

Variation of Quantitative Traits of Spring Wheat Genotypes under Different Ecological Conditions

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Abstract. The breeding program of spring wheat involves testing the agronomic performance of different genotypes in different environmental conditions to highlight their yield potential and grain quality. Twelve spring wheat genotypes were tested in a different field conditions-ARDS Turda, ARDS Livada and ARDS Lovrin, for their agronomic performances during 2024. Even though the climatic conditions in the three research centers had certain specific features, they allowed us to identify certain high-performing genotypes. Thus, regarding grain yield capacity, the genotypes T. 2601-22 and T. 2585-22 were noted as performing for all three ecological conditions, their average production being 4905 respectively 4694 ka ha⁻¹. Hectoliter weight is an important morpho-physiological traits based on which the adaptability of the genotype to different climate and stress conditions can be evaluated. In our study these traits rage between 68.07 to 73.77 kg hl⁻¹. For grain quality, the genotypes T. 4173-19, T. 2584-22 and T. 2585-22 recorded higher indices for protein content, respectively wet gluten content. The testing of wheat genotypes in different ecological conditions allowed the identification of the perspective line T. 2585-22 and T. 2601-22 having a high productivity, respectively T. 4173-19 and T. 2584-22 as superior grain quality, combining the two agronomic characters in a favourable way.

Keywords: adaptability, grain quality, grain yield, spring wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the main crops worldwide and phenotypic expression of yield and yield components can be limited by environmental conditions (Filip et al., 2023; Saieed et al., 2024; Frantova et al., 2025). Even if the adaptability of wheat plants are very large, local conditions of different microclimate can limit or support the expression of yield and quality potential (Tommaso et al., 2023). Generally, winter wheat is known by its high yield potential (Hüner et al., 2025; Koppel and Ingver, 2008) while spring wheat by superior grain quality indices. Spring wheat is an ecotype of wheat plants with reduced requirements for vernalization (Peter et al., 2025).

The agronomic value of a genotype is given by the its yield and grain quality performances under different stress and non-stress conditions. Even though spring wheat has a lower yield compared to winter wheat, it achieves satisfactory yield in relation to its vegetation period being even comparable, and in extreme cases even superior to the winter wheat crop (Lozinskiy et al., 2023). Recent and intensive spring wheat genotype have 85-90 days growing cycle (Berghuijs et al., 2023; Lkhagvadulam et al., 2025) but in our climatic conditions and considering the germplasm used, the spring wheat created at ARDS Turda requires a vegetation period of approximately 100-120 days. Obtaining high-performance spring wheat genotypes with a short vegetation period that allows avoiding high temperatures and hot periods that have negative effects on the formation and development of the main productivity elements are primary objectives in improving this form of wheat (Perry and D'Antuono, 1989; Feng et al., 2021).

Hectoliter weight is an important agronomic trait that can be influenced by cultivar, climatic conditions and grain properties (Okur and Onel, 2025). Improving the hectoliter mass character involves complex mechanisms, but the pursuit of this character and the success of its improvement significantly characterize the agronomic value of the respective genotype (Swelam et al., 2022).

Aims: the main purpose of this paper is to identify the best performing wheat genotypes both in terms of grain production and their quality in different ecological conditions.

MATERIAL AND METHODS

12 spring wheat genotypes (three control genotypes: Pădureni, and Feleacu- Romanian genotypes, respectively Triso- foreign genotype, and 9 perspective lines) were tested in a field condition in three different ecological conditions: (1) Agricultural Research and Development Station from Turda- ARDS Turda (longitude 23° 47'; latitude 46°35'; altitude 427 m), (2) Agricultural Research and Development Station Livada- ARDS Livada (23°03' longitude, 47°54' latitude, altitude 130 m), respectively (3) Agricultural Research and

Development Station Lovrin- ARDS Lovrin (20°77' longitude, 45°97' latitude, altitude 87 m) during 2024 growing season for their grain yield potential and grain quality. The genotypes analyzed were organized in a randomized complete block design with three replicates in each agroclimatic conditions. The sowing rate of field plots was 600 grains sqm and a basic fertilization (50 kg ha⁻¹ N) were applied before sowing. The plants were harvested with a plot combine (Wintersteiger) at full maturity, the grain yield being reported at 14%.

