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RESEARCH ON THE ADAPTABILITY AND PERFORMANCE OF SEVERAL WHEAT VARIETIES IN A NO-TILL FARMING SYSTEM UNDER RAINFED CONDITIONS IN THE MERENI AREA, CONSTANȚA COUNTY (2021–2024)

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Abstract*. In the context of accelerated climate change, characterized by rising average temperatures and decreasing water resources, modern agriculture is compelled to adopt sustainable and adaptive technologies. This study evaluates the agronomic performance of three winter wheat varieties (Avenue, Glosa, and Artico) cultivated under a no-till system, in rainfed conditions, in the semi-arid area of Mereni, Constanța County, during the 2021–2024 period.The research integrated relevant climatic data (precipitation, average temperature, number of hot days) with agronomic parameters (plant density at emergence and harvest, number of grains per spike, thousand-kernel weight – TKW, and theoretical yield). The results highlighted the superior performance of the Avenue variety, with consistent yields and high adaptability to abiotic stress. Glosa showed good stability under moderate conditions, while Artico, although promoted as drought-tolerant, exhibited a significant decline in performance during dry years.Regression and correlation analyses revealed a negative relationship between temperature and TKW, as well as between the number of hot days and yield per hectare. The no-till technology played an important compensatory role, supporting plant density and yield maintenance under unfavorable climatic conditions. The study confirms the importance of selecting adapted varieties and implementing conservation technologies to sustainably maintain production in areas at high risk of aridification.*

Keywords*: wheat, minimum tillage, climate change, drought, technology*

INTRODUCTION

Climate change represents one of the most pressing challenges facing contemporary agriculture, with an increasingly visible impact on temperate climate zones that are rapidly evolving toward semi-arid and arid conditions. In recent decades, there has been a significant rise in global average temperature approximately 1.2°C above pre-industrial levels—and climatological estimates suggest a possible increase of up to 2°C in the coming years (BANDOC & PRĂVĂLIE, 2015; PRĂVĂLIE et al., 2016). This trend is driving the intensification of extreme weather events, such as heatwaves, prolonged droughts, uneven and torrential rainfall, hailstorms, strong winds, and even tornadoes—factors that negatively affect crop performance (GACIU, 2023).

Temperate-continental regions, such as Dobrogea, are particularly susceptible to these climatic transformations. The commune of Mereni, located in Constanța County, is frequently affected by soil water deficits, extended drought periods, and irregular precipitation patterns, making it essential to reassess the agricultural technologies currently in use in order to adapt to new conditions and ensure stable, sustainable yields.

In response to these challenges, Romanian agriculture has increasingly shifted toward sustainable practices aimed at conserving natural resources and enhancing agroecosystem resilience. One of the modern technologies with high adaptive potential is the no-tillage system an agricultural method that minimizes soil disturbance by avoiding plowing, retaining crop

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residues on the surface, and using direct seeding (HERA, 1999; TABĂRĂ, 2006; BANDOC et al., 2014). This approach significantly contributes to preserving soil structure, reducing compaction and erosion, maintaining moisture in the arable layer, and enhancing microbiological activity (DUMA COPCEA et al., 2023).

The efficiency of the no-till system has been demonstrated in numerous studies. MARIN et al. (2015) highlight its positive impact on energy efficiency in cereal crops, and recent research confirms its benefits for soil quality and water retention under hydric stress conditions (DUMA COPCEA et al., 2023). In Dobrogea, this technology is already successfully applied in large-scale farming operations, such as AgroPav in Nalbant (Tulcea) and AgroSis in Târgușor (Constanța), where it is implemented across hundreds or even thousands of hectares (MANOLE et al., 2023).

Winter wheat (*Triticum aestivum* L.) remains one of the most important crops in Romania, due to its adaptability to a wide range of soil and climatic conditions, as well as its high economic and nutritional value (MUNTEAN et al., 2006; PANAITESCU, 2016). In regions with low precipitation and limited access to irrigation, careful selection of varieties becomes crucial for yield optimization. NIȚĂ et al. (2024) indicate that wheat yield is strongly influenced by the frequency of heatwave days during the growing season and by water availability during critical developmental stages such as flowering and grain filling.
In another study, MANOLE et al. (2018) analyzed the behavior of new wheat and barley varieties under the climatic conditions of the 2018 agricultural year, revealing significant productivity variations depending on the applied technology and specific weather patterns. These findings underscore the importance of matching selected varieties with locally adapted agricultural technologies to support sustainable crop production.

The concept of sustainable agriculture implies a balance between production efficiency, environmental protection, and economic viability (DRĂGOI et al., 2024; CAKPO, 2025). As early as the late 20th century, HERA (1999) emphasized the need for high-performing, sustainable agriculture capable of addressing long-term food security demands. Recent studies confirm that integrating no-till technology with locally adapted varieties can lead to stable and competitive yields even in the absence of irrigation (MANOLE et al., 2023; MIRON et al., 2024; TRUȘCĂ et al., 2024).

In this context, the present study aims to evaluate the suitability and performance of three wheat varieties cultivated under no-tillage and rainfed conditions in the locality of Mereni, Constanța County, during the 2021–2024 period. The study integrates relevant climatic data annual average temperatures, total precipitation, and the frequency of heatwave days with agronomic indicators such as plant density, thousand-kernel weight, average and estimated yield, in order to identify the relationships between varieties, applied technology, and climatic conditions.

Through its findings, this paper seeks to contribute to the development of strategic directions for adapting regional agricultural technologies in the context of current and future climate change, with the overarching goal of ensuring the sustainability of wheat production in areas at increased risk of aridification.

MATERIAL AND METHODS

This study aims to evaluate the suitability and favorability of three winter wheat varieties: Avenue, Glosa, and Artico, cultivated under a no-till system in rainfed conditions in the area of Mereni commune (Constanța County), during the 2021–2024 agricultural period. Suitability is defined as the capacity of a variety to adapt to local conditions, while favorability

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reflects the extent to which the environment supports agricultural performance. This research aligns with the growing need to adapt agricultural systems to new climate realities, marked by increasing drought frequency, limited water resources, and the progressive aridification of regions such as Dobrogea.

