



Agromorphological traits and productive tillering response of winter wheat (*Triticum aestivum* L.) as affected by cultivar and sowing density in the Ilfov area, Romania

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Abstract. Crop architecture in winter wheat is shaped by cultivar, sowing density (s.d.) and seasonal growing conditions. This study assessed the effects of cultivar and s.d. on selected agromorphological traits and productive tillering in four winter wheat cultivars — Glosa, FDL Abund, Python and Promitor — grown under the pedoclimatic conditions of Moara Domneasă, Ilfov County, Romania, during the 2022–2023 and 2023–2024 agricultural years. The experiment was arranged as a bifactorial 4×5 split-plot design, with four replications. The tested s.d. were 350, 450, 550, 650 and 750 germinating seeds (g.s.) m^{-2} ; Glosa and 550 g.s. m^{-2} were used as the cultivar and s.d. controls, respectively. Spring plant density, productive tillering coefficient (PTC), plant height, number of spikelets per spike and number of grains per spike were analysed separately for each year. The two seasons differed in precipitation regime, with 445.0 mm recorded in 2022–2023 and 623.2 mm in 2023–2024, compared with the multiannual average of 640.6 mm. Higher sowing densities were associated with increased spring plant density, with maximum values recorded at 750 g.s. m^{-2} in both years. Conversely, the lowest s.d., 350 g.s. m^{-2} , was associated with higher PTC, greater plant height and more developed spike traits, suggesting a greater expression of individual plant productivity under lower interplant competition. Cultivar response differed according to trait: Glosa (control) and Python showed favourable productive tillering capacities, FDL Abund recorded higher plant height and grain number per spike and Promitor tended to form more spikelets per spike. Overall, the results suggest that cultivar and s.d. should be evaluated together when interpreting winter wheat crop architecture under the pedoclimatic conditions of southern Romania.

Keywords: winter wheat, sowing density, productive tillering, plant morphology, spike traits.

Introduction. Winter wheat (*Triticum aestivum* L.) is one of the most important cereal crops worldwide and remains a strategic species for food security, due to its wide adaptability, high economic value and essential role in human nutrition (Shewry, 2009; Peng et al., 2011; Golea et al., 2023).

In Romania, wheat occupies a central position among field crops, and its performance is strongly influenced by the interaction between cultivar, crop management and local pedoclimatic conditions (Marin, 2014; Soare & Chiurciu, 2016; Chiurciu et al., 2020). In the context of climate variability, the optimization of technological factors such as sowing density and cultivar choice has become increasingly important, especially where annual variation in temperature and rainfall affects plant establishment, tillering, plant growth, spike (ear) formation and grain filling. In southern Romania, changes in temperature and rainfall distribution — including increased maximum temperatures during vegetative growth and grain filling and strong year-to-year precipitation variability — have been associated with modifications in wheat phenology and cultivar performance (Croitoru et al., 2012; Marinciu et al., 2013; Berca et al., 2021). Earlier studies also indicated that winter wheat development and yield may be affected by changes in thermal and hydric regimes, highlighting the need to evaluate crop-management adaptation options under regional climate scenarios (Cuculeanu et al., 1999). Therefore, cultivar evaluation under specific local conditions remains necessary for identifying well-adapted cultivar and sowing density combinations. Among the traits involved in yield formation, spike-related traits and productive tillering have a central role in winter wheat productivity. The number of spikelets per spike and number of grains per spike contribute

directly to the expression of cultivar productivity. Tillering allows wheat plants to compensate for plant losses, low stand density or uneven emergence, contributing directly to the final number of fertile spikes per unit area. Tillers initiated early generally have a higher probability of survival and a greater contribution to grain yield, developing stronger stems and more favourable spike traits. Tilley et al. (2019) showed that early-formed tillers contributed the largest share of final grain yield, while late tillers formed close to stem elongation contributed very little, suggesting that productive tillering should be evaluated not only quantitatively, but also in relation to tiller survival, timing of formation and final spike productivity. Sowing density is one of the most important agronomic factors affecting plant establishment, tillering, canopy structure and yield components in winter wheat (Kiss et al., 2018; Bastos et al., 2020; Aula et al., 2022). Low sowing densities may reduce spike number when tillering is insufficient, whereas excessive densities can intensify competition for light, water and nutrients, reducing productive tillers per plant, and number of grains per spike (Petrović et al., 2008; Kiss et al., 2018; Bastos et al., 2020). The optimal density therefore depends on cultivar characteristics, tillering potential, sowing date, nutrient availability, soil conditions and annual climatic variation. Several studies confirmed that wheat response to plant density is strongly influenced by genotype and environment. Kiss et al. (2018) reported that sowing date and plant density affected plant height, spike fertility, productive tillers and grain number. Bastos et al. (2020) demonstrated that the agronomic optimum density varies according to yield environment and tillering potential. Aula et al. (2022) emphasized the need to periodically re-evaluate winter wheat seeding decisions, because cultivars, planting date, row spacing and seeding rate (sowing density) interact with changing climatic conditions and influence yield components. These findings support adapting density recommendations to the cultivar and local environment. The effect of plant density can also be understood through the balance between population productivity and individual plant productivity. Increasing density usually increases plant number and spike number per unit area, but may reduce individual plant and spike productivity. Yang et al. (2019) showed that increasing plant density can increase the number of superior tillers and spikes per square metre, but excessive density does not necessarily bring additional yield benefits. Petrović et al. (2008) showed that high winter wheat yields may be achieved at lower sowing rates under optimal sowing conditions, due to the combined influence of genotype, environmental conditions, soil properties and sowing rate. Jaenisch et al. (2022) highlighted that spike number and kernels per spike can compensate each other depending on management and environment. Zhou et al. (2026) confirmed that varieties with contrasting spike productivity respond differently to density, reinforcing that optimization should consider cultivar yield formation strategy. Plant density also modifies canopy architecture and the crop microenvironment. Zhang et al. (2023) showed that planting density affects canopy structure and yield components in winter wheat, while Manntschke et al. (2025) reported that high planting density modifies tiller number and plant height. These results indicate that agromorphological traits such as plant height, tillering and spike traits are important indicators of how cultivars respond to population pressure. In Romania, Bunta (2002) showed that Romanian cultivars differed in yield stability and ecological plasticity, with plant height being more cultivar-dependent, whereas plant density and grain number per spike were more influenced by environment. Racz et al. (2015) showed that yield and the main yield components of winter wheat varieties are strongly influenced by environmental conditions, and that newer genotypes can perform better under contrasting environments. Marinciu et al. (2022) reported that environmental variation explained most yield variation under organic conditions, but cultivar effect was also significant, with modern cultivars generally yielding more than older ones. Voinea et al. (2022) reported that sowing density influenced grain yield and related traits in winter wheat under Romanian ecological production conditions, with medium density giving superior production results compared with low and high densities. Chirilă et al. (2025) showed differences among cultivars in plant height and plant density among other agronomic traits under the conditions of the Western Plain of Romania, confirming that cultivar response to local environment varies across Romanian growing regions. Considering these aspects, the evaluation of

agromorphological traits and productive tillering in winter wheat cultivars grown at different sowing densities is important for understanding how each cultivar uses the available vegetation space and how plant architecture responds to local conditions.

