives of the farm (Liptac et al., 2024).

Reproductive efficiency is a major determinant of the biological and economic performance of goat production systems. Fertility, prolificacy, age at first kidding, kidding interval, abortion rate, and kid survival are among the main parameters used to assess reproductive performance, as they directly influence herd replacement and overall flock productivity (Šavorić et al., 2024).

Goats are generally classified as seasonally polyestrous animals, although the onset and duration of reproductive activity depend on several factors, including breed, photoperiod, climatic conditions, nutritional status, physiological stage, and production system (Luo et al., 2020).

Estrus induction and synchronization are important tools for controlling reproductive activity, particularly when mating or artificial insemination is planned outside the natural breeding season. These protocols facilitate the induction of estrus within a predetermined period, the application of artificial insemination and the concentration or distribution of kidding according to the production objectives of the farm (Lopez-Sebastian et al., 2008).

Artificial insemination contributes to the improvement of goat populations by enabling the wider use of genetically valuable bucks and accelerating genetic progress. The efficiency of this biotechnology is influenced by several factors, including semen quality, the synchronization protocol, the insemination technique and the interval between estrus induction and insemination (Leboeuf et al., 2000).

In dairy goat production, the planned modulation of reproductive activity may advance kidding and the onset of lactation, thereby contributing to a more consistent milk supply throughout the year. Therefore, the application of estrus induction and synchronization protocols in association with artificial insemination may represent an effective approach to improving reproductive performance and organizing milk production in Carpathian goat herds (Luo et al., 2020).

MATERIAL ȘI METODĂ DE CERCETARE

MATERIAL AND METHOD

The biological material consisted of 100 primiparous females belonging to the Carpathian breed and registered in the Carpathian Breed Herdbook. The animals were divided into two equal groups ($n = 50$), differentiated according to the reproductive management strategy applied.

The selection of the females included in the study focused exclusively on young females, since this category allows the effect of reproductive activity modulation on the onset of reproductive function to be evaluated.

The use of adult goats would have introduced additional influences associated with previous reproductive experience, which could have affected the interpretation of the effects of the reproductive management method applied.

Group L1 consisted of primiparous goats approximately 7 months of age, with a mean body weight of 31.56 kg, in which estrus was induced, followed by artificial insemination between 15 and 30 August.

Group L2 included primiparous goats 8 months of age, with a mean body weight of 34.77 kg, which were naturally mated during spontaneous estrus between 15 and 30 September.

The scheduling of the two groups - August for artificial insemination following estrus induction and September for natural mating-was intentionally established to highlight two different approaches to the organization of reproduction: controlled reproduction, in which ovarian activity was initiated through estrus induction and synchronization, and seasonal reproduction, based on the spontaneous onset of estrus.

The selection of August for the artificially inseminated group allowed reproductive activity to be initiated before estrous manifestations became consistent within the herd. At the time of insemination, the females in this group had a lower mean body weight, under which conditions spontaneous estrus may occur irregularly or may be absent. Estrus induction ensured the controlled initiation of ovarian activity and allowed the females to be introduced into reproduction at an earlier stage.

In contrast, mating in September coincided with a higher body weight of the females, indicating a more advanced stage of body development that favoured the spontaneous onset of estrus. Therefore, the difference between the mating periods was not based on calendar criteria but on the physiological characteristics of the females, and the differences observed between the groups could be attributed mainly to the reproductive method applied.

Furthermore, the earlier initiation of reproductive activity advanced the kidding period and, consequently, the onset of lactation. This aspect is of practical importance because it provides the opportunity to obtain an additional period of milk production and contributes to a more even distribution of dairy product availability throughout the year.

Both groups were reared and managed under an intensive production system. Under this system, the animals had no access to pasture and were permanently housed, receiving a constant feed ration. Each goat received 2 kg of

concentrate mixture daily, consisting of 70% maize, 10% barley, 10% sunflower, and 10% soybean meal, together with 2.5 kg of alfalfa, administered in three meals throughout the day. Before the breeding period, the animals were subjected to nutritional flushing by increasing the energy content of the ration to stimulate reproductive activity.

The experimental protocol included nutritional flushing before breeding, estrus induction and synchronization followed by artificial insemination in L1, natural mating during spontaneous estrus in L2, and the subsequent evaluation of reproductive indices, milk production, and lactation length. Before breeding, the goats were subjected to nutritional flushing to optimize body condition and support reproductive function.

The selected age and body weight ranges allowed the influence of age at first mating on reproductive indices, milk production, and lactation length to be evaluated under intensive production conditions.

Nutritional flushing consisted of gradually increasing energy intake by supplementing the regular ration with approximately 300 g of cereals per goat per day, mainly maize grain combined with barley. The programme began 30 days before mating or artificial insemination and continued for seven days after the goats were introduced into reproduction. Its purpose was to stimulate ovarian activity, promote the onset and synchronization of estrus, and improve the reproductive response.

Estrus induction and synchronization in L1 were performed according to the methodology described by Nadolu et al. (2021). Chronogest CR intravaginal sponges containing 20 mg fluorogestone acetate (FGA; Intervet) were inserted and maintained intravaginally for 11 days.

At sponge withdrawal, each goat received 400 IU of pregnant mare serum gonadotropin (PMSG). Artificial insemination was performed 43 ± 1 h after sponge withdrawal.

Fresh semen was collected using an artificial vagina from Carpathian bucks included in the selection and genetic improvement programme of the breed herdbook. The goats in L1, hormonally synchronized using the Chronogest–Folligon protocol, were inseminated intracervically using an insemination pipette and an illuminated vaginoscope. This procedure allowed visualization of the external cervical os and assessment of the degree of cervical opening. Each insemination dose had a volume of 0.25 mL.

Following treatment, the goats were monitored at eight-hour intervals to identify behavioural signs of estrus, including restlessness, repeated sniffing, and the standing response in the presence of a buck. In most cases, estrus occurred within 24–48 h after completion of the hormonal treatment.

The main reproductive indices were calculated based on the number of goats mated, the number of goats that kidded, and the total number of kids born, using the following formula:

Fertility rate (%) = (number of goats that kidded / number of mated goats) × 100

Prolificacy (%) = (number of kids / number of goats that kidded) × 100

Standardized milk-recording methods were applied to assess the productive performance of the goats. Milk production was determined gravimetrically according to the ICAR A4 recording method and the provisions of Order No. 22/2006 over three consecutive months. Individual milk yield was recorded twice daily, in the morning and evening, to accurately determine daily milk production.

To estimate total milk production throughout lactation, we used the Fleischmann formula, which allows production to be calculated based on the quantities of milk obtained at each daily check, taking into account the intervals between checks and the total duration of lactation (Pascal, 2019). The formula applied is as follows:

$$SM = I_0 M_1 + I_1 \left(\frac{M_1 + M_2}{2} \right) + I_2 \left(\frac{M_2 + M_3}{2} \right) + \dots + I_{n-1} \left(\frac{M_{n-1} + M_n}{2} \right) + I_n M_n$$

where,

SM- milk yield per lactation;

M₁, M₂, M_n- quantity of milk at the 24-hour check;

I₀- period in days between the date milking started and the date of the first check;

I₁, I₂, I_{n-1}- number of days between 2 controls;

I_n- number of days between the date of the last control and the date of lactation termination.

The statistical significance of the differences between the average milk yields was tested using Single Factor ANOVA in Excel 2007.

Lactation length was calculated as the interval between the kidding date and the cessation of milk secretion. Lactation was considered complete when individual daily milk yield decreased below 0.2 kg/goat/day, after which the goats entered the dry period.

REZULTATE ȘI DISCUȚII

RESULTS AND DISCUSSIONS

Research on Reproductive Indices in Primiparous Carpathian Goats Reared under Intensive Farming Conditions

The reproductive performance of the goats in L1, which were subjected to an estrus induction and synchronization protocol followed by artificial insemination, was slightly higher than that recorded in the naturally mated goats from L2 (Table 1).

The data presented in Table 1 highlight differences between the two groups in the main reproductive indices. The number of goats subjected to breeding was higher in L1 (50 goats) than in L2 (40 goats), which was also reflected in the number of goats that kidded: 47 in L1 and 36 in L2, respectively.

Table 1. Reproductive performance of primiparous Carpathian goats

Specification	U.M	L1	L2
Goats	INDIVIDUAL	50	50
Mated goats		50	40
Goats that aborted		3	4
Goats that kidded		47	36
Total kids born		73	51
Live-born kids		60	48
Stillborn kids		13	3
Fertility rate	%	94.00 ^{ns}	90.00 ^{ns}
Prolificacy		155.32 ^{ns}	141.67 ^{ns}

The fertility index was higher in L1 (94.00%) than in L2 (90.00%), while the prolificacy index followed the same trend, with values of 155.32% in L1 and 141.67% in L2.

L1, in which the estrus induction and synchronization protocol was followed by artificial insemination, recorded higher fertility and prolificacy indices than the naturally mated group (Figure 1).

The fertility and prolificacy values obtained in L1 fall within the ranges characteristic of indigenous goat populations and are supported by the available literature.

Priseceanu et al. (2015) reported a mean fertility rate of 94.76% in Carpathian goat populations, while Zamfirescu et al. (2014) described fertility values of 95.00-100.00% as characteristic of the breed. Thus, the value obtained in L1 was close to previously published data, whereas that recorded in L2 was slightly lower. Nevertheless, both groups showed good reproductive efficiency under the conditions of the present study.

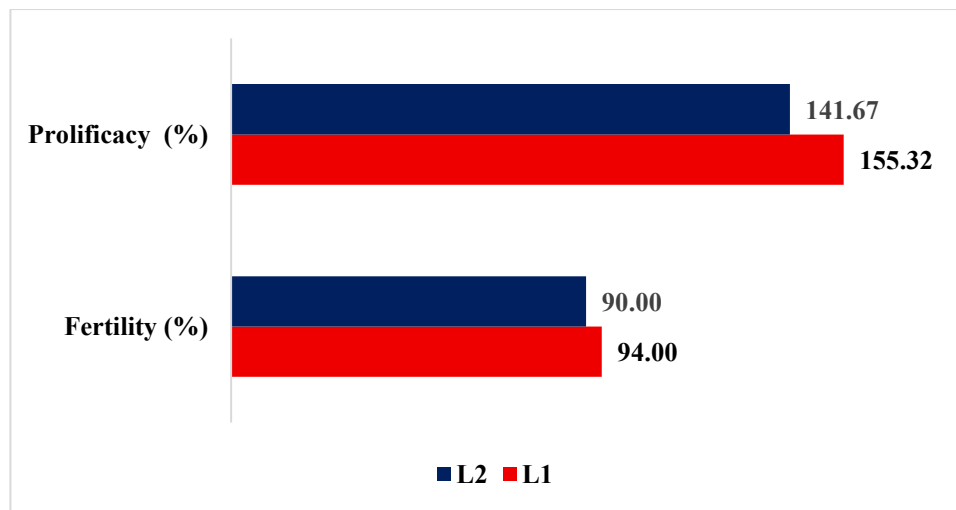


Figure 1. Reproductive indices in primiparous Carpathian goats.

Prolificacy followed the same numerical trend, reaching 155.32% in L1 and 141.67% in L2, without a statistically significant difference between the groups ($p = 0.27$). Priseceanu et al. (2015) reported values ranging from 136.55 to 146.77%, while Gavojdian et al. (2017) recorded a mean prolificacy of $148.00 \pm 0.49\%$ in Carpathian goats. Zamfirescu et al. (2014) described values of 105.00-115.00% for this breed, whereas the more recent breed characterization provided by Vlaic et al. (2024) indicates a broader range of 130.00-160.00%. Therefore, the prolificacy obtained in both groups was within the reproductive potential described for the Carpathian breed.

The differences observed between the two groups are consistent with findings reported in the literature regarding the use of reproductive biotechnologies in goats. Nacu et al. (2010) demonstrated the effectiveness of hormonal protocols for estrus induction and synchronization, emphasizing the importance of coordinating the timing of insemination with estrus expression to achieve high pregnancy rates. Similarly, Nadolu et al. (2021) reported pregnancy rates exceeding 70% in Carpathian goats following artificial insemination with fresh semen, confirming the potential of these technologies to improve herd reproductive efficiency.

Research on Milk Production and Lactation Length in Young Carpathian Does Reared under Intensive Management Conditions

After the kids were separated from their dams, milk production was monitored monthly in the females from both groups for three consecutive

months, beginning in May, with recordings performed at regular 28-day intervals.

The quantities of milk obtained during the morning and evening milkings were weighed individually for each goat.

The results of the milk production assessment in primiparous goats from L1 are presented in Table 2.

Table 2. Mean Milk Production and Lactation Length in Primiparous Carpathian Goats from L1.

Parameter	Minimum (Kg/milk/ female)	Maximum (Kg/milk/ female)	MEAN + SD (Kg/milk/ female)	CV %	Lactation length (days)	P-value
Control 1	0.71	1.12	0.91±0.18	19.78	289	p>0.05;
Control 2	0.82	1.25	0.99±0.12	12.12		p=0.181
Control 3	0.62	1.05	0.88±0.14	15.90		

At the first milk recording, conducted in May, individual milk production ranged from 0.71 to 1.12 kg of milk/doe, with a mean value of 0.91 kg of milk/doe.