The study was conducted on the farm "Întreprindere Individuală Iancu Ionuț," located in southeastern Romania, in a region representative of Dobrogea's agricultural landscape. The local climate is excessively continental, characterized by hot summers, low precipitation, and frequent droughts—factors that necessitate the implementation of agricultural technologies adapted to water stress. Under these conditions, the no-till system, an agricultural method based on the elimination of mechanical soil disturbance—was fully applied to a large plot for the entire duration of the study.

The three tested varieties present distinct agronomic profiles: Avenue, a foreign variety with high yield potential, resistance to abiotic stress, high tillering capacity, and an awnless spike; Glosa, a well-established Romanian variety adapted to southern and southeastern conditions, valued for yield stability, resistance to lodging, heat, and overwintering, with an awned spike; and Artico, a foreign, drought-tolerant variety with an awnless spike and strong winter hardiness, recommended for low rainfall areas.

The applied technology adhered strictly to no-tillage principles: the soil was neither plowed nor mechanically disturbed, and sowing was carried out directly in double rows at 19 cm spacing, using a uniform seed rate across all varieties. The preceding crop was the same each year, and fertilization was uniform—complex fertilizers (NPK) were applied at sowing, followed by topdressing in spring. Similarly, plant protection treatments (fungicides, herbicides, and insecticides) were administered identically for all varieties and throughout all three study years. Agro-productive performance was assessed throughout the entire vegetative cycle by monitoring development stages and measuring the following indicators: plant density at emergence and harvest (plants/m²), determined through sampling on standardized areas; thousand-kernel weight (TKW), determined by weighing a representative sample of fully developed grains using an analytical balance; number of grains per spike, established by manual collection and analysis; test weight, expressed in kg/hl, according to the SR 13574:2010 standard, as an indicator of commercial grain quality; average yield per hectare, calculated by relating harvested grain mass to the cultivated area; and grain quality indices such as moisture, protein content, and gluten content, analyzed in the laboratory.

Data collected during the 2021–2024 period were centralized and statistically analyzed using the Python programming language and specialized packages for agricultural data processing. To identify statistical significance and relationships between climatic factors, varieties, and agricultural performance, the following methods were applied: Pearson correlations, to highlight direct relationships between climatic variables (temperature, precipitation, frequency of hot days) and agricultural indicators (density, yield, quality); linear regressions, to quantify the influence of environmental factors on yield and TKW; analysis of variance (ANOVA), to test the significance of differences between varieties in terms of yield and grain quality; and comparative analyses among varieties to determine specific agronomic behaviors under the pedoclimatic conditions of Mereni.

All agrophytotechnical interventions were applied uniformly throughout the study period and across all varieties, allowing observed performance differences to be objectively attributed to the genetic characteristics of the varieties and their responses to climatic conditions and the no-till technology employed.

RESULTS AND DISCUSSION

The present agronomic study was carried out within the "Întreprindere Individuală Iancu Ionuț," a family-run farm founded in 2001, which began its activity with 250 hectares of leased land in the commune of Mereni, Constanța County. Today, the farm cultivates approximately 950 hectares, 600 hectares owned and 350 hectares leased, spread across the communes of Mereni and Lanurile. The farmland is predominantly consolidated, with parcels ranging between 40 and 60 hectares, while irrigation is only possible in the Lanurile area. Since 2020, the entire surface has been transitioned to a no-till system, representing one of the first large-scale initiatives of its kind in the region.

The crop structure is diverse, including wheat, barley, rapeseed, sunflower, corn, and peas, grown in rotation. In the context of sustainable agriculture and the growing need to adapt to new climatic conditions, characterized by limited water availability and the moderately fertile soils typical of Dobrogea, the implementation of conservation technologies and the careful selection of varieties has become essential.

This research followed the agronomic behavior of three winter wheat varieties: Avenue, Glosa, and Artico, grown under a no-till system, in rainfed conditions, in the commune of Mereni, during the 2021–2024 period. Each variety was cultivated on a compact 35-hectare plot, totaling 105 hectares dedicated to the experiment. The preceding crop was, in all cases, peas – chosen for the agronomic advantages it brings: early harvest, improved soil structure, nitrogen input through symbiosis with *Rhizobium* bacteria, reduced weed and disease pressure, and the absence of shared pathogens with wheat.

For winter wheat, a phased fertilization scheme was applied, tailored to the demands of an intensive yet sustainable system: phase I – sowing (October): Eurofertil Top 49 NPS Zn (Timac Agro) was applied at a rate of 200 kg/ha. This complex fertilizer provides nitrogen, phosphorus, sulfur, and zinc—elements essential for early plant development and tillering. Phase II – vegetative growth restart (March): AzoSpeed liquid fertilizer (Timac Agro) was applied at 30 L/ha. With stabilized nitrogen forms and volatilization inhibitors, it was distributed using specialized equipment. Phase III – booting stage (late April): K-Sil (Lebosol) and Aminicat 30 (Agrovital) were each applied at 3 L/ha. The first supplies potassium and soluble silicon, enhancing resistance to abiotic stress, while the second is a biostimulant based on amino acids and micronutrients, supporting metabolic activity and grain filling.

The seed used for all three varieties belonged to the C1 biological category, with a physical purity of 99.80% and a germination capacity of 97%. The thousand-kernel weight was 44 g for Avenue, 43 g for Glosa, and 39 g for Artico. Before sowing, the seed was treated with Austral Plus, a broad-spectrum insecto-fungicide, applied at 500 ml per 100 kg.

Sowing was done in the first ten days of October, with slight annual adjustments to ensure that plants reached the 2–3 tiller and 3–4 leaf stage before winter. The rows were spaced at 19 cm, sown in double rows, at a depth of 4 cm. A density of 322 viable seeds per square meter was used, equivalent to 140 kg/ha, targeting a harvest density of 550–700 ears per square meter.

For sowing, a John Deere N530 no-till drill was used, with a 9.1-meter working width, equipped with ProSeries openers that allow for precise seed placement and proper furrow closure using toothed press wheels. The system ensures variable hydraulic pressure between 75 and 181 kg, adapting to soil firmness.