Therefore, this research aimed to assess the influence of cultivar and sowing density on selected agromorphological traits and productive tillering of winter wheat in the Ilfov area, Romania.

Material and Method. The research was carried out during two agricultural years, 2022–2023 and 2023–2024, at the Moara Domnească Agricultural Research-Development Didactic Station, Ilfov County, Romania, within the experimental fields of the University of Agronomic Sciences and Veterinary Medicine of Bucharest. The trial was established on reddish preluvosol, representative for the Moara Domnească area (Mihalache et al., 2010). The climatic conditions recorded during the two experimental years (Table 1) differed notably from the 1991–2020 multiannual average. Both years were warmer than the long-term mean, with average temperatures of 13.4°C in 2022–2023 and 14.5°C in 2023–2024, compared to 11.9°C multiannually. Total precipitation varied considerably: 2022–2023 was a drier year (445.0 mm vs. the multiannual 640.6 mm), whilst 2023–2024 approached the long-term average (623.2 mm). These contrasting conditions provided an adequate framework for assessing the response of winter wheat cultivars and sowing densities to variable growing environments.

Table 1
Thermal and rainfall conditions at Moara Domnească during the 2022–2023 and 2023–2024 agricultural years, compared with the 1991–2020 multiannual average

Month	Monthly mean temperature (°C)			Precipitation (mm)		
	1991-2020	2022-2023	2023-2024	1991-2020	2022-2023	2023-2024
October	12.3	14.0	15.6	50.4	10.3	21.1
November	6.3	8.9	7.9	45.2	32.9	124.7
December	0.7	2.8	3.8	45.1	25.8	32.6
January	-1.0	4.4	0.6	38.7	81.1	37.8
February	1.4	2.8	7.4	33.1	6.0	19.7
March	6.1	7.9	8.2	45.8	30.5	54.3
April	11.9	10.4	14.9	53.1	79.6	81.2
May	17.4	16.5	16.4	67.8	43.9	36.3
June	21.5	21.7	25.4	82.7	46.9	29.4
July	23.7	25.5	27.4	73.3	47.3	42.2
August	23.7	25.3	26.4	44.7	24.1	39.0
September	18.4	21.1	20.1	60.8	16.6	104.9
Mean/Total	11.9	13.4	14.5	640.6	445.0	623.2

Source: <https://open-meteo.com/>

Four winter wheat cultivars — Glosa, FDL Abund, Python and Promitor — were selected from the Official Catalogue of Crop Plant Varieties in Romania (ISTIS, 2022) based on their documented agronomic potential and adaptability to variable growing conditions. Basic seed, category B, was used throughout. A bifactorial 4 × 5 split-plot experiment with four replications was established, comprising four winter wheat cultivars as Factor A ($a_1 = \text{Glosa}$, $a_2 = \text{FDL Abund}$, $a_3 = \text{Python}$, $a_4 = \text{Promitor}$) and five sowing densities as Factor B ($b_1 = 350$, $b_2 = 450$, $b_3 = 550$, $b_4 = 650$ and $b_5 = 750$ g.s. m⁻²). Glosa was used as the cultivar control, while 550 g.s. m⁻² was used as the sowing-density control. Both experimental years followed the same conventional management framework. The preceding crop was maize in 2022–2023, then chickpea in 2023–2024. Seedbed preparation involved ploughing and disking. Pre-sowing basal fertilisation consisted of 60 kg a.i. ha⁻¹ each of nitrogen and phosphorus, with an additional nitrogen top-dressing of 60 kg N a.i. ha⁻¹ applied in early spring at the resumption of vegetation. Sowing took place in October. Grain harvest took place at full maturity, in early July 2023 and in late June 2024.

Plant density was recorded in spring at the tillering stage to evaluate the effect of sowing density on plant stand. Productive tillering was assessed through the productive

tillering coefficient (PTC). Plant morphology was evaluated based on plant height, while spike fertility was characterised by the number of spikelets per spike and the number of grains per spike. Statistical processing was carried out using ANOVA. The effects of cultivar and sowing density were analysed separately for each agricultural year, after preliminary data validation, in order to identify response patterns for plant stand, tillering, morphological and spike fertility traits. Differences from the control variant were assessed using the least significant difference (LSD) test, calculated at the 5%, 1% and 0.1% probability levels. The corresponding LSD values are presented below each table.

Results and Discussion

Influence of sowing density on spring plant density. In the first experimental year (2022–2023), reducing s.d. to 350 or 450 g.s. m⁻² resulted in lower spring plant density values compared with the control (Table 2). At 350 g.s. m⁻², all cultivars recorded very significant negative differences, ranging from -102.67 to -142.67 plants m⁻². At 450 g.s. m⁻², the reductions were also statistically significant in Glosa, FDL Abund and Python, while Promitor showed a non-significant decrease.

In contrast, increasing s.d. was associated with statistically supported positive changes. At 650 g.s. m⁻², significant increases were recorded in Glosa (+44.00), FDL Abund (+53.33) and Promitor (+50.67 plants m⁻²), while Python showed only a non-significant increase. At the highest s.d., all cultivars recorded very significant increases, ranging from +86.67 to +120.00 plants m⁻² compared with the control. In absolute terms, the highest spring plant density values were recorded at 750 g.s. m⁻² in all four cultivars.

Table 2
Spring plant density (PD, no. plants m⁻²) of winter wheat as affected by sowing density (SD) in the 2022–2023 and 2023–2024 growing seasons