At the second milk recording, conducted in June, mean milk production increased, with individual values ranging from 0.82 to 1.25 kg of milk/doe and a mean of 0.99 kg of milk/doe.

At the third milk recording, conducted in July, milk production ranged from 0.62 to 1.05 kg of milk/doe, with a mean value of 0.88 kg of milk/doe, slightly lower than those recorded during the previous assessments.

Milk production across the three successive recordings showed moderate fluctuations in daily milk yield, with no statistically significant differences among recording times ($p = 0.181$; $p > 0.05$).

Mean milk production was similar across the three recordings, with a slightly higher value at the second recording. The coefficient of variation indicated greater differences among does at the first recording, followed by lower within-group variability during the subsequent recordings.

In L2, kidding occurred over a longer period than in L1, which was reflected in differences in milk production after the kids were separated from their dams (Table 3).

Table 3. Mean Milk Production and Lactation Length in Primiparous Carpathian Goats from L2.

Parameter	Minimum (Kg/milk/ female)	Maximum (Kg/milk/ female)	MEAN + SD (Kg/milk/ female)	CV %	Lactation length (days)	P-value
Control 1	0.80	1.16	0.91±0.11	12.92	258	p>0.05; p= 0.296
Control 2	0.83	1.18	0.98±0.12	13.80		
Control 3	0.76	1.05	0.85±0.11	13.62		

At the first milk recording, individual daily milk production ranged from 0.80 to 1.16 kg of milk/doe, with a mean of 0.91 kg of milk/doe. At the second recording, the values ranged from 0.83 to 1.18 kg of milk/doe, with a mean of 0.98 kg of milk/doe, whereas at the third recording, they ranged from 0.76 to 1.05 kg of milk/doe, with a mean of 0.85 kg of milk/doe.

One-way ANOVA revealed no statistically significant differences among the mean values recorded during the three milk recordings ($p = 0.296$; $p > 0.05$).

The mean milk production values obtained in primiparous Carpathian goats from both L1 and L2 were within the ranges reported for this breed (Figure 2).

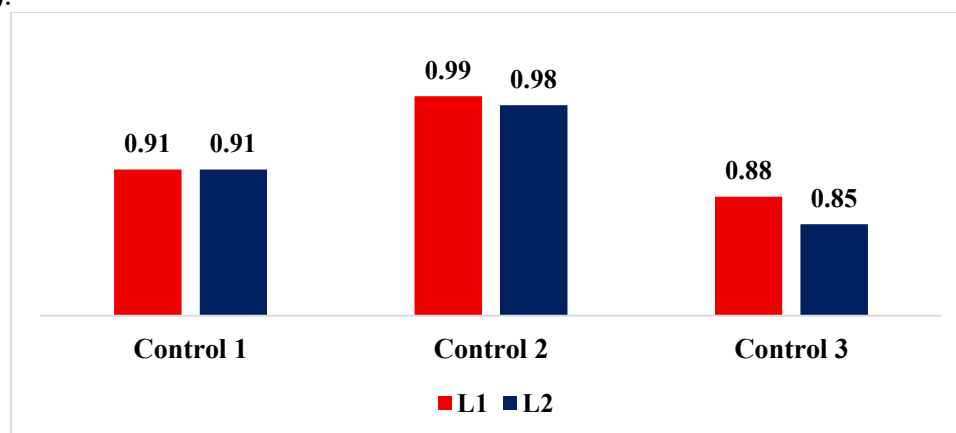


Figure 2. Mean Daily Milk Production in the Two Groups at the Three Milk Recordings (kg of milk/female/day)

Răducuță et al. (2015) reported differences between production systems in Carpathian goats, with mean daily milk yields of 0.92 kg of milk/doe/day under

the extensive system and 1.09 kg of milk/doe/day under the semi-intensive system, corresponding to mean lactation lengths of 226.26 and 233.34 days, respectively. Compared with these findings, the mean milk yields obtained in the present study were close to those reported for the extensive system. However, lactation length was greater, particularly in L1 (289 days), and was also higher in L2 (258 days), indicating satisfactory lactation persistency in the primiparous goats evaluated.

Mean daily milk yield increased until the second milk recording and subsequently declined at the third recording. This pattern is consistent with the findings of Pascal et al. (2019), who reported that Carpathian goats produced more than 70% of their total milk yield during the first approximately 150 days of lactation. This period was associated with the highest production levels and was followed by a progressive decline in milk secretion during the latter part of lactation.

The lactation lengths recorded in the present study, namely 289 days in L1 and 258 days in L2, were within the ranges reported for the Carpathian breed in the Romanian literature. Zamfir et al. (2008) indicated that lactation length in this breed may reach 282–289 days, whereas Chetroiu et al. (2015) reported values ranging from 247 to 269 days, depending on lactation number.

Estrus induction and synchronization followed by artificial insemination were associated with numerically higher fertility and prolificacy values in L1 than in the naturally mated L2 group. However, because the differences were not statistically significant, the reproductive performance of the two groups may be considered comparable under the conditions of the present study.

The mean daily milk yields obtained in both groups indicated a moderate production level characteristic of the Carpathian breed. The small differences between the groups suggest comparable productive performance during the three milk recordings, irrespective of the reproductive strategy applied.

Across the three milk recordings, the highest mean daily milk yield was recorded at the second recording, followed by a decline at the third. This pattern was consistent with previous findings reported for the Carpathian breed.

Overall, the findings highlight the importance of reproductive management and systematic milk recording in primiparous Carpathian goats for the appropriate expression and evaluation of their productive potential.

CONCLUZII

CONCLUSIONS

Under the conditions of the present study, primiparous Carpathian goats subjected to estrus induction and synchronization followed by artificial insemination recorded numerically higher reproductive indices than naturally mated does. Fertility was 94.00% in L1 and 90.00% in L2, while prolificacy reached 155.32% and 141.67%, respectively. However, the differences between the groups were not statistically significant, indicating comparable reproductive performance under the experimental conditions. These findings support the use of estrus induction and synchronization combined with artificial insemination as an effective approach for the controlled organization of reproductive activity in primiparous Carpathian goats.

Mean daily milk yield was similar in the two groups, ranging from 0.85 to 0.99 kg/doe/day across the three milk recordings, without statistically significant differences among recording times. The highest mean milk yield was recorded at the second recording, followed by a decline at the third. Lactation length was greater in L1 than in L2, reaching 289 and 258 days, respectively. Thus, estrus induction and synchronization followed by artificial insemination were not associated with evident changes in mean daily milk yield but, by advancing kidding and the onset of lactation, allowed a longer lactation period to be achieved.

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**RESEARCH ON THE PHENOLOGICAL PERFORMANCE AND
PRODUCTIVITY OF FIG (*FICUS CARICA* L.) CULTIVARS UNDER
THE CONDITIONS OF THE CONSTANȚA RESEARCH AND
DEVELOPMENT STATION FOR FRUIT GROWING
CERCETĂRI PRIVIND COMPORTAREA FENOLOGICĂ ȘI
PRODUCTIVITATEA UNOR SOIURI DE SMOCHIN ÎN CONDIȚIILE
STAȚIUNII DE CERCETARE-DEZVOLTARE PENTRU
POMICULTURĂ CONSTANȚA**

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REZUMAT

Cultivarea smochinului (*Ficus carica* L.) prezintă un interes tot mai mare și în afara arealelor tradiționale mediteraneene, ceea ce evidențiază necesitatea evaluării comportării soiurilor în condiții locale de mediu. Studiul de față a urmărit comportarea fenologică, caracteristicile fructelor, rezistența la temperaturile scăzute din timpul iernii și înmulțirea vegetativă a soiurilor de smochin ‘Black Mission’ și ‘Brown Turkey’ în condițiile din sud-estul României. Experimentul a fost desfășurat în perioada 2024–2025 la Stațiunea de Cercetare-Dezvoltare pentru Pomicultură Constanța. Fenofazele au fost monitorizate pe parcursul perioadei de vegetație, iar fructele recoltate au fost supuse analizelor biometrice și biochimice. Ambele soiuri au trecut cu succes peste perioada de iarnă, fără simptome vizibile de afectare provocate de îngheț. Umflarea mugurilor a fost înregistrată la 22 aprilie 2025, urmată de dezmugurire și apariția primelor fructe la 2 mai. Fructele soiului ‘Black Mission’ au avut o greutate medie de 68,08 g, o înălțime de 60,31 mm și diametre transversale de 45,66 și 44,67 mm. Valorile medii ale pH-ului, conținutului de substanță uscată și conținutului de zahăr au fost de 4,84, 18,52% și, respectiv, 21,94 °Brix. Înmulțirea vegetativă a determinat un procent de înrădăcinare de 100% pentru butașii soiului ‘Brown Turkey’ menținuți în apă și de 57% pentru butașii soiului ‘Black Mission’ plantați într-un substrat alcătuit din pământ și nisip. Rezultatele oferă dovezi preliminare că ambele soiuri își pot parcurge cu succes principalele fenofaze de creștere și fructificare în condițiile de mediu din sud-estul României. Sunt necesare studii multianuale, pe un număr mai mare de probe, pentru confirmarea comportării soiurilor și a adaptării acestora pe termen lung.

ABSTRACT

Fig (*Ficus carica* L.) cultivation is gaining increasing interest beyond traditional Mediterranean growing areas, emphasizing the need to evaluate cultivar performance under local environmental conditions. This study assessed the phenological behavior, fruit characteristics, winter cold response, and vegetative propagation of ‘Black Mission’ and ‘Brown Turkey’ fig cultivars under the conditions of southeastern Romania. The experiment was conducted during 2024–2025 at the Research and Development Station for Fruit Growing Constanța. Phenological stages were monitored during the growing season, while harvested fruits were subjected to biometric and biochemical analyses. Both cultivars successfully overwintered without visible frost injury. Bud swelling was recorded on 22 April 2025, followed by bud break and the appearance of the first fruits on 2 May. ‘Black Mission’ fruits had a mean weight of 68.08 g, a height of 60.31 mm, and transverse diameters of 45.66 and 44.67 mm. Mean fruit pH, dry matter, and sugar content were 4.84, 18.52%, and 21.94 °Brix, respectively. Vegetative propagation resulted in 100% rooting for ‘Brown Turkey’ cuttings maintained in water and 57% for ‘Black Mission’ cuttings established in a soil–sand substrate. The results provide preliminary evidence that both cultivars can successfully complete their main vegetative and reproductive stages under the environmental conditions of southeastern Romania. Multi-year studies with larger sample sizes are required to confirm cultivar performance and long-term adaptation.

Cuvinte cheie: *Ficus carica* L.; smochin; fenologie; calitatea fructelor; caractere biometrice; înrădăcinare; adaptarea soiurilor; sud-estul României.

Keywords: *Ficus carica* L.; fig; phenology; fruit quality; biometric traits; rooting; cultivar adaptation; southeastern Romania.

INTRODUCERE INTRODUCTION

The common fig (*Ficus carica* L.) is one of the oldest cultivated fruit species and has a long history of cultivation in the Mediterranean region and other areas characterized by warm and relatively dry climatic conditions. Its long association with human societies has been related to the adaptability of the species, the nutritional value of its fruits, and the possibility of consuming them both fresh and processed (Falistocco, 2020). Although traditionally associated with Mediterranean environments, fig cultivation has increasingly attracted attention in regions located beyond its conventional growing areas, where

suitable local climatic conditions may allow successful plant growth and fruit production.

Fig fruits are valued for their distinctive sensory characteristics and nutritional composition. They contain carbohydrates, dietary fiber, minerals, vitamins, phenolic compounds, and other bioactive constituents that contribute to their nutritional and functional value. Different parts of the plant, including fruits, leaves, and latex, have also been investigated for their phytochemical composition and potential biological activities (Mawa et al., 2013). The nutritional characteristics and potential health benefits of fig fruits further support the growing interest in this species for fresh consumption and processing (Hussain et al., 2021).

The agronomic and commercial value of fig cultivation depends considerably on the genotype and its interaction with local environmental conditions. Fig genotypes may exhibit substantial variability in vegetative development, phenological behavior, fruit morphology, fruit weight, color, and biochemical characteristics. Consequently, morphological and pomological characterization represents an important approach for identifying genotypes with desirable traits and evaluating their suitability for particular growing environments (Khadivi et al., 2018). Such differences are particularly relevant when cultivars are introduced into climatic regions that differ from the traditional Mediterranean production areas.

In Romania, fig has historically been associated mainly with the warmer southern and south-western regions, where climatic conditions are more favorable for plant survival and fruiting (Botu and Botu, n.d.). Recent observations indicate that the potential cultivation area of *F. carica* may be expanding, with successful growth also being reported in more northern areas of Romania (Odagiu et al., 2021). This development increases the importance of evaluating fig cultivars under local pedoclimatic conditions rather than relying exclusively on information obtained from traditional fig-producing regions.

