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PRELIMINARY DATA ON THE ADAPTABILITY OF NATIVE ALMOND VARIETIES IN SOUTH-EASTERN ROMANIA

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Abstract

This study presents preliminary data on the adaptability of two Romanian almond (Prunus amygdalus L.) cultivars, 'Mirela' and 'Veronica', under the specific eco-pedo-climatic conditions of southeastern Romania, a region characterized by heavy clay soils and increasing climatic variability. The experiment was established in December 2022 at the Moara Domnească Experimental Base, Ilfov County. The main objective was to evaluate the viability of trees during the establishment, as an indicator of adaptability to local abiotic stress factors. Soil analyses were performed before and after planting, while climatic data were collected through an automated weather station.
Results showed a survival rate of approximately 75% for both cultivars, despite the recorded precipitation deficit in 2023 (281.94 mm). The analysis of the soil revealed high clay content, slightly acidic pH in the surface horizon (6.17), and a sharp decline in available phosphorus with depth, whereas mobile potassium increased in lower horizons. The study provides a scientific basis for extending almond cultivation into non-traditional regions of Romania and highlights the importance of continued monitoring in the context of climate change.

***Key words**: almond, local cultivars, adaptability, soil fertility, viability, southeastern Romania.*

INTRODUCTION

Almond (*Prunus amygdalus* L. sin., *Amygdalus communis* L.) belongs to the Rosaceae family, subfamily Prunoidae, group Amygdalae and has its origins in the mountainous regions of Central Asia (Grasselly, 1976). This species is adapted to a Mediterranean climate with hot summers and mild, dry winters (Băluță & Stănică, 2023).
The optimum temperatures of the species are between 12 and 35°C, and the absolute minimums are 10°C and the maximums are 40°C (outside the absolute temperature range, growth stops). Frost resistance is very low, the limit being -22°C (Coman et al., 2014). Cold resistance decreases as the trees approach the start of vegetation. Open flowers are destroyed at -2.0°C and set fruits do not withstand if the temperature drops below -1.5°C (Sumedrea et al., 2014). The ability to develop a deep and extensive root system allows it to better access water and nutrients. It can also grow on less fertile soil. It prefers loamy or sandy-loamy soil, which allows good aeration and water infiltration. Excess moisture increases the risk of root diseases. Also, the soil pH should be neutral to slightly alkaline. Acid soils are commonly amended with lime (calcium carbonate or similar materials) to raise the pH and improve growing conditions for most crops (Brady & Weil, 2016).
In our country, almonds have found optimal climatic conditions in the southeast, in Constanta, Valu lui Traian, Mangalia, Tulcea, in the Banat Region, the Oltenia Region and generally along the Danube until it flows into the Black Sea.
Almonds have an exceptional nutritional and medicinal importance, due to their rich content in proteins and healthy fats, vitamins and minerals. They contribute to reducing the risk of cardiovascular diseases and improving brain function (Kalita et al., 2018).
They are also widely used in the cosmetic industry, primarily due to the properties of almond oil, which is rich in vitamins E and A and is known for its moisturizing, nourishing, and anti-inflammatory effects on the skin and hair (Kaur & Saraf, 2010; Hamid & Sarmidi, 2014).
All these benefits of almonds, along with support from European funding schemes and

national agricultural development programs, have led to an increase in almond cultivation areas across Romania. This trend positions the country to become a competitive almond producer within the European market (Melhaoui et al., 2019).
The objective of this study is to evaluate the influence of soil and agro-climatic factors on the adaptability and physiological behaviour of two almond (*Prunus dulcis*) cultivars, 'Veronica' and 'Mirela', under the specific pedoclimatic conditions of the Moara Domnească area. This location presents a challenging environment for almond cultivation due to its soil composition, which has a high clay content - a characteristic generally not recommended for this species. The experimental orchard is currently in its second-year post-establishment. Given this early stage of development, the primary parameter evaluated in this investigation is the survival rate (viability) of the young trees, serving as an initial indicator of their resilience and potential for adaptation.