Cultivar	550		Sig.	350				450				650				750			
	PD	%		PD	%	Diff.	Sig.	PD	%	Diff.	Sig.	PD	%	Diff.	Sig.	PD	%	Diff.	Sig.
2022–2023																			
Glosa	641.33	100.00	C	516.00	80.46	-125.33	ooo	569.33	88.77	-72.00	ooo	685.33	106.86	44.00	*	758.67	118.30	117.33	***
FDL Abund	606.67	100.00	C	486.67	80.22	-120.00	ooo	557.33	91.87	-49.33	o	660.00	108.79	53.33	*	726.67	119.78	120.00	***
Python	664.00	100.00	C	521.33	78.51	-142.67	ooo	593.33	89.36	-70.67	oo	676.00	101.81	12.00	-	750.67	113.05	86.67	***
Promitor	592.00	100.00	C	489.33	82.66	-102.67	ooo	564.00	95.27	-28.00	-	642.67	108.56	50.67	*	706.67	119.37	114.67	***
LSD 5% = 42.41; LSD 1% = 56.74; LSD 0.1% = 74.52																			
2023–2024																			
Glosa	672.00	100.00	C	542.67	80.75	-129.33	ooo	602.67	89.68	-69.33	ooo	738.67	109.92	66.67	**	781.33	116.27	109.33	***
FDL Abund	642.67	100.00	C	512.00	79.67	-130.67	ooo	584.00	90.87	-58.67	oo	712.00	110.79	69.33	***	752.00	117.01	109.33	***
Python	712.00	100.00	C	546.67	76.78	-165.33	ooo	628.00	88.20	-84.00	ooo	726.67	102.06	14.67	-	800.00	112.36	88.00	***
Promitor	625.33	100.00	C	521.33	83.37	-104.00	ooo	589.33	94.24	-36.00	-	682.67	109.17	57.33	**	757.33	121.11	132.00	***
LSD 5% = 39.30; LSD 1% = 52.58; LSD 0.1% = 69.05																			

In the second experimental year (2023–2024), spring plant density values were generally higher compared with the first year (Table 2). Increasing s.d. to 650 g.s. m⁻² resulted in distinctly significant increases in Glosa (+66.67) and Promitor (+57.33), and very significant increases in FDL Abund (+69.33 plants m⁻²). At 750 g.s. m⁻², the increases were very significant across all tested cultivars. As in the previous year, the highest absolute values of spring plant density were recorded at 750 g.s. m⁻².

Comparing the two growing seasons, the higher values recorded in 2023–2024 were associated with a more favourable seasonal context, characterised mainly by higher precipitation. The control s.d. 550 g.s. m⁻² was exceeded statistically only when s.d. was increased. The recurrence of maximum values at 750 g.s. m⁻² in both years may be

related to the direct relationship between s.d. and the number of established plants, while the annual growing conditions appeared to influence the final survival rate rather than the overall response pattern.

Influence of cultivar on spring plant density. Under the drier conditions of the 2022–2023 growing season, differences among cultivars were relatively limited (Table 3). None of the tested cultivars recorded statistically significant positive increases in spring plant density compared with Glosa. Python recorded slightly higher numerical values than Glosa at 550, 350 and 450 g.s. m⁻², but these differences were not statistically significant. FDL Abund generally showed lower values, also without statistical significance. Promitor recorded the lowest values and showed significant negative differences at 550, 650 and 750 g.s. m⁻². When averaged across s.d., Python recorded the highest numerical spring plant density, followed closely by Glosa and FDL Abund, while Promitor showed the lowest average value.

Table 3

Spring plant density (PD, no. plants m⁻²) of winter wheat as affected by cultivar in the 2022–2023 and 2023–2024 growing seasons

Cultivar	SD (g.s. m ⁻²)																			
	550				350				450				650				750			
	PD	%	Diff.	Sig.	PD	%	Diff.	Sig.	PD	%	Diff.	Sig.	PD	%	Diff.	Sig.	PD	%	Diff.	Sig.
2022–2023																				
Glosa	641.33	100.00	C	C	516.00	100.00	C	C	569.33	100.00	C	C	685.33	100.00	C	C	758.67	100.00	C	C
FDL Abund	606.67	94.59	-	-	486.67	94.32	-	-	557.33	97.89	-	-	660.00	96.30	-	-	726.67	95.78	-	-
			34.67				29.33				12.00				25.33				32.00	
Python	664.00	103.53	22.67	-	521.33	101.03	5.33	-	593.33	104.22	24.00	-	676.00	98.64	-9.33	-	750.67	98.95	-8.00	-
Promitor	592.00	92.31	-	o	489.33	94.83	-	-	564.00	99.06	-5.33	-	642.67	93.77	-	o	706.67	93.15	-	o
			49.33				26.67								42.67				52.00	
LSD 5% = 42.41; LSD 1% = 56.74; LSD 0.1% = 74.52																				
2023–2024																				
Glosa	672.00	100.00	C	C	542.67	100.00	C	C	602.67	100.00	C	C	738.67	100.00	C	C	781.33	100.00	C	C
FDL Abund	642.67	95.63	-	-	512.00	94.35	-	-	584.00	96.90	-	-	712.00	96.39	-	-	752.00	96.25	-	-
			29.33				30.67				18.67				26.67				29.33	
Python	712.00	105.95	40.00	*	546.67	100.74	4.00	-	628.00	104.20	25.33	-	726.67	98.38	-	-	800.00	102.39	18.67	-
															12.00					
Promitor	625.33	93.06	-	o	521.33	96.07	-	-	589.33	97.79	-	-	682.67	92.42	-	oo	757.33	96.93	-	-
			46.67				21.33				13.33				56.00				24.00	
LSD 5% = 39.30; LSD 1% = 52.58; LSD 0.1% = 69.05																				

Even under the more favourable rainfall conditions of the second season (2023–2024), the overall ranking remained largely similar (Table 3). FDL Abund and Promitor did not exceed the control cultivar Glosa at any s.d., while Python recorded higher numerical values at most s.d., with the only statistically significant positive increase observed at 550 g.s. m⁻² (+40.00 plants m⁻²). Averaged across all s.d., Python again recorded the highest numerical mean value, followed by Glosa and FDL Abund, while Promitor presented the lowest average.

Cultivar influence showed moderate variability in spring plant establishment. Across the two growing seasons, Glosa maintained relatively stable values, while Python tended to record higher average plant density.

Influence of sowing density on productive tillering coefficient. Increasing s.d. to 650 or 750 g.s. m⁻² was generally associated with statistically supported decreases in the PTC compared with the control in 2022–2023 (Table 4). In contrast, reducing s.d. was associated with more intensive expression of productive tillering. At the minimum density of 350 g.s. m⁻², very significant increases in the PTC were recorded in all four cultivars: Glosa (+0.35), FDL Abund (+0.35), Python (+0.46) and Promitor (+0.37). At 450 g.s. m⁻², positive differences were also recorded, ranging from significant (FDL Abund and Promitor) to distinctly significant (Glosa) to very significant (Python) levels compared with the control. In absolute values, all four cultivars recorded the highest PTC at 350 g.s. m⁻².