Previous research conducted in Romania has demonstrated variability in fruit quality traits among fig genotypes, confirming the importance of genotype selection for obtaining fruits with desirable commercial and quality characteristics (Bona et al., 2022). Southeastern Romania, particularly the Dobrogea region, presents specific environmental conditions that may favor fig cultivation, while winter temperatures and seasonal climatic variability may still influence plant development, phenological stages, and productivity. Local evaluation is therefore necessary to determine the behavior of individual cultivars and their potential for cultivation under these conditions.

Despite the increasing interest in fig cultivation in Romania, information concerning the phenological behavior and productive performance of commercial cultivars under the specific conditions of southeastern Romania remains limited. Studies integrating phenological observations with biometric and biochemical fruit characteristics can provide useful information for cultivar evaluation and for assessing the potential expansion of this crop.

Therefore, the objective of the present study was to evaluate the phenological behavior and productive performance of two fig (*Ficus carica* L.) cultivars, 'Black Mission' and 'Brown Turkey', under the environmental conditions of southeastern Romania. The study focused on the main phenological stages, winter cold response, fruit biometric and biochemical characteristics, and cultivar-specific performance under the conditions of the Research and Development Station for Fruit Growing Constanța.

MATERIAL ȘI METODĂ DE CERCETARE MATERIAL AND METHOD

2.1. Experimental site and plant material

The study was conducted during 2024–2025 at the Research and Development Station for Fruit Growing Constanța, located in Valu lui Traian, southeastern Romania. The experimental material consisted of two fig (*Ficus carica* L.) cultivars, 'Black Mission' and 'Brown Turkey', established in the experimental collection of the station.

The plants were established at a spacing of 4×4 m. The two cultivars differed in their training system: 'Brown Turkey' plants were trained as single-trunk trees, whereas 'Black Mission' plants were maintained in a bush form. Standard orchard management practices were applied during the experimental period, including soil tillage, mechanical weed control, irrigation, and phytosanitary treatments.

2.2. Phenological observations

Phenological observations were performed during the 2025 growing season to characterize the development and fruiting behavior of the two fig cultivars under the environmental conditions of southeastern Romania. The main developmental stages monitored included the beginning of vegetative bud swelling, bud break, and the appearance of the first fruits.

The beginning of bud swelling was recorded when the first visible changes in vegetative buds were observed, while bud break was considered to have occurred when active vegetative growth became evident. The appearance

of the first developing fruits was also recorded for each cultivar. These observations were used to characterize the timing of the main phenological stages under the climatic conditions prevailing during the study year.

Winter cold response was assessed visually after the 2024–2025 winter using a five-point scale based on the degree of damage observed on the aerial parts of the plants. The scale ranged from 1, corresponding to severe frost injury and almost complete damage to the plant, to 5, indicating the absence of visible frost injury and complete resistance under the recorded winter conditions.

2.3. Fruit biometric and biochemical determinations

Fully developed fruits were manually harvested at physiological maturity and subjected to biometric and biochemical evaluation. Harvest maturity was determined based on external fruit characteristics, including color, firmness, and fruit position on the shoot.

Individual fruit weight was determined and expressed in grams (g). Fruit dimensions were measured in millimeters (mm), including fruit height and two transverse diameter measurements. These measurements were used to characterize the morphological variability of the harvested fruits.

Biochemical determinations included fruit pH, dry matter content (%), and sugar content. These parameters were evaluated to characterize the internal fruit quality of the studied cultivars and to complement the biometric assessment.

2.4. Vegetative propagation by cuttings

The propagation capacity of the two cultivars was also evaluated using cuttings prepared in July 2024. Fifty cuttings were collected from each cultivar. Different rooting conditions were used for the two cultivars. ‘Brown Turkey’ cuttings were placed individually in containers filled with water, whereas ‘Black Mission’ cuttings were planted in pots containing a 1:1 mixture of garden soil and river sand. Rooting success was evaluated as the percentage of cuttings that successfully developed roots relative to the initial number of cuttings used for each cultivar. The rooting response was subsequently compared between the two propagation conditions.

2.5. Phytosanitary management

Phytosanitary treatments were applied throughout the growing season according to the management practices used in the experimental orchard. Copper-based treatment (Alcupral, 0.3%) was applied in February and March, followed by fungicide and insecticide treatments during the vegetation period. The products used included Score (0.02%), Fury (0.015%), Mospilan (0.02%),

Dithane (0.2%), Cyperguard (0.02%), and Topsin (0.07%). Treatments were applied between February and August 2025 according to the phytosanitary requirements of the crop.

REZULTATE ȘI DISCUȚII RESULTS AND DISCUSSIONS

3.1. Fruit biometric and biochemical characteristics

The biometric evaluation of ‘Black Mission’ fruits revealed noticeable variability among the analyzed samples. Individual fruit weight ranged from 51.41 to 87.88 g, with a mean value of 68.08 g. The coefficient of variation for fruit weight reached 21.00%, indicating a relatively high degree of variability among the evaluated fruits. Mean values of 45.66 and 44.67 mm were recorded for the two transverse fruit diameters, while mean fruit height was 60.31 mm (Table 1).

Table 1. Biometric and biochemical characteristics of ‘Black Mission’ fig fruits under the conditions of southeastern Romania

Parameter	Mean $\pm$ SD	CV (%)	Range
Fruit weight (g)	68.08 $\pm$ 14.30	21.00	51.41–87.88
Fruit diameter 1 (mm)	45.66 $\pm$ 4.90	10.73	39.70–52.75
Fruit diameter 2 (mm)	44.67 $\pm$ 5.65	12.65	39.44–51.70
Fruit height (mm)	60.31 $\pm$ 5.63	9.33	52.15–67.72
Fruit pH	4.84 $\pm$ 0.26	5.39	4.40–5.10
Dry matter (%)	18.52 $\pm$ 0.72	3.86	18.00–19.40
Sugar content (°Brix)	21.94 $\pm$ 4.60	20.96	17.80–29.70

SD – standard deviation; CV – coefficient of variation.

Fruit dimensions showed lower variability than fruit weight. Fruit height presented the lowest biometric coefficient of variation (9.33%), followed by the first (10.73%) and second (12.65%) transverse diameters. This suggests that fruit shape and dimensions were relatively more uniform than individual fruit mass. The greater variability observed for fruit weight may reflect differences in fruit development and position on the plant, although the present dataset does not allow these potential sources of variation to be tested separately.

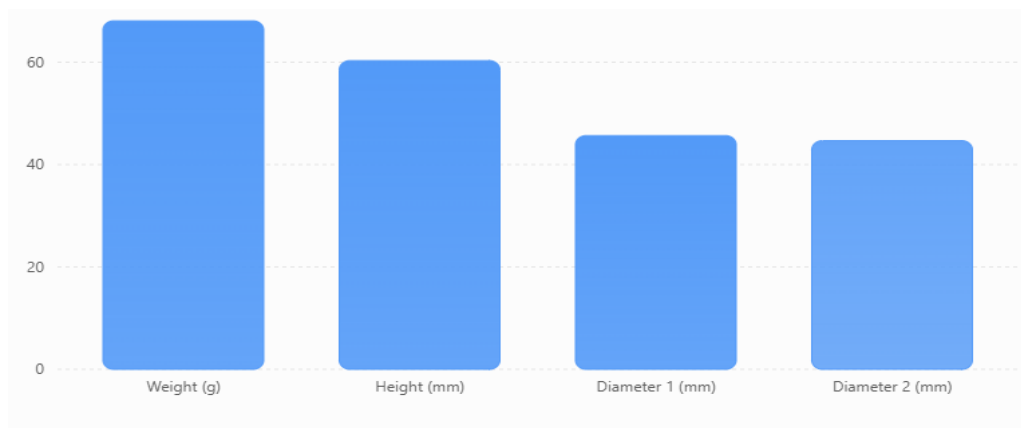


Figure 1. Mean biometric characteristics of ‘Black Mission’ fig fruits evaluated under the conditions of southeastern Romania in 2025.

The biometric assessment of Black Mission fruits showed substantial variation in fruit weight, while fruit dimensions were comparatively more uniform. Mean fruit weight reached 68.08 g, with values ranging from 51.41 to 87.88 g. Mean fruit height was 60.31 mm, whereas the two transverse diameters averaged 45.66 mm and 44.67 mm, respectively. The higher coefficient of variation observed for fruit weight indicates greater variability in fruit development than in fruit shape under the environmental conditions of southeastern Romania. The biochemical evaluation provided additional information regarding fruit quality. Fruit pH ranged from 4.40 to 5.10, with a mean of 4.84, whereas dry matter content varied within a relatively narrow interval of 18.00–19.40%, resulting in a mean value of 18.52%. Sugar content showed considerably greater variability, ranging from 17.80 to 29.70, with a mean value of 21.94 and a coefficient of variation of 20.96%.

The observed variability confirms the importance of combining morphological and biochemical traits when evaluating fig fruit quality. Khadivi et al. (2018) emphasized the usefulness of morphological and pomological characterization for identifying variability among edible fig genotypes. In Romania, Bona et al. (2022) also reported differences in fruit quality attributes among fig genotypes from the south-western part of the country. The present results contribute complementary information for fig material cultivated under the environmental conditions of southeastern Romania.

3.2. Phenological behavior and winter cold response

The first visible phenological event recorded during the 2025 growing season was the beginning of vegetative bud swelling on 22 April. Bud break and the appearance of the first developing fruits were observed approximately ten

days later, on 2 May. These observations indicate a relatively rapid transition from the resumption of vegetative activity to the beginning of reproductive development under the climatic conditions recorded at the experimental site.

Both ‘Black Mission’ and ‘Brown Turkey’ received a score of 5 on the five-point winter cold-response scale following the 2024–2025 winter, corresponding to the absence of visible frost injury. Thus, under the specific climatic conditions of the evaluated winter, both cultivars successfully overwintered and resumed vegetative and reproductive development during the following spring.

These observations are relevant in the context of the potential expansion of fig cultivation in Romania. Odagiu et al. (2021) reported that the cultivation area of *F. carica* may extend towards regions situated farther north than its traditional Romanian growing areas. The absence of visible winter injury in the present experiment supports the suitability of the evaluated cultivars for the conditions encountered at the Constanța experimental site during the study period. Nevertheless, because winter response was evaluated during a single winter season, these findings should be interpreted as cultivar responses to the particular conditions of 2024–2025 rather than as evidence of general frost tolerance.

3.3. Rooting performance of fig cuttings

Clear differences were recorded in rooting success between the two propagation treatments. All 50 ‘Brown Turkey’ cuttings maintained individually in water developed roots, corresponding to a rooting rate of 100%. In contrast, 57% of the ‘Black Mission’ cuttings planted in the garden soil and river sand substrate successfully rooted.

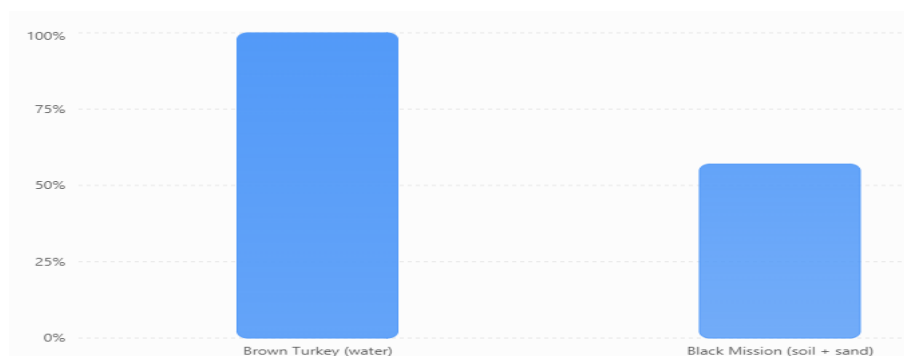


Figure 2. Rooting success of ‘Brown Turkey’ and ‘Black Mission’ fig cuttings under the propagation conditions evaluated in the experiment.

Vegetative propagation produced contrasting rooting responses between the two propagation methods. Brown Turkey cuttings rooted in water achieved 100% rooting success, whereas Black Mission cuttings rooted in a substrate composed of garden soil and river sand achieved 57% rooting success. This represents a difference of 43 percentage points between the two propagation variants. The 43 percentage-point difference between the two treatments demonstrates that successful vegetative propagation was achievable under both conditions, although rooting was substantially greater in the water treatment. This result has practical relevance because vegetative propagation represents a simple approach for maintaining cultivar characteristics and producing planting material.

The difference should not, however, be interpreted exclusively as a cultivar effect. In the present experiment, cultivar and rooting environment were not evaluated independently: 'Brown Turkey' was rooted in water, whereas 'Black Mission' was rooted in a 1:1 mixture of garden soil and river sand. Consequently, the observed difference may result from the cultivar, the rooting environment, or their combined influence. A factorial experiment in which both cultivars are tested under the same propagation treatments would be required to distinguish these effects.

Taken together, the results indicate that fig cultivation has potential under the environmental conditions of southeastern Romania. The successful overwintering of both cultivars, the resumption of vegetative and reproductive development during spring, and the biometric and biochemical characteristics of the analyzed fruits provide preliminary evidence of their adaptation to the experimental site. The nutritional and functional value associated with fig fruits further increases the potential interest of this crop, as previously discussed by Mawa et al. (2013) and Hussain et al. (2021). Longer-term evaluations involving several growing seasons, a larger number of plants and fruits, and direct statistical comparisons between cultivars are required before broader recommendations regarding cultivar performance can be established.