Rainfall analysis across the three agricultural years (2021–2024) revealed significant variation in both total quantities and monthly distribution, which had a direct impact on the development of winter wheat in no-till, non-irrigated conditions. In the 2021–2022 season, total

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rainfall over the ten monitored months reached 336.7 mm, slightly below the multiannual average, yet relatively well-distributed. Notable amounts in January (45.2 mm) and April (99.5 mm) supported plant growth during sensitive phenological phases such as stem elongation, booting, and heading, partially offsetting the general moisture deficit. The 2022–2023 season brought an even lower rainfall total—313.7 mm. Major deficits during winter and May negatively affected tillering and grain filling, both of which were reflected later in yields. The 2023–2024 season was the most extreme, with only 208.3 mm of precipitation, unevenly distributed throughout the growing season. The lack of rain impacted all stages of crop development, with wheat experiencing continuous water stress from emergence to physiological maturity.

The accompanying chart (fig. 1), illustrates the monthly precipitation totals between September and June for each study year, compared to the multiannual norms. Clear differences emerge from one year to the next, but so does the crucial role of rainfall distribution, even in years with overall low totals.

In this challenging climatic context, the no-till system proved to be a reliable strategy, helping conserve soil moisture in the upper horizon, reduce evaporative losses, and protect soil structure. Although in early spring plants may show slower vegetative development due to cooler soils and the absence of tillage, this conservation-based approach offers higher resilience during periods of climatic stress. Thus, in years marked by severe soil drought and uneven rainfall, no-till farming allowed the wheat crop to remain viable, even if maximum yield potential was not achieved. The results reinforce the idea that no-tillage represents an adaptive and sustainable solution for areas undergoing progressive aridification, offering a balance between yield stability and natural resource preservation.

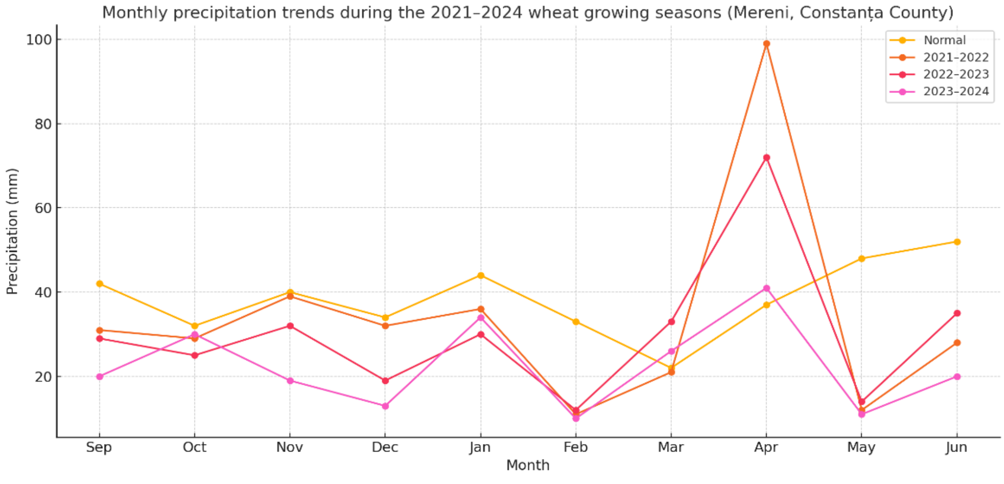

Figure 1 – Graph showing the evolution of precipitation during the wheat growing season between 2021 and 2024

Based on the climatic data collected over the three agricultural years (2021–2024), a clear trend of increasing average monthly temperatures can be observed when compared to the normal multiannual average. The average temperature recorded during the September–June

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interval consistently exceeded the reference value, with a positive deviation of over 3°C each year.

The autumn seasons were marked by high temperatures, which favored rapid emergence and early development of the wheat crop. Winters were mild, lacking consistent snow cover and often recording temperatures above 0°C, conditions that allowed vegetation to continue even during the cold season. In spring, temperatures continued to rise, especially in March and April, accelerating the pace of plant development.

Although this thermal regime theoretically created favorable conditions for vigorous crop establishment, the absence of adequate water supply led to increased water stress. Higher temperatures caused an accelerated depletion of soil moisture reserves, especially in years with deficient precipitation, such as 2023–2024. Thus, even though plants had a promising start in autumn, the onset of water stress during the advanced stages of growth negatively affected their productive potential.

The graph below provides a comparative illustration of the average monthly temperatures recorded between September and June for each agricultural year, relative to the multiannual average. A consistent pattern of above-normal temperatures can be observed, confirming the regional warming trend and reinforcing the need for agricultural technologies adapted to thermal and hydric stress, such as the no-till system.

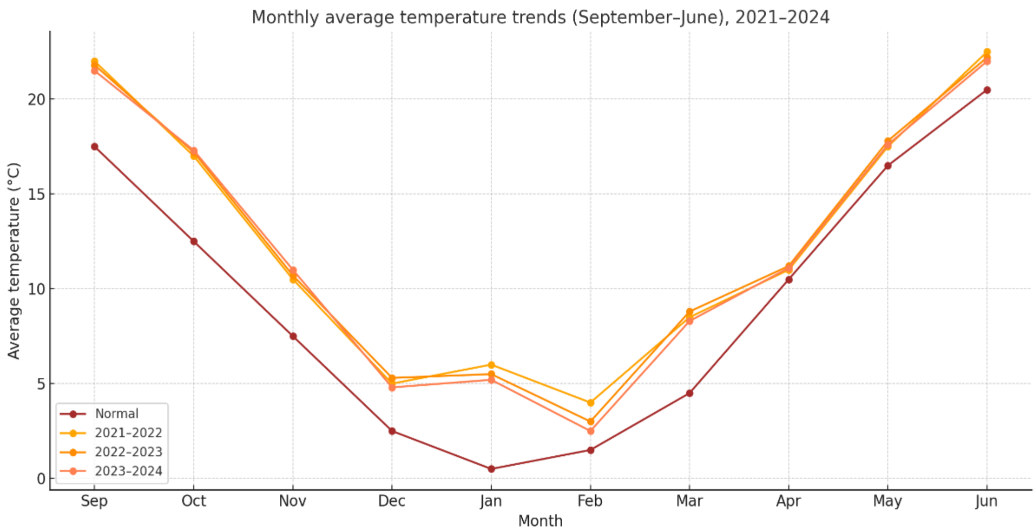

Figure 2 – Graph showing the evolution of average temperatures during the wheat growing season between 2021 and 2024

Within the no-till technology framework, the combined application of herbicides, fungicides, and liquid fertilizers represents a modern and efficient strategy, aligned with the principles of sustainable agriculture and adapted to the semi-arid climate of Dobrogea. This integrated approach brings multiple agronomic, economic, and environmental advantages, playing a key role in the success of winter wheat grown under non-irrigated conditions.