MATERIALS AND METHODS

The study was conducted at the Moara Domnească Experimental Base, which is part of the Research and Development Station for Fruit Growing Băneasa. The location is situated in the northeast of Bucharest, in the Vlăsia Plain (a subunit of the Romanian Plain), Ilfov County, approximately 25 km from the capital (Lat. 44.50418179, Lon. 26.24626838).
The experimental orchard was established at the end of 2022 by planting two native almond varieties - 'Veronica' and 'Mirela'. The trees were planted at a spacing of 4 meters between rows and 2 meters within rows, resulting in a planting density of approximately 1250 trees/ha. The plantation is equipped with a drip irrigation system, and standard almond cultivation practices were applied throughout.
The 'Veronica' cultivar is characterized by low to medium vigor and a slightly open canopy structure. It blooms in the middle of the season, and fruiting occurs predominantly on spur clusters and mixed shoots. The fruits are medium-sized, oval-shaped, slightly pointed at the tip, and convex on the dorsal side. The shell is greyish green in color and covered with fine hair. The kernel is oval, with a pointed tip, pearly white in color, and has an average weight of approximately 2.2 g. This variety shows good tolerance to fungal diseases and drought, which contributes to lower phytosanitary treatment costs. It is a productive cultivar, with an average yield of up to 2.3 kg of kernel/tree (Băluță, 2022).
The 'Mirela' cultivar exhibits medium vigor and has a slightly open growth habit. Its blooming period is mid-to-late and extends over a relatively long duration. Fruiting occurs mainly on spur clusters. The in-shell fruits are medium to large, with a thick shell of medium hardness when cracked. The kernel is short but broad, with an average weight of approximately 2.5 g, and a low incidence of double kernels. This variety is productive but shows some sensitivity to alternate bearing. The fruits contain low levels of mineral elements but are rich in oils, with a low linoleic acid content and a high oleic acid content, according to the fatty acid profile. The oleic acid content varies between 60% to 75%, linoleic acid content is between 16% to 30% (Yada et al., 2011). Together, these two fatty acids typically make up over 85-90% of the total lipid content in almonds (Houmy et al., 2014). The fruits of both cultivars can be consumed fresh or processed for use in the food and pharmaceutical industries (Opriță et al., 2022).
The soil type at Experimental Base Moara Domnească is a reddish preluvosoil.
To determine the suitability and degree of adaptability of almond to the pedological conditions in the study area, Moara Domneasca, soil samples were taken to analyze its main physical and chemical properties. The evaluation of these characteristics is essential for establishing the soil's capacity to support healthy almond growth, considering the species' specific requirements for texture, structure, pH and nutrient content.
The samples were analyzed according to the "Methodology for the Elaboration of Soil Studies" – I.C.P.A. Bucharest, 1987, in the Agrochemistry Laboratory of the Fruit Growing Research and Development Station Băneasa, Bucharest (Dogaru, 2024).

Soil Chemical Analysis Determinations

Soil sampling was carried out according to STAS 7184/1-84, at a depth of 0-20 cm. Each soil sample consisted of 20 subsamples, combined to represent the average characteristics of the soil.

In the laboratory, the samples were analyzed using STAS methods, also employed by ICPA Bucharest, as follows:

- **pH** was determined in aqua extract, with a soil-to-water ratio of 1:2.5, using a Hanna pH meter, according to SR 7184-13.
- **The colorimetric determination of mobile phosphorus** in ammonium lactate-acetate extract (PAL) was carried out using the Egner-Riehm-Domingo method. The values were read using a UV-VIS spectrophotometer (CAMSPEC M 330), and the results were expressed in ppm, according to STAS 7184/19-82.
- **The determination of mobile potassium content** (KAL) was performed in ammonium lactate-acetate extract, using the Egner-Riehm method, through flame photometry. The results were expressed in ppm, in accordance with STAS 7184/19-82.
- **The humus content** was determined by wet oxidation using the Walkley-Black-Gogoaşă method, followed by titrimetric measurement, according to STAS 7184/21-82.

  Depending on the soil pH, additional agrochemical indicators of fertility were also determined:
- **Hydrolytic acidity (Ah)** was determined using the Kappen method, with results expressed in me/100 g soil.
- **Sum of exchangeable bases (SB)** was determined by the Kappen method as well, and results were also expressed in me/100 g soil, according to STAS 7184/12-88.
- **Base saturation percentage (V_{Ah})** was calculated using the formula $V_{Ah} = SB * 100/ (SB + Ah)$, according to STAS 7184/12-88.

