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COMPARATIVE STUDY ON THE TECHNOLOGICAL AND AGRO–ECONOMIC TRAITS OF SELECTED PLANT SPECIES IN ROMANIA

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Abstract: This study presents a comparative analysis of six key field crops widely cultivated in Romania: alfalfa (Medicago sativa), corn (Zea mays), durum wheat (Triticum durum), winter barley (Hordeum vulgare), winter oat (Avena sativa), and sorghum (Sorghum bicolor). Technological parameters—including vegetation period, fertilization and irrigation requirements, and soil preferences—were analyzed together with agro–economic indicators such as implementation and maintenance costs, average yields, and market prices. The results indicate that corn and sorghum achieve the highest grain productivity and cost–efficiency, while alfalfa improves soil fertility through biological nitrogen fixation, reducing subsequent fertilizer needs. Winter barley and oats contribute to rotational flexibility through early land release, whereas durum wheat, though sensitive to pedo–climatic conditions, remains attractive for its premium market value. The integration of these crops into well–designed rotations enhances resource use efficiency, improves farm resilience to climate variability, and supports the objectives of the EU Common Agricultural Policy (CAP) for sustainable and profitable farming systems in Romania.
Keywords: technological traits; agro–economic performance; crop rotation; sustainability; climate resilience

INTRODUCTION

Romania's agricultural sector is undergoing a profound transformation as it adapts to new market demands, climate variability, and the requirements of the European Union's Common Agricultural Policy (CAP) 2023–2027. The country benefits from diverse pedo–climatic conditions, ranging from the fertile chernozems of the Danube Plain to the sandy soils of Dobrogea and the hilly areas of Transylvania, which collectively allow the cultivation of a wide array of field crops (*Ion, 2010*). This diversity provides opportunities for crop rotation systems that improve soil fertility, reduce pest pressure, and stabilize yields.

In recent years, increased frequency of droughts, rising fertilizer and energy costs, and the push towards climate–smart agriculture have forced farmers to re–evaluate crop choices (*Năescu & Alionte, 2008*). Crops that are drought–resilient, such as sorghum, or capable of biologically fixing nitrogen, such as alfalfa, are becoming more important in sustainable rotations. Likewise, cereals like corn and barley remain dominant due to their high productivity and multiple uses in food, feed, and bioeconomy applications (*Kazungu et al., 2023*).

Another consideration is market orientation. Premium crops like durum wheat, used extensively for pasta production, can provide higher profit margins but require stricter technological discipline and optimal soil–climatic conditions (*Dimitrios, 2023*). Winter barley and oats are critical not only as feed grains but also as rotational crops that release land early, enabling double cropping or timely establishment of subsequent crops (*Ruja et al., 2021*). Their integration into farming systems contributes to better land use efficiency and risk management.

The importance of balancing technological feasibility with economic profitability has been highlighted by several studies that recommend mixed systems integrating legumes, cereals, and industrial crops for maximum resilience (*El Chami & El Moujabber, 2024*). Furthermore, the EU's Green Deal and Farm–to–Fork Strategy emphasize reducing synthetic fertilizer use and increasing nitrogen–use efficiency, which further supports the inclusion of legumes such as alfalfa to naturally supply nitrogen to the soil (*Avgoustaki & Xydis, 2021*). Figure 1 presents the drivers and outcomes of crop selection in the current context of Romanian agriculture.

This paper aims to contribute to this debate by conducting a systematic comparative study of six representative crops cultivated under Romanian conditions: alfalfa (*Medicago sativa*), corn (*Zea mays*), durum wheat (Triticum durum), winter barley (*Hordeum vulgare*), winter oat (*Avena sativa*), and sorghum (*Sorghum bicolor*). By examining both technological

parameters (crop cycle, fertilization, irrigation, soil preferences) and agro–economic traits (implementation cost, yield, and profitability), we provide farmers and policymakers with a decision–support framework for optimizing rotations, improving resource efficiency, and enhancing farm income under conditions of climate change and market volatility.

