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WINTER WHEAT PERFORMANCE IN THE GREAT ISLAND OF BRĂILA DURING 2025–2026 IN RELATION TO IRRIGATION TIMING CULTIVAR AND SOWING DENSITY

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Abstract. *This study compared winter wheat (Triticum aestivum L.) grain yield and quality across irrigation regimes, cultivars and sowing densities during the 2025–2026 agricultural year in the Great Island of Brăila, Romania. The field arrangement comprised eight irrigation regimes, four cultivars (Abund, Miranda, Pitar and Voinic) and two target sowing densities (300 and 500 germinable seeds m⁻²), giving 64 treatment combinations. Three harvest observations of 4.8 m² were recorded per combination, providing 192 yield and quality records. Grain yield was recalculated from harvested mass and standardised to 14% moisture using dry-matter conservation. The overall mean was 8,520 kg ha⁻¹. The autumn-irrigated A2 category had the highest irrigation-regime mean (9,726 kg ha⁻¹), compared with 6,046 kg ha⁻¹ in the non-irrigated control. Miranda had the highest cultivar mean (9,033 kg ha⁻¹), whereas Pitar had the highest protein concentration (13.95%) and thousand-grain weight (47.74 g). Voinic had the highest mean test weight, gluten content and sedimentation index. Increasing target density from 300 to 500 germinable seeds m⁻² increased mean yield by 491 kg ha⁻¹ (5.9%) and reduced thousand-grain weight by 1.14 g. The highest combination mean was recorded for A2 × Miranda × 500 germinable seeds m⁻² (10,556 kg ha⁻¹). The field plan does not document independent replicated plots or randomisation; therefore, harvest observations were conservatively treated as within-plot subsamples. Results describe one site and season and identify combinations for subsequent replicated evaluation.*

Keywords: *Triticum aestivum L.; irrigation timing; cultivar; sowing density; grain quality.*

INTRODUCTION

Water availability and crop establishment jointly influence winter wheat productivity. Irrigation studies show that water distribution and scheduling affect yield and water productivity (BEELKHIER et al., 2025; YAN et al, 2022), while cultivar differences in root and shoot growth can modify resource use (LI et al, 2022). These relationships justify evaluating irrigation regimes together with cultivar and sowing density.

Winter wheat can compensate for lower plant populations through tillering, but the response depends on genotype and yield environment (BASTOS et al, 2020). Spatial competition also affects tiller development (LIU et al, 2023). Increasing seed input therefore does not necessarily produce a proportional yield gain.

Grain quality must be evaluated alongside yield. Water management can alter quality in a genotype-dependent manner (SHENG et al, 2022), and coordinated irrigation and nitrogen management can affect both yield and quality (TONG et al, 2024; ZHAO et al, 2024). These findings provide a context for local evaluation rather than transferable treatment recommendations.

This study describes grain yield, quality and selected biometric traits across eight irrigation regimes, four cultivars and two sowing densities in the Great Island of Brăila during 2025–2026. Comparisons identify promising combinations without assuming independent replication of harvest subsamples.

MATERIAL AND METHODS

Experimental site and treatment arrangement

The field study was conducted at SCDA Brăila in the Great Island of Brăila, Romania. The recorded field footprint was 153 × 41 m (6,273 m²), including access strips, with 64 treatment plots of 4 × 18 m. Wheat was sown on 1 October 2025 and harvested on 9–10 July 2026.

Factor A comprised A1 (non-irrigated), A2 (nominal establishment irrigation), A3 (nominal stem-elongation irrigation), A4 (nominal grain-filling irrigation), and their combinations A2A3, A2A4, A3A4 and A2A3A4. Cultivars were Abund (B1), Miranda (B2), Pitar (B3) and Voinic (B4). Target densities were 300 (C1) and 500 (C2) germinable seeds m^{-2}, giving 64 combinations.

Recorded irrigation and crop management

The A2 component supplied 200 m^3 ha^{-1} on 23 October 2025 to A2A4 and A2A3A4, and on 6 November to A2 and A2A3. A3 and A4 components each supplied 400 m^3 ha^{-1}, on 11 March and 19 May 2026, respectively, according to the treatment maps. Seasonal irrigation totals were 0, 200, 400, 400, 600, 600, 800 and 1,000 m^3 ha^{-1} for A1, A2, A3, A4, A2A3, A2A4, A3A4 and A2A3A4. Stage labels follow the field plan and were not verified by treatment-specific BBCH observations.