CONCLUZII

CONCLUSIONS

The present study provides preliminary information on the phenological behavior, fruit characteristics, and vegetative propagation of fig (*Ficus carica* L.) under the environmental conditions of southeastern Romania. Both 'Black Mission' and 'Brown Turkey' successfully overwintered during 2024–2025 without visible frost injury and resumed vegetative and reproductive

development during the following spring. Bud swelling began on 22 April 2025, followed by bud break and the appearance of the first fruits on 2 May.

The biometric and biochemical evaluation of 'Black Mission' fruits indicated favorable fruit characteristics, with a mean fruit weight of 68.08 g, a mean height of 60.31 mm, and mean transverse diameters of 45.66 and 44.67 mm. Fruit quality was characterized by a mean pH of 4.84, dry matter content of 18.52%, and sugar content of 21.94 °Brix. Fruit weight and sugar content showed greater variability than fruit dimensions and dry matter content.

Vegetative propagation was successful under both evaluated conditions, although rooting success reached 100% for 'Brown Turkey' cuttings maintained in water and 57% for 'Black Mission' cuttings established in the soil–sand substrate. Since cultivar and rooting environment were not evaluated independently, these differences cannot be attributed exclusively to cultivar effects.

The results indicate that the evaluated fig cultivars can successfully complete their main vegetative and reproductive stages under the conditions encountered at the Constanța experimental site. Nevertheless, the study represents a preliminary assessment based on a limited experimental period and sample size. Multi-year investigations involving larger numbers of plants and fruits, identical experimental conditions for cultivar comparisons, and detailed climatic monitoring are required to confirm cultivar performance and to assess the longer-term potential of fig cultivation in southeastern Romania.

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**COMPARATIVE ASSESSMENT OF GERMINATIVE ENERGY AND
GERMINATIVE CAPACITY IN SEVEN MAIZE CULTIVARS
EVALUAREA COMPARATIVĂ A ENERGIEI GERMINATIVE ȘI A
FACULTĂȚII GERMINATIVE LA ȘAPTE CULTIVARE DE PORUMB
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REZUMAT

Băuturile răcoritoare reprezintă produse consumate pe scară largă, a căror formulare poate include zaharuri, acidulanți, conservanți, coloranți, îndulcitori, antioxidanți și alte ingrediente funcționale. Evaluarea efectelor biologice ale amestecurilor complexe este relevantă deoarece răspunsul celular poate reflecta acțiunea combinată a mai multor componente. În studiul de față a fost evaluat potențialul citotoxic și citogenotoxic al trei băuturi comerciale pe modelul *Allium cepa*: suc natural de portocale Olympus, suc natural de portocale Pfanner 100% Orange și Fanta de portocale. Radicelele de *A. cepa* au fost expuse timp de 6 și 24 de ore, iar efectele au fost investigate prin analiza mitozelor și a modificărilor citologice pe preparate squash colorate prin reacția Feulgen. Pentru fiecare variantă au fost analizate 500 de celule. Indicele mitotic al matorului a fost 79,8, în timp ce după 6 ore valorile au fost 54,0 pentru Olympus, 59,6 pentru Pfanner și 60,2 pentru Fanta. După 24 de ore, valorile au fost 62,8, 61,8 și, respectiv, 61,4. Pe lângă inhibarea diviziunii celulare, au fost observate heterocromatinizare, vacuolizare, picnoză, micronuclei, punți cromatidice, plasmoliză și citochineze anormale. Rezultatele indică un răspuns citotoxic al tuturor celor trei produse, dependent de produs și de durata expunerii. Modelul *Allium cepa* se dovedește util pentru screeningul preliminar al efectelor citologice ale unor produse alimentare complexe, însă rezultatele nu trebuie extrapolate direct la riscul pentru sănătatea umană fără investigații suplimentare.

ABSTRACT

Soft drinks are widely consumed products whose formulations may include sugars, acidulants, preservatives, colorants, sweeteners, antioxidants, and other functional ingredients. Assessing the biological effects of complex mixtures is relevant because the cellular response may reflect the combined action of multiple components. In the present study, the cytotoxic and cytogenotoxic potential of three commercial beverages was evaluated using the *Allium cepa* model: Olympus natural orange juice, Pfanner 100% Orange natural

orange juice, and Fanta orange. *A. cepa* root tips were exposed for 6 and 24 hours, and the effects were investigated by analyzing mitotic activity and cytological alterations in squash preparations stained using the Feulgen reaction. For each variant, 500 cells were analyzed. The mitotic index of the control was 79.8, whereas after 6 hours the values were 54.0 for Olympus, 59.6 for Pfanner, and 60.2 for Fanta. After 24 hours, the values were 62.8, 61.8, and 61.4, respectively. In addition to inhibition of cell division, heterochromatinization, vacuolization, pyknosis, micronuclei, chromatid bridges, plasmolysis, and abnormal cytokinesis were observed. The results indicate a cytotoxic response for all three products, dependent on the product and exposure duration. The *Allium cepa* model proved useful for preliminary screening of the cytological effects of complex food products; however, the results should not be directly extrapolated to human health risk without further investigation.

Cuvinte cheie: *Allium cepa*; citotoxicitate; citogenotoxicitate; indice mitotic; băuturi răcoritoare; aberații cromozomiale; micronuclei.

Keywords: *Allium cepa*; cytotoxicity; cytogenotoxicity; mitotic index; soft drinks; chromosomal aberrations; micronuclei.

INTRODUCERE INTRODUCTION

Soft drinks comprise a diverse category of food products, including carbonated beverages, fruit juice-based products, flavored beverages, and other ready-to-consume formulations. Their composition may include water, sugars or sweeteners, carbon dioxide, acidulants, flavorings, preservatives, and colorants, while some products additionally contain caffeine, vitamins, minerals, or other functional substances (Kregiel, 2015). The use of additives aims to ensure microbiological and physicochemical stability, control acidity, preserve the product, and obtain consistent organoleptic characteristics.

Toxicological interest does not necessarily arise from the isolated presence of a single ingredient, but also from the fact that commercial products are complex systems in which several substances are present simultaneously. Preservatives, sweeteners, colorants, and acidulants have been investigated in different biological systems for their potential cytotoxic and genotoxic effects. Studies using *A. cepa* have demonstrated, for example, cytogenetic effects associated with food preservatives, including chromosomal alterations and inhibition of mitotic activity (Onyemaobi et al., 2012; Pandey et al., 2014; Rosculete et al., 2020). Similarly, some studies of sweeteners and colorants have

reported alterations in cell proliferation, micronuclei, and other cytogenetic changes (Rizk et al., 2016; Rampanelli et al., 2024; Singh & Chadha, 2024).

The *Allium cepa* test is one of the most widely used assays for the preliminary evaluation of cytotoxicity and genotoxicity. The sensitivity of root meristems, high proliferation rate, and chromosome visibility facilitate the quantification of alterations induced by chemical substances (Nicuță et al., 2025). The method has been used to assess additives, wastewater, pesticides, metals, and other complex mixtures, and recent literature confirms its utility as a toxicological screening tool (Atapattu & Jayawardena, 2026; Torres-Bugarín et al., 2026).

The aim of the present study was to comparatively evaluate the effects of three commercial soft drinks on cell proliferation and chromatin organization in the root meristem of *A. cepa* by comparing two exposure durations, 6 and 24 hours. The objectives were: (1) to determine the mitotic index; (2) to compare the cellular response among products and exposure durations; and (3) to identify cytological and chromosomal alterations associated with the treatments.

MATERIAL ȘI METODĂ DE CERCETARE **MATERIAL AND METHOD**

Biological material and experimental variants

The experimental model consisted of *Allium cepa*, using root tips containing actively proliferating meristematic tissue. The bulbs were cleaned and placed in individual containers with water at room temperature, and the water was changed daily. After approximately one week, when the rootlets reached approximately 2 cm, the water was replaced with test beverages. Three products were investigated: Olympus natural orange juice, Pfanner 100% Orange natural orange juice, and Fanta orange. Each product was tested for 6 and 24 hours, resulting in six experimental variants, designated V1–V6. The control consisted of biological material maintained under germination conditions without treatment with the tested beverages.

The experimental design was: V1 – Olympus, 6 h; V2 – Pfanner, 6 h; V3 – Fanta, 6 h; V4 – Olympus, 24 h; V5 – Pfanner, 24 h; V6 – Fanta, 24 h. For each variant, five microscope slides were prepared; 10 microscopic fields per slide were examined, resulting in a total of 500 cells analyzed for each variant.

Material preparation and staining

After treatment, the rootlets were collected, fixed, and stored in fixative in a refrigerator for 12–15 hours. Hydrolysis was performed with 1 N HCl for 16

minutes at 60°C. The material was subsequently stained with Schiff reagent for approximately one hour and then kept in water to enhance contrast. Microscopic preparations were made using the squash technique: the stained meristematic tip was transferred to a slide, covered with a coverslip, and mechanically spread to obtain a thin and uniform layer of cells.

Cell observation and counting were performed using an ML-4 IOR light microscope, while an OPTIKA B-293 research microscope equipped with a Levenhuk M 1000 PLUS video camera was used to document alterations in the genetic material. The Feulgen reaction is a DNA-specific histochemical method used to visualize chromatin and chromosomes in cytological preparations (Biggiogera et al., 2024).

Assessment of the mitotic index and cytological alterations

For each sample, 500 cells were counted and classified as interphase cells or cells in the mitotic phases: prophase, metaphase, anaphase, and telophase; cytokinesis was also recorded. The mitotic index (MI) was calculated according to the equation: $MI = (\text{number of cells undergoing mitosis} / \text{total number of cells analyzed}) \times 100$. In addition, cytological and chromosomal alterations such as heterochromatinization, vacuolization, pyknosis, micronuclei, chromatid bridges, plasmolysis, and abnormal cytokinesis were recorded. The analysis presented is descriptive comparative, based on the cell counts performed.

REZULTATE ȘI DISCUȚII RESULTS AND DISCUSSIONS

Mitotic index

The control presented 399 dividing cells out of 500 analyzed, corresponding to a mitotic index of 79.8. After 6 hours of exposure, the number of dividing cells decreased to 270 for V1 (Olympus), 298 for V2 (Pfanner), and 301 for V3 (Fanta), corresponding to mitotic indices of 54.0, 59.6, and 60.2, respectively. Thus, all three products reduced cell proliferation compared with the control, with the greatest reduction observed for Olympus.

After 24 hours, 314 dividing cells were recorded in V4 (Olympus), 309 in V5 (Pfanner), and 307 in V6 (Fanta), resulting in mitotic indices of 62.8, 61.8, and 61.4, respectively. Among the 24-hour variants, V6 showed the lowest value, whereas V4 showed the highest. All values remained below the control level.

Compared with the control, the relative reduction in the mitotic index was approximately 32.3 for V1, 25.3 for V2, and 24.6 for V3 after 6 hours. After 24 hours, the relative reduction compared with the control was approximately 21.3

for V4, 22.6 for V5, and 23.1 for V6. These descriptive differences indicate evident inhibition of cell proliferation under all experimental conditions, with a profile dependent on both the product and exposure duration.

Table 1. Mitotic index and number of dividing cells for the control and experimental variants

Variant	Product	Time	Dividing cells	MI
Control	—	—	399/500	79.8
V1	Olympus	6 h	270/500	54.0
V2	Pfanner 100%Orange	6 h	298/500	59.6
V3	Fanta	6 h	301/500	60.2
V4	Olympus	24 h	314/500	62.8
V5	Pfanner 100% Orange	24 h	309/500	61.8
V6	Fanta	24 h	307/500	61.4

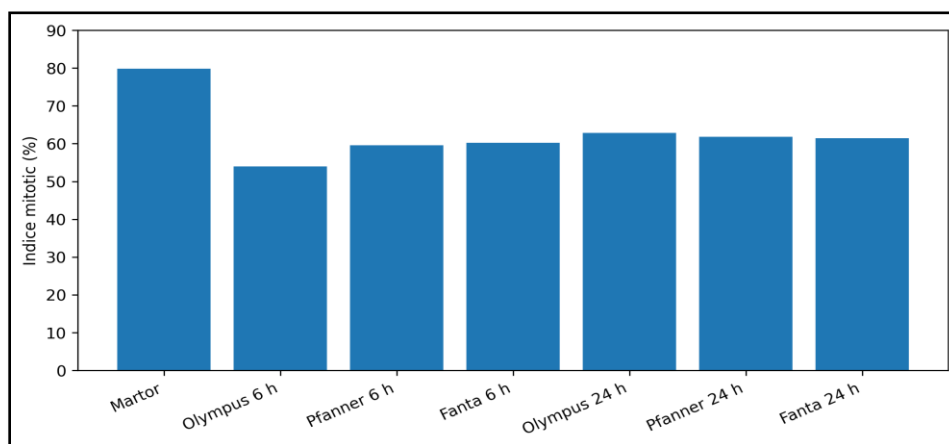


Fig. 1. Mitotic index of *Allium cepa* meristematic cells after 6 and 24 hours of treatment.