Table 4

Productive tillering coefficient (PTC) of winter wheat as affected by sowing density (SD) in the 2022–2023 and 2023–2024 growing seasons

Cultivar	SD (g.s. m ⁻²)																		
	550				350				450				650				750		
	PTC	%	Sig.	PTC	%	Diff.	Sig.	PTC	%	Diff.	Sig.	PTC	%	Diff.	Sig.	PTC	%	Diff.	Sig.
2022–2023																			
Glosa	1.12	100.00	C	1.47	131.77	0.35	***	1.26	112.98	0.15	**	0.97	86.80	-0.15	oo	0.86	77.18	-0.26	ooo
FDL Abund	0.93	100.00	C	1.28	137.47	0.35	***	1.05	112.67	0.12	*	0.84	90.30	-0.09	-	0.75	80.86	-0.18	ooo
Python	1.10	100.00	C	1.56	142.05	0.46	***	1.30	118.18	0.20	***	0.97	88.18	-0.13	oo	0.88	79.55	-0.23	ooo
Promitor	0.81	100.00	C	1.18	145.23	0.37	***	0.93	113.85	0.11	*	0.74	91.38	-0.07	-	0.66	80.92	-0.16	oo
LSD 5% = 0.09; LSD 1% = 0.12; LSD 0.1% = 0.15																			
2023–2024																			
Glosa	1.13	100.00	C	1.55	137.78	0.43	***	1.30	115.56	0.18	***	0.99	87.56	-0.14	oo	0.91	80.60	-0.22	ooo
FDL Abund	0.96	100.00	C	1.34	138.96	0.38	***	1.08	111.69	0.11	*	0.86	89.35	-0.10	o	0.94	97.40	-0.03	-
Python	1.09	100.00	C	1.54	141.38	0.45	***	1.29	118.85	0.21	***	0.94	86.21	-0.15	oo	0.88	81.15	-0.21	ooo
Promitor	0.84	100.00	C	1.23	146.87	0.39	***	0.99	117.61	0.15	**	0.75	89.25	-0.09	o	0.70	83.58	-0.14	o
LSD 5% = 0.08; LSD 1% = 0.11; LSD 0.1% = 0.15																			

In the 2023–2024 agricultural year, the general level of productive tillering was higher than in the first year (Table 4), which may be partly attributed to the more favourable precipitation conditions recorded in this season. The same compensation tendency was observed: reducing s.d. to 350 g.s. m⁻² was associated with very significant increases in the PTC across all tested cultivars, while the 450 g.s. m⁻² produced very significant increases in Glosa and Python and distinctly significant increases in Promitor. As in the first year, the absolute values showed that all cultivars recorded the highest PTC at 350 g.s. m⁻².

Influence of cultivar on productive tillering coefficient. Under the drier conditions of the 2022–2023 agricultural year, differences among cultivars were observed, yet none of the tested cultivars recorded statistically supported positive increases in the PTC compared with Glosa (Table 5). FDL Abund and Promitor recorded very significant negative differences across all sowing densities, while Python showed no statistically supported differences from the control at any density. Averaged across s.d., Python recorded the highest PTC, followed closely by Glosa, while FDL Abund and Promitor showed lower average values.

Table 5

Productive tillering coefficient (PTC) of winter wheat as affected by cultivar in the 2022–2023 and 2023–2024 growing seasons

Cultivar	SD (g.s. m ⁻²)																			
	550				350				450				650				750			
	PTC	%	Diff.	Sig.	PTC	%	Diff.	Sig.	PTC	%	Diff.	Sig.	PTC	%	Diff.	Sig.	PTC	%	Diff.	Sig.
2022–2023																				
Glosa	1.12	100.00	C	C	1.47	100.00	C	C	1.26	100.00	C	C	0.97	100.00	C	C	0.86	100.00	C	C
FDL Abund	0.93	83.00	-	ooo	1.28	86.59	-	ooo	1.05	82.77	-	ooo	0.84	86.34	-	oo	0.75	86.96	-	o
			0.20				0.20				0.22				0.13				0.11	
Python	1.10	98.43	-	-	1.56	106.11	0.09	-	1.30	102.97	0.04	-	0.97	100.00	0.00	-	0.88	101.45	0.01	-
			0.02																	
Promitor	0.81	72.71	-	ooo	1.18	80.14	-	ooo	0.93	73.27	-	ooo	0.74	76.55	-	ooo	0.66	76.23	-	ooo
			0.31				0.29				0.34				0.23				0.21	
LSD 5% = 0.09; LSD 1% = 0.12; LSD 0.1% = 0.15																				
2023–2024																				
Glosa	1.13	100.00	C	C	1.55	100.00	C	C	1.30	100.00	C	C	0.99	100.00	C	C	0.91	100.00	C	C
FDL Abund	0.96	85.56	-	ooo	1.34	86.29	-	ooo	1.08	82.69	-	ooo	0.86	87.31	-	oo	0.94	103.39	0.03	-
			0.16				0.21				0.23				0.13					
Python	1.09	96.67	-	-	1.54	99.19	-	-	1.29	99.42	-	-	0.94	95.18	-	-	0.88	97.32	-	-
			0.04				0.01				0.01				0.05				0.02	
Promitor	0.84	74.44	-	ooo	1.23	79.35	-	ooo	0.99	75.77	-	ooo	0.75	75.89	-	ooo	0.70	77.20	-	ooo
			0.29				0.32				0.32				0.24				0.21	
LSD 5% = 0.08; LSD 1% = 0.11; LSD 0.1% = 0.15																				

The more favourable precipitation conditions of 2023–2024 led to a slight shift in the cultivar ranking regarding the mean values across s.d. (Table 5). In this second season, Glosa recorded the highest average PTC, followed closely by Python, while FDL Abund and Promitor consistently maintained the third and fourth positions, respectively. FDL Abund and Promitor again recorded very significant negative differences compared with Glosa across most sowing densities, while Python remained statistically non-significant from the control at all densities. Similar to the previous year, none of the tested cultivars produced statistically supported positive increases compared with the control cultivar Glosa.

Influence of sowing density on plant height. Reducing s.d. to 350 g.s. m⁻² was associated with plant height increases, with significant differences recorded in all four cultivars: Glosa (+2.77), FDL Abund (+2.93), Python (+3.15) and Promitor (+3.28 cm) in 2022–2023 agricultural year (Table 6). Increasing s.d. to 650 or 750 g.s. m⁻² tended to reduce plant height. In absolute values, all cultivars reached their highest plant height at the minimum sowing density of 350 g.s. m⁻².