One of the main benefits of combining treatments lies in the reduction of machinery passes across the field, which helps preserve soil structure, minimize compaction, and lower

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operational costs related to fuel and labor. Moreover, liquid fertilizers such as AzoSpeed, applied during peak nutrient demand stages, ensure efficient nutrient uptake that aligns with the physiological needs of the plants. The products used in this technological program proved to be compatible and synergistic, allowing simultaneous application without any phytotoxicity risks. Among the combinations used were AzoSpeed + Axial Pro and Pixxaro + Revystar XL—both demonstrating high efficacy in weed and disease control while also stimulating the plants' physiological response through the supply of micronutrients and biostimulants.

Disease and pest control were carried out through an integrated approach that combined preventive measures (including seed treatment) with strategically timed chemical interventions based on crop development stages. The first phytosanitary treatment was applied in the second decade of April, during the booting stage, a critical phase in which the plants rapidly accumulate biomass and become vulnerable to weed competition, fungal infections, and insect attacks. In a single pass, the following products were applied: Pixxaro EC, a herbicide targeting broadleaf weeds; Revystar XL, a systemic fungicide with both preventive and curative action, effective against powdery mildew, brown rust, and septoria; and Decis Expert, a contact insecticide targeting aphids and other pests active during stem elongation and early flowering. This combined treatment provided effective control over biotic stress factors, ensuring a healthy and uniform vegetative start while reducing soil disturbance and the number of mechanical interventions.

To protect the wheat spike and flag leaf during the grain filling stage, a second phytosanitary treatment was carried out in the first decade of May. The main goal was to prevent yield losses and quality degradation caused by late-season pests and diseases. The treatments included Revytrex (BASF), a next-generation fungicide with long-lasting action against septoria and yellow rust, applied at a rate of 1 L/ha, and Affirm Opti (Syngenta), a biochemical insecticide based on emamectin benzoate, applied at 1.5 kg/ha, effective against lepidopteran pests and aphids. Applications were performed in the early morning, under optimal weather conditions, to maximize solution adhesion and the efficacy of the active ingredients. This precise timing between the phenological stage and chemical intervention contributed to maintaining the integrity of the foliage and preserving grain quality parameters.

Wheat harvesting took place at the end of June, using a Claas Tucano 320 combine equipped with a cereal-specific header. The operation was completed in a single pass, starting around 9:30 a.m., when grain moisture ranged between 11.5–12.8%, ensuring favorable conditions for storage and the preservation of grain quality.

Plant density at emergence was determined through direct field observations, once the first true leaf had fully developed. For each tested wheat variety, five adjacent double rows were selected, and on each row, three repetitions were made by counting the number of plants per linear meter. These figures were then converted into plants per square meter, taking into account row spacing and the configuration of the seeder.

Although the sowing density was set at 322 viable seeds/m², the actual average emergence values were slightly lower. This suggests that a portion of the seeds either did not germinate or failed to penetrate the soil surface layer—likely due to the specific conditions of each agricultural year. When comparing emergence densities, the following averages were recorded: Avenue – 308 plants/m² in 2021–2022, 302 in 2022–2023, and 288 in 2023–2024; Glosa – 305 plants/m² in 2021–2022, 300 in 2022–2023, and 283 in 2023–2024; Artico – 303 plants/m² in both 2021–2022 and 2022–2023, and 276 in 2023–2024.

A general downward trend in emergence density is evident in the final experimental year (2023–2024), most likely due to reduced rainfall and increased thermohydric stress during

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the emergence phase. Nevertheless, the recorded values still fall within the optimal range for winter wheat in no-till systems, and the differences between varieties remain moderate.

The comparative graph (fig. 3), clearly shows that Avenue and Artico exhibited stronger emergence in the first two years, while Glosa maintained relatively stable densities. Furthermore, in the most climatically challenging year (2023–2024), all varieties experienced a drop in emergence, indicating that environmental conditions had a greater influence than the genetic potential of the varieties.

The determination of plant density at harvest (fig.4), provided a clear picture of the stability of each wheat variety analyzed under the no-till farming system, in the specific climatic conditions of the Mereni area, Constanța County. This evaluation stage allowed for direct comparisons between varieties and across agricultural years, highlighting each variety's ability to maintain viable plants throughout the entire vegetation cycle, especially in years marked by abiotic stress.

For the Avenue variety, average harvest densities remained high throughout the analyzed period, reaching 567 ears/m² in the 2021–2022 season, 531 ears/m² in 2022–2023, and 508 ears/m² in 2023–2024. This evolution indicates strong adaptability and a superior capacity to preserve vegetative density across all three seasons, even under the more challenging climatic conditions of the final year. The decline recorded in 2023–2024 was moderate, confirming the variety's resilience within a conservation agriculture regime.

Glosa, a local Romanian variety, showed a balanced agronomic behavior, with harvest densities of 532 ears/m² in the first year, 508 in the second, and 491 ears/m² in the driest year. Although these values are slightly lower than those recorded for Avenue, Glosa demonstrated good stability in the face of climatic variability. The reduction in density was gradual and less pronounced than in other varieties. This supports the idea that locally adapted varieties may offer an adaptive advantage in areas with an excessively continental climate, such as Dobrogea.

In contrast, the Artico variety recorded lower average densities at harvest compared to the other two varieties: 509 ears/m² in 2021–2022, 480 in 2022–2023, and 474 ears/m² in 2023–2024. Although this variety is recommended for semi-arid regions, the results suggest a higher sensitivity to the combined stress of high temperatures and limited precipitation, particularly during flowering and grain filling. This trend implies that despite its genetic potential for drought tolerance, its performance can be significantly affected under extreme climatic conditions if not supported by appropriate technological interventions.

Overall, the data confirm that harvest density is influenced by both the genetic potential of the variety and the environmental conditions, as well as by the effectiveness of the no-till system in preserving soil structure and water resources. Avenue stood out with the most consistent results, followed by Glosa, which demonstrated notable adaptability. Artico, although viable, showed more fluctuating performance depending on the pedoclimatic and hydric conditions in each year.

