

A winter wheat breeding program for good and stable yielding in various environments

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Abstract. *The present paper describes the specific scheme of wheat breeding adopted in our laboratory, which try to be a solution to climatical changes. To do this, the best method is to induce yield stability by evaluating the new genotypes in different, contrasting environments (climatical and soil conditions). A substantial number of varieties (cultivars and breeding lines) are verified even in the first stage of research, in two contrasting locations, followed next years in more environments. The best breeding line, Lovrin 9 Z, was evaluated in the network of NARDS (National Agricultural Research and Development Stations), in 14 locations, distribute in two large zone: first, south and west and second, north and east Romania. The descendent slope of linear trend suggest that the general tendency is that the better yielding varieties are more stable, an important objective of wheat breeding in our activity. The breeding line Lovrin 9 Z are encloused in this category, having a subunit coefficient of regression. That means that it performs well, even in suboptimal conditions (drought, unfertile soils, etc.). Before to extend the promising variety in production, it is useful to compare it with the best cultivars from the future areas of cultivation. Thus, the promising line Lovrin 9 Z was competitive to some very performant cultivars: Propulso, Avenue, Pibrac, Arcachon, its grains yield exceeding 9000 kg/ha.*

Keywords: *breeding line, wheat, strategy, yield, stability*

INTRODUCTION

Wheat, one of the first domesticated food crops, is grown on over 220 million hectares worldwide (Kumar et al., 2025). Bread wheat is one of the most widely grown and most consumed food crops all over the world (Bunta, 2020). For this reason, winter wheat has a primordial position in food security in entire the world.

Wheat production is influenced by both biotic and abiotic constraints: biotic stresses (insects, nematodes, alongside fungal, viral and bacterial diseases) and abiotic stresses (heat, drought, cold, salinity), separately or together (Alam et al., 2024).

The climatical changes from the last period seems to be dramatically for the cultivated plants. The extreme variations of temperature, precipitations, their distributions during the growth period of plants, seams to become the new normality. (Saulescu et al., 2006). The consequences on grain yield are serious. The precipitations in excess or in deficit in some areas or periods, temperatures extremely scorching, or cold in anormal period, stresses extremely the plants. The consequences consist in reduced yield and quality of grains. Heat stress during grain filling is considered (Ikram et al., 2022) one of the major abiotic factors influencing wheat grain yield quality.

Changing abiotic conditions affect the types of microbes that cause disease in wheat (Yang et al., 2024). The growth of wheat depends on climate resources such as temperature, solar radiation, precipitation, etc., that affects biological processes, such as photosynthesis, respiration, and substance conversion. Drought affects protein changes, osmotic adjustment, opening and closing of stomata, photosynthesis inhibition, transpiration reduction, growth inhibition, and lead to the decrease of wheat yield.

Food security is affected by limited arable land, growing food demands, and environmental degradation (Yang et al., 2024). Therefore, selection of high-yield, stable-yield and climate-resistant varieties is essential. Diversifying wheat varieties is expected to mitigate some of the negative effects of climate change.

To ensure food safety and security, developing climate-resistant superior wheat cultivars has become imperative (Kumar et al., 2025). Increasing the yield stability is possible to be realised combining the particularly good yielding capacity with good resistance to biotic and abiotic factors of stress (Saulescu et al., 2006). Cultivation of varieties with large adaptability to contrasting environmental conditions can reduce the risks to drop of yield in unfavourable years or areas (Mustatea et al., 2008).

Many traits determine grain yield: spike numbers/ha, grain number/spike, thousand grain weight, growth duration, plant height, etc. (Yang et al., 2024). Wheat breeding could offset some of the effects of climate change, so being necessary to increase the investment in wheat breeding. To proving an abundant number of new wheat varieties and suitable variety replacement rate is important for food safety. The diversification of wheat varieties will contribute to the stability of the food production system.

The main goal of wheat breeding programs is to develop new genotypes that ant perform existing ones for specific environmental conditions with better resistance to diseases, climate resilience, and good nutritional quality (Kumar et al., 2025). Increasing genetic gain enables the development of wheat varieties with greater yield potential, disease resistance, and adaptability to diverse growing conditions.

Plant breeders develop new cultivars that are better adapted to specific environments and capable of utilizing available resources efficiently. Systematic plant selection consists in bulk, pedigree, modified pedigree, modified pedigree/bulk, selected bulk. The most used strategies in wheat breeding programs (including CIMMYT) are the selected bulk.

The time from when a cross is made to when a new wheat cultivar is released is between 6 and 13 years but often depends on the growth habit of the specific wheat (spring or winter wheat). Modern techniques, such as genomic selection and speed breeding, accelerate genetic gain and improve breeding efficiency. A speed breeding system with an extended photoperiod (22 h), in combination with marker-assisted selection (MAS) and genomic selection (GS) were described by Cha et al. (2023). To identify lines of wheat with tolerance to drought, the Ukrainians researchers use the method of simazine 10-4 like a photosystem II (PS II) (Nazarenko et al., 2021).

Nutrient content is becoming increasingly more important to fight malnutrition, but significant negative correlations among grain yield and mineral content complicate their combined improvement (Hassouni et al., 2024). *Aegilops tauschii* is an inexhaustible resource for genetic mining, a useful resource for the wheat, to combine good flour quality and grain yield under stress conditions using marker-assisted selection (Ikram et al., 2022).

Zinc deficiency affects 17% of the world's populations. (Hui et al., 2025). The average grain zinc concentration in global wheat is from 50 to 80 mg/kg⁻¹, with optimal for human body exceeding 40 mg/kg⁻¹. Shuttle breeding, a method involving the alternating growth of wheat breeding material across diverse environments is adapted for selecting varieties with enhanced Zn concentration.

In Romania, diversifying of wheat assortment reduce genetical vulnerability to biotic and abiotic factors, contributing to yield stability (Saulescu et al., 2007). Romanian wheat varieties have a large ecological plasticity, so, many of them being cultivated in Hungary, Bulgaria, Türkiye, or even in Canada. In present, the objective of wheat breeding in INCDA Fundulea is to improve the cultivar structure of winter wheat by creating new varieties more productive and stables in the conditions of climatical changes (Marinciu et al., 2022). The progress in grain yield was not accompanied by increased production variability, coefficients of variation in the new cultivars being like those of older cultivars. Recently, the highest yields were obtained by new lines: Columna, Consecvent, Concurrent and by recently registered cultivars: Ursita, Biharia and Abund.

In the areas with less favourable environmental conditions, selection pressure must be stronger, but thus, many precious genes are lost. For this reason, the earlier testing of breeding materials must be done in more different environmental conditions, from very favourable ones to less favourable (Voica, 2009). In such less favourable conditions, genetical progress may be diminish by climatical changes (Bunta, 2018). In Oradea, for 30 years, its was around 50 kg/ha/year (1.1%/year), the productive potential of wheat breeding lines created at Oradea was, in 2018, near 10.000 kg/ha.

In a series of studies regarding the adaptability of wheat varieties to less favourable pedological conditions from Albota, Voica (2012) classified the cultivars tested in: better adapted to the unfavourable environmental conditions (Glosa), well adapted to the favourable conditions (Izvor), large adapted to the contrasting conditions (Trivale) and well adapted to both favourable and unfavourable conditions. Some cultivars (Serina, Exotic, Apache), with highest yield variation coefficient, are considered less adapted to the conditions of region.

Many authors were concerned on yield stability in variable environmental conditions. Stability statistics are classified in four groups (Lin et al, 1986):

- 1.Group A -that consists in standard deviation and coefficient of variation, based on deviation from average.
- 2.Group B – considers the interactions between genotype and environment: echo-valence, coefficient of regression, intercept, and deviation from regression.
- 3.Group C – based on deviation from regression.