Table 6
Plant height (PH, cm) of winter wheat as affected by sowing density (SD) in the 2022–2023 and 2023–2024 growing seasons

Cultivar	SD (g.s. m ⁻²)																		
	550			350				450				650				750			
	PH	%	Sig.	PH	%	Diff.	Sig.	PH	%	Diff.	Sig.	PH	%	Diff.	Sig.	PH	%	Diff.	Sig.
2022–2023																			
Glosa	90.83	100.00	C	93.60	103.05	2.77	*	91.56	100.81	0.73	-	88.06	96.95	-2.77	o	86.61	95.36	-4.22	oo
FDL Abund	98.38	100.00	C	101.31	102.98	2.93	*	99.08	100.71	0.70	-	97.35	98.95	-1.03	-	96.60	98.20	-1.78	-
Python	77.91	100.00	C	81.06	104.04	3.15	*	80.09	102.79	2.18	-	76.83	98.60	-1.09	-	76.03	97.58	-1.89	-
Promitor	93.61	100.00	C	96.89	103.50	3.28	*	94.72	101.19	1.11	-	92.51	98.83	-1.10	-	91.14	97.36	-2.47	-
LSD 5% = 2.61; LSD 1% = 3.47; LSD 0.1% = 4.52																			
2023–2024																			
Glosa	91.24	100.00	C	94.72	103.81	3.48	**	92.61	101.51	1.37	-	89.55	98.15	-1.69	-	87.98	96.42	-3.26	oo
FDL Abund	100.37	100.00	C	103.00	102.62	2.63	*	102.31	101.93	1.94	-	98.61	98.25	-1.76	-	96.90	96.53	-3.48	oo
Python	81.34	100.00	C	83.35	102.47	2.01	-	82.15	101.00	0.81	-	80.47	98.93	-0.87	-	80.01	98.36	-1.33	-
Promitor	96.41	100.00	C	98.86	102.54	2.45	*	97.36	100.99	0.95	-	94.48	97.99	-1.94	-	93.20	96.67	-3.21	oo
LSD 5% = 2.30; LSD 1% = 3.07; LSD 0.1% = 4.00																			

In 2023–2024, plants were generally taller than in the previous year (Table 6), which may be partly attributed to the more favourable precipitation conditions recorded in this season. However, the sowing density-related response remained similar. Reducing s.d. to 350 g.s. m⁻² produced a distinctly significant increase in Glosa (+3.48 cm) and significant increases in FDL Abund (+2.63 cm) and Promitor (+2.45 cm). The absolute values again showed that the highest plant height in all cultivars was recorded at 350 g.s. m⁻².

Influence of cultivar on plant height. In the 2022–2023 season, differences in plant height among cultivars were evident (Table 7). FDL Abund recorded very significant increases compared with the control cultivar Glosa across the whole s.d. gradient, with differences ranging from +7.51 cm at 450 g.s. m⁻² to +9.99 cm at 750 g.s. m⁻², and absolute values between 96.60 cm and 101.31 cm. Promitor also recorded statistically supported increases, significant and distinctly significant, with absolute values ranging from 91.14 cm to 96.89 cm across the tested s.d. In contrast, Python recorded very significant negative differences compared with Glosa at all s.d., with differences ranging from -10.59 cm to -12.92 cm and absolute values between 76.03 cm and 81.06 cm, indicating a distinctly shorter growth habit. When averaged across all s.d., FDL Abund recorded the highest plant height, followed by Promitor, Glosa and Python, suggesting that cultivar had a stronger influence on plant height than sowing density under the conditions of this experimental year.

Under the more favourable climatic conditions of the second year (2023–2024), the same general ranking was maintained (Table 7). FDL Abund recorded very significant

increases compared with Glosa across all sowing densities, with differences ranging from +8.28 cm to +9.70 cm and absolute values between 96.90 cm and 103.00 cm.

Table 7

Plant height (PH, cm) of winter wheat as affected by cultivar in the 2022–2023 and 2023–2024 growing seasons

Cultivar	SD (g.s. m ⁻²)																			
	550				350				450				650				750			
	PH	%	Diff.	Sig.	PH	%	Diff.	Sig.	PH	%	Diff.	Sig.	PH	%	Diff.	Sig.	PH	%	Diff.	Sig.
2022–2023																				
Glosa	90.83	100.00	C	C	93.60	100.00	C	C	91.56	100.00	C	C	88.06	100.00	C	C	86.61	100.00	C	C
FDL Abund	98.38	108.31	7.55	***	101.31	108.23	7.71	***	99.08	108.20	7.51	***	97.35	110.54	9.28	***	96.60	111.53	9.99	***
Python	77.91	85.78	-	ooo	81.06	86.61	-	ooo	80.09	87.47	-	ooo	76.83	87.24	-	ooo	76.03	87.78	-	ooo
			12.92				12.54				11.48				11.24				10.59	
Promitor	93.61	103.06	2.78	*	96.89	103.51	3.29	*	94.72	103.45	3.16	*	92.51	105.05	4.45	**	91.14	105.22	4.53	**
<i>LSD 5% = 2.61; LSD 1% = 3.47; LSD 0.1% = 4.52</i>																				
2023–2024																				
Glosa	91.24	100.00	C	C	94.72	100.00	C	C	92.61	100.00	C	C	89.55	100.00	C	C	87.98	100.00	C	C
FDL Abund	100.37	110.01	9.14	***	103.00	108.74	8.28	***	102.31	110.47	9.70	***	98.61	110.12	9.06	***	96.90	110.14	8.92	***
Python	81.34	89.15	-9.90	ooo	83.35	88.00	-	ooo	82.15	88.70	-	ooo	80.47	89.86	-9.08	ooo	80.01	90.94	-7.97	ooo
							11.37				10.46									
Promitor	96.41	105.67	5.17	***	98.86	104.38	4.15	***	97.36	105.13	4.75	***	94.48	105.50	4.92	***	93.20	105.94	5.23	***
<i>LSD 5% = 2.30; LSD 1% = 3.07; LSD 0.1% = 4.00</i>																				

Promitor also recorded very significant positive differences at all densities, with differences ranging from +4.15 cm to +5.23 cm and absolute values between 93.20 cm and 98.86 cm. Python again recorded very significant negative differences compared with Glosa, with absolute values between 80.01 cm and 83.35 cm. When averaged across all s.d., FDL Abund remained the tallest cultivar, followed by Promitor, Glosa and Python, confirming the stability of cultivar ranking for plant height across both experimental years.

Influence of sowing density on number of spikelets per spike. During the 2022–2023 season, reducing s.d. to 350 g.s. m⁻² was associated with statistically supported increases in the number of spikelets per spike (Table 8). Significant increases were recorded in Glosa (+0.67) and FDL Abund (+0.67), while distinctly significant increases were observed in Python (+1.05) and Promitor (+0.83 spikelets). Increasing s.d. did not produce statistically supported positive increases. In absolute values, all four cultivars recorded the highest number of spikelets per spike at 350 g.s. m⁻².