Regarding the climatic conditions during the experimental period, they were quite different in the different research centres (table 1 and table 2). The temperature conditions from ARDS Turda can be characterized as hot (3,38°C deviation from multiannual mean) during the vegetative period of spring wheat except for May, when the average monthly temperature was slightly higher than the multi-annual average for this period (table 1). The same behaviour of temperature condition can be observed in conditions of ARDS Lovrin, the average temperature for vegetative period of spring wheat variety being higher with 3,82 °C comparative to multiannual mean for this period. In case of temperature conditions from ARDS Livada the highest month deviation temperature was observed in March- 4,6°C which had a negative influence of plant emergency.

Table 1. Temperature conditions in the three research centers (ARDS Turda, ARDS Livada respectively ARDS Lovrin)

Temperature (°C)	March	April	May	June	July	Aug	Average
Turda							
Decade I	8,1	14,8	15,5	20,2	22,7	21,3	17,1
Decade II	7,1	13,2	14,6	20,8	27,3	25,5	18,08
Decade III	10,9	12,0	17,1	24,2	22,4	23,6	18,37
Monthly average	8,8	13,3	15,8	21,7	24,0	23,4	17,83
Average 65 years	4,4	10,0	15,0	18,0	19,8	19,5	14,45
Deviation	4,4	3,3	0,8	3,7	4,2	3,9	3,38
Characterization	hot	hot	normal	hot	hot	hot	hot
Livada							
Decade I	9,2	14,8	17,3	20,0	22,8	21,4	17,58
Decade II	7,5	12,5	15,9	20,3	27,9	25,2	18,22
Decade III	11,2	12,1	19,1	23,7	22,4	24,0	18,75
Monthly average	9,3	13,1	17,4	21,3	24,4	23,5	18,17
Average 65 years	4,7	10,5	15,8	20,5	20,5	19,9	15,32
Deviation	4,6	2,6	1,6	0,8	3,9	3,6	2,85
Characterization	hot	warm	warmy	normal	hot	hot	warm
Lovrin							
Decade I	8,6	15,8	17,4	22,1	25,3	24,7	18,98
Decade II	8,4	13,3	17,4	22,7	31,5	29,4	20,45
Decade III	11,6	12,2	19,5	26,0	24,9	26,1	20,05
Monthly average	9,6	13,8	18,1	23,6	27,1	26,7	19,82
Average 65 years	5,3	10,7	16,3	19,8	22,2	21,7	16,0
Deviation	4,3	3,1	1,8	3,8	4,9	5,0	3,82
Characterization	hot	hot	warmy	hot	hot	hot	hot

The rainfall conditions were similar in all three research centers, cumulative precipitation deficit ranging between 98,6 mm in ARDS Turda conditions to 115,7 mm at ARDS Livada (table 2). In the last years the rainfall conditions were generally deficient, but the difficult situation is when those occurs during the main vegetative and generative stages of spring wheat plants. So, in case of ARDS Turda the rainfall conditions can be characterize as optimal in the early vegetative stages (March- May) being deficient during the pre-anthesis stage, during anthesis respectively in grain filling period (June and July), significantly affecting the production capacity of plants.