Other authors (Keim and Kronstad, 1979) proposed regression analyse to classify the cultivars in:

- Adapted to unfavourable environmental conditions when the slope of linear regression is subunit ($b < 1$)
- Adapted to favourable environmental conditions ($b > 1$).
- Large adapted to different environmental conditions ($b > 1$ and a positive).

The diversity of environmental conditions is reflected by the genotype's amplitude of yield variations (Bunta, 2020). The present paper describes the specific scheme of wheat breeding adopted in our laboratory, which try to be a solution to climatical changes, the best method to do this is yield stability in different, contrasting climatical and soil conditions.

MATERIAL AND METHODS

The years 2023, 2024 and 2025 were draughtiness, but the winter wheat culture was less affected than spring ones. To be able to identify simultaneously breeding lines adapted to fertile soil and acid, less fertile one, at Lovrin respective Oradea, in the year 2022/2023 a similar Preliminary Yield Trials with twenty-five genotypes (19 breeding lines and 6 valuable cultivars) was conducted. The experiment was conducted like two factors division (location and variety). The next year (2024) the experiment was repeated in Oradea and in 2025, the best breeding line, Lovrin 9 Z, were promoted in Advanced Yield Trials.

The quality of grains was appreciated by wet gluten (%), protein content (%), hardness (%), starch (%), hectolitre mass (kg/hl) and thousand kernel weight (g).

The Advance Yield Trials consists in 25 cultivars and breeding lines, the best ones from entire country (from ARDS Lovrin, ARDS Turda, ARDS Simnic, ARDS Caracal, ARDS Albota and NARDI Fundulea). The twenty-five varieties were evaluated in ten locations representative for south and west of Romania (Fundulea, Braila, Marculesti, Teleorman, Caracal, Albota, Simnic, Lovrin, Oradea and Livada) and four locations from north and east Romania (Turda, Targu Mures, Secuieni and Perieni). In addition, in some locations, varied the technological factors, too: F1 = fertilised optimal with nitrogen, F2= fertilised and fungicide control, F3= fertilised, late seeding, F4 = without nitrogen fertiliser. That means a total of 22 different environmental conditions.

For all environmental conditions, were analysed the regression of every cultivar comparative to yield average of entire experiment, in all environmental conditions (Brukner et Froberg, 1987).

To verify the competitiveness of the new breeding line Lovrin 9 Z, it was evaluated at Diosig, Bihor County, beside of 46 cultivars and promising breeding lines from entire Europe. The quality indicators were determined, too.

Finally, the best breeding line (Lovrin 9Z) has promoted in the network of the State Institute for Testing and Registration Varieties (SITRV).

In all the trial experiments, the design was a balanced square lattice, with 25 variants, in three replications. The results of yields were processed by ANOVA (analyse of variance), the significance of differences being estimated by Fisher test, respectively LSD (limit standard deviation) for 5%, 1% and 0.1% (Ceapoiu, 1968).

Linear regression between characters, present in the graphics, was calculated in accord with Finlay and Wilkinson (1963).

RESULTS AND DISCUSSIONS

Table 1 presents the grains yields of 19 promising breeding lines comparative to six cultivars speeded in culture in the West Romania in that period. Some of breeding lines, including Lovrin 9 Z, significantly exceeded the experimental average (7235 kg/ha), but do not equal the best cultivars: Selenio, Anapurna and Ingenio.

Table 1. Winter wheat preliminary trial. Oradea, 2023

Clas.	Genotype	Yield		Difference to average (kg/ha)	Significance of difference
		(kg/ha)	relative (%)		
1	SOLENIO	9280	128.3	+2045	***
2	ANAPURNA	9084	125.6	+1849	***
3	INGENIO	8588	118.7	+1353	***
4	Lovrin 9 Z	8111	112.1	+876	*
5	FLORA 13.248 G536	8084	111.7	+849	*
6	Lovrin 9X 154523	8051	111.3	+816	*
7	FLORA 12.381 G11	7656	105.8	+421	
8	BIHARIA	7585	104.8	+350	
9	FLORA 13.173 G392	7421	102.6	+186	
10	FLORA 09.513 G112182	7404	102.3	+169	
11	FLORA 12.381 G1114	7326	101.2	+101	
Experimental average		7235	100.0	0	-
12	FLORA 13.269 G61	7210	99.7	-25	
13	FLORA 13.347 G212	6974	96.4	-261	
14	FLORA 13.468 G6296	6939	95.9	-296	
15	OTILIA	6911	95.5	-324	

16	DACIC	6900	95.4	-335	
17	FLORA 13.299 G18	6826	94.3	-409	
18	FLORA 13.322 G1151	6676	92.3	-559	
19	Lovrin 6X R	6653	92.0	-582	
20	FLORA 12.375 G231	6516	90.1	-719	0
21	FLORA 05.897 G2 IV	6418	88.7	-817	0
22	FLORA 13.322 G12	6273	86.7	-962	00
23	FLORA 12.375 G23	6200	85.7	-1035	00
24	FLORA 09.731 G101333	6099	84.3	-1136	00
25	FLORA 12.379 G22	5700	78.8	-1535	000

LSD 5% = 710 kg/ha.

LSD 1% = 962 kg/ha.

LSD 0,1% = 1289 kg/ha.

The same variants were evaluated in the same experiment in the experimental field of Wheat Breeding Laboratory in Lovrin (Timis County). Although the soil is more fertile in Lovrin than in Oradea, the stronger deficit of humidity limited the yielding potential of genotypes: experimental average was only 4512 kg/ha. It is important to constate that the same's breeding lines were in the top of classification: Lovrin 9 Z, Lovrin 9 X154523, FLORA 13.248 G 536., the significance of difference being very distinguish.

Table 2. Winter wheat preliminary trial. Lovrin, 2023.

Class.	Genotype	Yield		Difference to average (kg/ha)	Significance of difference
		(kg/ha)	relative (%)		
1	Lovrin 9 Z	6133	135.9	+1621	***
2	Lovrin 9X 154523	6124	135.7	+1612	***
3	FLORA 13.248 G536	5804	128.6	+1292	**
4	ANAPURNA	5396	119.6	+884	*
5	SOLENO	5324	118.0	+812	*
6	INGENIO	5303	117.5	+798	*
7	FLORA 13.173 G392	5075	112.5	+563	
8	OTILIA	4729	104.8	+217	
9	FLORA 13.347 G212	4680	103.7	+168	
10	FLORA 12.375 G231	4622	102.4	+110	
11	FLORA 09.513 G112182	4597	101.9	+85	
Experimental average		4512	100.0	0	-
12	FLORA 05.897 G2 IV	4494	99.6	-18	
13	FLORA 13.468 G6296	4394	97.4	-118	
14	FLORA 12.381 G11	4355	96.5	-157	
15	FLORA 12.375 G23	4348	96.4	-164	
16	BIHARIA	4129	91.5	-383	
17	FLORA 13.299 G18	4109	91.01	-403	
18	FLORA 12.381 G1114	4070	90.2	-442	
19	FLORA 13.322 G12	3913	86.7	-599	
20	FLORA 09.731 G101333	3867	85.7	-645	
21	FLORA 13.322 G1151	3863	85.6	-649	
22	Lovrin 6X R	3837	85.0	-675	
23	DACIC	3600	79.8	-912	0
24	FLORA 13.269 G61	3184	70.6	-1328	00
25	FLORA 12.379 G22	2847	63.1	-1665	000

LSD 5% = 785 kg/ha.