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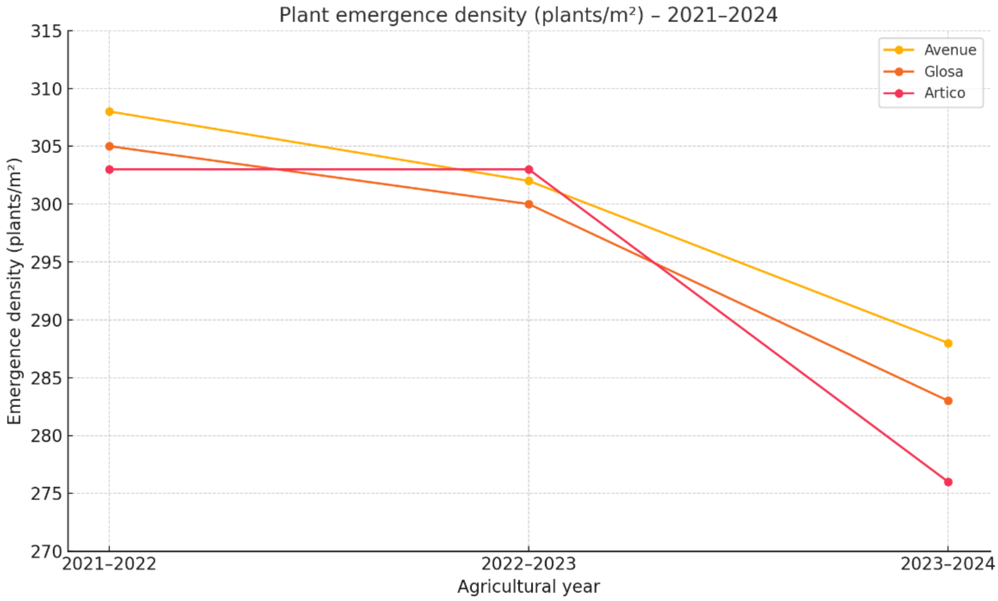

Figure 3 – Graph of plant emergence density between 2021 and 2024

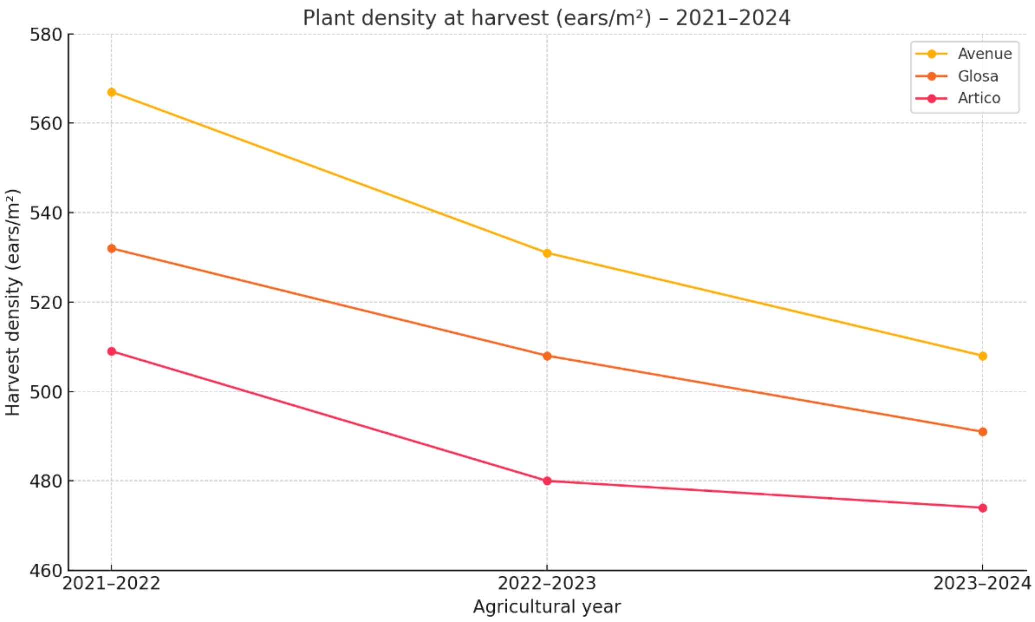

Figure 4 – Graph of plant density at harvest between 2021 and 2024

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To assess the influence of climatic factors on the agronomic performance of the three wheat varieties analyzed (Avenue, Glosa, and Artico), linear regression and Pearson correlation methods were applied between total precipitation (September–June) and plant density at harvest. The results indicate significant positive relationships between rainfall patterns and the number of ears harvested per square meter in all three cases, although the strength of the correlations varied by variety. For Avenue, the Pearson correlation coefficient was $r = 0.73$, with a p-value < 0.05, confirming a statistically significant link between annual precipitation and final plant density. This suggests that the variety clearly benefits from higher rainfall, showing strong water-use efficiency, low losses in favorable years, and relatively stable performance under moderate water stress.

Glosa showed an even stronger correlation ($r = 0.80$), indicating a greater dependency on water availability to maintain harvest density. This result reflects both the physiological sensitivity of the variety during critical development stages and its strong response to favorable agroclimatic conditions, making it competitive in years with sufficient rainfall. Artico, on the other hand, displayed a weaker positive correlation ($r = 0.65$), suggesting a slightly higher drought tolerance but also a more noticeable loss in density during severely dry years, such as 2023–2024. While this variety is promoted as suitable for arid zones, the data suggest that its performance under extreme conditions may be influenced by other physiological or technological factors that could be optimized through targeted management.

These findings confirm the hypothesis that rainfall regime is a critical factor in determining crop density stability in wheat, especially under no-till systems, where moisture availability in the surface soil layer directly affects tillering and spike formation. Moreover, the differences observed between varieties highlight the importance of selecting genetics in line with local climate conditions. The use of conservation tillage practices, such as no-till, can either amplify or mitigate these effects, depending on the annual context.

The integrated analysis of the three linear regressions clearly demonstrates a positive relationship between annual precipitation and final harvest density for all tested wheat varieties. However, the results also show that the no-till system plays a compensatory and stabilizing role under unfavorable climatic conditions.