Distribution of mitotic phases

After 6 hours, the control presented 171 prophase cells, 16 metaphase cells, 12 anaphase cells, 105 telophase cells, and 95 cells undergoing cytokinesis.

In V1, 169 prophase cells, 23 metaphase cells, 2 anaphase cells, 48 telophase cells, and 28 cells undergoing cytokinesis were recorded. V2 presented 165 prophase cells, 63 metaphase cells, 1 anaphase cell, 56 telophase cells, and 13 cells undergoing cytokinesis, whereas V3 presented 133 prophase cells, 30 metaphase cells, 3 anaphase cells, 113 telophase cells, and 22 cells undergoing cytokinesis, according to fig. 2. The data indicates a shift in the distribution of cells among the mitotic phases, particularly through a reduction in anaphase cells and changes in the relative proportions of mitotic phases.

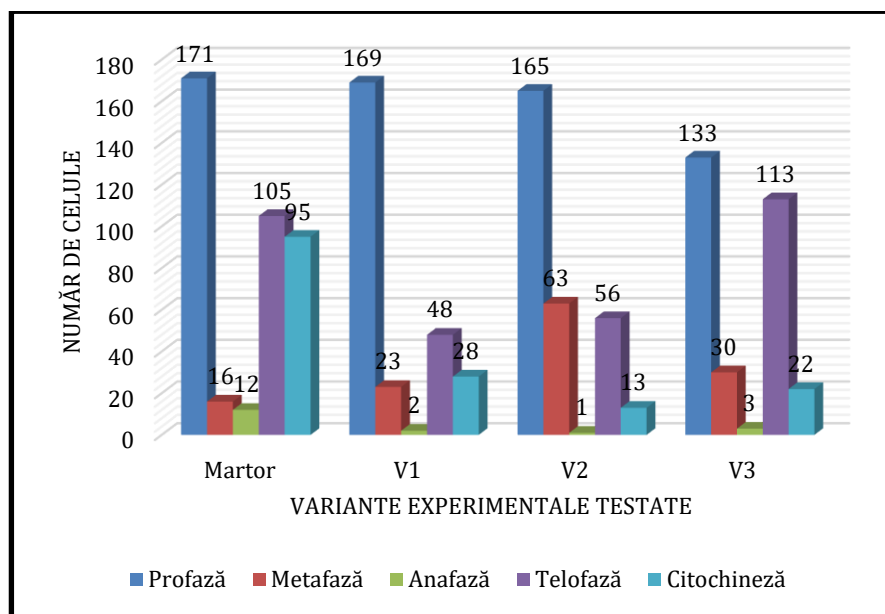


Fig. 2. Frequency of mitotic division phases in *Allium cepa* after treatment with the three types of soft drinks for 6 hours.

After 24 hours, the control presented 171 prophase cells, 16 metaphase cells, 12 anaphase cells, 105 telophase cells, and 95 cells undergoing cytokinesis. For V4, 111 prophase cells, 24 metaphase cells, 4 anaphase cells, 84 telophase cells, and 91 cells undergoing cytokinesis were recorded. V5 presented 140 prophase cells, 63 metaphase cells, 3 anaphase cells, 82 telophase cells, and 21 cells undergoing cytokinesis, whereas V6 presented 109 prophase cells, 73 metaphase cells, 2 anaphase cells, 66 telophase cells, and 57 cells undergoing cytokinesis, according to fig. 3. In V6, the lowest mitotic index among the 24-hour variants was observed together with the highest number of metaphases and a reduced number of anaphases.

Cytological and chromosomal alterations

Microscopic examination revealed, compared with the control, alterations in chromatin and cellular organization after both treatment durations. After 6 hours, prophase cells with heterochromatinization, marked chromatin condensation, and vacuolization were described; prophase cells associated with micronuclei; metaphase cells with pycnotic chromosomes or pycnotic star-shaped metaphases; plasmolyzed cells; nuclei of different sizes; longitudinally oriented cytokinesis; and anaphase cells with chromatid bridges.

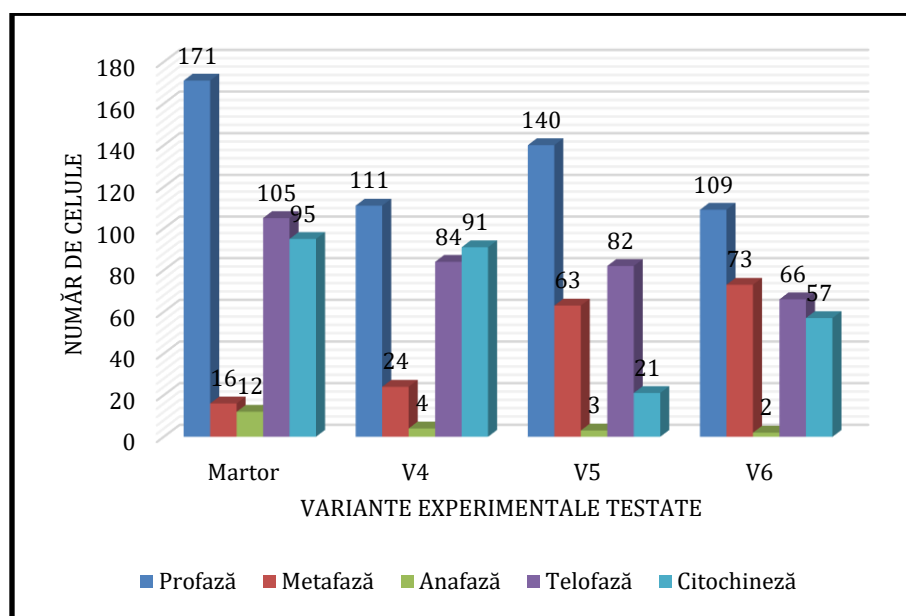


Fig. 3. Frequency of mitotic division phases in *Allium cepa* after treatment with the three types of soft drinks for 24 hours.

After 24 hours, prophase cells with heterochromatinization and vacuolization, micronuclei, pycnotic metaphases with pronounced condensation, chromatid bridges in anaphase and telophase, and unequal or longitudinally oriented cytokinesis were also observed. The presence of micronuclei and chromatid bridges is relevant for assessing cytogenotoxic potential, whereas a reduction in the mitotic index represents a cytotoxic/proliferative indicator.

The main finding of the study is the reduction of the mitotic index in all six experimental variants compared with the control. In an *Allium* test, a decrease in meristem proliferation indicates that the treatment interferes with the cell cycle.

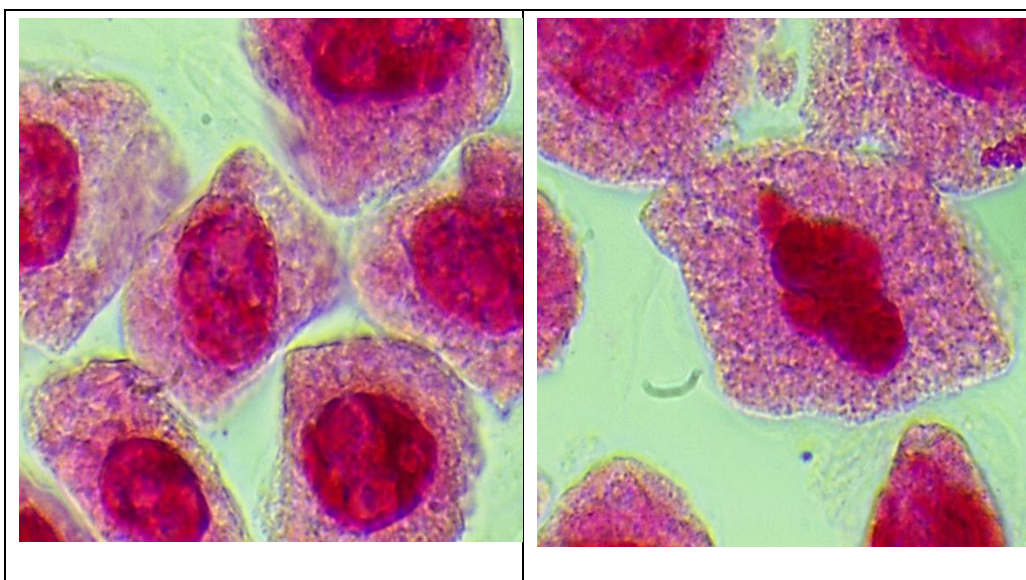


Fig. 4. Experimental variant 1 (a) Many prophase cells with vacuolization and heterochromatinization are visible (1000×). (b) A metaphase cell with pycnotic chromosomes is visible centrally, together with a prophase cell containing a micronucleus (1000X).

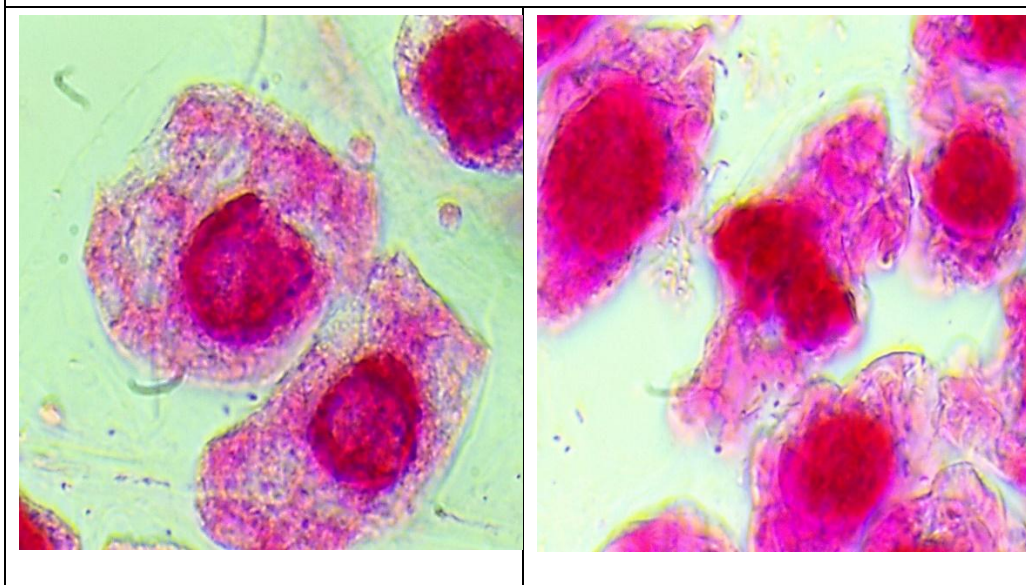


Fig. 5. Experimental variant 2 (a) Numerous prophase cells with vacuolization and strongly condensed chromatin are visible (1000X). (b) A plasmolyzed cell in metaphase, with pycnotic chromosomes, is visible centrally (1000X).

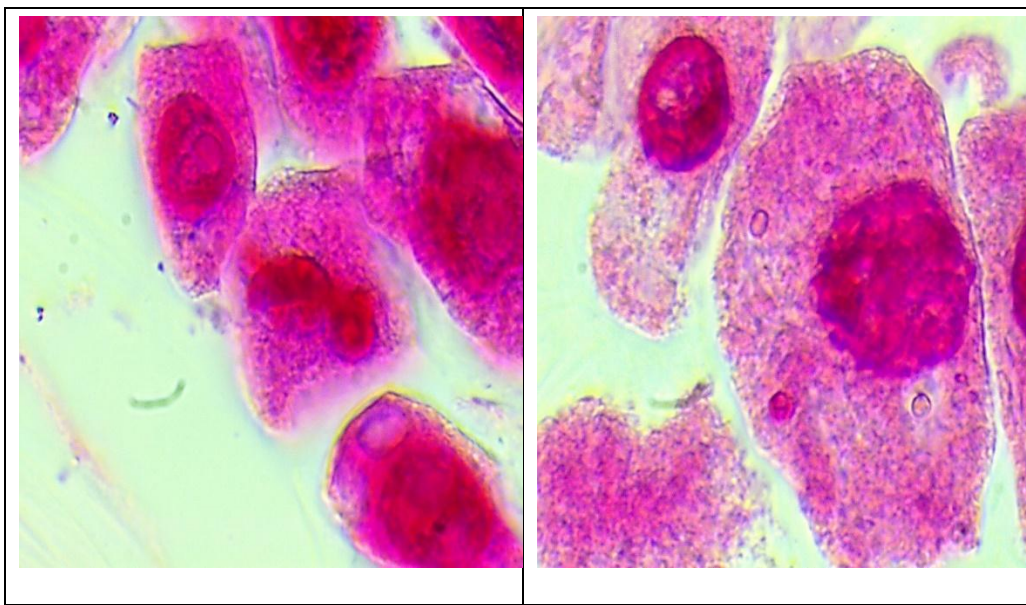


Fig. 6. Experimental variant 3 (a) Numerous prophase cells with vacuolization, micronuclei, and heterochromatinization are visible (1000X). (b) Prophase cells and, centrally, a metaphase cell with pycnotic chromosomes and a micronucleus are visible (1000X).