LSD 1% = 1047 kg/ha.

LSD 0,1% = 1364 kg/ha.

Considering the two experiments being parts of the same experiment with two factors (genotype and location), in table 3 are present the analyse of variance (ANOVA) of 25 winter wheat yields, in two locations:

Lovrin and Oradea. Fisher test (F test), reported to the error variance, show that the differences between genotypes are statistical ensured. At the same time, the differences between the yields of the two locations are ensured, too. Since F test reported to the variance of interaction (location * genotype), we can appreciate that, in the future, the repeated experiment in various locations will supply comparable results.

For selection is important to know that a big part of the performants breeding lines will confirm, in another environmental conditions. That is why we evaluate the breeding lines even in the first year when the quantity of seeds permits them.

Table 3. ANOVA for grain yield of 25 winter wheat genotypes in two locations.
(Lovrin and Oradea, 2023)

Source of variation	Sum of square (SS)	Degree of freedom (DF)	Variance (s^2)	Fisher test (F)	
				to s^2_{er}	to s^2_{gxl}
Blocs	19875868	4			
Locations	277878093	1			
Genotypes	94635850	24	3943160.4	17.32**(1.98)	6.30**(2.66)
Locations*Genotypes	15031186	24	626299.4	2.75**(1.98)	
Error	21852999	96	227635.4		
TOTAL	429273996	149			

Table 4. The averages of yields from Lovrin and Oradea, 2023.

Class.	Genotype	Yield		Difference to average (kg/ha)	Significance of difference to:	
		(kg/ha)	relative (%)		error	interaction (l*g)
1	SOLENIO	7302.0	123.4	+1383.0	***	**
2	ANAPURNA	7240.0	122.3	+1321.0	***	**
3	Lovrin 9 Z	7122.0	120.3	+1203.0	***	**
4	Lovrin 9X 154523	7087.5	119.7	+1168.5	***	*
5	INGENIO	6945.5	117.3	+1026.5	***	*
6	FLORA 13.248 G536	6944.0	117.3	+1025.0	***	*
7	FLORA 13.173 G392	6248.0	105.6	+329.0		
8	FLORA 12.381 G11	6005.5	101.5	+86.5		
9	FLORA 09.513 G112182	6000.5	101.4	+81.5		
Experimental average		5919.0	100.0	0.0	-	-
10	BIHARIA	5857.0	99.0	-62.0		
11	FLORA 13.347 G212	5827.0	98.4	-92.0		
12	OTILIA	5820.0	98.3	-99.0		
13	FLORA 12.381 G1114	5698.0	96.3	-225.0		
14	FLORA 13.468 G6296	5666.5	95.7	-252.5		
15	FLORA 12.375 G231	5569.0	94.1	-350.0		
16	FLORA 13.299 G18	5467.5	92.4	-451.5		
17	FLORA 05.897 G2 IV	5456.0	92.2	-463.0		
18	FLORA 12.375 G23	5274.0	89.1	-645.0	0	
19	FLORA 13.322 G1151	5269.5	89.0	-650.5	0	
20	DACIC	5250.0	88.7	-669.0	0	
21	Lovrin 6X R	5245.0	88.6	-674.0	0	
22	FLORA 13.269 G61	5197.0	87.8	-722.0	0	
23	FLORA 13.322 G12	5093.0	86.0	-826.0	00	
24	FLORA 09.731 G101333	4983.0	84.2	-936.0	000	0
25	FLORA 12.379 G22	4273.5	72.2	-1645.5	000	000
				LSD 5%	544,5 kg/ha	904.9 kg/ha
				LSD 1%	723,2 kg/ha	201.9 kg/ha
				LSD 0,1%	932,2kg/ha	1549.2 kg/ha

To compare the averages of breeding lines in both locations (table 4) is a first step in evaluation of yield stability. Also, it can appreciate that, beside Solenio, Anapurna and Ingenio, three very performant cultivars, the breeding lines: Lovrin 9 Z, Lovrin 9 X 154523 and FLORA 13.248 G 536 realise particularly good yields (around 7000 kg/ha), with more than 1000 kg/ha comparative to experimental average. These differences are statistical ensured, both to error and interaction (1*g).

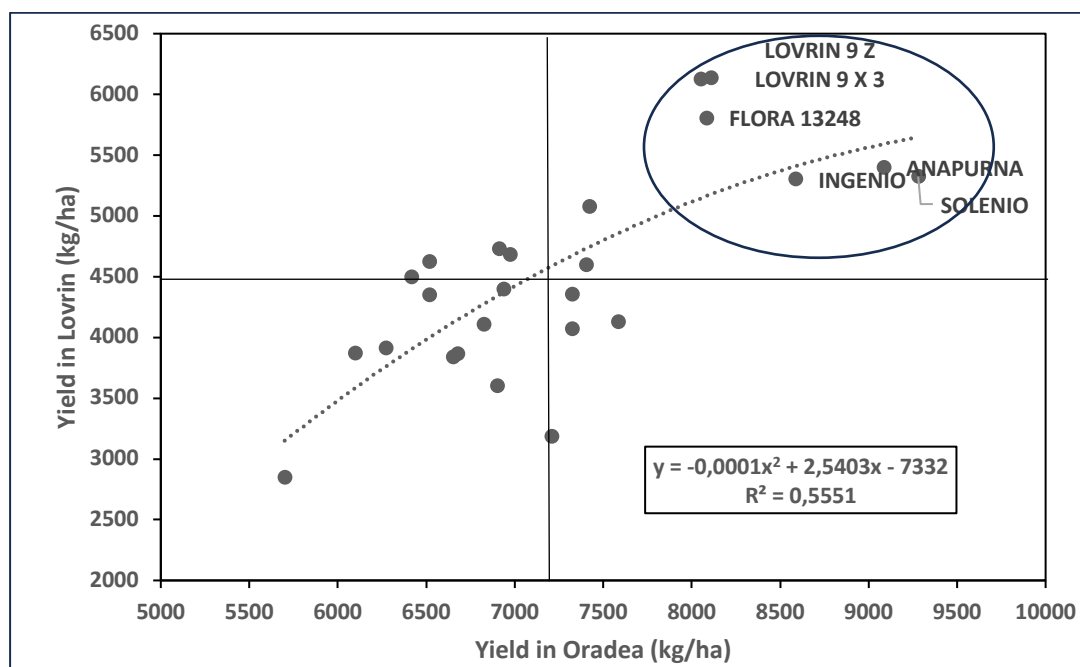


Figure 1. The quadratic trend line between grain yield obtained in two locations.

In figure 1 are presented the quadratic linear trend between the wheat yield realised by all twenty-five genotypes, in Lovrin and Oradea. This type of trend line was the most significant for the tendency (correlation) between the series of genotypes yields linear, polynomial, exponential, logarithmic or power. It is important to underline that the best three breeding lines (Lovrin 9 Z, Lovrin 9 X 154523 and FLORA 13.248 G 536) are grouped into the same framework with the best cultivars: Solenio, Anapurna and Ingenio.

Not only yield potential is a criterion in selection of breeding lines but the quality of grains has a similar importance. In table 5 are presented the most important indicators for quality of grain yield: the content of total protein (%), the percent of wet gluten, the hardness of grain (%), the starch content (%), the hectolitre mass (kg/hl) and the thousand kernel weight (g).

To promote a breeding line, it must be at least above of the average value of all genotypes. All the four promising lines (Lovrin 9 Z, Lovrin 9 X 154523 and FLORA 13.248 G 536) exceed the averages of genotypes: 12.04% protein, 27.7% wet gluten, 55.1% grain hardness, 71.8% starch, 79.1 kg/hl hectolitre mass and 43.13 g thousand kernel weight (TKW).