By maintaining permanent soil cover and minimizing mechanical intervention, the no-till system helps conserve moisture in the arable layer, protects soil structure, and reduces water evaporation during periods of drought. Thus, even in the 2023–2024 season—marked by the lowest recorded rainfall (208.3 mm) and the highest number of heatwave days (18)—plant densities at harvest remained viable: 508 ears/m² for Avenue, 491 for Glosa, and 474 for Artico. This relative stability of plant density under pronounced climate stress highlights the resilience of the no-till system. While differences in response to precipitation were observed between varieties, all three clearly benefited from the advantages of this conservation-based approach.
Therefore, the data support the hypothesis that, in arid or semi-arid climates, no-till technology not only supports crop development in favorable years but also mitigates the negative effects of drought, enabling the maintenance of reasonable productive densities. Without this system, losses would likely have been significantly greater, especially in years with low rainfall and high temperatures.

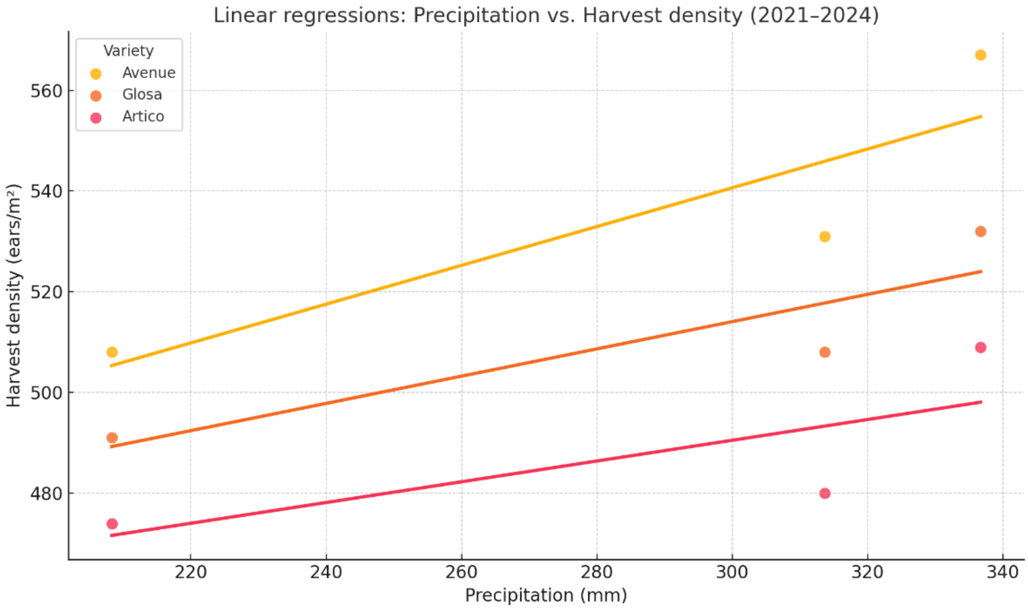

Figure 5 – Combined graph of the three linear regressions

To estimate the productive potential of the three wheat varieties analyzed under the no-till system, three of the most important yield components were correlated: number of grains per spike, thousand-kernel weight (TKW), and harvest density. These agronomic indicators were analyzed together over a three-year period (2021–2024) to highlight varietal differences and the influence of varying climatic conditions.

The Avenue variety recorded the highest theoretical yield values, with a peak of 7,733 kg/ha in the 2021–2022 agricultural year, which was considered climatically favorable. This performance was supported by high plant density (567 ears/m²), a relatively high number of grains per spike (31), and a consistently high TKW (44 g). In the following years, due to reduced precipitation and rising temperatures, yield decreased to 6,244 kg/ha in 2022–2023 and to 5,689 kg/ha in 2023–2024, a decline explained by lower TKW and reduced density.

Glosa showed a balanced agronomic response, with a yield of 6,554 kg/ha in 2021–2022, but gradually lost potential in the following years, dropping to 5,689 kg/ha in 2022–2023 and 4,639 kg/ha in 2023–2024. Although its density and number of grains per spike remained relatively stable, thermal stress and drought had a significant impact on grain weight, with TKW falling from 44 g to just 35 g in the final year.

Artico was the most affected by restrictive climatic conditions. While in the reference year 2021–2022 it managed a theoretical yield of 6,128 kg/ha, in 2022–2023 this dropped to 4,867 kg/ha, and in 2023–2024 it plummeted to just 3,379 kg/ha, the lowest value across the entire study. These declines were caused by simultaneous reductions in density, number of grains per spike, and especially grain weight, with TKW reaching a minimum of only 31 g.

The comparative analysis of the three fundamental yield components shows that Avenue has the highest potential to capitalize on the no-till technology, particularly in favorable

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years. It is followed by Glosa, which displayed good adaptability under moderate conditions. Artico, although theoretically drought-tolerant, showed lower efficiency in dry years, particularly in terms of grain weight formation.

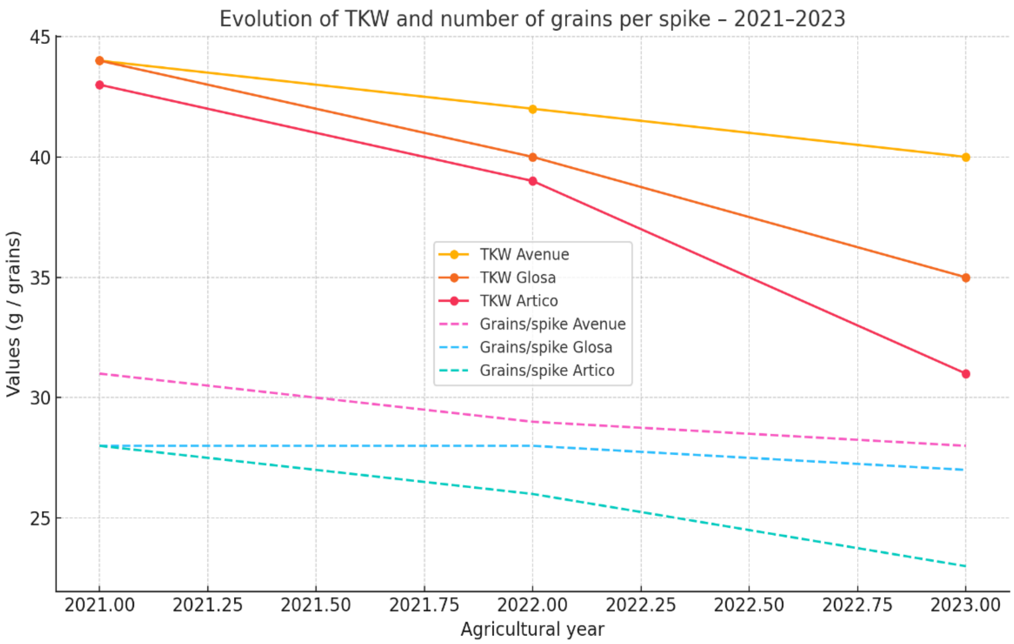

Figure 6 – Graph showing the evolution of TKW and number of grains per spike during the experimental period

To gain a deeper understanding of the influence of climatic factors on the productive performance of wheat grown under a no-till system, correlations and linear regressions were conducted between average annual temperature and thousand-kernel weight (TKW), as well as between the number of hot days and theoretical yield per hectare.