Table 2. Rainfall conditions in the three research centers (ARDS Turda, ARDS Livada respectively ARDS Lovrin)

Rainfall (mm)	March	April	May	June	July	Aug	Average
Turda							
Decade I	14,3	0,6	36,4	15,4	35,3	21,4	123,4
Decade II	22,1	14,8	5,5	9,9	1,9	0	54,2
Decade III	1,3	23,4	18,8	10,9	12,1	15,3	81,8
Monthly average	37,7	38,8	60,7	36,2	49,3	36,7	259,4
Average 65 years	24,3	45,6	69,4	84,6	78,0	56,1	358,0
Deviation	13,4	-6,8	-8,7	-48,4	-28,7	-19,4	-98,6

Characterization	excessively rainy	dry	dry	excessively dry	excessively dry	very dry	very dry
Livada							
Decade I	9,8	9,0	8,4	35,8	21,8	13,2	98,0
Decade II	15,2	16,5	6,5	75,4	0,0	0,0	113,6
Decade III	15,0	16,1	15,3	36,0	5,8	2,5	90,7
Monthly average	40,0	41,6	30,2	147,2	27,6	15,7	302,3
Average 65 years	45,7	50,9	75,5	90,8	80,8	74,3	418,0
Deviation	-5,7	-9,3	-45,3	56,4	-53,2	-58,6	-115,7
Characterization	dry	dry	excessively dry	excessively wet	excessively dry	excessively dry	excessively dry
Lovrin							
Decade I	23,4	2,2	0,8	14,2	35,6	0,0	76,2
Decade II	6,8	10,8	3,6	10,2	0,0	0,0	31,4
Decade III	4,8	10,0	11,0	16,0	0,2	25,0	67,0
Monthly average	35,0	23,0	15,4	40,4	35,8	25,0	174,6
Average 65 years	32,3	42,7	57,3	68,1	55,8	32,3	288,5
Deviation	2,7	-19,7	-41,9	-27,7	-20,0	-7,3	-113,9
Characterization	normal	excessively dry	excessively dry	excessively dry	excessively dry	dry	excessively dry

For ARDS Livada, the rainfall conditions were deficient throughout the entire growing season (-115,7 mm), except for June, but even if the rainfall for in excess for this month (+56,4 mm) the negative effects of the lack of rainfall before and after June have significantly affected the development the productive traits of the wheat plants.

In case of ARDS Lovrin rainfall conditions, the characterization for this period is also excessively dry, but in the main generative stages the level of rainfall was not so pronounced, so that the productivity elements manifested themselves favourably.

RESULTS AND DISCUSSIONS

The obtained results highlighted the perspective line T. 2601-22 as performant genotype for grain yield in ecological conditions from ARDS Lovrin and ARDS Turda, with a medium grain yield over 7 046 kg ha⁻¹ respectively 4 387 kg ha⁻¹ (figure 1). Comparative to the old spring wheat variety Pădureni all studied genotype exhibited superior grain yield in all ecological conditions except the perspective line T. 4173-19 which has similar production in ARDS Livada conditions. On the other hands, in ecological conditions of ARDS Livada the perspective line T. 2584-22 has recorder the highest grain yield exceeded the control genotypes -Pădureni, Triso and Feleacu with 1 000 to 1 600 kg ha⁻¹. Also, in ARDS Turda conditions comparative to the relatively new spring wheat genotypes- Triso and Feleacu- the perspective lines T. 4194-19, T. 2578-22, T. 2584-22, T. 2585-22 and T. 2601-22 registered superior yield with differences between 300 to 650 kg ha⁻¹ comparative to Feleacu variety, respectively 50 to 350 kg ha⁻¹ comparative to Triso variety.