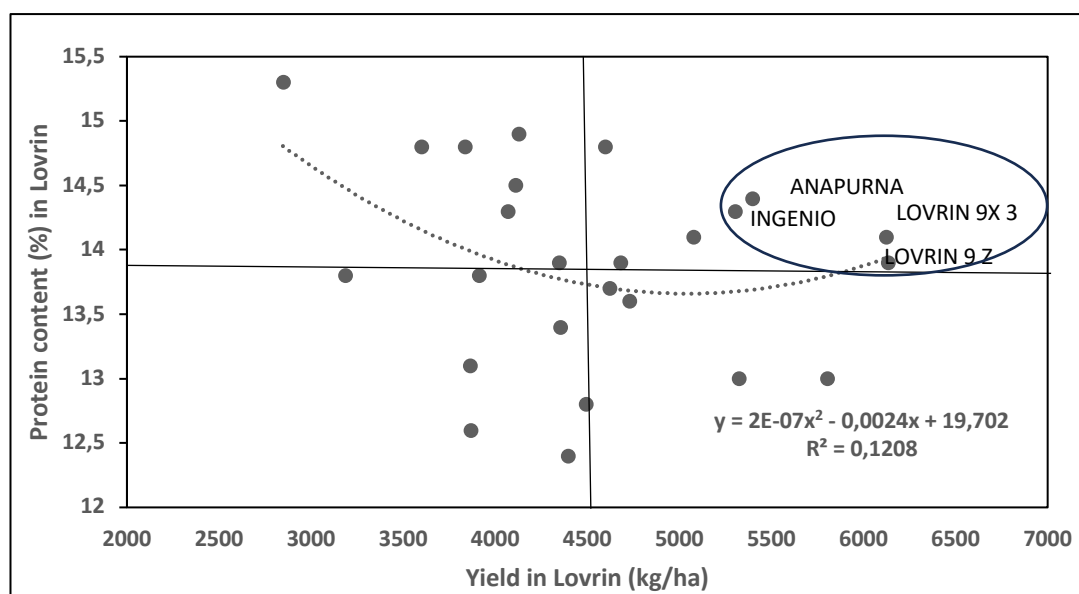
It is well known that exists a negative correlation between yield potential of winter wheat and indicators of quality. For breeders, these is a challenge to break this relationship, being important to identify the exceptions. Though the trend between yield and protein content is descendent (Fig. 2), the breeding lines Lovrin 9 Z and Lovrin 9 X 154523 make exception from this rule. This is an additional argument to consider these two lines promising one.

In figure 3, the trend line between yield and protein content between genotypes evaluated at Oradea, is quadratic, too, but the curve is in reverse trend. Again, the third lines have remarkably high yields associated with good protein content, underlying the performance of line FLORA 13248.

Figure 4 return the relationship between the protein content of genotypes in Lovrin and Oradea. The trend lines the most representative is a logarithmic one. From all lines, Lovrin 9 X 154523 has, cumulated, the best content of protein, both in Lovrin and in Oradea.

Table 5. Quality indicators of some new wheat breeding lines comparative to six performants cultivars.
Oradea, 2023.

Nr.	Genotype	Protein (%)	Wet gluten (%)	Hardness (%)	Starch (%)	Hectolitre mass (kg/hl)	TKW (g)
1	OTILIA	11.9	28.0	55	71.2	80.3	40.88
2	ANAPURNA	12.7	30.6	57	71.7	79.8	42.50
3	SOLENIO	11.1	28.0	57	72.3	78.9	46.57
4	INGENIO	11.2	26.5	52	71.4	75.9	46.77
5	BIHARIA	12.6	30.2	59	71.7	76.6	43.06
6	DACIC	12.2	27.0	54	70.8	77.6	47.58
7	LOVRIN 6X R	12.2	27.3	55	71.2	77.9	45.56
8	FLORA 13.269 G61	12.7	29.0	53	77.0	76.4	35.53
9	FLORA 12.381 G11	11.7	26.6	57	71.9	81.1	40.72
10	FLORA 13.322 G12	12.3	29.3	52	70.4	79.9	39.02
11	FLORA 12.381 G1114	12.3	28.3	55	71.2	80.4	40.94
12	FLORA 12.375 G231	12.2	28.3	54	71.1	80.2	43.57
13	FLORA 13.347 G212	12.1	27.7	55	71.2	78.0	39.23
14	FLORA 13.468 G6296	11.0	25.4	55	72.6	80.7	46.78
15	LOVRIN 9 Z	12.2	28.4	56	72.0	80.5	46.83
16	LOVRIN 9 X 154523	12.1	28.0	57	71.9	80.7	47.43
17	FLORA 13.322 G1151	11.8	27.4	57	72.0	76.9	37.67
18	FLORA 13.248 G536	13.2	27.9	57	71.4	79.6	45.77
19	FLORA 13.173 G392	12.1	27.6	55	71.4	79.4	42.52
20	FLORA 09.731 G101033	11.4	24.7	51	72.0	81.6	42.99
21	FLORA 09.513 G112182	11.9	25.2	55	72.3	80.9	44.30
22	FLORA 05.897 G2IV 700112	12.8	29.0	56	71.1	77.0	44.98
23	FLORA 13.299 G18	12.0	27.7	57	71.5	79.2	43.58
24	FLORA 12.375 G231	11.7	27.4	54	71.3	80.1	45.23
25	FLORA 12.379 G22	11.5	26.8	53	71.4	77.4	38.32
EXPERIMENTAL AVERAGE		12.04	27.7	55.1	71.8	79.1	43.13

**Figure 2.** Relationship between yield and protein content of genotypes in Lovrin.

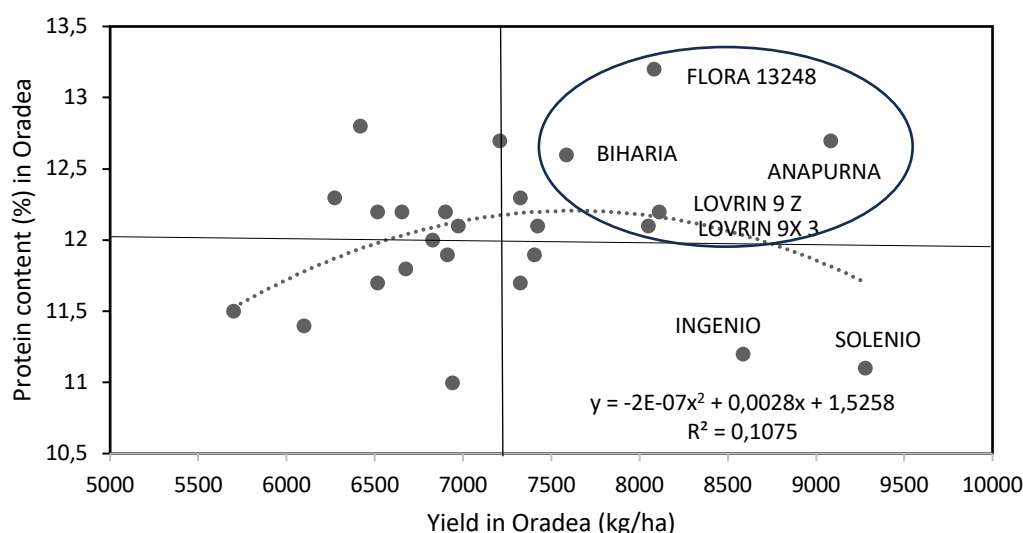


Figure 3. Relationship between yield and protein content of genotypes in Oradea.