RESULTS AND DISCUSSIONS

The following soil characteristics were determined (by granulometric analysis for determination of the soil content in clay, dust and sand): a high percentage of clay ranging from 40.55% in the upper horizon 0-40 cm, to 41.63% at a depth of 41-53 cm and 47.39% at depths greater than 54 cm (Table 1).

The clay texture determines a low mobility of nutrients and a poor permeability of the water in the soil (Negrușier et al., 2024). Under these conditions, the almond root system is prone to asphyxiation and fungal infections, manifested by stunted growth and reduced plant vigor.

A study conducted in almond production areas in Spain showed that clayey soils can induce root asphyxiation problems and stress caused by flooding, significantly affecting tree survival and growth (Forcada et al., 2020).

Table 1. The granulometric composition of the soil (Experimental Base Moara Domnească, 2019)

Horizon	**Ao**	**Ao/Bt**	**Bt**	**C**
Depth(cm)	0-40	41-53	54-200	Over 200
Clay (%)	40.55	41.63	47.39	36.18
Coarse sand (%)	0.36	0.52	0.37	0.42
Fine sand (%)	34.33	21.54	27.59	32.04
Dust (%)	24.75	56.28	30.34	32.04
Texture	Clay loam	Clay loam	Clay loam	Clay loam

- **Nitrogen index (IN)** was determined as $IN = H * V_{Ah}/100$, in accordance with STAS 7184/12-88

Climatic condition can be an important factor in evaluating almond adaptability. Climatic data on temperature and precipitation were collected using an Adcon automated weather station, operational since its installation on June 5, 2020.

The soil content in humus is good in the first 40 cm of profile, where most of the roots of young trees are located, reaching the value of 3.26%, then suddenly decreases up to 1% in the Bt horizon profile (Table 2).

Total nitrogen is higher in the superficial layer (0.144%) and decreases in depth (0.07%), following the typical trend of organic matter mineralization. Total cation exchange capacity values (28.04-30.0 meq/100 g) indicate a high nutrient retention capacity, specific to soils with high clay and organic matter content (Dogaru & Damian, 2021).

The pH is slightly acidic at the soil surface (6.4), reaching alkaline (8.3) in the C horizon

Almonds tolerate slightly acidic pH, but do not provide ideal conditions for the efficient absorption of essential nutrients, especially calcium, magnesium and phosphorus (https://www.yara.us/crop-nutrition/almond/ growth -requirements/). For optimal and healthy development, the pH should be between 6.5-8.0 (Muhammad et al., 2017).

Table 2. Physical and chemical properties of the profile soil (Experimental Base Moara Domneasca, 2019)

Horizon	**Ao**	**Ao/Bt**	**Bt**	**C**
Humus, (%)	3.26	1.87	1.00	1.00
Soluble Ca (mg/100g soil)	55	32	32	30
Hydrolitic acidity (meq)	2.8	2.04	1.72	0.18
Exceangeable Bases (meq)	22.6	23.62	26.28	-
Total cation exchange capacity (meq)	28.65	28.04	30.01	-
Degree of saturation in bases (%)	78.94	84.28	87.53	-
pH	6.4	6.6	6.8	8.3
Total N (%)	0.144	0.102	0.075	0.07
Phosphorus soluble in AL (mg/100 g soil)	50	40	40	30

Other indicators like the nitrogen index (NI), hydrolytic acidity, humus, organic carbon and so on were determined during before planting (2022).
One of the most important factors in agriculture is the environment in which the plant grows and develops. Substrates must be able to provide the necessary water, nutrients and oxygen for plants, as well as support for the whole plant (Miller & Jones, 1995).
The range of analyses, which includes pH, potentially available phosphorus content, potentially available potassium content, and humus content, highlights the soil's fertility status (Table 3).
With values of 2.70 and 4.50, the nitrogen index in the analyzed profiles (2022) indicates a good to very good nitrogen fertility, which supports a proper vegetative growth in the early stages of almond development.
Soluble phosphorus (AL) levels were adequate in the 0-20 cm soil layer (81.11 mg/kg) but decreased notably in the 20-40 cm layer (55.56 mg/kg), which may adversely affect deep root system development, particularly during the establishment phase. These values are adequate for almond cultivation (according to Romanian agrochemical norms: >30 mg/kg = well supplied). The mobile potassium content is high (192-233 mg/kg) in both layers, which favors the flowering and fruiting processes. Potassium is essential for drought resistance – an important advantage in the climatic conditions of 2023.
The degree of base saturation is over 90% in the upper horizons (very good values), which reflects a soil well supplied with essential cations (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}).
Fertility indicators, such as humus content, total nitrogen, and mobile potassium, exhibit progressively higher values with increasing depth of the analyzed soil profiles. This trend indicates a greater accumulation of nutrients in the lower horizons, which may be utilized by employing rootstocks with deep rooting systems. Such rootstocks can access these resources in deeper soil layers, thus contributing to the sustainable development of almond cultivation.