Recorded common fertilisation comprised DAP 18–46–0 at 103 kg ha^{-1} before sowing and 106 kg ha^{-1} at sowing; urea and NPK 20–24–0 +12, each at 51 kg ha^{-1} on 9 March; and NPK 20–24–0 +12 and DAP, each at 51 kg ha^{-1} on 20 April. Crop protection was applied in autumn and spring. Fertilisation was not an experimental factor.

Harvest measurements and moisture correction

Each combination had three harvest records (R1–R3), each representing 4.8 m², giving 192 observations. Grain mass, moisture, protein, gluten, sedimentation index, test weight and thousand-grain weight were recorded. Granomat moisture was used for yield correction. Quality values are reported on the instrument-recorded basis because calibration details and the compositional moisture basis were not specified.

Grain yield was standardised to 14% moisture by conserving dry matter: $Y_{14} = (m / 4.8) \times 10{,}000 \times (100 - U) / 86$, where m is harvested grain mass (kg) and U is moisture (%).

Biometric measurements and descriptive analysis

Five plants per combination were measured on 15 July (320 observations). Traits included height, spike length, fertile and sterile spikelets, grains per spike and grain mass per spike. Their sampling correspondence with harvest areas was not recorded, so biometric observations were analysed separately.

The field plan shows each combination once and does not document randomised blocks. R1–R3 were therefore treated conservatively as within-plot harvest subsamples. Combination means were averaged with equal weight to obtain factor means. All harvest records were retained. Differences and percentages are descriptive, with no inferential ANOVA, confidence intervals or significance tests.

RESULTS AND DISCUSSION

Overall yield and irrigation regimes

Mean yield was 8,520 kg ha^{-1}, with individual harvest observations ranging from 4,082 to 10,972 kg ha^{-1}. A2 had the highest regime mean (9,726 kg ha^{-1}), 60.9% above A1 (Figure 1). All irrigated categories exceeded the non-irrigated control.

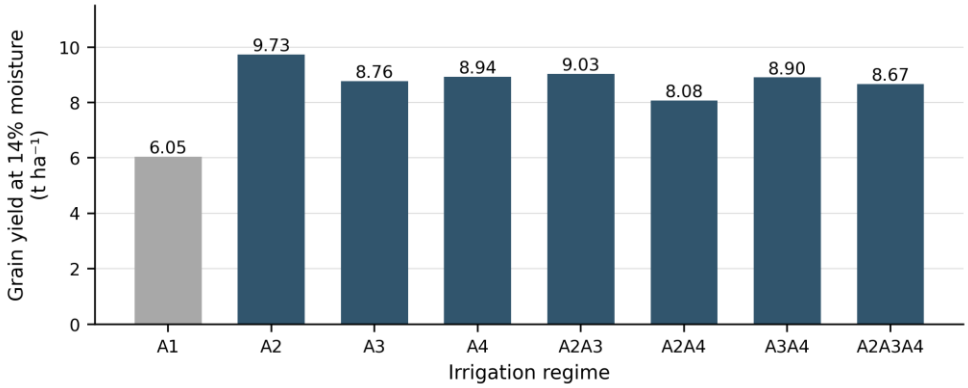


Figure 1. Mean grain yield by irrigation regime at 14% moisture. Each mean represents eight combinations and three harvest subsamples per combination

Yield did not increase monotonically with irrigation input. A2A3A4 averaged 8,675 kg ha⁻¹, 1,051 kg ha⁻¹ below A2. Differences in application date, field position and harvest heterogeneity prevent interpreting this contrast as damage caused by additional irrigation.

The A2 result prioritises autumn irrigation for further evaluation, but establishment and soil-water mechanisms were not measured. Its component was also applied on different autumn dates. Studies using water-status monitoring illustrate how these factors could be separated in subsequent trials (BELKHER et al, 2025; YAN et al, 2022).

Nitrogen accumulation and split application influence wheat responses under supplemental irrigation (ZHANG et al, 2020, 2021; ZHENG et al, 2020). Related drip-irrigation studies assess root and shoot traits [6] and photosynthetic capacity [3]. Here, those mechanisms remain hypotheses because fertilisation was common to all treatments.

Cultivar performance and grain quality

Miranda had the highest cultivar mean yield (9,033 kg ha⁻¹), exceeding Abund by 528 and Pitar by 824 kg ha⁻¹. It also had the lowest cultivar means for protein, gluten, sedimentation and test weight (Table 1).

Table 1

Cultivar means for grain yield and quality across irrigation and density treatments

Cultivar	Yield (kg ha⁻¹)	Protein (%)	Gluten (%)	Sed. (ml)	TW (kg hl⁻¹)	TGW (g)
Abund	8,505	13.61	28.79	49.93	78.51	44.77
Miranda	9,033	12.77	26.27	39.72	77.89	46.07
Pitar	8,209	13.95	29.55	49.60	79.36	47.74
Voinic	8,331	13.93	29.79	51.14	81.01	43.15

Each cultivar mean represents 16 combinations and 48 harvest observations. Sed. = instrument-recorded sedimentation index; TW = test weight; TGW = thousand-grain weight.