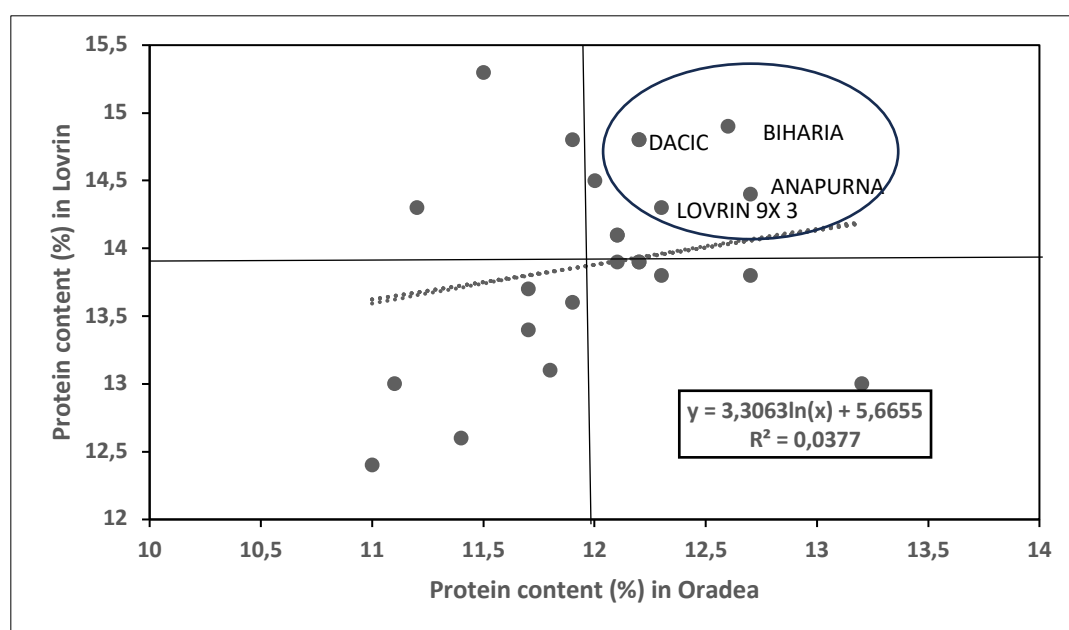


Figure 4. Relationship between protein content of genotypes in Lovrin and Oradea.

Every year, the componence of Winter Wheat Preliminary Trial is changed, according with the results from previous year. So, around 30% to 50% of breeding lines with inferior performance are changed with new ones (Table 6). Even the soil and technological factors are the same, climatical conditions, including biotic and abiotic stress factors, are changing.

In 2024, in Oradea the experimental yield average was 6237 kg/ha, comparative to 7235 kg/ha in 2023 (Table 1), in principal because the drought was more severely. For breeding, more important than the level of yield is the position in the top of varieties. The minimal conditions are to exceed the experimental average, and this target is touch by Lovrin 9 Z. Another new breeding lines, better, comes from behind: FLORA 13.133 G 52644, FLORA 13.173 G 2633, LOVRIN 6 X 9252742, etc. Their yield exceeded 7000 kg/ha, with significant positive difference to experimental average.

The best breeding line, Lovrin 9 Z, was promoted to be evaluated in the network of NARDS (National Agricultural Research and Development Stations). This network consists in 14 Agricultural Research and Development Stations (including Fundulea Institute), distribute in two large zone: first, south and west and second, north and east Romania.

In addition to a large and spread distribution of locations in some of them are evaluated too, some technological variants. In table 7 are presented the yields realised by the best actual cultivars and breeding lines, in the south and west network. The different technological variants were noted as follow: F1 = fertilised optimal with nitrogen, F2= fertilised and disease control, F3= fertilised, late seeding in autumn, F4 = without nitrogen fertiliser. The experiment was conducted during the year 2025, a year with near optimal condition for winter wheat.

Considering the locations and technological variants, the total environmental conditions are 16, with good chance to evidence a good ecological plasticity between genotypes. The biggest yield in the year 2025 was registered in Lovrin, with a yield average (of all twenty-five genotypes) of 9043 kg/ha, with yields between 6327 kg/ha and 11223 kg/ha.

At the other extreme, In Albota, the minimum yield average of genotypes was 4766 kg/ha, in the variant without nitrogen fertilisation, the soil being acid one, with low natural fertility. Although, our creations (Biharia and Lovrin 9 Z) performed well, being in the top of the genotypes yields. Our breeding line Lovrin 9 Z performed very well in Livada, in north-west Romania, where the hydric regime is better than in the south of country (Fundulea, Caracal, Marculesti).

Table 6. Winter wheat preliminary trial. Oradea, 2024.

Class.	Genotype	Yield		Difference to average (kg/ha)	Significance of difference
		(kg/ha)	relative (%)		
1	FLORA 13.133 G 52644	7299	117.0	+1062	**
2	FLORA 13.173 G 2633	7168	114.9	+931	*
3	INGENIO	7135	114.4	+898	*
4	LOVRIN 6 X 9252742	7029	112.7	+792	*
5	GDD 11231255	6993	112.1	+756	*
6	ANAPURNA	6893	110.5	+656	
7	SOLENIO	6803	109.1	+566	
8	FLORA 13.418 G 2322	6542	104.9	+305	
9	FLORA 12.815 G 12011522	6499	104.2	+262	
10	LOVRIN 9 Z	6484	104.0	+247	
11	DACIC	6478	103.9	+241	
12	FLORA 13.248 G 53390	6456	103.5	+219	
13	LOVRIN 6X R	6322	101.4	+85	
Experimental average		6237	100,0	0	-
14	FLORA 13.173 G 392	6185	99.2	-52	
15	FLORA 09.513 G 112182	6010	96.4	-227	
16	LOVRIN 9 X 154523	5960	95.6	-277	
17	FLORA 13.248 G 536	5950	95.4	-287	
18	OTILIA	5865	94.0	-372	
19	FLORA 13.299 G 10101611	5817	93.3	-420	
20	FLORA 12.381 G 11	5804	93.1	-433	
21	BIHARIA	5564	89.2	-673	
22	FLORA 13.173 G 31655	5531	88.7	-706	0
23	FLORA 13.248 G 100111	5348	85.7	-889	0
24	FLORA 12.142 G 22311	5210	83.5	-1027	00
25	FLORA 12.375 G 21811	4584	73.5	-1653	000

LSD 5% = 706,0 kg/ha.

LSD 1% = 960,0 kg/ha.

LSD 0,1% = 1.248,0 kg/ha.

Analysing the yield performance of genotypes around entire zone, the breeding line Lovrin 9 Z has an average yield of 7397 kg/ha, followed by Biharia (7276 kg/ha), they being surpassed only by the new cultivar Columna (registered by NARDI Fundulea).

The breeding line Lovrin 9 Z was tested in the north and east Romania, too, at the same time (table 8), in 4 locations (Turda, Targu Mures, Secuieni and Perieni), in 6 environments. In that zone, the pluviometry regime was better, the medium fertility of the soils being superior. Consequently, the yield average of all twenty-five genotypes in

all six environments was 9050 kg/ha, with maximum yield average in Secuieni, 10006 kg/ha, in F4 variant (without nitrogen fertilisation). It is important to underline that, even the breeding line Lovrin 9 Z was not in every location in top position, overall, its yield average was the biggest (9948 kg/ha), with a maximum of 10939 kg/ha, in Secuieni (F1 variant, with nitrogen fertilisation).