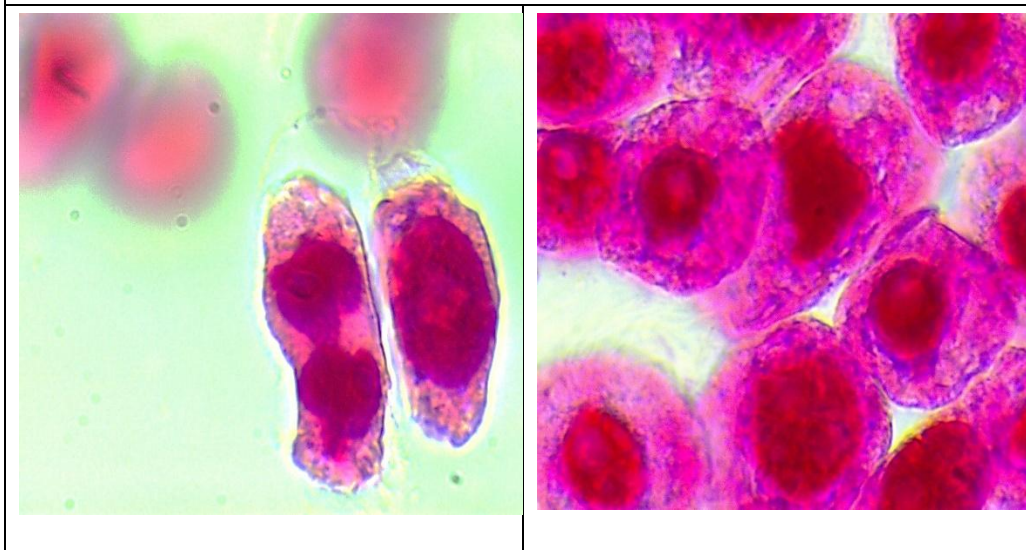


Fig. 7. Experimental variant 4 (a) Prophase cells with highly condensed chromatin and, centrally, a pycnotic metaphase cell is visible (1000X). (b) A pycnotic anaphase cell with a chromatid bridge and a prophase cell with a heterochromatinized, hypertrophied nucleus are visible (1000X).

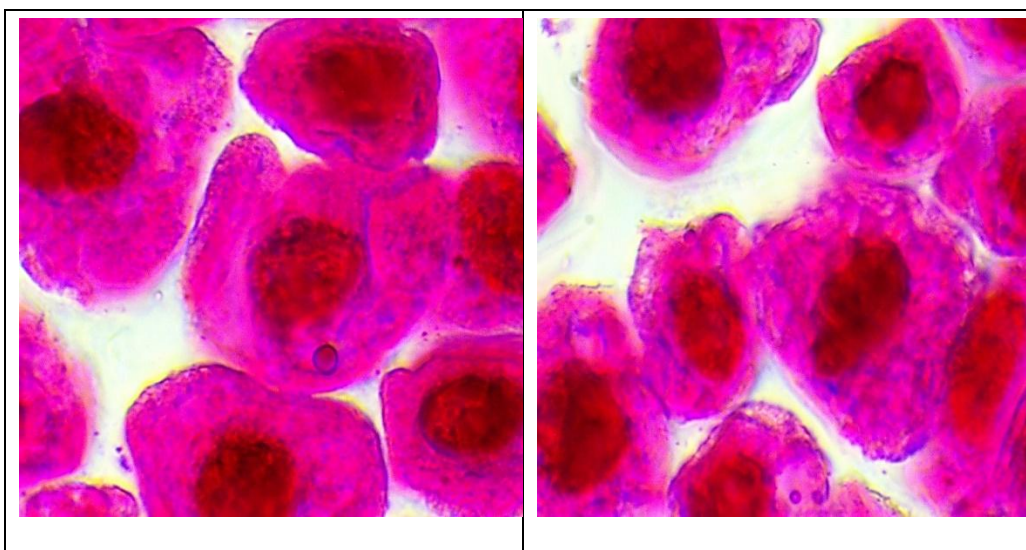


Fig. 8. Experimental variant 5 (a) Prophase cells with vacuolization, heterochromatinization, and a micronucleus are visible (1000X). (b) Prophase cells with vacuolization and strongly condensed chromatin, and a pycnotic metaphase cell, are visible (1000X).

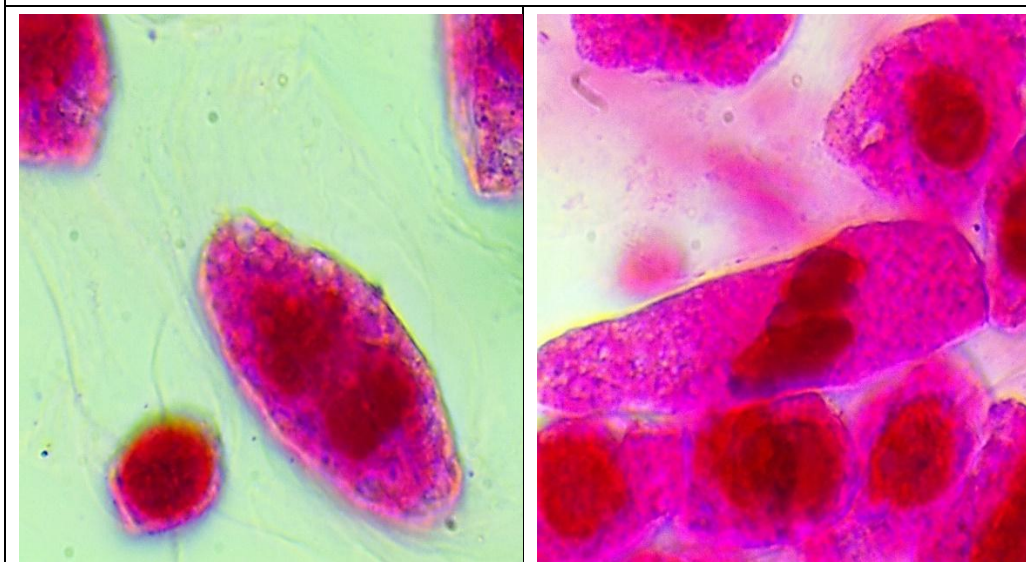


Fig. 9. Experimental variant 6 (a) Prophase cells with heterochromatinized nuclei and, centrally, a metaphase cell with overcondensed chromosomes is visible (1000X). (b) A telophase cell with a chromatid bridge is visible centrally, together with prophase cells showing heterochromatinization (1000X).

The model is particularly suitable for screening because meristematic tissue has a high proliferative activity and chromosomes can be directly observed during mitosis (Nicuță et al., 2025; Torres-Bugarín et al., 2026).

After 6 hours, Olympus produced the most pronounced reduction in the mitotic index (54.0), followed by Pfanner (59.6) and Fanta (60.2). This profile shows that, under the experimental conditions used, the initial meristem response was more pronounced for Olympus. However, it is not possible to attribute this effect causally to a specific preservative or other ingredient because the study tested commercial products as mixtures and did not experimentally quantify the chemical composition of each beverage. Therefore, the hypothesis concerning the contribution of additives should be regarded as a possible explanation rather than a demonstrated conclusion.

After 24 hours, the mitotic index values were closer among products, ranging from 61.4 to 62.8. Fanta showed the lowest value (61.4), whereas Olympus showed the highest (62.8). The result suggests a complex temporal response. The increase in the mitotic index from 6 to 24 hours should not automatically be interpreted as cellular adaptation, as it may reflect changes in cell-cycle kinetics, selection of surviving cell populations, or secondary physiological responses, although under these conditions it may represent an adaptive mechanism. The morphological alterations support the interpretation of the mitotic index. Heterochromatinization and pyknosis indicate substantial alterations in chromatin organization, whereas vacuolization and plasmolysis suggest disturbances in cellular homeostasis (fig. 4, 5, 6, 7, 9). Micronuclei may result from chromosomes or chromosomal fragments that are not properly incorporated into the daughter nucleus (fig. 6, 8), while chromatid bridges indicate errors in chromosome segregation (fig. 7, 9). In the context of an *Allium* test, the association between mitotic inhibition and such alterations provides a more comprehensive picture of the cytological response than the use of the mitotic index as the sole endpoint.

The results are qualitatively consistent with the literature that has used *A. cepa* to evaluate beverages and food additives. Chandraker et al. (2014) reported clastogenic effects of a soft drink on root cells, while Farhan and Tawfiq (2016) reported cytotoxic and carcinogenic alterations in the *Allium* model after exposure to a Cola-type beverage. Studies on preservatives have also described effects on mitotic activity and the occurrence of chromosomal aberrations (Alabi et al., 2024; Islam et al., 2016; Magomya et al., 2020; Onyemaobi et al., 2012; Pandey et al., 2014; Rosculete et al., 2020). These similarities support the usefulness of the model for screening but do not demonstrate that the products analyzed here have the same molecular mechanisms.

An important aspect is the mixture nature of the beverages investigated. Acidity, sugars, sweeteners, preservatives, colorants, and other components may simultaneously contribute to the cellular response. The literature on additives indicates that biological effects may vary according to concentration, exposure duration, and combinations of compounds (Aleem Yoosuf & Shah, 2021; Jurcevic Zidar et al., 2024; Morshdy et al., 2024). In citrus-based beverages, citric acid is frequently used as an acidity regulator and may contribute to product characteristics; cytogenetic effects of citric and benzoic acids have previously been investigated in *A. cepa* (Yilmaz et al., 2008).

From a methodological perspective, the study has the advantage of using a simple and reproducible endpoint: the counting of cells in different mitotic phases, combined with microscopic assessment of chromatin alterations. Nevertheless, more robust validation would benefit from independent biological replicates, inferential statistical analysis, quantification of the frequency of each type of chromosomal aberration, and physicochemical characterization of the products. In addition, testing individual ingredients and reconstructed mixtures would allow separation of beverage matrix effects from effects specific to additives.

Therefore, the data obtained support the conclusion that the three products exerted detectable cytological effects on the *A. cepa* meristem under the experimental conditions investigated. However, they do not draw a direct conclusion regarding the toxicity of these beverages to humans or the establishment of clinical risk. The *Allium* test should be regarded as a screening and toxicological hypothesis-generating tool that can subsequently support more complex investigations.

CONCLUZII CONCLUSIONS

All three tested beverages reduced the mitotic index of the *Allium cepa* meristem compared with the control after both 6 and 24 hours. After 6 hours, the greatest inhibition of proliferation was observed for Olympus natural orange juice (MI = 54.0), followed by Pfanner 100% Orange (59.6) and Fanta (60.2). After 24 hours, the mitotic indices were closer among the products: 62.8 for Olympus, 61.8 for Pfanner, and 61.4 for Fanta.

Relevant cytological and cytogenetic alterations were identified, including heterochromatinization, vacuolization, pyknosis, micronuclei, chromatid bridges, plasmolysis, and abnormal cytokinesis.

The results confirm the usefulness of the *Allium cepa* test as a screening method for evaluating the cellular effects of complex food products. The data does not allow the effects to be attributed to a specific additive and cannot be directly extrapolated to toxicity in humans; biological replicates, statistical analyses, and chemical characterization of the products are required for a more comprehensive assessment.

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**STUDIES ON THE INFLUENCE OF THE IRRIGATION REGIME ON
THE YIELD AND QUALITY OF RADISH
STUDII PRIVIND INFLUENȚA REGIMULUI DE IRIGARE ASUPRA
PRODUCȚIEI ȘI CALITĂȚII RIDICHILOR DE LUNĂ**

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REZUMAT

Lucrarea „Studii privind ridichile de lună în cultură irigată”, evidențiază modul în care această cultură poate fi dezvoltată în sere, prin irigare prin picurare. Scopul meu a fost să descopăr cum putem produce ridichi de calitate, cu aspectul perfect, în sezonul rece, atunci când prețul de vânzare este foarte bun. Desfășurat pe o perioadă de 31 de zile, de la 5 noiembrie până la 6 decembrie 2025, experimentul a constatat în alegerea soiurilor Cherry Belle și Yulka, cele mai populare în rândul consumatorilor. Având în vedere că ridichile au rădăcini scurte și sunt foarte sensibile la secetă, am aplicat irigarea prin picurare, asigurându-ne că plantele au avut la dispoziție mereu o umiditate optimă, astfel încât să nu-și schimbe gustul. La terminare, am măsurat cele mai importante caracteristici ale plantelor (lungimea frunzelor, diametrul rădăcinii, greutatea ridichii).

Din aceste rezultate am putut observa că o irigare uniformă a solului a favorizat o dezvoltare armonioasă și rapidă a soiului Yulka. Principala concluzie este că o simplă instalație de irigare prin picurare într-un solar poate aduce ridichi de lună de cea mai bună calitate, chiar și iarna.

ABSTRACT

The study "Studies on early radishes under irrigation" highlights how this crop can be cultivated in greenhouses using drip irrigation. My goal was to discover how to produce high-quality radishes with a perfect appearance during the cold season, when market prices are very favorable. Conducted over a 31-day period—from November 5 to December 6, 2025—the experiment involved selecting the Cherry Belle and Yulka varieties, which are the most popular among consumers. Given that radishes have short roots and are highly sensitive to drought, I employed drip irrigation to ensure the plants always had access to optimal moisture levels, thereby preventing any alteration in flavor. Upon completion, I measured key plant characteristics: leaf length, root diameter, and radish weight.