Table 8

Number of spikelets per spike (NSS) of winter wheat as affected by sowing density (SD) in the 2022–2023 and 2023–2024 growing seasons

Cultivar	SD (g.s. m ⁻²)																			
	550				350				450				650				750			
	NSS	%	Sig.	NSS	%	Diff.	Sig.	NSS	%	Diff.	Sig.	NSS	%	Diff.	Sig.	NSS	%	Diff.	Sig.	
2022–2023																				
Glosa	16.20	100.00	C	16.87	104.12	0.67	*	16.27	100.41	0.07	-	15.93	98.35	-0.27	-	15.40	95.06	-0.80	o	
FDL Abund	15.83	100.00	C	16.50	104.21	0.67	*	16.15	102.00	0.32	-	15.63	98.74	-0.20	-	15.43	97.47	-0.40	-	
Python	16.85	100.00	C	17.90	106.23	1.05	**	17.30	102.67	0.45	-	16.62	98.63	-0.23	-	16.18	96.04	-0.67	o	
Promitor	17.67	100.00	C	18.50	104.72	0.83	**	17.87	101.13	0.20	-	17.40	98.49	-0.27	-	17.27	97.74	-0.40	-	
<i>LSD 5% = 0.60; LSD 1% = 0.80; LSD 0.1% = 1.06</i>																				
2023–2024																				
Glosa	17.50	100.00	C	18.40	105.14	0.90	**	18.00	102.86	0.50	-	16.70	95.43	-0.80	o	15.83	90.46	-1.67	ooo	
FDL Abund	17.00	100.00	C	18.09	106.41	1.09	***	17.60	103.53	0.60	-	16.75	98.55	-0.25	-	16.05	94.41	-0.95	oo	
Python	17.33	100.00	C	18.57	107.12	1.23	***	17.82	102.79	0.48	-	17.02	98.17	-0.32	-	16.78	96.83	-0.55	-	
Promitor	18.13	100.00	C	19.03	104.96	0.90	**	18.53	102.21	0.40	-	17.83	98.35	-0.30	-	17.47	96.32	-0.67	o	
<i>LSD 5% = 0.60; LSD 1% = 0.80; LSD 0.1% = 1.06</i>																				

The more favourable precipitation regime of 2023–2024 made the response to sowing density more pronounced (Table 8). Reducing s.d. to 350 g.s. m⁻² was associated with very significant positive differences in FDL Abund (+1.09) and Python (+1.23), and distinctly significant positive differences in Glosa (+0.90) and Promitor (+0.90). At the highest s.d. of 750 g.s. m⁻², negative differences were recorded in all cultivars, reaching very significant levels in Glosa (-1.67) and distinctly significant levels in FDL Abund (-0.95). The absolute values showed that, as in the previous year, the highest number of spikelets per spike was recorded at 350 g.s. m⁻², while the lowest values were consistently associated with 750 g.s. m⁻².

Influence of cultivar on number of spikelets per spike. In the 2022–2023 season, differences among the studied cultivars were observed (Table 9). Promitor recorded very significant positive increases compared with Glosa across the whole s.d. range, with differences between +1.47 spikelets at 550 and 650 g.s. m⁻² and +1.87 spikelets at 750 g.s. m⁻², and absolute values ranging from 17.27 to 18.50 spikelets per spike. Python also recorded positive differences, distinctly significant at 350 and 450 g.s. m⁻² and significant at the remaining densities, with absolute values between 16.18 and 17.90 spikelets per spike. FDL Abund showed no statistically supported differences from Glosa at any sowing density in this year.

Table 9
Number of spikelets per spike (NSS) of winter wheat as affected by cultivar in the 2022–2023 and 2023–2024 growing seasons

Cultivar	550				350				450				650				750			
	NSS	%	Diff.	Sig.	NSS	%	Diff.	Sig.	NSS	%	Diff.	Sig.	NSS	%	Diff.	Sig.	NSS	%	Diff.	Sig.
2022–2023																				
Glosa	16.20	100.00	C	C	16.87	100.00	C	C	16.27	100.00	C	C	15.93	100.00	C	C	15.40	100.00	C	C
FDL Abund	15.83	97.74	-	-	16.50	97.83	-	-	16.15	99.28	-	-	15.63	98.12	-	-	15.43	100.22	0.03	-
Python	16.85	104.01	0.65	*	17.90	106.13	1.03	**	17.30	106.35	1.03	**	16.62	104.29	0.68	*	16.18	105.09	0.78	*
Promitor	17.67	109.05	1.47	***	18.50	109.68	1.63	***	17.87	109.84	1.60	***	17.40	109.21	1.47	***	17.27	112.12	1.87	***
LSD 5% = 0.60; LSD 1% = 0.80; LSD 0.1% = 1.06																				
2023–2024																				
Glosa	17.50	100.00	C	C	18.40	100.00	C	C	18.00	100.00	C	C	16.70	100.00	C	C	15.83	100.00	C	C
FDL Abund	17.00	97.14	-	-	18.09	98.32	-	-	17.60	97.78	-	-	16.75	100.32	0.05	-	16.05	101.39	0.22	-
Python	17.33	99.05	-	-	18.57	100.91	0.17	-	17.82	98.98	-	-	17.02	101.90	0.32	-	16.78	106.02	0.95	**
Promitor	18.13	103.62	0.63	*	19.03	103.44	0.63	*	18.53	102.96	0.53	-	17.83	106.79	1.13	***	17.47	110.34	1.64	***
LSD 5% = 0.60; LSD 1% = 0.80; LSD 0.1% = 1.06																				

Under the more favourable climatic conditions of 2023–2024, the general cultivar ranking was maintained, though the pattern of statistically supported differences was somewhat narrower (Table 9). Promitor again recorded positive differences compared with Glosa, reaching very significant levels at 650 g.s. m⁻² (+1.13) and 750 g.s. m⁻² (+1.64), with absolute values between 17.47 and 19.03 spikelets per spike. Python recorded a distinctly significant positive difference only at the highest s.d. (+0.95 at 750 g.s. m⁻²), while FDL Abund again showed no statistically supported differences from the control.

Across both seasons, Promitor consistently recorded the highest number of spikelets per spike, followed by Python, while FDL Abund showed values comparable to or slightly below Glosa, suggesting that this cultivar may rely on other compensatory components of spike productivity.

Influence of sowing density on number of grains per spike. Increasing s.d. did not produce statistically supported positive increases in 2022–2023 (Table 10). In contrast, reducing s.d. to 350 g.s. m⁻² was associated with very significant increases in Python (+3.93) and Promitor (+3.50 grains), and significant increases in Glosa and FDL Abund. In absolute values, all four cultivars recorded the highest number of grains per spike at 350 g.s. m⁻².