About Finlay and Wilkinson (1963), the genotypes can be classified in four categories, by plotting coefficient of regression (slope, b) against yields averages. In figure 5, the values of yields for every genotype are distributed in four frames done by intercept of average of all genotypes (6896 kg/ha) with unitary coefficient of regression (slope, $b=1$). In the frame I, there is a single genotype (Lovrin 90), with $b>1$ and average of yield under general average. The conclusion is that this genotype is underperforming and unstable without interest for breeding program.

Frame II ($b<1$ and yields under general average) include genotypes stable, but at a nonresponding level of yield. Like frame I, frame II includes genotypes without interest (Dacic, Albota 95-13, Simnic 1412). Much more interest presents frame III, where the genotypes have the slope subunit ($b<1$) and yields exceeded the general average: Lovrin 9 Z, Columna, Biharia, Gospodar. These genotypes are stable, yielding performant even in unfavourable environments. Otilia, Consecvent and Voinic, presents in frame IV, are performant genotypes, with good yielding capacity, but with $b>1$, which means that these genotypes have very good yield in fertile soils, but they are unstable.

In this figure, the ascendance of linear trend suggests that, in that zone, the increasing yields become more unstable, depending on soil and climatic conditions.

In figure 6 are transposed the results from table 8, by the same method. The four frames are delimited by yield average of all genotypes (9050 kg/ha) and unitary coefficient of variation ($b=1$). For this time, Glosa, Andrada and Georgiana are recovered in frame I, also, these cultivars are poor yielding and additional, unstable. Other genotypes (frame II) are without interest, low yielding and unstable (Pitar, Luminita, Semnal).

The varieties placed in frame III (Ursita, Consecvent, Gospodar) are valuable, with good yielding potential and stable from one environment to another. However, in frame IV are placed the best ones' genotypes: Lovrin 9 Z, Columna, Granprim. These genotypes are good yielding and respond very well to high soil fertility. One can appreciate that Lovrin 9 Z has better stability than Columna (its b is smaller).

The descendent slope of linear trend suggests that the general tendency is that the better yielding varieties are more stable, an important objective of wheat breeding in our activity.

Graphical representation of the experimental yields all over the country (all 14 locations and fertilisation variants, twenty-two environments) is presented in figure 7. In the first time, it is to underline the large variability of the average level of the yields from a location to another (Marculesti, Albota and Oradea, with low yields, in contrast with Lovrin, Turda, Targu Mures and Secuieni, with yields equal or bigger than 9000 kg/ha).

Before to be registered, multiplied and extended in the large agriculture, the promising breeding lines are evaluated abroad the best cultivars and breeding lines in the production conditions, in a demonstrative lot. So, in 2025, the promising wheat line Lovrin 9 Z was cultivated together with another forty-six genotypes (Table 9) in a demonstrative lot in Diosig, Bihor County. The plot of every variety had two thousand m², and in addition to yield, some quality indicators were evaluated: protein (%), wet gluten (%) and hectolitre mass (kg/hl).

The average of the entire lot yield was 8372 kg/ha, a proof of important level of technology and variant values. The amplitude of yields was 3492 kg/ha, from 6195 kg/ha to 9687 kg/ha, proving a large scale of yield potential of all forty-seven genotypes. In this heavy competition, only six genotypes exceeded 9000 kg/ha, including Lovrin 9 Z. In addition, our new breeding line has all three qualitative indicators superior to lot average, a positive additional point to its value.

After all steps of testing in different locations and conditions, the best one from the breeding lines (Lovrin 9 Z) was promoted in 2025 in the SITRV network (State Institute for Testing and Registration Varieties), in 7 locations, in the north part of Romania (Dej, Ludus, Radauti, Satu Mare, Sibiu, Simleu Silvaniei, Targu Secuiesc). Figure 8 presents graphically the yields results in every location and the average of locations, comparative to three checks (Glosa, Semnal, Andrada). The best performance of breeding line Lovrin 9 Z was registered at Ludus (10896 kg/ha), confirming its big yielding potential. Even the average in all locations confirms its superiority to all three checks (8132 kg/ha).

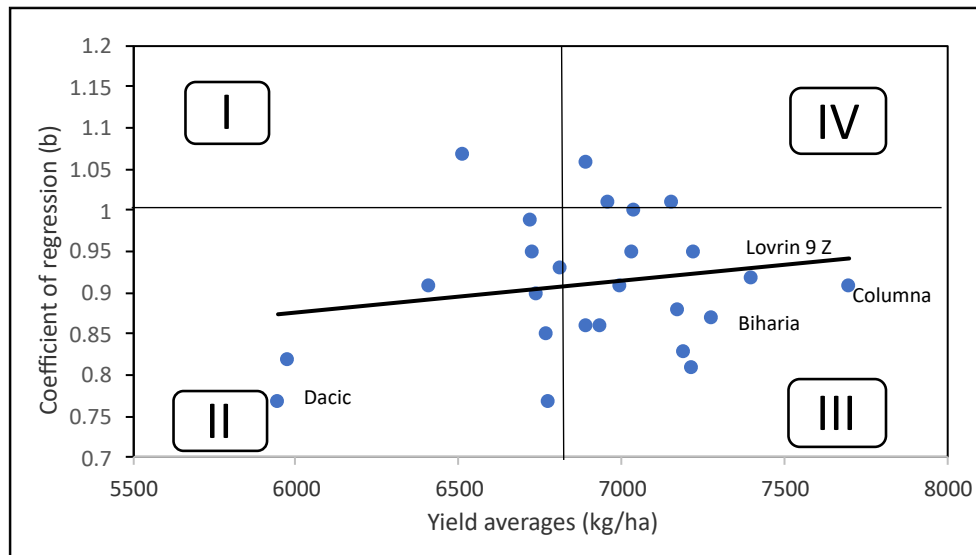
Taking account of all positive results up to this stage of breeding line Lovrin 9 Z, it has started the seed multiplication, beginning with the breeder seeds. By this, the period between the official registration and extension in culture is shortened to a minimum.

Table 7. Average grain yields of 25 winter wheat genotypes in sixteen environments (south and west Romania, 2025).