Table 3. Chemical properties of the soil, before planting (Experimental Base Moara Domneasca, 2022

Depth (cm)	0 - 20	20 - 40
pH	6.17	6.31
Soluble Bases (mg/100 g soil)	24.95	24,57
Hydrolytic acidity (mg/100 g soil)	1,82	2.60
Humus, (%)	2.90	4.98
Organic Carbon	1.68	2.89
Total cation exchange capacity	26.77	27.17
Degree of saturation in bases (%)	93.20	90.43
Nitrogen index	2.70	4.50
Phosphorus soluble in AL (mg/kg)	81.11	55.56
Potassium soluble in AL (mg/kg)	192.00	233.00

Another significant limiting factor for almond adaptability is climatic conditions, especially temperature and precipitation. The alternation of temperatures during winter, characterized by periods of warming followed by the sudden return of frost, negatively affects almond flower buds. This thermal variation can lead to the premature triggering of physiological processes in the buds, which thus become more sensitive to subsequent low temperatures, resulting in significant fruit losses (Keleta et al., 2022).
Moara Domneasca, located in Ilfov County, Romania, has traditionally exhibited a temperate-continental climate, marked by warm summers and cold winters. However, beginning in 2022, notable alterations in the local climatic

regime have been observed, likely attributable to broader climate change trends.

The average annual temperature in the area is approximately 12°C, and annual precipitation typically ranges between 550 and 600 mm. In this study, we considered the mean values of temperature and precipitation.

In 2023, extreme temperature variations were recorded. The absolute minimum was observed in February (-8.6°C), while the highest temperature occurred in July, reaching 40.5°C, surpassing the maximum recorded in 2022. The average monthly temperatures in 2023 ranged from a low of 3.2°C in February to a high of 26.0°C in August (Figure 1).

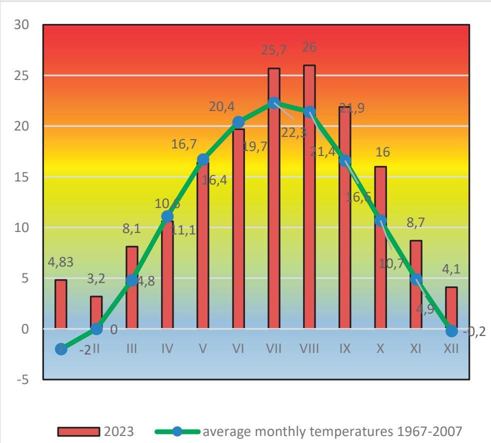

Figure 1. Annual average temperatures 2023 compared to multi-year average temperatures - Moara Domnească

Regarding precipitation, the year 2023 was exceptionally dry. Almond (*Prunus amygdalus*) is considered a species with good drought tolerance.

However, the total rainfall recorded in 2023, of only 281.94 mm, representing less than half of the multiannual average of 610.9 mm, is significantly below the average water requirements of almond, which vary between 600 and 800 mm annually (Egea et al., 2010; Goldhamer, 1999).

Precipitation distribution throughout the year was uneven (Figure 2), with the lowest recorded in September (0.3 mm) and the highest in April (59.4 mm).

This irregular distribution of rainfall affected the percentage of establishment and initial development of young almond tree.