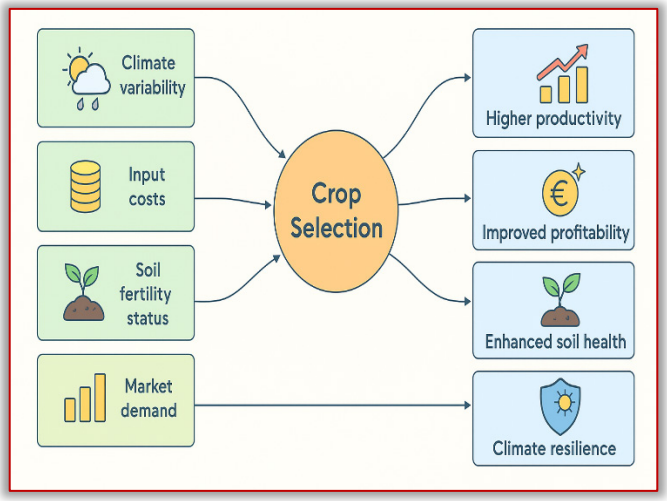

Figure 1 – Drivers and outcomes of crop selection

The crops analyzed in this study represent essential pillars of Romanian agriculture due to their combined contribution to food security, feed supply, and soil fertility management. Corn is the most widely cultivated cereal in Romania, covering over 2.4 million hectares annually and serving as a primary energy source for livestock feed and the bioethanol industry (*Dragomir eta al., 2022; Gumovschi A., 2021; Halmajan eta al., 2017; MADR, 2024*).

Sorghum has gained increasing importance as a drought–tolerant alternative, capable of producing stable yields even under water scarcity, making it a valuable tool for climate adaptation strategies (*Kazungu et al., 2023*). Durum wheat, though occupying a smaller share of arable land, is crucial for the pasta industry and offers premium prices, incentivizing its cultivation in suitable areas (*Dimitrios, 2023; Kalender & Dogan, 2021*). Winter barley and oats provide flexibility within rotations, allow early land release, and supply high–quality feed for monogastric animals *(Ruja et al., 2021*). Alfalfa plays a unique role as a perennial forage crop, improving soil nitrogen content through biological fixation, reducing fertilizer costs, and enhancing subsequent cereal yields (*El Chami & El Moujabber, 2024; Salceanu et al., 2023*).

The strategic integration of these species ensures both agronomic sustainability and economic resilience, aligning with the objectives of the EU Common Agricultural Policy (CAP) 2023–2027, which prioritizes climate–smart farming, resource efficiency, and soil health restoration (*European Commission, 2022*).

MATERIALS AND METHODS

The study is based on a synthesis of multiple data sources, including technical crop sheets for Romania published by the Ministry of Agriculture and Rural Development (*MADR, 2023–2025*), official price data from the National Agency for Fiscal Administration (ANAF), and relevant scientific literature on agronomy and crop physiology (*Ion, 2010; Dimitrios, 2023; Kazungu et al., 2023*).

Parameters Analyzed

For each of the six selected species—alfalfa, corn, durum wheat, winter barley, winter oat, and sorghum—two major categories of parameters were assessed:

— TECHNOLOGICAL PARAMETERS: crop cycle duration, sowing period, irrigation requirements, fertilizer recommendations (N, P_2O_5, K_2O), soil type suitability, and crop rotation implications.

— AGRO–ECONOMIC PARAMETERS: costs for seedbed preparation, sowing, and crop maintenance (fertilization, plant protection treatments, mechanized operations), main and secondary yields, and official selling prices.

Comparative Analysis Methodology

Data were normalized to standard units (EUR/ha for costs, tons/ha for yield) to allow direct comparison across species. Yield data were expressed as national averages under normal technological conditions, and where available, supplemented with results from research station trials. Prices were expressed as RON/kg based on the most recent annual averages reported by ANAF and Romanian grain exchanges.

This integrated approach ensured that both biological and economic performance were evaluated consistently, providing a holistic view of crop competitiveness under Romanian farming conditions.

RESULTS

The comparative assessment revealed clear distinctions between the six species in terms of both technological requirements and economic performance. The results are presented in two subsections—technological traits and agro–economic traits—followed by a graphical interpretation and discussion of their implications for Romanian farming systems.

Technological Traits

Table 1 summarizes the technological characteristics of the crops. Perennial forage crops such as alfalfa demonstrated the ability to remain productive for up to 3–5 years, offering rotational benefits through biological nitrogen fixation. Corn and sorghum showed the highest adaptability and yield potential, with sorghum being particularly resilient to drought stress. Durum wheat and winter barley required precise technological management, with barley benefiting from early sowing and taking advantage of winter moisture. Winter oat was identified as a crop with moderate soil requirements and good nutrient use efficiency.