The results showed that uniform soil irrigation fostered harmonious and rapid development in the Yulka variety. The main conclusion is that a simple drip irrigation system in a greenhouse can yield top-quality radishes, even in winter.

Cuvinte cheie: ridichi, irigare, picurare.

Keywords: radishes, irrigation, drip irrigation

INTRODUCERE

INTRODUCTION

The main challenge in greenhouse cultivation, particularly during the winter months or the transition between seasons, is maintaining adequate soil moisture. Radishes have relatively shallow root systems and respond rapidly to water shortages. If the soil dries out, even for a short period, the roots may become excessively pungent, develop a woody texture, or crack when irrigation is resumed, rendering them unmarketable. Therefore, installing a drip irrigation system is no longer an optional improvement but an essential component of the cultivation technology, ensuring a consistent level of soil moisture.

MATERIAL ȘI METODĂ DE CERCETARE

MATERIAL AND METHOD

The greenhouse located within the faculty premises is intended for the cultivation and research of vegetable crops, providing a specially designed environment for teaching, practical training, and experimental activities.

The use of modern technologies for monitoring and controlling environmental factors enables the optimization of cultivation processes, the achievement of high yields and superior crop quality, and the efficient use of available resources. Thus, the greenhouse represents an example of the application of modern technologies in horticulture and provides an important resource for the professional training of students and academic staff.

For the purposes of this research, the experiments were conducted at the experimental teaching facility of Ovidius University of Constanța, taking into account the characteristics of the experimental site and the climatic conditions of the area. The main objective of this study was to evaluate the morphological characteristics of radish plants and the yields obtained from two radish cultivars grown under protected cultivation conditions.

Throughout the growing season, morphophysiological observations and biometric measurements were carried out for each experimental treatment.

REZULTATE ȘI DISCUȚII

RESULTS AND DISCUSSIONS

Modern agriculture faces numerous challenges, including access to water and the maintenance of soil fertility under increasingly evident climate change. In this context, selecting an appropriate cultivation system, whether under irrigated or rainfed conditions, is essential for achieving stable yields and ensuring the efficient use of available resources.

This study investigated several morphological and productivity-related characteristics of plants, providing insights into how cultivation conditions influence plant growth and development.

The experiment was conducted on radish plants grown under irrigated conditions. Throughout the growing season, observations of plant development and a series of biometric measurements were carried out. These assessments aimed to highlight the effects of water availability on vegetative growth and the main yield-related traits contributing to crop productivity.

Observations were conducted on a representative number of plants from each irrigated experimental treatment, and the collected data were subsequently analyzed to identify differences between the two radish cultivars.

The following section presents the results obtained regarding the length and weight of the leaves and modified roots.

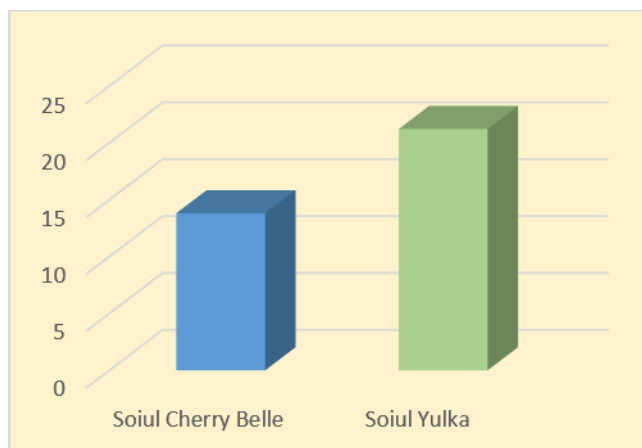


Figure 1. Distribution of leaf length

Under drip irrigation conditions, clear differences in leaf length were recorded between the two cultivars. The Cherry Belle cultivar exhibited an average leaf length of 13.8 cm, whereas the Yulka cultivar recorded a significantly higher value of 21.2 cm.

These results indicate greater vegetative growth in the Yulka cultivar under drip irrigation conditions, suggesting more efficient utilization of water and nutrients.

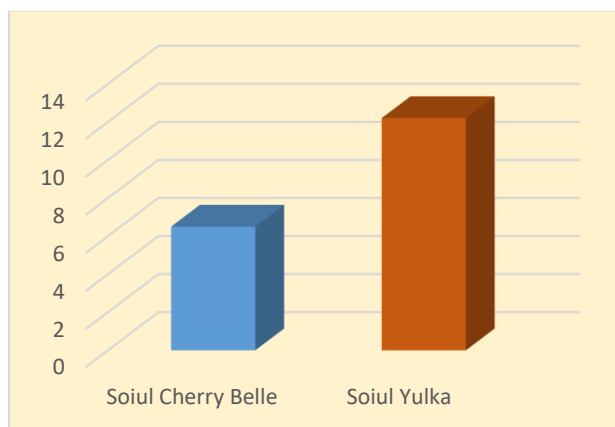


Figure 2. Distribution of leaf weight

Under greenhouse cultivation and drip irrigation conditions, leaf biomass showed significant differences between the two cultivars analyzed. The Cherry Belle cultivar recorded an average leaf biomass of 6.5 g, whereas the Yulka cultivar reached a value of 12.2 g, almost twice as high.

Greater leaf biomass contributes to increased photosynthetic activity and may positively influence crop productivity.

Regarding radish root diameter, significant differences were observed between the two cultivars analyzed. The Cherry Belle cultivar recorded an average diameter of 57.75 mm, considerably exceeding that of the Yulka cultivar, which exhibited a value of 30.35 mm.

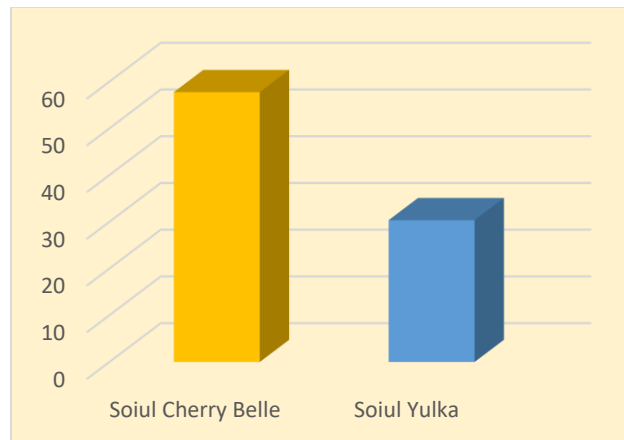


Figure 3. Distribution of root diameter

The results demonstrate a greater capacity for swollen root development in the Cherry Belle cultivar, which may represent an advantage in terms of marketability and productivity.

To assess the influence of water availability on radish development, root weights were measured.

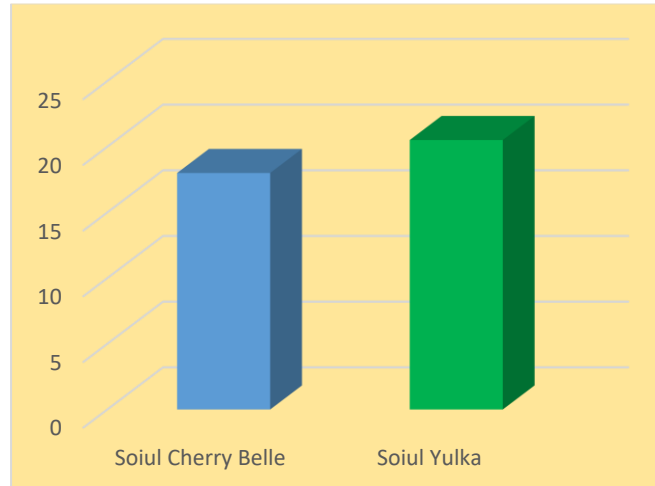


Figure 4. Distribution of root weight

The results indicate higher productivity in the Yulka cultivar under the experimental conditions investigated, suggesting a greater capacity for biomass accumulation in the swollen root.

The comparative evaluation of accumulated belowground biomass highlights the superior productive performance of the Yulka cultivar compared with Cherry Belle.

CONCLUZII CONCLUSIONS

Following the experimental study conducted at Ovidius University of Constanța, which aimed to investigate the effects of irrigation on the radish cultivars analyzed, the following conclusions were drawn:

1. Monitoring conducted between 5 November 2025 and 6 December 2025 revealed an overall decline in vegetative growth, characterized by reductions in leaf length, weight, and number, as well as root diameter. This biometric decline was directly associated with the restrictive climatic conditions specific to the cold season, particularly the shortening of the photoperiod and decreasing temperatures.

2. The Yulka cultivar demonstrated markedly greater physiological tolerance and structural stability under thermal stress conditions compared with the Cherry Belle cultivar. While Cherry Belle exhibited reduced values of leaf-related parameters, Yulka maintained relatively stable leaf biomass and even showed a slight increase in vegetative development.

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**STUDY OF THE PARTICULARITIES OF SOIL GENESIS
IN THE TECHIRGHIOL LAKE AREA
STUDIUL PARTICULARITĂȚILOR GENEZEI SOLURILOR DIN
ZONA LACULUI TECHIRGHIOL**

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REZUMAT

Cercetările au fost efectuate asupra solurilor situate în zona limitrofă lacului Techirghiol, din județul Constanța. Scopul studiului a fost evidențierea particularităților proceselor de formare a solurilor în condițiile specifice mediilor saline și ale conținutului ridicat de argilă din materialul parental. De asemenea, studiul a urmărit identificarea diferențelor dintre proprietățile acestor soluri și cele ale solurilor zonale întâlnite în imediata vecinătate. În vederea realizării cercetării, au fost deschise și caracterizate cinci profiluri de sol, atât din punct de vedere morfologic, cât și pedogenetic. Pe baza investigațiilor efectuate în teren și a rezultatelor analizelor de laborator realizate asupra probelor de sol, s-a constatat existența unui facies pedologic distinct, determinat de condițiile pedogenetice locale, respectiv: material parental bogat în argilă, exces de apă freatică salină și climat arid, influențat de mediul litoral. Totodată, studiul urmărește să stabilească dacă solurile din această zonă prezintă caracter takiric. În cadrul sistemului de clasificare World Reference Base for Soil Resources (WRB), termenul „takiric” este utilizat ca un calificativ pentru solurile care prezintă caracteristici asemănătoare celor de tip takir. Principalele caracteristici ale unui sol cu caracter takiric includ: o suprafață cu textură foarte fină, argiloasă; formarea unei cruste compacte și dure în urma uscării; apariția poligoanelor de contracție (crăpături) în perioadele secetoase; alternanța pronunțată dintre perioadele scurte de umezire sau inundare și cele de secetă intensă; un conținut ridicat de argilă fină și, frecvent, de săruri; o structură masivă sau foarte slab dezvoltată; precum și o vegetație rară, caracteristică regiunilor aride și semiaride. Astfel de soluri se întâlnesc frecvent în depresiunile aride, câmpiile deșertice, pe fundul fostelor lacuri temporare și în regiunile continentale uscate. În esență, termenul „takiric” desemnează un sol bogat în argilă, caracterizat prin formarea unei cruste superficiale și apariția crăpăturilor de contracție, ca urmare a alternanței perioadelor de umezire și uscare într-un climat arid. Rezultatele obținute contribuie atât la înțelegerea proceselor de geneză a solurilor în condiții

specifice de mediu, cât și la fundamentarea unor decizii adecvate privind utilizarea terenurilor agricole de către fermieri.

ABSTRACT

The research was conducted on soils located in the area surrounding Lake Techirghiol, in Constanța County. The aim of the study was to highlight the particular features of soil formation under conditions specific to saline environments and to the high clay content of the parent material. The study also investigated the differences between the properties of these soils and those of the zonal soils found in the immediate surrounding area. For the purposes of the research, five soil profiles were established and characterized from both morphological and pedogenetic perspectives. Based on the field investigations and the analytical results obtained from the soil samples, it was found that a distinct soil facies exists, determined by local pedogenetic conditions, namely: clay-rich parent material, excess saline groundwater, and an arid climate influenced by the coastal environment. At the same time, the study investigates whether the soils in this area may exhibit a takiric character. Within the World Reference Base for Soil Resources classification system, the term “takiric” is used as a qualifier for soils that display takir-like characteristics. The main characteristics of a soil with a takiric subtype/qualifier include: a very fine, clayey surface; the formation of a compact and hard crust after drying; the occurrence of contraction polygons (cracks) during dry periods; a pronounced alternation between short periods of moisture or flooding and intense drought; a high content of fine clay and frequently salts; a massive or very weakly developed structure; and sparse vegetation, typical of arid and semi-arid regions. Such soils commonly occur in arid depressions, desert plains, former temporary lake bottoms, and dry continental regions. In summary, the term “takiric” refers to a crusted, clay-rich, and cracked soil formed under alternating wet–dry conditions in an arid climate. These results contribute both to the understanding of soil genesis processes under specific environmental conditions and to supporting appropriate land-use decisions by farmers.

Cuvinte cheie: soluri, caracteristicile solurilor, lacul Techirghiol.