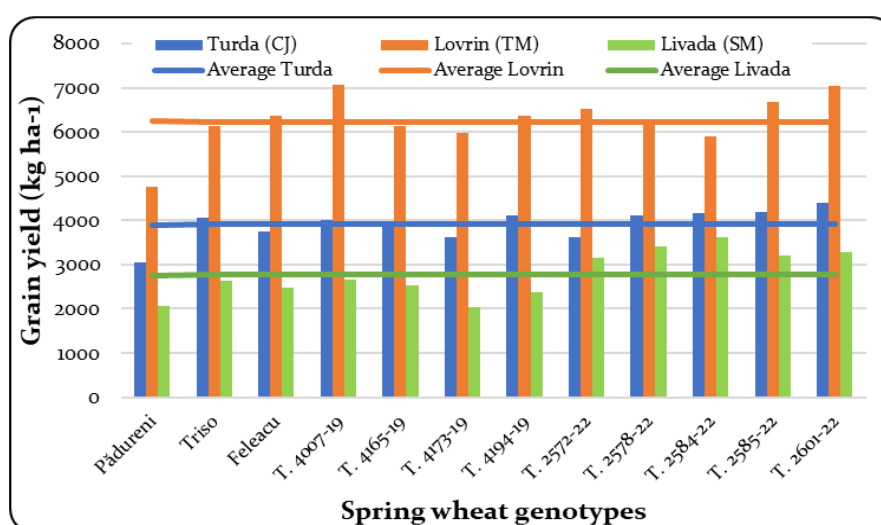


Figure 1. Grain yield of studied spring wheat genotypes in three different environment conditions (ARDS Turda, ARDS Lovrin, respectively ARDS Livada)

In ecological conditions of ARDS Lovrin, the average grain yield of all studied genotypes raise 6 200 kg ha⁻¹ the highest production being observed in case of T. 4007-19 (7 067 kg ha⁻¹) followed by T. 2601-22 (7 046 kg ha⁻¹) surpassing the Pădureni variety with more than 2 200 kg ha⁻¹. Comparative to Triso and Feleacu varieties superior grain yield were observed for the same perspective spring wheat lines alongside by T. 4194-19, T. 2572-22 and T. 2585-22 whose production was higher than the average of the genotypes studied.

Regarding the mean grain yield for studied genotypes in the three locations the highest grain yield was registered for T. 2601-22 (4 905 kg ha⁻¹) followed by T. 2585-22 (4 694 kg ha⁻¹) these being superior to Pădureni variety with more than 1 400 kg ha⁻¹, respectively 1 600 kg ha⁻¹. The same superiority is maintained in the case of compared grain yield of both perspective spring wheat with Triso and Feleacu varieties, the differences between these being smaller (400 to 700 kg ha⁻¹).

The hectolitic weight values was range between 58.6 kg hl⁻¹ at Feleacu variety in agroecological conditions from ARDS Livada to 79.3 kg hl⁻¹ at T. 2572-22 spring wheat perspective line in local conditions of ARDS Lovrin (figure 2).

Regarding the grain hectolitic weight of studied genotypes the lowest mean value was registered in ARDS Livada conditions (65.43 kg hl⁻¹) the climatic conditions during the generative stage having a negative effect on the development of this character (Dunăreanu and Bonea, 2022). However, can be mention that four of the studied genotypes (T.4165-19, T. 2572-22, T. 2584-22 respectively T. 2585-22) has registered superior mean values compared to genotypes mean value.

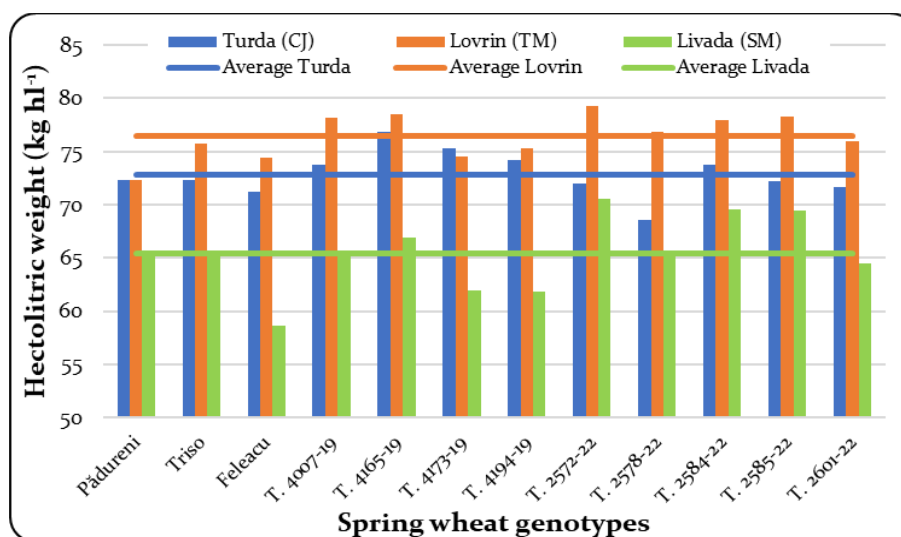


Figure 2. Hectolitic weight of studied spring wheat genotypes in three different environment conditions (ARDS Turda, ARDS Lovrin, respectively ARDS Livada)