Genotype location	Fundulea				Braila	Marcu- lesti	Teleorman		Caracal		Albota		Simnic	Lovrin	Oradea	Livada	Average of genotype (kg/ha)
	F1	F2	F3	F4	F4	F4	F1	F4	F1	F4	F1	F4	F1	F1	F1	F1	
COLUMNA	6929	7173	6634	6736	9840	5240	9875	9868	8883	9219	6252	5063	6705	9709	5665	9116	7682
LOVRIN 9 Z	6316	6948	6535	6306	9287	4842	9341	10035	7680	7865	6489	5493	6585	9565	5836	9223	7397
BIHARIA	6267	5848	6181	5955	8682	4609	8697	8719	9019	8501	5931	5511	6933	10993	5685	8890	7276
GOSPODAR	5981	6270	5719	5993	9372	4982	8505	8755	9666	8087	5838	5045	6775	11223	5174	8054	7215
EVIDENT	6747	6661	6565	6550	8875	4945	8805	9146	9563	8722	5738	4991	7279	7759	4677	8509	7221
SIMNIC 10	5819	6419	6145	6200	8972	4757	8140	8653	9061	9329	5390	4432	7040	10801	5655	8232	7190
URSITA	6250	6476	6357	6722	8567	5243	8998	8750	9125	8999	5650	4144	6259	9835	4681	8700	7172
VOINIC	6296	6902	6184	6346	8486	5189	8561	8480	9126	8320	5762	5175	6211	10199	5370	7833	7150
GRANPRIM	6705	6900	6446	6536	8592	5141	9248	9157	7267	8728	5834	4867	5419	8079	5422	8274	7038
FAGUR	6680	6225	6272	6127	8836	4636	8479	8843	9609	8822	5463	4837	6226	8914	5122	7398	7031
BRIA	6339	6051	5832	6106	8000	5288	9127	8940	8941	8749	5626	4831	5353	9710	4802	8153	6990
CONSECVENT	6148	6592	5994	6297	8855	5128	8173	8252	7829	8699	6061	5213	5560	9817	4762	7966	6959
TURDA 100-18	5950	6202	5910	6194	8809	5143	9968	9324	8849	8356	5024	4251	5985	7417	5311	8245	6934
HARNIC	6101	6480	5776	6336	8073	4282	8152	8348	8374	8361	5807	4953	6973	9220	5162	7840	6890
OTILIA	5816	6602	5697	6328	8862	4788	8013	8068	8518	8467	5424	4624	5172	10727	5324	7808	6890
ABUND	5850	5989	5709	5753	8648	4719	8145	8445	8398	8484	5442	4824	5726	10070	4867	7871	6809
GLOSA	6228	6218	5518	5995	9338	4742	8622	8677	10425	8182	5625	4491	5964	6855	3582	7881	6771
GLORIOS	5363	5539	5426	5313	8269	5009	8241	8245	9634	8695	5579	4712	5412	10049	5110	7703	6769
CAROM	5657	5069	5764	5685	8459	5085	8457	8119	8202	8309	5885	4648	5178	10025	4957	8277	6736
PITAR	6032	6143	5942	6013	8439	4741	8792	8998	8267	8710	5384	4350	6255	7822	4136	7521	6722
IZVOR	5537	5601	5969	5693	8379	3670	8396	8099	8343	8197	6271	5087	6168	8879	5250	7996	6721
LOVRIN 90	5317	5563	5532	5410	8009	5051	8513	8041	8053	7800	5217	4571	6424	8335	4608	7760	6513
SIMNIC 1412	5613	5074	5944	5696	7941	4519	8027	8090	8450	8202	4963	4548	6723	6759	3578	8374	6406
ALBOTA 95-13	4562	4590	5142	4803	8557	4433	7717	8020	7447	8741	4972	3882	5677	6327	3052	7591	5970
DACIC	4072	3867	4664	4480	7906	3260	8013	7969	8124	8103	5414	4598	3937	6978	5547	8183	5945
Average of location (kg/ha)	5943	6056	5914	5983	8642	4778	8600	8642	8674	8506	5642	4766	6078	9043	4933	8136	6896

Table 8. Average grain yields of 25 winter wheat genotypes in six environments (north and est Romania, 2025).

Class.	Genotype location	Turda		Targu Mures	Secuieni		Perieni	Average of genotype (kg/ha)
		F1	F4	F1	F1	F4	F1	
1	LOVRIN 9 Z	10663	9691	10315	10939	10753	7336	9948
2	URSITA	10176	9751	10019	11788	11237	6101	9845
3	COLUMNNA	10659	9631	9837	10057	11159	7201	9757
4	CONSECVENT	10287	9638	9288	10944	11358	6630	9691
5	GRANPRIM	10056	9058	10043	10348	10632	7692	9638
6	GOSPODAR	9910	9374	9837	10871	10169	6956	9519
7	TURDA 109-12	9612	8802	9431	10965	10206	7778	9466
8	ABUND	9714	8698	9342	10736	10470	6608	9261
9	CODRU	9418	8751	10157	9468	10084	7202	9180
10	CEZARA	8233	7542	10191	10469	11140	7438	9169
11	FAGUR	9579	9255	8255	9792	11307	6772	9160
12	OTILIA	10028	9261	9066	9691	10215	6487	9125
13	EVIDENT	8899	8297	10198	9952	9550	7603	9083
14	TURDA 100-18	10449	9202	9040	9635	9947	5900	9029
15	VOINIC	9672	8795	9087	9657	10121	6617	8991
16	TURDA 75-16	9837	8904	9397	8661	9900	6970	8945
17	TURDA 61-18	9908	9033	10232	8572	9130	6671	8924
18	HARNIC	9382	8731	9277	10058	9681	6195	8887
19	LUMINITA	9674	9189	9592	8953	10013	5635	8843
20	SEMNAL	10382	9628	8763	8168	9087	6597	8771
21	TURDA 28-19	9472	8815	9601	8788	9588	6102	8728
22	GEORGIANA	9625	8594	9809	7102	8724	7531	8564
23	PITAR	9265	8701	7765	8901	9185	6071	8315
24	ANDRADA	9687	8741	9131	7824	8387	5328	8183
25	GLOSA	8017	6952	7621	7140	8119	5453	7217
Average of location (kg/ha)		9704	8921	9412	9579	10006	6675	9050

**Figure 5.** The varieties grouping about their yield and regression coefficient, in 16 environments.

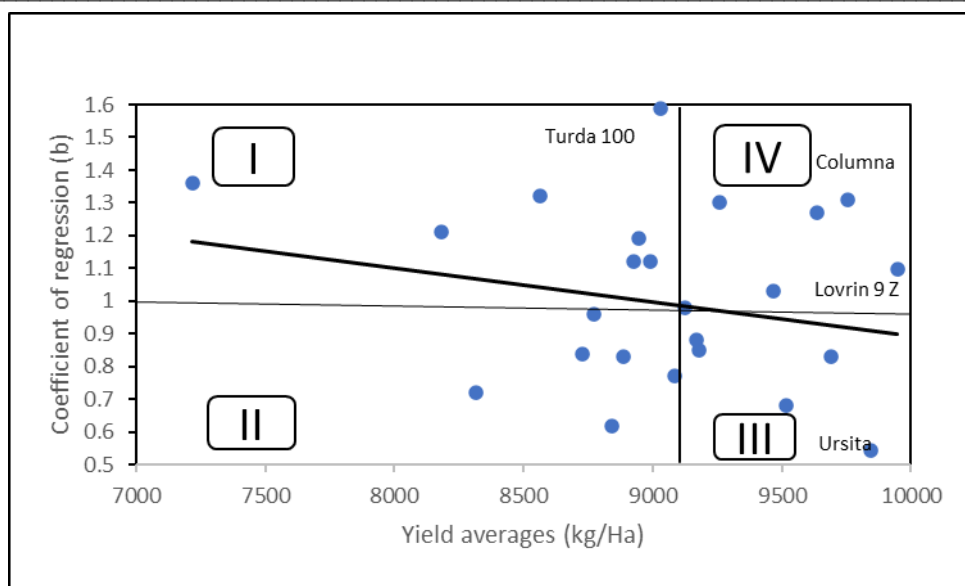


Figure 6. The varieties grouping about their yield and regression coefficient, in 6 environments.

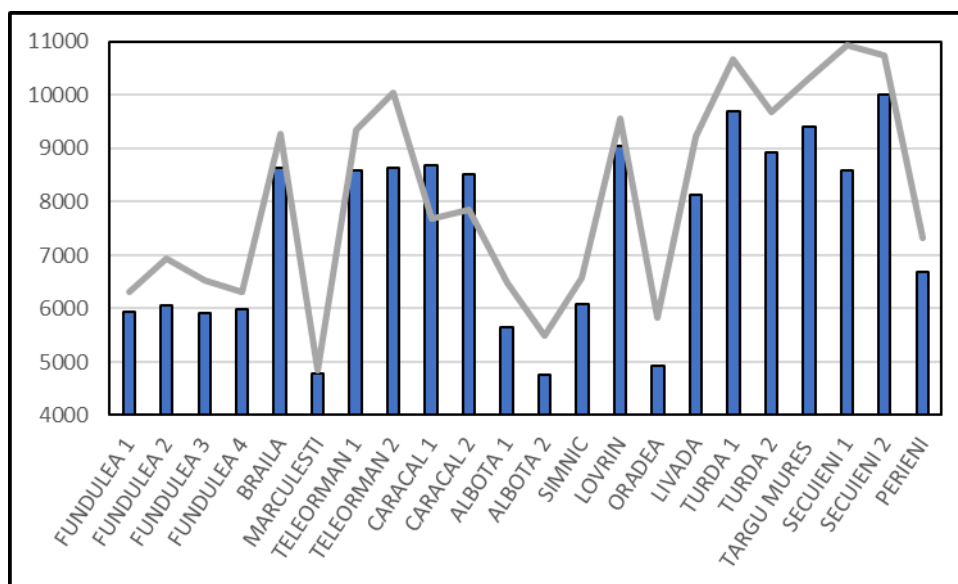


Figure 7. The yield average of breeding line Lovrin 9 Z in 22 environments, comparative to the average of 25 genotypes.