Pitar led for protein (13.95%) and thousand-grain weight (47.74 g). Voinic led for gluten (29.79%), sedimentation (51.14 ml) and test weight (81.01 kg hl^{-1}). These instrument-recorded traits do not establish commercial baking classes.

Yield and quality rankings differed, supporting joint selection criteria. Genotype-dependent water responses (SHENG et al, 2022) and irrigation–nitrogen studies (TONG et al, 2024; ZHAO et al 2024), provide relevant comparisons, but protein dilution or nitrogen remobilisation cannot be established from these records.

Sowing density and joint response patterns

Increasing sowing density from 300 to 500 germinable seeds m^{-2} raised mean yield from 8,274 to 8,765 kg ha^{-1} (+491 kg ha^{-1}; 5.9%). Thousand-grain weight declined from 46.00 to 44.86 g. Protein and gluten differed by only 0.05 and 0.16 percentage points.

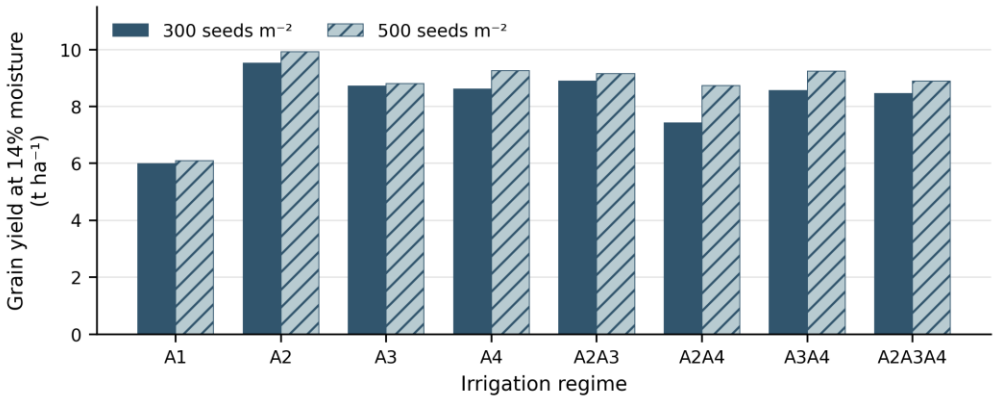


Figure 2. Mean grain yield at the two target sowing densities within each irrigation regime. Descriptive means without independent plot-level replication

The higher density had a higher observed mean under every irrigation regime (Figure 2), with gains ranging from 74 kg ha^{-1} under A3 to 1,314 kg ha^{-1} under A2A4. Assigned seed densities should not be equated with verified final populations.

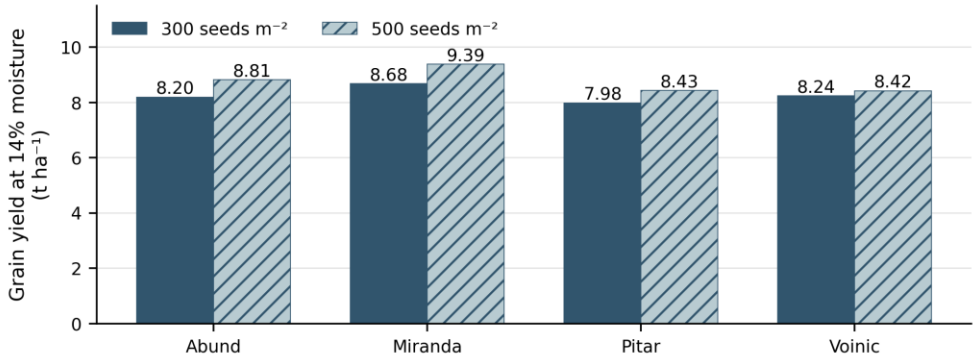


Figure 3. Cultivar mean grain yield at the two target sowing densities. Each bar averages eight irrigation regimes

Miranda showed the largest cultivar-level density increment (711 kg ha^{-1}), while Voinic showed the smallest (184 kg ha^{-1}; Figure 3). Population plasticity and tillering offer possible explanations (BASTOS et al, 2020; LIU et al, 2022), but these are not statistically established cultivar × density interactions.