The correlation analysis between average temperature and TKW revealed a negative relationship for all three varieties studied. Although the p-values were not statistically significant (due to the limited number of agricultural years), the correlation coefficients (r) indicated a clear downward trend in grain weight under higher temperatures: $r = –0.56$ for Avenue, $r = –0.61$ for Glosa, and $r = –0.71$ for Artico. This outcome is biologically consistent, as elevated temperatures during the grain-filling stage shorten the duration of reserve accumulation, thereby reducing the final grain weight.

Even more pronounced was the effect of hot days on yield. The correlations obtained were extremely strong and negative, indicating a significant drop in productivity during years with a high number of days exceeding 35°C. The correlation coefficients were $r = –0.94$ for Avenue, $r = –1.00$ for Glosa, and $r = –1.00$ for Artico, with the latter two also being statistically significant ($p < 0.05$). These findings highlight the fact that intense heat stress during the May–

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June period directly affects wheat yield, particularly in physiologically sensitive varieties such as Glosa and Artico.

Among the varieties, Avenue proved to be the most tolerant to thermal stress, maintaining a higher yield even in years with frequent heatwaves. This confirms the variety's strong adaptability to semi-arid conditions, especially when paired with no-till technology, which helps conserve soil moisture and mitigates the effects of evaporation and soil overheating. The results clearly indicate that the number of hot days is a critical climatic factor with a severe impact on yield, and that the interaction between variety genetics and no-till technology can make a decisive difference in maintaining viable productivity levels.

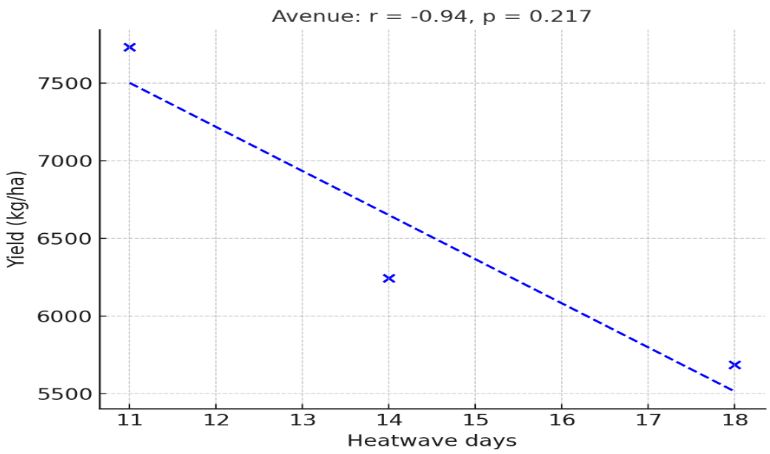

Figure 7 – Individual graph for the Avenue variety – regression between heatwave days and theoretical yield (kg/ha)

The individual graph below, for the Glosa variety, highlights the strong negative relationship between the number of heatwave days and theoretical yield (kg/ha).

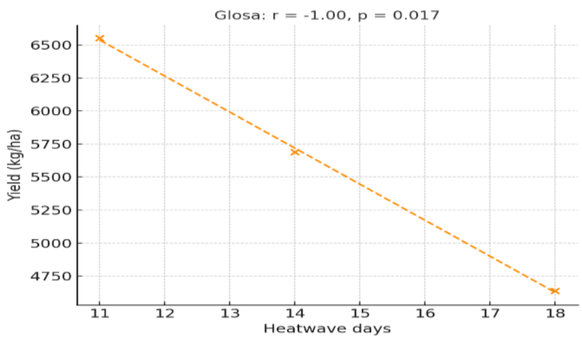

Figure 8 – Individual graph for the Glosa variety – regression between heatwave days and theoretical yield (kg/ha)

The regression for the Avenue variety, shown in the graph below, illustrates the relationship between average annual temperature and thousand-kernel weight (TKW). A clear downward trend is observed: higher temperatures are associated with a decrease in grain weight.

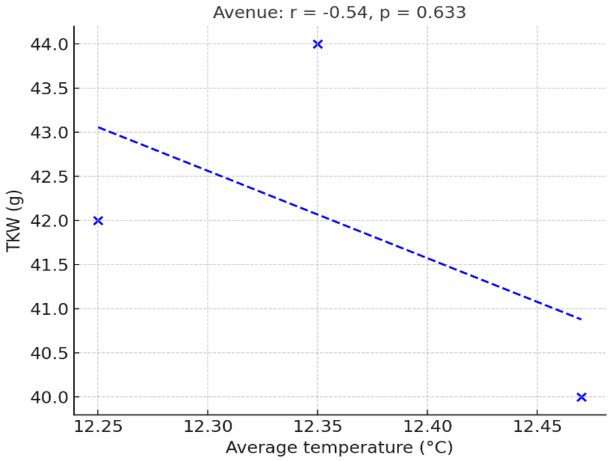

Figure 9 – Individual graph for the Avenue variety – regression between average temperature and theoretical yield (kg/ha)

The regression for the Artico variety, shown in Figure 10, highlights the clear decrease in TKW (thousand-kernel weight) as the average annual temperature increases. The regression line confirms a strong negative relationship, indicating the high thermal sensitivity of this variety during the grain-filling stage.