Table 9. Results of yield and quality indicators in a testing field (Diosig, Bihor- county, 2025).

Class.	Genotype	Firm proprietor	Yield (kg/ha)	Protein (%)	Wet gluten (%)	Hectoliter mass (kg/hl)
1	PROPULSO	RAGT	9687	13.6	25.8	74.7
2	AVENUE	LIMAGRAIN	9627	13.2	24.6	74.9
3	PIBRAC	SYNGENTA	9197	14.5	27.1	74.9
4	ARCACHON	ROUA SEMINTE	9191	13.9	25.1	73.1
5	LOVRIN 9 Z	A.R.D.S. LOVRIN	9055	14.7	27.0	76.0
6	ORMESSON	BIOCROP	9030	14.2	25.9	74.3
7	EPISODE	KWS	8919	14.0	26.0	74.4
8	SONATINE	LIDEA	8881	14.2	27.0	74.6
9	SACRAMENTO	RAGT	8850	14.0	26.1	75.2
10	COMILFO	ROUA SEMINTE	8840	14.7	28.8	73.0
11	EXTREME	KWS	8711	14.4	26.8	75.4
12	MACUMBA	LIDEA	8647	14.3	26.1	75.2
13	IRUN	LIDEA	8647	14.2	25.9	75.4
14	COSMIC	ROUA SEMINTE	8637	13.5	24.5	70.8
15	FALADO	SYNGENTA	8636	13.9	26.7	75.1
16	SOLINDO	LIDEA	8570	14.2	27.1	76.7
17	GABRIO	SYNGENTA	8540	13.8	25.3	74.3
18	FARMEO	RAGT	8532	14.7	27.1	74.4
19	SORELLO	ISTROSSED	8532	14.4	26.7	72.6
20	STK 4	SOITECK PTK	8520	14.0	25.5	71.8
21	PAPILLON	SAATEN UNION	8520	14.7	27.5	72.7
22	RUBISKO	RAGT	8512	13.9	25.0	74.4
23	BIHARIA	A.R.D.S. LOVRIN	8511	15.0	27.5	75.5
24	BORDER	LIMAGRAIN	8485	14.1	26.7	77.0
25	ANAPURNA	LIMAGRAIN	8485	14.1	28.0	76.7
26	ZAMPANO	PROBSTDORFER	8363	14.6	27.1	72.6
27	PASSION	SYNGENTA	8353	14.3	27.3	73.8
28	MUSQUETON	SAATEN UNION	8351	14.0	26.4	74.6
29	ASTERION	LIMAGRAIN	8343	12.9	24.2	75.2
30	APILCO	LIMAGRAIN	8296	14.0	26.5	76.5
31	MONACO	PROBSTDORFER	8287	14.5	28.1	77.7
32	PG 102	SOITECK PTK	8264	14.7	28.1	74.2
33	APEXUS	DONAU SAAT	8202	14.2	26.1	77.1
34	ABSALON	LIMAGRAIN	8136	14.2	26.6	76.5
35	GLOSA	N.A.R.D.I. FUNDULEA	8125	14.6	26.8	76.4
36	SPHERE	KWS	8117	13.4	25.9	77.1
37	CHEVINGNON	DONAU SAAT	7919	14.6	28.1	72.6
38	ULTIM	KWS	7881	14.3	26.9	74.1
39	ATTRAKTION	BIOCROP	7798	14.5	28.2	77.0
40	FOXX	BIOCROP	7789	14.4	27.5	76.5
41	CENTURION	SAATEN UNION	7752	15.3	29.2	74.0
42	AMICUS	DONAU SAAT	7751	13.9	26.6	78.5
43	DIMENZIO	ISTROSEED	7693	15.2	27.2	74.1
44	DACIC	A.R.D.S. LOVRIN	7675	16.2	31.1	74.4
45	SPIRELLINA	ISTROSSED	7514	16.4	32.2	75.6
46	ARONIO	PROBSTDORFER	6898	14.2	27.2	76.1
47	SOITECK PTK	STK EXP	6195	15.9	28.3	73.1
EXPERIMENTAL AVERAGES			8372	14.4	26.9	74.9

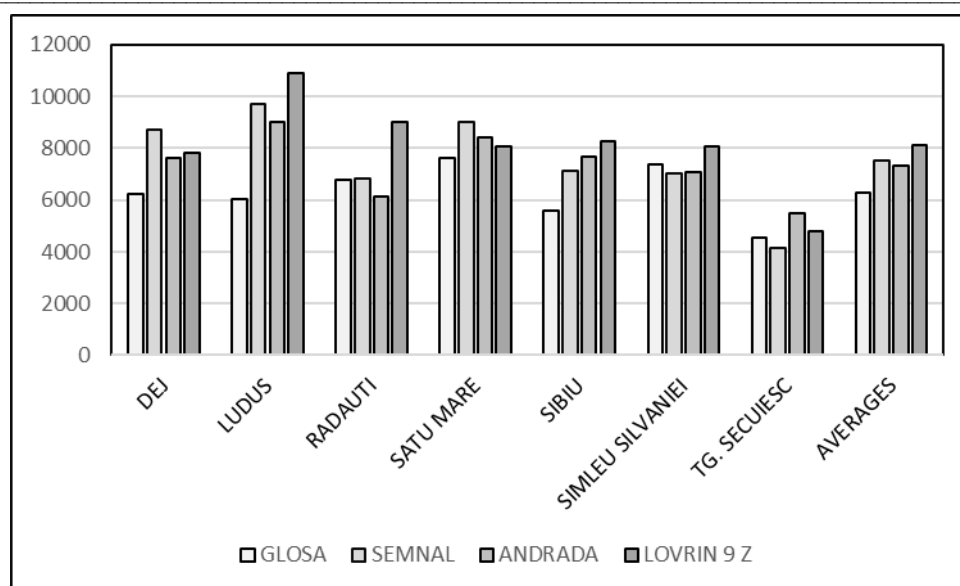


Figure 8. Results regarding the yield of breeding line Lovrin 9 Z in SITRV network (2025).

CONCLUSIONS

To improve the wheat breeding efficiency, is important to beginning the selection of yield potential as soon is possible, preferable in 2-3 locations. Every year, third part to half of testing lines must be changed by new coming ones.

The repetition of yield testing for promising breeding line in next year is necessary in conditions of changing the intensity of climatical factors from a year to another.

Evaluating the promising lines in contrasting environments is an efficient method to find genotypes well yielding and stable, simultaneously.

Before to extend the promising variety in production, it is useful to compare it with the best cultivars from the future areas of cultivation.

The breeding line Lovrin 9 Z is a promising one. If it will be registered, our recommendation is to extend it in west and north Romania, areas affected in a smaller amount by drought.

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