Table 10

Number of grains/ spike (NGS) of winter wheat as affected by sowing density (SD) in the 2022–2023 and 2023–2024 growing seasons

Cultivar	SD (g.s. m ⁻²)																		
	550			350				450				650				750			
	NGS	%	Sig.	NGS	%	Diff.	Sig.	NGS	%	Diff.	Sig.	NGS	%	Diff.	Sig.	NGS	%	Diff.	Sig.
2022–2023																			
Glosa	33.53	100.00	C	35.47	105.77	1.93	*	34.10	101.69	0.57	-	30.83	91.95	-2.70	oo	30.17	89.96	-3.37	ooo
FDL Abund	36.27	100.00	C	38.33	105.70	2.07	*	37.47	103.31	1.20	-	35.50	97.89	-0.77	-	33.63	92.74	-2.63	oo
Python	33.27	100.00	C	37.20	111.82	3.93	***	34.20	102.81	0.93	-	32.37	97.29	-0.90	-	31.33	94.19	-1.93	o
Promitor	31.67	100.00	C	35.17	111.05	3.50	***	33.23	104.95	1.57	-	29.73	93.89	-1.93	oo	28.37	89.58	-3.30	ooo
<i>LSD 5% = 1.64; LSD 1% = 2.20; LSD 0.1% = 2.89</i>																			
2023–2024																			
Glosa	35.18	100.00	C	36.93	105.00	1.76	*	35.27	100.28	0.10	-	32.63	92.77	-2.54	oo	31.10	88.41	-4.08	ooo
FDL Abund	38.22	100.00	C	39.02	102.10	0.80	-	38.52	100.79	0.30	-	38.06	99.58	-0.16	-	35.38	92.58	-2.84	oo
Python	35.73	100.00	C	38.37	107.37	2.63	**	36.43	101.96	0.70	-	34.93	97.76	-0.80	-	33.33	93.28	-2.40	oo
Promitor	34.31	100.00	C	36.37	106.01	2.06	**	34.60	100.85	0.29	-	32.56	94.90	-1.75	o	30.18	87.97	-4.13	ooo
<i>LSD 5% = 1.50; LSD 1% = 2.01; LSD 0.1% = 2.64</i>																			

In the second season (2023–2024), which was more favourable in terms of total precipitation, the general fertility of spikes was higher (Table 10). However, the statistically supported positive differences were again mainly associated with lower s.d. Reducing s.d. to 350 g.s. m⁻² resulted in distinctly significant increases in Python (+2.63) and Promitor (+2.06), and a significant increase in Glosa (+1.76 grains). At 750 g.s. m⁻², very significant negative differences were recorded in Glosa (-4.08), FDL Abund (-2.84) and Promitor (-4.13), while Python recorded a distinctly significant decrease (-2.40), confirming the same compensatory pattern observed in the first year. The absolute values showed a consistent pattern, with all cultivars recording the highest number of grains per spike at 350 g.s. m⁻².

Influence of cultivar on number of grains per spike. In the 2022–2023 growing season, FDL Abund recorded the highest number of grains per spike, with very significant positive differences compared with Glosa at 450 (+3.37), 650 (+4.67) and 750 g.s. m⁻² (+3.47 grains). Python and Promitor showed only isolated statistically supported differences from the control, while averaged across all s.d., FDL Abund consistently ranked first (Table 11).

Table 11

Number of grains/ spike (NGS) of winter wheat as affected by cultivar in the 2022–2023 and 2023–2024 growing seasons

Cultivar	SD (g.s. m ⁻²)																			
	550			350				450				650				750				
	NGS	%	Diff.	Sig.	NGS	%	Diff.	Sig.	NGS	%	Diff.	Sig.	NGS	%	Diff.	Sig.	NGS	%	Diff.	Sig.
2022–2023																				
Glosa	33.53	100.00	C	C	35.47	100.00	C	C	34.10	100.00	C	C	30.83	100.00	C	C	30.17	100.00	C	C
FDL Abund	36.27	108.15	2.73	**	38.33	108.08	2.87	**	37.47	109.87	3.37	***	35.50	115.14	4.67	***	33.63	111.49	3.47	***
Python	33.27	99.20	-	-	37.20	104.89	1.73	*	34.20	100.29	0.10	-	32.37	104.97	1.53	-	31.33	103.87	1.17	-
Promitor	31.67	94.43	-	o	35.17	99.15	-	-	33.23	97.46	-	-	29.73	96.43	-	-	28.37	94.03	-	o
<i>LSD 5% = 1.64; LSD 1% = 2.20; LSD 0.1% = 2.89</i>																				
2023–2024																				
Glosa	35.18	100.00	C	C	36.93	100.00	C	C	35.27	100.00	C	C	32.63	100.00	C	C	31.10	100.00	C	C
FDL Abund	38.22	108.65	3.04	***	39.02	105.65	2.09	**	38.52	109.21	3.25	***	38.06	116.62	5.42	***	35.38	113.77	4.28	***
Python	35.73	101.58	0.56	-	38.37	103.88	1.43	-	36.43	103.29	1.16	-	34.93	107.05	2.30	**	33.33	107.18	2.23	**
Promitor	34.31	97.54	-	-	36.37	98.48	-	-	34.60	98.09	-	-	32.56	99.77	-	-	30.18	97.05	-	-
<i>LSD 5% = 1.50; LSD 1% = 2.01; LSD 0.1% = 2.64</i>																				

Under the more favourable precipitation conditions of the second season (2023–2024), the general ranking was maintained. FDL Abund continued to record very significant positive differences compared with Glosa across all sowing densities, reaching the highest difference of +5.42 grains at 650 g.s. m⁻². Python also recorded distinctly significant positive differences at 650 and 750 g.s. m⁻². Promitor showed no statistically supported differences from Glosa at any density in this year.

Averaged across all s.d., FDL Abund again recorded the highest number of grains per spike, followed by Python, Glosa and Promitor, confirming the consistency of cultivar ranking across both experimental years.

Conclusions. The results obtained under the pedoclimatic conditions of Ilfov County indicate that both cultivar and sowing density influenced the agromorphological traits and productive tillering of winter wheat, with the magnitude and direction of the response varying by trait and agricultural year.

Sowing density had a direct effect on spring plant density, with the highest values recorded at 750 g.s. m⁻² in all cultivars and both years. For the productive tillering coefficient, plant height, number of spikelets per spike and number of grains per spike, the lowest sowing density of 350 g.s. m⁻² was consistently associated with the most favourable individual plant expression, while increasing density above the control (550 g.s. m⁻²) tended to reduce these traits.

Cultivar influence on spring plant density was limited. For the remaining traits, cultivar differences were more pronounced: FDL Abund recorded the greatest plant height and the highest number of grains per spike, Promitor recorded the highest number of spikelets per spike, and Python showed PTC values comparable to those of the control cultivar Glosa.

The 2023–2024 season was generally associated with higher trait values, which may be partly attributed to more favourable precipitation conditions.

Overall, the study confirms that sowing density and cultivar interact in shaping winter wheat crop architecture, and that their joint evaluation is necessary for interpreting agromorphological responses under the specific conditions of the Ilfov area. Further research over additional growing seasons would support more precise cultivar-density recommendations for this region.

Acknowledgements. This work was conducted as part of the doctoral research of the first author. The authors wish to thank the University of Agronomic Sciences and Veterinary Medicine of Bucharest and the Moara Domneasca Agricultural Research-Development Didactic Station for their financial and logistical support throughout the field experiments.