Table 1. Technological traits of the six crops studied

Crop	Vegetation Period (days)	Irrigation Requirement	Fertilizer Needs (kg/ha)	Soil Preference	Rotation Role
Alfalfa	60–70 to first cut, 3–5 years exploitation	Recommended under drought	P_2O_5: 80–120; N: only poor soils; K_2O: 70–80	Neutral, well–drained chernozem, alluvial	Excellent predecessor, improves soil N
Corn	100–150	Recommended; 3–4 irrigations	N: 90–200; P_2O_5: 30–100; K_2O: 40–80	Deep loamy soils, humus ≥3%	Good for rotations, returns K
Durum Wheat	262–266	Recommended	N: 100; P_2O_5: 60–80; K_2O: 40–60	Warm, well–drained chernozems	Exhaustive crop, needs 3–4 yr break
Winter Barley	255–265	Beneficial in dry years	N: 50–90; P_2O_5: 60–80; K_2O: 40–60	Medium–textured soils	Early land release, good for rapeseed
Winter Oat	~300	Optional (20–30% yield gain)	N: 30/t grain; P_2O_5: 7/t; K_2O: 30/t	Loamy or sandy–loam	Moderate nutrient consumer
Sorghum	100–140 (grain)	1–7 irrigations	N: 70–100 (200 if irrigated); P_2O_5: 60–80; K_2O: 40–60	Poor, sandy, eroded soils tolerated	Can be grown in monoculture 3–5 yrs

*source: (https://www.madr.ro/culturi–de–camp/cereale/.html; Ion V., 2010; EU, 2022; Gumovschi A., 2021, Naescu and Alionte, 2008)

Agro–Economic Traits

Implementation and maintenance costs varied considerably between crops (as shown in Table 2). Durum wheat exhibited a more moderate cost range (200–500 EUR/ha) than previously reported, which positions it closer to barley and oats in terms of financial accessibility. Nevertheless, profitability still depends on securing good grain quality and market prices. Corn and sorghum were associated with high yields and good cost–to–output ratios, while alfalfa demonstrated cost efficiency due to its multi–year exploitation potential. Barley and oats remained competitive due to their relatively low input requirements and early land release.

Table 2. Agro–economic traits of the six crops studied

Crop	Implementation Cost (EUR/ha)	Maintenance Cost (EUR/ha)	Main Yield (t/ha)	Price (RON/kg)	Remarks
Alfalfa	220–420	140–220	35–45 (green mass)	900–1100 / ton hay	Multi–year use reduces costs
Corn	470–680	300–460	6–8 grain	0.8–1.1	High energy feed and industrial uses
Durum Wheat	200–500	160–280	3–4 grain	0.7–1.1	Premium for pasta industry
Winter Barley	260–390	150–270	5–7 grain	1.0	Preferred for brewing industry
Winter Oat	340–500	180–300	1.7–5 grain	0.9–0.95	Valued for feed and specialty markets
Sorghum	360–440	200–300	4–7 grain or 25–50 silage	1.2–1.5	Excellent drought resilience

*source: https://www.madr.ro/culturi–de–camp/cereale/.html; https://bursacereale.com/stocks/; https://static.anaf.ro/static/10/Anaf/AsistentaContribuabili_r/preturi_medii/arhiva_preturi_agricole.htm.

The combined results highlight that cereals such as corn and sorghum dominate in terms of yield potential, while legumes like alfalfa provide crucial agronomic benefits by improving soil nitrogen balance and reducing fertilizer dependency. Durum wheat remains a strategic crop due to its higher market value, though it is

more sensitive to pedo–climatic conditions. Winter barley and oats, with their early harvesting period, support flexible rotations and timely soil preparation for successive crops. These insights justify a more detailed visual comparison of yield performance, production costs, and irrigation responses across the selected species.

In Figure 2, a comparison between the average grain yield is shown, confirming that corn and sorghum are the most productive cereals.

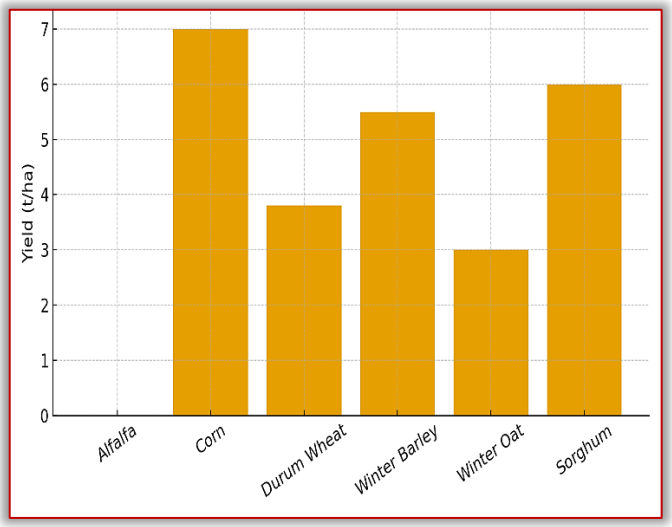

Figure 2 – Average Grain Yield per Hectare

Figure 3 shows the cost per ton of grain, where corn and sorghum have the best economic efficiency, while durum wheat, even with lower implementation costs, remains more expensive to produce per ton due to lower yields.