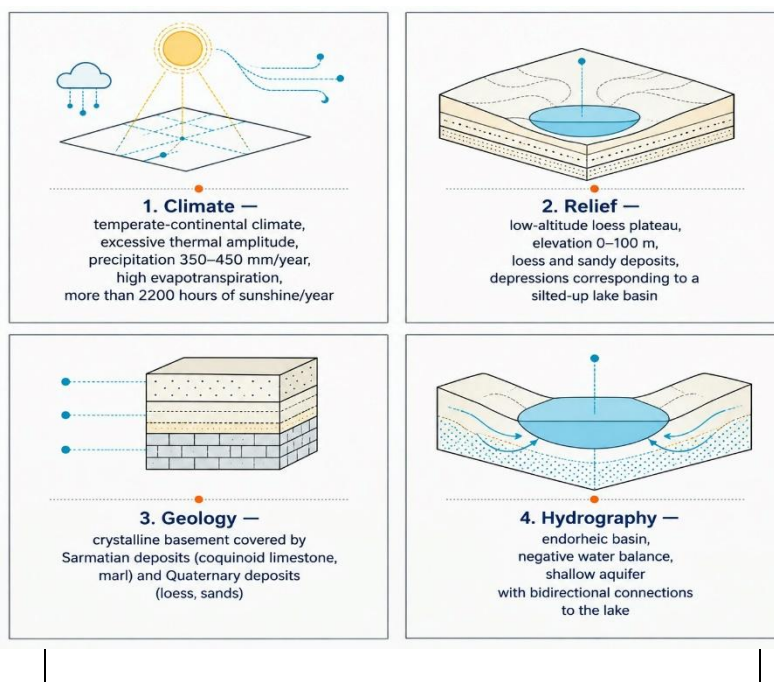
Keywords: facies soil, characteristics of soils, Lake Techirghiol.

INTRODUCERE INTRODUCTION

Lake Techirghiol is a saline lake system whose geomorphological, hydrological and ecological characteristics are directly reflected in the soils of the adjacent area. The source material indicates that the geomorphological evolution of the basin created an environment with high salinity, while the limited freshwater input contributed to salt concentration. The lake covers approximately 10.68 km², reaches a maximum depth of about 9 m and is separated from the Black Sea by a barrier spit. The salt concentration of the lake water is reported at approximately 95 g/l.

Within the investigated area, soil characteristics result from the interaction of climatic, geomorphological, geological and hydrological factors. The climate is excessively temperate-continental with Pontic influences, low precipitation of approximately 350–450 mm/year, high evapotranspiration and summer temperatures of 22–24°C, with heat-wave episodes above 35°C. The chronic water deficit and high evaporative potential favor salt accumulation.

The relief consists of a low Dobrogean platform, with elevations of 0–100 m and gently undulating surfaces developed on loess-like deposits. Regional fracture systems have favored the development of complex aquifers and local fragmentation of geological formations. Together with the proximity of the lake and variations in groundwater level, these conditions generate a heterogeneous pedological mosaic.



The vegetation includes halophytic species such as *Salicornia europaea*, *Suaeda maritima*, *Atriplex tatarica* and *Artemisia santonica*, as well as xerophytic steppe vegetation. Anthropogenic pressures identified in the source material include urbanization, tourism, intensive agriculture, groundwater abstraction, diffuse pollution and sapropelic mud exploitation.

The objective of this paper is to synthesize the pedogenetic characteristics and soil quality of the area adjacent to Lake Techirghiol, emphasizing the relationships between salinity, water regime, clay-rich parent material and land use.

MATERIAL ȘI METODĂ DE CERCETARE

MATERIAL AND METHOD

The analysis is based on the data and interpretations included in the study entitled “Soil quality in the area adjacent to Lake Techirghiol”. The investigated area covers approximately 2,950 ha and includes agricultural land, pastures and unproductive land. Soil characterization was based on five soil profiles described from morphological and pedogenetic perspectives.

The main indicators considered were soil reaction (pH), humus content, CaCO₃ content, electrical conductivity and texture. Taxonomic classification was reported according to the Romanian Soil Taxonomy System (SRTS 2012), while land-quality assessment followed the ICPA soil-bonitation approach, integrating soil, relief, climate and hydrological regime.

The interpretation of pedogenetic processes considered salinization, alkalization, gleying, carbonation and bioaccumulation. For areas characterized by alternating wet and dry conditions, the source material also discusses the possible occurrence of takiric features, including a very fine clayey surface, a compact crust after drying and contraction cracks during dry periods.

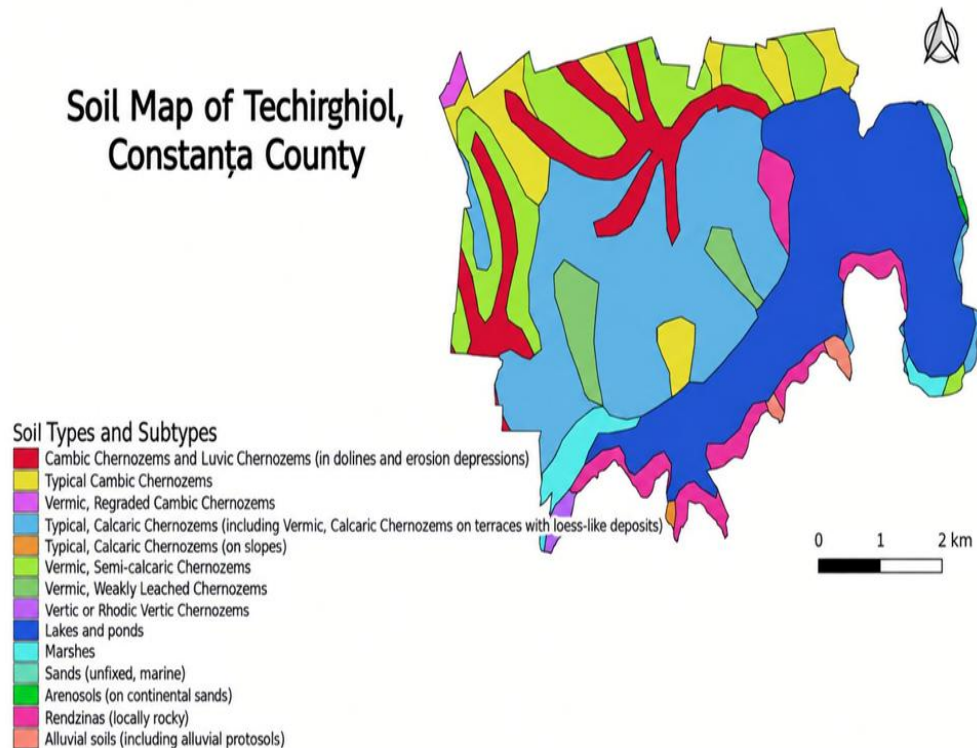
REZULTATE ȘI DISCUȚII

RESULTS AND DISCUSSIONS

According to the analyzed material, four soil classes, seven soil types and thirteen subtypes were identified within the approximately 2,950 ha study area, according to SRTS 2012. The dominant pedogenetic processes are controlled by the combination of the semi-arid climate, groundwater level, proximity to the lake and parent material. The result is a complex soil mosaic in which highly productive agricultural soils coexist with soils strongly affected by salinity and poor drainage.

The Chernisols class occupies the largest area and includes carbonate, typical, cambic, argic, vermic, vertic and rodic Chernozems. These soils are characterized by high natural fertility, humus contents of approximately 3–5%, loamy texture and slightly alkaline reaction. They represent the most valuable agricultural land in the studied area and are less affected by the direct influence of the lake.

Hydrisols and Salsodisols include soils with stronger hydrological and saline influence. Salinized Gleysol occurs in low-lying sectors with poor drainage and mineralized groundwater; its profile is characterized by greyish-blue colors and rusty mottles associated with redox processes. Gleyic Solonchak is representative of the immediate vicinity of the lake and shows very high electrical conductivity, alkaline reaction and a superficial salt crust.



<i>Profile</i>	<i>pH</i>	<i>Humus (%)</i>	<i>CaCO₃ (%)</i>	<i>Electrical conductivity</i>	<i>Texture</i>	<i>Class</i>
Carbonatic Chernozem (TCH-01)	7.4–8.1	3.5–5	2.1–14.5	0.45–0.60 dS/m	Loamy	Cernisols
Gleyic Solonchak (TCH-02)	8.5–8.8	0.9–1.8	6.2–8.5	8.5–12.2 dS/m	Loamy-sandy	Salsodisols
Salinized Gleysol (TCH-06)	8.0–8.6	low	high	high	Clay-loamy	Hydrisols

The values demonstrate a clear contrast between zonal soils and soils under the direct influence of the lake. For Gleyic Solonchak, electrical conductivity reaching 12.2 dS/m indicates severe salt accumulation and is associated with limited vegetation development. The source material states that electrical conductivity increases significantly with proximity to the lake.

The spatial distribution of land-quality classes confirms this relationship. The littoral zone includes classes IV–V associated with halomorphic soils; the transition zone includes classes III–IV with moderate salinization; and the peripheral zone includes classes II–III where slightly affected Chernozems predominate. Overall, land quality decreases progressively towards the lake as a result of high groundwater levels and salt accumulation.

Pedogenetic particularities

The literature reviewed on takyr soils in Central Asia highlights the fact that their development is closely associated with endorheic depressions and basins, fine-textured parent materials, and the alternation between temporary flooding and intense drying. Under arid conditions, episodic precipitation or runoff from adjacent areas may lead to temporary water accumulation and the deposition of fine materials, while subsequent evaporation promotes compaction, salt concentration, and clay shrinkage.

The takyr character is generally associated with a compact clayey surface that develops polygonal cracks upon drying, with platy or shale-like structure in the layer beneath the crust and very low permeability. The bibliographic material reviewed emphasizes that, in typical Central Asian soils, the crusts may reach several centimeters in thickness, and their development is controlled by the repetition of wetting and drying cycles.

An important aspect is that the relationship between salinization and takyr characteristics should not be interpreted in a simplistic manner. Soils exhibiting

takyr properties may be associated with saline environments; however, the distribution of salts within the profile may vary. In certain situations, the surface crust may have a lower salt content than the underlying horizons, as a result of ion redistribution during flooding and evaporation phases. In other situations, particularly in highly saline evaporative basins, salts may also accumulate in the upper part of the profile. This variability is important for interpreting saline soils along the Romanian coast, as the simple association of crust formation, clay content, and salinization is not sufficient to identify a genuine takyr character.

In the case of the soil from the southern part of Lake Techirghiol, the crust can be detached relatively easily, while the distance between cracks is approximately 2–3 cm. A platy structure is present both within the crust layer and in the upper soil horizon, characteristics that are specific to the formation processes of soils exhibiting takyr properties.

Based on the available information, the soil from the southern part of Lake Techirghiol exhibits several characteristics that justify considering a possible affinity with soils having takyr properties. The main arguments are its clayey texture, the endorheic nature of the relief, the temporary concentration of rainwater through runoff from the slopes, the alternation between wetting and drying, the formation of a surface crust, the presence of cracks, and the shale-like or platy structure in the upper part of the profile. These characteristics are consistent with the pedogenetic processes described for takyr soils in Central Asia.

Nevertheless, classifying the soil as having a genuine takyr character requires careful analysis of the relevant morphological and taxonomic criteria and cannot be established solely by analogy with soils from Uzbekistan or Turkmenistan. In particular, the climatic differences are substantial: the Techirghiol area is less arid, precipitation is higher, and the temperature regime is more moderate than in the typical regions where takyr develop. Furthermore, the observed crust is relatively easy to detach, while the small crack spacing, approximately 2–3 cm, may indicate a different development of the drying and compaction processes.

Therefore, the current data support, rather, the hypothesis that the soil in the southern area of Lake Techirghiol exhibits properties or morphological characteristics with takyr affinity than the firm conclusion that it should be directly classified as a soil with a takyr subtype. Such a classification would require systematic verification of the relevant diagnostic criteria concerning the thickness and consistency of the crust, the continuity and geometry of the cracks, the structure of the surface and subsurface horizons, the texture of the fine fractions, the hydraulic properties, the distribution of salts, and the relationship

between these properties and the other diagnostic characteristics of the soil profile.

From a pedogenetic perspective, the combination of clay-rich parent material, saline groundwater and an arid coastal-influenced climate creates conditions for a distinct soil facies. Alternating wetting and drying can produce a crusted surface and contraction cracks. These features are consistent with the takiric character, although the supplied material does not provide sufficient evidence for a definitive taxonomic classification based solely on this characteristic.

CONCLUZII CONCLUSIONS

Soils in the area adjacent to Lake Techirghiol show high pedological variability resulting from the interaction of climate, relief, parent material, groundwater and proximity to the lake.

2. Salinization, alkalization and gleying are key processes differentiating soils in low-lying sectors and in the immediate vicinity of the lake.

3. Chernozems have the most favorable characteristics for agricultural use, whereas halomorphic and hydromorphic soils have lower fertility and productivity.

4. The electrical conductivity of Gleyic Solonchak, reaching 8.5–12.2 dS/m, demonstrates the severity of saline influence.

5. Soil protection requires permanent pedological and ecological monitoring, reduction of anthropogenic pressures and integrated land-management measures.

6. Interdisciplinary research projects are recommended to investigate relationships among soil quality, lake-water dynamics and regional climate change, involving local authorities, research institutions and the community.

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