Even the climatic conditions (especially rainfall) from ARDS Turda were not favourable for development of hectolitic weight, the mean values for this trait range between 68.6 kg hl⁻¹ for T. 2578-22 to 76.8 kg hl⁻¹ at T. 4165-19. Thus, from the studied genotypes can be highlighted five perspective lines (T. 4007-19, T. 4165-19, T. 4173-19, T. 4194-19, T. 2584-22) with individual mean value higher than genotypes mean value (72.84 kg hl⁻¹).

In conditions of ARDS Lovrin the hectolitic weight recorded the highest values compared to the other two research centres, the mean value of studied genotypes being 76.43 kg hl⁻¹. Compared to these genotypes mean value five perspective spring wheat lines have registered superior individual mean value: T. 4007-19, T. 4165-19, T. 2572-22, T. 2584-22 and T. 2585-22.

Due to the superior adaptability, T. 4165-19, T. 2572-22 and T. 2584-22 stands out as being the most valuable genotypes for hectolitic weight having high values in all three research centres.

In case of quality indices, the highest mean grain protein content was favoured by Livada ecological conditions (15.3%), followed by Lovrin (14.54%) and Turda (13.4%) ecological conditions. Of the 12 genotypes analysed in ARDS Turda conditions the highest grain protein content was registered at Pădureni variety (15.4 %) that is known to have superior grain quality exceeding by approximately 15% the average protein content of the other genotypes analysed. Between the perspective lines can be noted the T. 2584-22 genotype which has recorded the second highest value (14.8 %) for grain protein content, followed by T. 2585-22 and T. 2578-22 whose average value was higher than the average of the genotypes analysed.

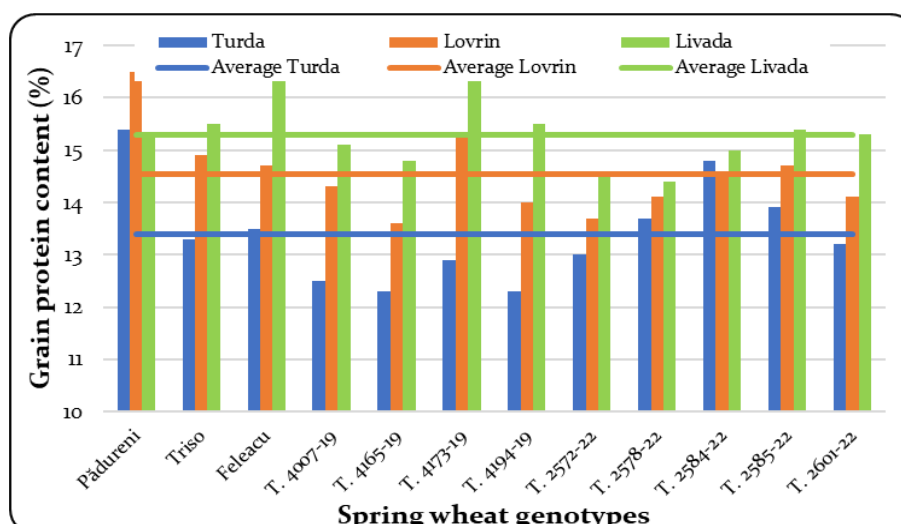


Figure 3. Grain protein content of studied spring wheat genotypes in three different environment conditions (ARDS Turda, ARDS Lovrin, respectively ARDS Livada)

Agroecological conditions from Lovrin favoured the accumulation grain protein content for Pădureni variety (16,5%) followed by T. 4173-19 (15,3%), Triso variety (14,9%) Feleacu variety and T. 2585-22 both with 14,7% grain protein content. An interesting reaction regarding protein accumulation in grain was observed in Livada conditions, the mean value of Pădureni (15,3%) variety being surpassed by Feleacu variety and T. 4173-19 perspective line both with 16,4% grain protein content. As a performant genotype for protein content the obtained results indicate the T. 2584-22 in Turda conditions, T. 4173-19 for Livada and Lovrin conditions.