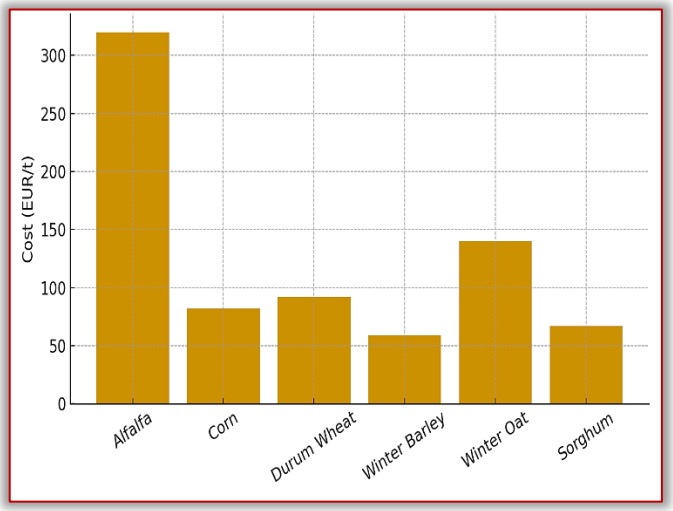

Figure 3 – Implementation Cost per Ton of Grain Produced

Figure 4 illustrates irrigation responsiveness, highlighting sorghum and corn as the most irrigation–sensitive crops, with yield increases of up to 50% and 45%, respectively.

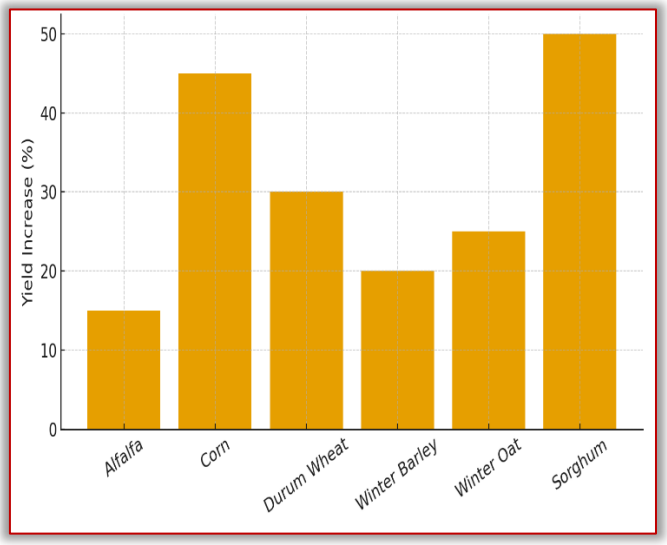

Figure 4 – Irrigation Impact on Yield

The combined assessment of technological and economic parameters confirms the complementary roles of the selected species in Romanian crop rotations.

Corn and sorghum stand out as the most productive cereals, ensuring both grain yield and biomass availability for feed and energy uses. Alfalfa contributes significantly to soil fertility by biologically fixing nitrogen, thereby reducing the need for synthetic inputs in subsequent crops. Winter barley and oats offer agronomic advantages through early harvesting, which facilitates timely preparation for follow–up crops. Durum wheat, though sensitive to pedo–climatic conditions, remains economically attractive when cultivated under optimal management due to its premium market value (*Roja et al. 2021*).

Integrating these species into diversified rotations enhances productivity, improves resource use efficiency, and strengthens resilience against drought and market fluctuations, aligning with the EU's objectives for sustainable and climate–adaptive agriculture.

CONCLUSIONS

This comparative study demonstrates that integrating alfalfa, corn, durum wheat, winter barley, winter oat, and sorghum into Romanian farming systems offers both agronomic and economic benefits. Corn and sorghum provide the highest grain and biomass yields, making them essential for feed security and bio–based value chains. Alfalfa improves soil fertility through biological nitrogen fixation, reducing dependence on synthetic fertilizers and supporting sustainable nutrient cycles. Winter barley and oats contribute to rotational flexibility by releasing land early and facilitating double cropping or timely sowing of

subsequent crops. Durum wheat, while more sensitive to pedo–climatic conditions, remains profitable when managed under optimal technology due to its premium market price.

Adopting diversified crop rotations that combine high–yield cereals with legumes and drought–tolerant species enhances farm resilience, optimizes resource use, and mitigates the effects of climate variability. Such strategies are consistent with the European Union's Green Deal and Farm–to–Fork objectives, promoting sustainable production, efficient input management, and long–term profitability for Romanian agriculture.

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