Authors Contributions. AMP wrote the manuscript; DIM read and revised the manuscript.

Conflicts of Interest. The authors declare that there is no conflict of interest.

Data Availability. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Funding. This research received no external funding.

References

- Aula, L., Easterly, A.C., Creech, C.F. (2022). Winter wheat seeding decisions for improved grain yield and yield components. *Agronomy*, 12, 3061.
- Bastos, L.M., Carciochi, W., Lollato, R.P., Jaenisch, B.R., Rezende, C.R., Schwalbert, R., Prasad, P.V.V., Zhang, G., Fritz, A.K., Foster, C., Wright, Y., Young, S., Bradley, P., Ciampitti, I.A. (2020). Winter wheat yield response to plant density as a function of

- yield environment and tillering potential: a review and field studies. *Frontiers in Plant Science*, 11, 54.
- Berca, M., Robescu, V.O., Horoiş, R. (2021). Winter wheat crop water consumption and its effect on yields in southern Romania, in the very dry 2019-2020 agricultural year. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 49(2), 12309.
- Bunta, G. (2002). Behaviour of some winter wheat cultivars in western part of Romania. *Romanian Agricultural Research*, 17-18, 15-21.
- Chirilă, P.A., Hînda, I.A., Hetea, D.C. (2025). Comparative analysis of winter wheat (*Triticum aestivum* L.) cultivars under the pedoclimatic conditions of the Western Plain of Romania. *Research Journal of Agricultural Science*, 57(3), 94-98.
- Chiurciu, I.A., Soare, E., Constantin, D.M., Grigore, E., Bogan, E. (2020). Analysis regarding the evolution of the cereal sector in the North-East Region of Romania. *Scientific Papers Management, Economic Engineering in Agriculture and Rural Development*, 20(4), 139-146.
- Croitoru, A.E., Holobâcă, I.H., Lazăr, C., Moldovan, F., Imbroane, A. (2012). Air temperature trend and the impact on winter wheat phenology in Romania. *Climatic Change*, 111, 393-410.
- Cuculeanu, V., Marica, A., Simota, C. (1999). Climate change impact on agricultural crops and adaptation options in Romania. *Climate Research*, 12, 153-160.
- Golea, C.M., Stroe, S.G., Gâtlan, A.M., Codină, G.G. (2023). Physicochemical characteristics and microstructure of ancient and common wheat grains cultivated in Romania. *Plants*, 12, 2138.
- Jaenisch, B.R., Munaro, L.B., Jagadish, S.V.K., Lollato, R.P. (2022). Modulation of wheat yield components in response to management intensification to reduce yield gaps. *Frontiers in Plant Science*, 13, 772232.
- Kiss, T., Balla, K., Bányai, J., Veisz, O., Karsai, I. (2018). Associations between plant density and yield components using different sowing times in wheat (*Triticum aestivum* L.). *Cereal Research Communications* 46(2), 211-220.
- Manntschke, A., Hempel, L., Temme, A., Reumann, M., Chen, T.W. (2025). Breeding in winter wheat (*Triticum aestivum* L.) can be further progressed by targeting previously neglected competitive traits. *Frontiers in Plant Science* 16, 1490483.
- Marin, D.E. (2014). Evolution of supply and demand of wheat in Romania. *Scientific Papers Management, Economic Engineering in Agriculture and Rural Development* 14(1), 207-210.
- Marinciu, C., Mustăţea, P., Şerban, G., Ittu, G., Săulescu, N.N. (2013). Effects of climate change and genetic progress on performance of wheat cultivars, during the last twenty years in South Romania. *Romanian Agricultural Research*, 30, 3-11.
- Marinciu, C.M., Tanc, M., Şerban, G., Manda, V., Toncea, I., Petcu, V., Săulescu, N. (2022). Performance of some Romanian winter wheat cultivars under organic agriculture conditions. I. Grain yield. *Annals of the University of Craiova-Agriculture Montanology Cadastre Series*, 52(1), 241-246.
- Mihalache, M., Ilie, L., Marin, D.I. (2010). Research concerning the evolution of physical and chemical properties of reddish preluvosoil from Moara Domnească. *Scientific Papers, USAMV Bucharest, Series A, LIII*, 61-66.
- Peng, J.H., Sun, D., Nevo, E. (2011) Domestication evolution, genetics and genomics in wheat. *Molecular Breeding*, 28(3), 281-301.
- Petrović, S., Marić, S., Guberac, V., Drezner, G., Eded, A. (2008). Influence of environmental conditions and sowing rates on winter wheat yield. *Cereal Research Communications*, 36, 1307-1310.
- Racz, I., Kadar, R., Moldovan, V., Haş, I. (2015). Performance and stability of grain yield and yield components in some winter wheat varieties. *Romanian Agricultural Research*, 32, 11-18.
- Shewry, P.R. (2009). Wheat. *Journal of Experimental Botany*, 60(6), 1537-1553.
- Soare, E., Chiurciu, I.A. (2016). Research on the Romanian wheat market. *Scientific Papers Management, Economic Engineering in Agriculture and Rural Development*, 16(2), 287-292.

- Tilley, M.S., Heiniger, R.W., Crozier, C.R. (2019). Tiller initiation and its effects on yield and yield components in winter wheat. *Agronomy Journal*, 111(3), 1323-1332.
- Voinea, C., Melucă, C., Ilie, L. (2022). Effects of different sowing density in winter wheat in ecological productions in two different locations in Romania. *Scientific Papers. Series A. Agronomy*, LXV(1), 593-602.
- Yang, D., Cai, T., Luo, Y., Wang, Z. (2019). Optimizing plant density and nitrogen application to manipulate tiller growth and increase grain yield and nitrogen-use efficiency in winter wheat. *PeerJ*, 7, e6484.
- Zhang, F., Zhang, D., Li, L., Zhang, Z., Liang, X., Wen, Q., Chen, G., Wu, Q., Zhai, Y. (2023). Effect of planting density on canopy structure, microenvironment, and yields of uniformly sown winter wheat. *Agronomy*, 13, 870.
- Zhou, X., Qian, M., Wang, F., Gao, D., Zhao, G., Wang, S., Wang, D., Hu, X. (2026). Trait-based optimization of plant density in drip-fertigated wheat: yield formation and nitrogen-radiation-water use efficiency responses of varieties contrasting in individual spike productivity. *Plants* 15(8), 1167.
- *** Open-Meteo historical weather archive, <https://open-meteo.com> (last view: 30.05.2026)

Received: 17 May 2026. Accepted: 16 June 2026. Published online: 17 June 2026.

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How to cite this article:

Petre, A. M., Marin, D. I. (2026). Agromorphological traits and productive tillering response of winter wheat (*Triticum aestivum* L.) as affected by cultivar and sowing density in the Ilfov area, Romania. *AAB Bioflux*, 18(1), 38-50.