Highest yielding combinations

Table 2

Five highest combination means after correction to 14 percent grain moisture

Combination	Cultivar	Density (seeds m^{-2})	Yield (kg ha^{-1})	Protein (%)
A2B2C2	Miranda	500	10,556	12.80
A2B1C2	Abund	500	10,112	13.50
A2B1C1	Abund	300	10,001	14.17
A3A4B2C2	Miranda	500	9,953	13.10
A2B3C2	Pitar	500	9,948	13.77

A2 × Miranda × 500 seeds m^{-2} had the highest combination mean (10,556 kg ha^{-1}; Table 2). Four of the five leading combinations contained A2 alone. A2 × Abund × 300 seeds m^{-2} combined 10,001 kg ha^{-1} with 14.17% protein, 30.37% gluten and 53.03 ml sedimentation. These plots identify candidates for replicated testing rather than proven optima.

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Biometric traits and interpretation of yield formation

Table 3

Selected biometric means by irrigation regime

Regime	Height (cm)	Spike length (cm)	Grains per spike	Grain mass (g spike^{-1})
A1	111.17	10.27	46.33	2.29
A2	108.53	10.02	43.08	2.02
A3	108.50	9.82	42.75	2.08
A4	108.65	10.17	44.12	2.10
A2A3	106.40	9.93	46.77	2.40
A2A4	106.62	9.78	39.40	1.94
A3A4	107.75	10.33	50.52	2.54
A2A3A4	110.45	10.33	47.38	2.26

Means of five sampled plants per combination, giving 40 plants per irrigation regime. Grain mass is shown to two decimal places.

A3A4 had the largest mean grain number (50.52 grains spike^{-1}) and grain mass per spike (2.54 g), while A2A4 had the smallest values (39.40 and 1.94 g; Table 3). A2 did not lead for individual-spike grain mass despite its higher harvested yield.

At 300 and 500 seeds m^{-2}, mean grain mass was 2.22 and 2.19 g spike^{-1}, respectively. Plant samples and harvested areas represent different scales, and their undocumented spatial correspondence prevents reconstructing field yield by multiplying biometric and stand-count means.

Quality patterns across irrigation regimes

Table 4

Mean grain quality attributes by irrigation regime

Regime	Protein (%)	Gluten (%)	Sed. (ml)	TW (kg hl^{-1})	TGW (g)
A1	14.02	29.93	50.98	79.46	45.38
A2	13.69	28.82	48.06	79.51	46.06
A3	12.95	26.80	43.24	79.55	45.66
A4	13.21	27.47	44.67	79.72	45.70

Regime	Protein (%)	Gluten (%)	Sed. (ml)	TW (kg hl⁻¹)	TGW (g)
A2A3	13.24	27.59	45.25	79.00	45.26
A2A4	13.67	28.92	48.48	78.98	45.66
A3A4	13.79	29.32	49.40	78.79	44.85
A2A3A4	13.97	29.98	50.70	78.55	44.90

Protein was highest in A1 (14.02%) and A2A3A4 (13.97%), while A2 averaged 13.69% (Table 4). A3 had the lowest protein, gluten and sedimentation means. Thus, the regime yielding most grain did not lead for all quality traits.

Across harvest observations, protein ranged from 11.6 to 15.6%, gluten from 22.2 to 34.1%, sedimentation from 29.4 to 61.7 ml and test weight from 74.4 to 82.4 kg hl^{-1}. Water and nitrogen studies support considering several quality traits jointly [Tong et al, 2024; Zhang et al, 2021; Zheng et al, 2020).

Sampling variability and limits of interpretation

Within-plot yield variation reached 38.2% in A2A4B1C1. The third A2A4 harvest record was lower than the first two for every cultivar–density combination.

Groundwater conditions (SHE et al, 2023) and water–nitrogen combinations (TAN et al, 2021) can influence wheat water use. Without rainfall, evapotranspiration and a validated soil-water balance, irrigation input cannot be converted into crop water-use efficiency. Further work requires independently replicated irrigation units, recorded phenology and consistent water measurements.

CONCLUSIONS

In 2025–2026, A2 had the highest observed irrigation-regime mean (9,726 kg ha^{-1}), compared with 6,046 kg ha^{-1} for A1. More irrigation events did not consistently correspond to higher yield. Miranda led for yield, Pitar for protein and thousand-grain weight, and Voinic for gluten, sedimentation and test weight.

The 500 seeds m^{-2} target increased mean yield by 491 kg ha^{-1} and reduced thousand-grain weight by 1.14 g. A2 × Miranda × 500 seeds m^{-2} had the highest combination mean (10,556 kg ha^{-1}).

These descriptive results identify treatments for further testing. Independent replication, verified establishment, validated laboratory methods and additional seasons are required before recommending an optimum.

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