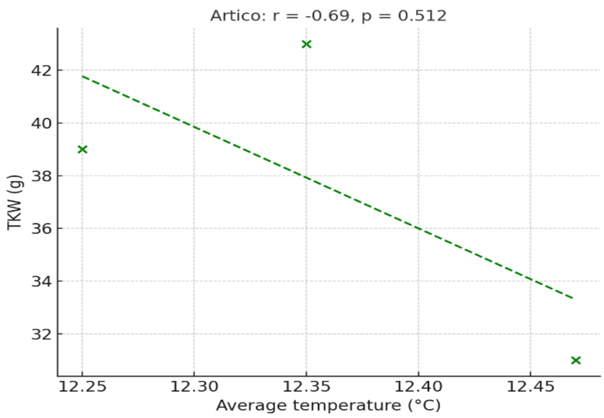

Figure 10 – Individual graph for the Artico variety – regression between average temperature and theoretical yield (kg/ha)

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Grain quality in wheat is determined not only by quantitative yield parameters, but also by qualitative indicators, which are essential for evaluating baking value and the crop's industrial performance. In this study, three key quality parameters were analyzed: protein content, wet gluten content, and hectoliter weight (HW), each reflecting a critical component of grain quality and being influenced by variety, applied technology, and climatic conditions.

Protein content varied significantly among varieties and agricultural years, strongly influenced by fertilization regime, water availability, and the intensity of thermohydric stress during the grain-filling stage. Avenue consistently recorded high protein levels, ranging between 12.5–13.8%, demonstrating a good capacity for protein accumulation even under moderate drought conditions. Glosa, although known for its stability, showed a slight decrease in protein content in 2023–2024 (below 12%), suggesting sensitivity to prolonged water deficits. Artico had the lowest protein levels across all years, ranging between 11.5–12.3%, likely reflecting less efficient nitrogen utilization under stress conditions.

Wet gluten content, a direct indicator of baking quality, is often correlated with protein levels but also influenced by protein structure. On average, Avenue recorded the highest values, with gluten levels ranging from 26–28%, placing it in the upper category for baking quality. Glosa had moderate to high levels (24–26%), while Artico, though drought-tolerant, recorded lower values, particularly in dry years (21–23%). This suggests that intense thermal and water stress not only reduces protein quantity but also affects gluten quality, compromising baking performance.

Hectoliter weight (measured in kg/hl) is a complex indicator reflecting kernel density and grain health. All three varieties recorded HW values above the minimum commercial quality threshold (76 kg/hl), with Avenue again standing out for its consistent and higher values (78–80 kg/hl). Glosa ranged between 76–78 kg/hl, while Artico dropped below 76 kg/hl in the driest year, indicating incomplete grain filling and a greater sensitivity to stress.

The results highlight a positive correlation between efficient fertilization, no-till technology, and the maintenance of grain quality indicators, even under challenging climatic conditions. The no-till system, by conserving soil moisture and protecting soil structure, contributes to improved grain formation and more efficient protein accumulation, particularly in genetically superior varieties like Avenue. Avenue stands out not only for its productivity but also for its superior grain quality, making it a strong recommendation for farms aiming at both agronomic and industrial performance. Glosa remains a stable and reliable option, while Artico may require further optimization to reach comparable quality parameters.

CONCLUSIONS

Over the course of the three agricultural years (2021–2024), the research demonstrated that the performance of wheat varieties cultivated under no-till systems in non-irrigated conditions is strongly influenced by climatic factors, particularly rainfall patterns, annual average temperatures, and the frequency of heatwave days. In this context, the comparative analysis of the three tested varieties: Avenue, Glosa, and Artico, highlighted significant differences in terms of adaptability, agronomic stability, and the capacity to capitalize on no-till technology.

Avenue proved to be the most consistent and high-performing variety throughout the entire study period. Even in agricultural years marked by severe thermohydric stress, this variety maintained viable harvest densities, a relatively high number of grains per spike, and superior thousand-kernel weight (TKW). Theoretical yield peaked at over 7,700 kg/ha in the first year, and the decline in subsequent years was moderate, indicating good stress tolerance. These results confirm that Avenue is well-suited for the semi-arid regions of Dobrogea, especially when combined with conservation agriculture practices.

Glosa, a native Romanian variety, showed good adaptability under moderate climatic stress. Although yield declined gradually in drier years, plant density at harvest remained stable, and the number of grains per spike showed little variation. The most notable vulnerability was observed in TKW, which dropped significantly in 2023–2024, reflecting sensitivity to high temperatures during the grain-filling stage. Nevertheless, Glosa remains a reliable choice in average or slightly unfavorable agricultural years.

Artico, although promoted as being adapted to arid regions, displayed increased sensitivity under intense thermohydric stress. In 2023–2024, all three yield components, harvest density, grains per spike, and grain weight, were severely affected, leading to the lowest theoretical yield of the entire study: 3,379 kg/ha. While this variety can perform reasonably well in favorable years, the data suggests that it requires a more carefully managed technological approach to compensate for its vulnerability.

Regression and correlation analyses confirmed the direct influence of climatic factors on crop performance. Clear negative relationships were recorded between average annual temperature and TKW, while the number of heatwave days showed a strong negative correlation with yield, particularly for Glosa and Artico, where these relationships were statistically significant. This emphasizes the critical role of thermal stress in shaping productivity and the need to integrate adapted agronomic solutions.

At the same time, the study demonstrated that no-till technology plays an essential role in maintaining plant density and crop viability during unfavorable agricultural years. By reducing mechanical soil disturbance and maintaining a protective surface layer, the no-till system promotes moisture conservation, reduces evaporation, and protects soil structure. In drought-affected years such as 2023–2024, all three varieties maintained a minimum productive density thanks to the positive effect of no-till practices, an outcome unlikely under conventional tillage systems.

Recommendations: the adoption of no-till technology is strongly recommended for areas with low rainfall and high thermohydric stress, such as Dobrogea. This system provides clear advantages in stabilizing yields and conserving water resources. Avenue should be considered a core choice for farms in southeastern Romania due to its high stability and yield under variable climate conditions. Glosa is suitable for operations seeking a balance between adaptability and quality, especially in years with moderate rainfall and balanced distribution. Artico can be successfully used in favorable years but requires careful technological management (fertilization, crop protection, and climate monitoring) to reduce the impact of extreme conditions. It is also recommended to integrate local climate monitoring systems and agronomic forecasting models to tailor technological inputs to environmental dynamics, thus improving resource efficiency and the sustainability of agricultural systems.

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