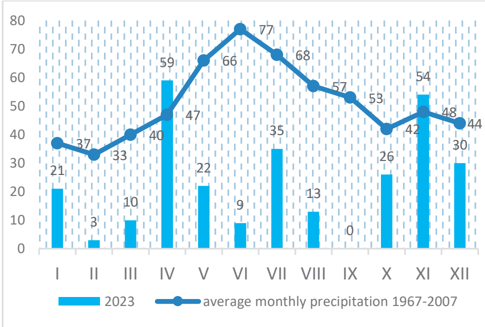

Figure 2. Average annual precipitation 2023, compared to multi-year averages (Source:own processing)

The lack of available soil moisture, particularly during the spring and summer months, critical periods for root system initiation and adaptation to the environment, can lead to losses among the planted material. These losses are reflected in the tree viability rate, calculated as the ratio between the number of dried trees and the total number of trees planted for each cultivar (Table 4). Thus, the percentage of losses was relatively similar between the two cultivars analyzed, with 24.33% for the 'Mirela' cultivar and 24.77% for 'Veronica'.

Table 4. Almond Tree viability in 2023 (Source: own processing)

Almond Cultivar	Viable Trees	Total Trees	Dry Trees (%)	Viable Trees (%)
Mirela	225	297	24.33	75.45
Veronica	113	151	24.77	75.67

This close percentage indicates that the climatic variations during the winter did not clearly favor or disadvantage either variety. It can be concluded that both cultivars demonstrated comparable adaptability to the local pedoclimatic conditions, and the observed tree losses are more likely the result of cumulative factors (such as planting stress, post-transplant shock, or localized deficiencies) rather than a direct consequence of temperature or precipitation extremes during the evaluated period.

The high temperatures recorded in 2023 did not appear to be the primary limiting factor, as tree establishment rates remained relatively high. However, the severe precipitation deficit created significant water stress for the young trees, negatively affecting their viability (Figure 3).

Figure 3. Correlation between Climatic Indicators and Almond tree Viability by cultivar (2023) (Source: own processing)

It is worth emphasizing that the implementation of an irrigation system is essential to alleviate water stress, support root system development, and ensure the overall physiological performance and resistance of almonds. In the context of prolonged periods of drought, supplementary irrigation plays an essential role in ensuring the long-term sustainability of almond crops. This aligns with the findings of García-Tejero et al., (2019), who demonstrated that deficit irrigation strategies, when properly managed, can enhance water-use efficiency without compromising yield, making them a sustainable approach in semiarid Mediterranean environments.

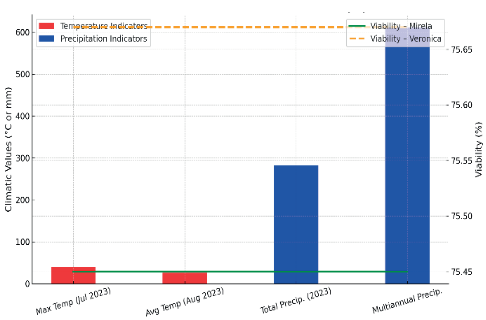

Figure 4. Image with almond tree ‘Mirela’ (Source: original photo)

Figure 5. Image with almond tree ‘Veronica’ (Source: original photo)

CONCLUSIONS

The preliminary results of the study conducted at the Moara Domneasca experimental base highlight a promising adaptability of the two Romanian almond cultivars, ‘Veronica’ and ‘Mirela’, to the pedoclimatic conditions of southeastern Romania. These findings suggest that almond can be successfully cultivated in the Moara Domneasca area, provided that appropriate technological measures are implemented, such as:

- selection of rootstocks suited to heavy-textured soils.
- application of soil amendments (organic and mineral) to improve soil structure.
- implementation of effective drainage systems and soil loosening operations.
- differentiated fertilization, considering the uneven distribution of macronutrients.
- use of leguminous intercrops to help loosen the soil.
- application of mulch (straw, leaves) for soil protection and enhancement.

The correlation between climatic data and the planting success rate highlighted the crucial importance of drip irrigation during the critical rooting months (May-August).

The results highlight that young trees establishment and early development are influenced not only by climatic conditions but also by a combination of pedoclimatic and technological factors, including planting stress and soil-specific fertility.

In summary, the cultivars ‘Mirela’ and ‘Veronica’ demonstrate stable agronomic performance under stress conditions,

representing a viable option for the expansion of almond cultivation in Romania.
However, it is essential to continue medium- and long-term research to evaluate fruiting performance, kernel quality, and disease dynamics in the context of current climate change.

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