Wet gluten content has range from 24.3% at T. 4194-19 spring wheat perspective line to 31.3% at Pădureni genotypes, the perspective spring wheat lines T. 2578-22, T. 2584-22 and T. 2585-22 having superior values to average wet gluten content in Turda conditions (figure 4). Compared to the Triso and Feleacu genotypes the same perspective spring wheat lines registered a light superiority which suggests a slight progress in the direction of grain quality in spring wheat.

The highest wet gluten content in Lovrin conditions was observed at Pădureni genotype (35.1%), T. 4173-19 spring wheat line having a close value (33.5%). Regarding the genotypes that has registered superior wet gluten content to genotypes mean (30,07%) along with the two genotypes mentioned, other genotypes can also be highlighted as performant – T. 2578-22, T. 2584-22 respectively T. 2585-22.

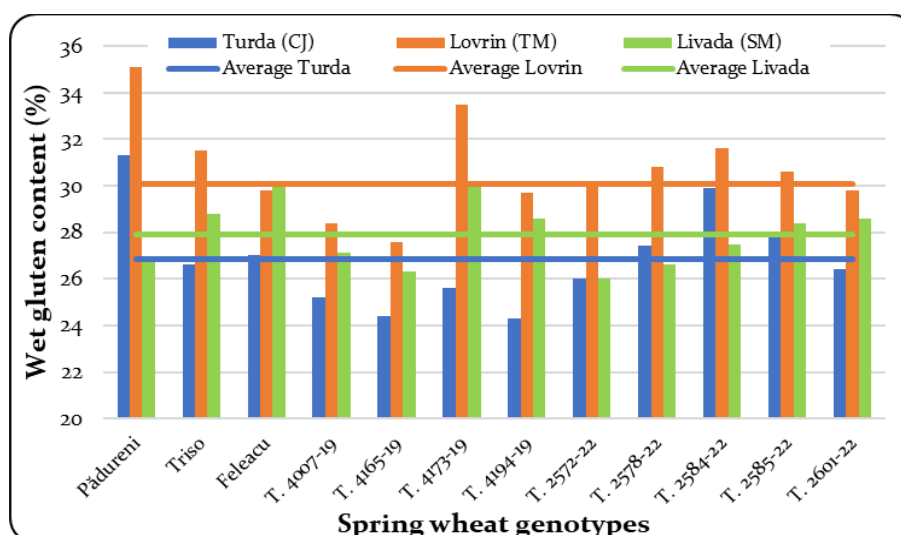


Figure 4. Grain wet gluten content of studied spring wheat genotypes in three different environment conditions (ARDS Turda, ARDS Lovrin, respectively ARDS Livada)

In ecological condition from ARDS Livada the highest wet gluten content was registered at T. 4173-19 (30,2%) genotype this value being at the same level of the control variety Feleacu (30,0%).

CONCLUSION

Testing wheat genotypes in different ecological conditions allowed the identification of the perspective lines T. 2585-22 and T. 2601-22, which possess high productivity, respectively T. 4173-19 and T. 2584-22, as having superior grain quality, the two agronomic characters being the main criteria characterizing the superior performances of a valuable and intensive genotype. Also, the perspective lines T. 4165-19 and T. 2572-22 may represent valuable gene sources for the ecological plasticity of future spring wheat genotypes due to their adaptability to different environmental conditions, based on the average values of hectolitre weight.

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